SPORTSKE NAUKE I ZDRAVLJE

SPORTS SCIENCE AND HEALTH

Volume 16 Issue 1

Naučno-stručni časopis iz oblasti sportskih i medicinsko-rehabilitacionih nauka
Scientific Journal in Sports and Medical-Rehabilitation Science

ISSN 2232-8211 (Print)
ISSN 2232-822X (Online)

Godina 16 • Broj 1
Jun 2026.
Republika Srpska
Bosna i Hercegovina

Volume 16 • Issue 1
June 2026
The Republic of Srpska
Bosnia and Herzegovina

UDC: 612
UDC: 613
UDC: 796

www.siz-au.com

APEIRON

SPORTSKE NAUKE I ZDRAVLJE

SPORTS SCIENCE AND HEALTH

Naučno-stručni časopis iz oblasti sportskih i medicinsko-rehabilitacionih nauka
Scientific Journal in Sports and Medical-Rehabilitation Science

Izdavač/Published by *Panevropski univerzitet "Apeiron" Banja Luka/ Pan-European University "Apeiron" Banja Luka, Bosnia and Herzegovina*

Urednik izdavača/Editor of University Publications Aleksandra Vidović, *Pan-European University "Apeiron" Banja Luka, Bosnia and Herzegovina*

Glavni urednik/Editor-in-Chief Velibor Srdić, *Pan-European University "Apeiron" Banja Luka, Bosnia and Herzegovina*

Odgovorni urednik/Editor Osmo Bajrić, *Pan-European University "Apeiron" Banja Luka, Bosnia and Herzegovina*

Redakcijski odbor/Editorial Board

Bojan Kozomara, Pan-European University "Apeiron", Bosnia and Herzegovina
Branimir Mikić , University of Travnik, Bosnia and Herzegovina
Boyanka Peneva, Sports Academy "Vasil Levski", Bulgaria
Duško Bjelica, University of Montenegro, Montenegro
Goran Bošnjak, University of Banja Luka, Bosnia and Herzegovina
Goran Oreb, University of Zagreb, Croatia
Jasenka Miljuš, Pan-European University "Apeiron", Bosnia and Herzegovina
Ludmil Petrov, St. Cyril and Methodius University of Veliko Tarnovo, Bulgaria
Marko Stojanović, University of Novi Sad Serbia
Miodrag Spasić, *Faculty of kinesiology Split, Croatia*
Nikolaos Oxizoglou, Regional Directory of State School Advisor of Physical Education Halkidiki & Thessaloniki, Greece
Velimir Vukajlović, Pan-European University "Apeiron", Bosnia and Herzegovina
Željka Cvijetić, Pan-European University "Apeiron", Bosnia and Herzegovina

Naučni odbor/Scientific Board

Aleksandar Janković, University of Novi Sad, Serbia
Branislav Mihajlović, Pan-European University "Apeiron", Bosnia and Herzegovina
Damir Sekulić, Faculty of kinesiology Split, Croatia
Igor Jukić, Kinezioloski fakultet, Sveučilište u Zagrebu, Hrvatska
Ivan Prskalo, Učiteljski fakultet Sveučilišta u Zagrebu, Hrvatska
Izet Rađo, University of Sarajevo, Bosnia and Herzegovina
Josip Lepeš, Ferenc Gál College Szeged, Hungary
Jovan Ćulum, Pan-European University "Apeiron", Bosnia and Herzegovina
Kemal Idrizović, University of Montenegro, Montenegro
Marko Badrić, University of Zagreb
Meta Zagorc, University of Ljubljana, Slovenia
Milan Nešić, Educons University, Serbia
Milovan Bratić, University of Nis, Serbia
Nenad Ponorac, University of Banja Luka, Bosnia and Herzegovina
Nijaz Skender, Pedagoški fakultet, Univerzitet u Bihaću, Bosna I Hercegovina
Osmo Bajrić, Pan-European University "Apeiron", Bosnia and Herzegovina
Ratko Pavlović, University of East Sarajevo, Bosnia and Herzegovina
Slobodan Goranović, University of Banja Luka, Bosnia and Herzegovina
Slobodan Simović, University of Banja Luka, Bosnia and Herzegovina
Stamenko Šušak, University of Novi Sad, Serbia
Višnja Đorđić, University of Novi Sad, Serbia
Vladan Pelemiš, University of Belgrade, Serbia
Vladimir Koprivica, University of Belgrade, Serbia
Yulia Mutafova, Sports Academy "Vasil Levski", Bulgaria
Zoran Milić, University of Novi Sad, Serbia
Žarko Kostovski, St. Cyril and Methodius University, Macedonia
Živorad Maličević, Pan-European University "Apeiron", Bosnia and Herzegovina

Kancelarija/Office

Panevropski univerzitet "Apeiron"
Pere Krece 13, 78000 Banja Luka,
Bosna i Hercegovina
tel. +387 (0) 51 247 975,
fax +387 (0) 51 430 921
siz@siz-au.com
www.siz-au.com

Pan-European University "Apeiron"
Pere Krece 13, 78000 Banja Luka,
Bosnia and Herzegovina
tel. +387 (0) 51 247 975,
fax +387 (0) 51 430 921
siz@siz-au.com
www.siz-au.com

Sekretar i tehnička podrška/ Secretariat and Technical Support Oliver Krička, Bosnia and Herzegovina
Lektura/Text editing Tanja Aničić, Tijana Vasiljević
Dizajn/Design Sretko Bojić
Web dizajn/Web Design Marko Milovanović
Štampa/Printed by MARKOS, Banja Luka
Tiraž: 300 kom. /Printed in 300 copies/

Tematske oblasti/Themes:

- Predškolsko vaspitanje u funkciji razvoja djece
- Savremeno školsko fizičko vaspitanje u funkciji pravilnog rasta i razvoja djece i omladine
- Savremeno fizičko vaspitanje i zdravlje mladih
- Studentski sport kao faktor zdravog življenja
- Sport u funkciji rekreacije građana- stanovništva i zdravlja
- Sportsko- rekreativne aktivnosti kao faktor borbe protiv stresa
- Primjena sportsko-rekreativnih aktivnosti u promjeni načina života ljudi
- Moderne sportsko-rekreativne aktivnosti (fitnes, ekstremni sportovi i dr.) I zdravlje vježbača
- Korektivna gimnastika i kineziterapija u otklanjanju posturalnih poremećaja
- Sport osoba sa posebnim potrebama u funkciji osposobljavanja za život i rad
- Sport invalida kao faktor zdravlja i resocijalizacije
- Vrhunski sport i zdravlje
- Ostale aktuelne teme vezane za sportske nauke i zdravlje

- Preschool education in the function of child development
- Modern school physical education in the function of proper growth and development of children and youth
- Modern physical education and youth health
- University sports as a factor of healthy living
- Sport in the function of recreation and health of citizens
- Sports and recreational activities as anti-stress factor
- Use of sports and recreational activities in the change of people's lifestyle
- Modern sports and recreational activities (fitness, extreme sports, etc.) and health of exercisers
- Corrective exercises and kinetic therapy in the elimination of postural disorders
- Sport for people with special needs as a function of training for life and work
- Disabled sports as a factor of health and social reintegration
- Top sport and health
- Other current topics related to sports science and health

Indexed in:

ebscohost.com
citefactor.org/contact
scopus.com
scholar.google.com
doisrpska.nub.rs
crossref.org
road.issn.org
cosmosimpactfactor.com
erihplus.nsd.no
worldcat.org
doaj.org
esjindex.org

UDC 612
UDC 613
UDC 796

SPORTS SCIENCE AND HEALTH is registered with the Ministry of Science and Technology of the Republic of Srpska by serial registration code 07.030-053-85-2/11, date 08.02.2011., number 612.
SPORTS SCIENCE AND HEALTH (ISSN 2232-8211) is an international journal published two time a year.

ISSN 2232-8211 (Print)
ISSN 2232-822X (Online)

SPORTSKE NAUKE I ZDRAVLJE

SPORTS SCIENCE AND HEALTH

Vol. 16 (2026) No. 1 (1-196)

Sadržaj / Contents

Digital Strategies of Sports Organizations and Youth Engagement in the Function of Developing Healthy Lifestyle Habits: Secondary Data Analysis 5
Digitalne strategije sportskih organizacija i angažman mladih u funkciji razvoja zdravih životnih navika: analiza sekundarnih podataka
Nina Uremović, Mirjana Landika, Vanja Sredojević

Differences in Functional Capabilities of Younger and Older Juniors in Water Polo 21
Razlike u funkcionalnim sposobnostima mlađih i starijih juniora u vaterpolu
Senad Bajrić, Edin Mirvić, Osmo Bajrić, Alma Dizdar

The Impact of Traditional Game-Based Activities on Self-Confidence and Motor Skill Development in Low Vision Children with Disabilities 33
Devi Catur Winata, Pamuji Sukoco, Sujarwo, liliana Puspa Sari, Mohammed Hasan Tuaimah, Andi Saparia, Ngurah Mahendra Dinatha

Parents' Perceptions of Physical and Health Education in the Experimental All-Day School Program in the Republic of Croatia 42
Ante Zekanović, Nijaz Skender, Naim Ćeleš

Development of a Modified Device of the Manos Reactive Agility Test Instrument for Basketball 49
Hermanto, Johansyah Lubis, Iman Sulaiman

Association Between Session RPE and Edwards' TRIMP as Indicators of Internal Load in Elite Male Basketball Players 58
Konstantinos Stratakis, Dino Adrović

Multiculturalism and Physical Activity: Evidence From a Higher Education-Based Intervention 63
Maria Giovanna Tafuri, Francesca Latino, Generoso Romano

Analysis of Quantitative Changes in Motor Abilities Under the Influence of a Programmed Training Process 79
Analiza kvantitativnih promjena motoričkih sposobnosti pod uticajem programiranog rada
Osmo Bajrić, Meta Zagorc, Bojan Guzina

Differences in the Effect of Regular and Specially Programmed Physical and Health Education on the Motor Status of Students 92
Razlike u uticaju redovne i posebno programirane nastave tjelesnog i zdravstvenog odgoja na motorički status učenika
Almir Kalabušić, Amela Bajrektarević, Elvira Nikšić, Faris Rašidagić

Parents' attitudes about motives for enrolling children in preschool institutions and early learning programs 107
Marica Travar, Nebojša Mitrović, Slađana Miljenović, Nataša Cvijanović, Neda Gavrić, Ranko Rajović

The Influence of Training Facility Management, Injury Risk Perception, and Self-Efficacy on Wushu Technical Performance 113
Novita, Martono, Hendra Setyawan, Sabariah, Rufi'i, Diah Andika Sari, Nuridin Widya Pranoto, Ratko Pavlovic

Lower Back Pain, Physical Activity and the Quality of Life 121
Romana Romanov, Doris Molnar, Zoran Milić, Ivica Nikolić, Nina Rasković

Revitalizing Mental Readiness: Mindsport Navigator Application (Minna) to Strive for the Best Performance of Undiksha FC 129
I Made Satyawan, I Nyoman Laba Jayanta, Ni Luh Putu Spyanawati, Gede Doddy Tisna, I Gusti Putu Suharta, Ni Putu Dwi Sucita Dartini, Prisca Widiati, Yovhandra Ockta

Training Plan Elements as Predictors of Exercise Motivation: A Cross-Sectional Study 135
Stefan Janković, Tatjana Tubić

The Effect of the Return Board Tool on Improving Backhand Topspin Skills in Table Tennis Athletes 141
Teguh Santosa, Hari Setiono, Fatchul Imron, Shodig Hutomono, Rivan Sagitha, Pratama, Susanto

The Effect of Small-Sided Games as a Contextual Training Method on Shooting Accuracy and Physical Activity Enjoyment in Futsal Extracurricular Participants 146
Yahya Eko Nopiyanto, Ipa Sari Kardi, Cahyo Wibowo, Muhammad Maulana Fajar, Eko Putra Utama.J, Herdiansyah Agus, Novriansyah

Differences in Situational-Motor Abilities of Young Water Polo Players 153
Razlike u situaciono-motoričkim sposobnostima mladih vaterpolista 153
Senad Bajrić, Edin Mirvić, Osmo Bajrić, Faris Rašidagić, Alma Dizdar

Relationship Between Morphological Characteristics and Motor Abilities in Children 166
Povezanost morfoloških karakteristika i motoričkih sposobnosti kod dece 166
Danijel Stokanović, Slobodan Pavlović, Ivko Nikolić

Sensory and motor neurones and spinal reflexes: a narrative review 185
Stefan Janković, Aleksandra Dominović-Kovačević, Oliver Krička, Sanja Gnjato

Instruction for authors submitting papers 192
Uputstvo za autore 193
Ethics 194
Etika 195

Godišnja pretplata 60 EUR-a /Annual subscription is 60 EUR; Full-text available free of charge at http://www.siz-au.com

Dragi čitaoci,

pred vama je majski broj Časopisa koji donosi niz aktuelnih tema i istraživanja. Iskreno se nadamo da će selekcija radova u ovom broju opravdati, pa i nadmašiti očekivanja šire čitalačke publike, te podstaknuti daljnje konstruktivne rasprave u akademskoj zajednici. Uredništvo je u ovaj broj uvrstilo 19 radova, autora iz Indonezije, Iraka, Hrvatske, Slovenije, Srbije, Italije i Bosne i Hercegovine.

U ovom broju ćete pročitati članke o multikulturalizamu i fizičkoj aktivnost: dokazi iz intervencije zasnovane na visokom obrazovanju, razvoju modifikovanog uređaja instrumenta Manos testa reaktivne agilnosti za košarku, poređenje sesije RPE sa Edwardsovim TRIMP-om za praćenje internog trenažnog opterećenja kod vrhunskih košarkaša, bolu u donjem dijelu leđa, fizičkoj aktivnosti i kvalitetu života, efekatu igara na skraćenom terenu kao kontekstualne metode treninga na preciznost šuta i uživanje u fizičkoj aktivnosti kod učesnika u vannastavnom futsalu, uticaju aktivnosti zasnovanih na tradicionalnim igrama na samopouzdanje i razvoj motoričkih vještina kod slabovide djece sa smetnjama u razvoju, uticaju upravljanja trenažnim objektima, percepcije rizika od povreda i samofikasnosti na tehničke performanse u vušuu, stavovima roditelja o motivima za upis djece u predškolske ustanove i programe ranog učenja, efekatu alata povratne table na poboljšanje bekhend topspin vještina kod stonotenisera, revitalizaciji mentalne spremnosti: aplikacija Mindsport Navigator (Minna) u cilju postizanja najboljih performansi FK Undikša, senzornim i motornim neuronima i spinalnim refleksima: narativni pregled, elementima trening plana kao prediktori motivacije za vježbanje, percepciji roditelja o fizičkom i zdravstvenom vaspitanju u eksperimentalnom programu cjelodnevne škole u Republici Hrvatskoj, analizi kvantitativnih promjena motoričkih sposobnosti pod uticajem programiranog rada, razlikama u funkcionalnim sposobnostima mlađih i starijih juniora u vaterpolu, razlikama u situaciono-motoričkim sposobnostima mladih vaterpolista, razlikama u uticaju redovne i posebno programirane nastave tjelesnog i zdravstvenog vaspitanja na motorički status učenika, digitalnim strategijama sportskih organizacija i angažman mladih u funkciji razvoja zdravih životnih navika: analiza sekundarnih podataka, povezanosti morfoloških karakteristika i motoričkih sposobnosti kod djece.

Prije svega, upućujemo iskrenu zahvalnost autorima, recenzentima i članovima uredništva na izuzetnom trudu, stručnosti i posvećenosti zahvaljujući kojima naš časopis kontinuirano raste i unapređuje svoj kvalitet sa svakim novim izdanjem. Predani rad svih aktera ključan je oslonac u održavanju visokih znanstvenih i stručnih standarda.

UREDNIŠTVO ČASOPISA

Dear readers,

In front of you is the May issue of the Journal, which brings a series of current topics and research. We sincerely hope that the selection of papers in this issue will meet, and even exceed, the expectations of the wider reading audience, as well as encourage further constructive discussions within the academic community. The Editorial Board has included 19 papers in this issue, by authors from Indonesia, Iraq, Croatia, Slovenia, Serbia, Italy, and Bosnia and Herzegovina.

In this issue, you will read articles on multiculturalism and physical activity: evidence from a higher education-based intervention, the development of a modified device of the Manos reactive agility test instrument for basketball, a comparison of session RPE with Edwards' TRIMP for monitoring internal training load in elite male basketball players, lower back pain, physical activity, and the quality of life, the effect of small-sided games as a contextual training method on shooting accuracy and physical activity enjoyment in futsal extracurricular participants, the impact of traditional game-based activities on self-confidence and motor skill development in low vision children with disabilities, the influence of training facility management, injury risk perception, and self-efficacy on wushu technical performance, parents' attitudes about motives for enrolling children in preschool institutions and early learning programs, the effect of the return board tool on improving backhand topspin skills in table tennis athletes, revitalizing mental readiness: mindsport navigator application (Minna) to strive for the best performance of Undiksha FC, sensory and motor neurons and spinal reflexes: a narrative review, training plan elements as predictors of exercise motivation, parents' perceptions of physical and health education in the experimental all-day school program in the Republic of Croatia, the analysis of quantitative changes in motor abilities under the influence of programmed work, differences in the functional abilities of younger and older juniors in water polo, differences in the situational-motor abilities of young water polo players, differences in the influence of regular and specially programmed physical and health education classes on the motor status of students, digital strategies of sports organizations and youth engagement in the function of developing healthy life habits: secondary data analysis, and the connection between morphological characteristics and motor abilities in children.

First and foremost, we express our sincere gratitude to the authors, reviewers and members of the editorial board for their exceptional effort, expertise, and dedication, thanks to which our journal continuously grows and improves its quality with each new issue. The dedicated work of all participants is a key pillar in maintaining high scientific and professional standards.

EDITORIAL BOARD OF THE JOURNAL

https://doi.org/10.7251/SSH2601005U
UDC: 004.738.5:[613.2:796/799
Original scientific paper
Originalni naučni rad

Digital Strategies of Sports Organizations and Youth Engagement in the Function of Developing Healthy Lifestyle Habits: Secondary Data Analysis

Digitalne strategije sportskih organizacija i angažman mladih u funkciji razvoja zdravih životnih navika: analiza sekundarnih podataka

Nina Uremović, Mirjana Landika, Vanja Sredojević

Pan-European University Apeiron, Banja Luka, Bosnia and Herzegovina

Correspondence:
Nina Uremović
Pan-European University Apeiron, Banja Luka, Bosnia and Herzegovina
nina.d.uremovic@apeiron-edu.eu

Panevropski univerzitet Apeiron, Banja Luka, Bosna i Hercegovina

Korespondencija:
Nina Uremović
Panevropski univerzitet Apeiron, Banja Luka,
Bosna i Hercegovina
nina.d.uremovic@apeiron-edu.eu

Abstract: *This paper analyzes how modern digital marketing strategies of sports organizations – including socialfirst content, video formats, real-time communication and multi-channel distribution models – affect youth engagement and the promotion of healthy lifestyle habits. The research is based on contemporary theoretical approaches to physical education and youth sports and examines how digital content can motivate young generations to be more actively involved in sports and recreational activities and to develop positive patterns of health-related behavior.*

The empirical part of the paper is based on the analysis of secondary data sources and the application of statistical methods, including descriptive statistics, correlation tests and multiple linear regression. The results show that the model explains approximately 30% of the variance in youth engagement rate (ER). The socialfirst content variable has a statistically significant effect ($p < 0.01$), while video content and real-time formats show positive, but statistically insignificant coefficients. Datadriven approaches recorded an effect close to the significance level ($p \approx 0.055$). Correlation analysis indicates moderate positive relationships between ER and the share of video content ($r = 0.365$) and real-time format ($r = 0.178$).

Despite the limitations of a small and partially standardized sample, the findings show a positive trend in encouraging youth engagement through modern digital formats. The contribution of the paper is reflected in connecting digital marketing with modern concepts of physical education and youth health, and in pointing out the potential of digital strategies to contribute to the promotion of sports behavior and active lifestyle.

Keywords: *Digital marketing, management of sports organizations, healthy lifestyle habits*
Jel classification: *M31, M10, I12, L83*

Sažetak: *Ovaj rad analizira na koji način savremene digitalne marketinške strategije sportskih organizacija – uključujući social-first sadržaj, video formate, real-time komunikaciju i multikanalne modele distribucije – utiču na angažman mladih i promociju zdravih životnih navika. Istraživanje se zasniva na savremenim teorijskim pristupima fizičkom vaspitanju i sportu mladih i ispituje kako digitalni sadržaji mogu motivisati mlade generacije da se aktivnije uključuju u sportske i rekreativne aktivnosti te da razvijaju pozitivne obrasce ponašanja povezane sa zdravljem.*

Empirijski dio rada zasniva se na analizi sekundarnih izvora podataka i primjeni statističkih metoda, uključujući deskriptivnu statistiku, korelacione testove i višestruku linearnu regresiju. Rezultati pokazuju da model objašnjava približno 30% varijanse engagement rate-a mladih (ER). Varijabla social-first sadržaja ostvaruje statistički značajan efekat ($p < 0.01$), dok video sadržaji i real-time formati pokazuju pozitivne, ali statistički neznačajne koeficijente. Data-driven pristupi bilježe efekat blizu nivoa značajnosti ($p \approx 0.055$). Korelaciona analiza ukazuje na umjerene pozitivne veze između ER-a i udjela video sadržaja ($r = 0.365$) te real-time formata ($r = 0.178$). Uprkos ograničenjima malog i djelimično standardizovanog uzorka, nalazi pokazuju pozitivan trend u podsticanju angažmana mladih kroz savremene digitalne formate. Doprinos rada ogleda se u povezivanju digitalnog marketinga sa savremenim konceptima fizičkog vaspitanja i zdravlja mladih te u ukazivanju na potencijal digitalnih strategija da doprinesu promociji sportskog ponašanja i aktivnog načina života.

Ključne reči: *PANAS, Digitalni marketing, menadžemnt sportskih organizacija, zdrave životne navike*
Jel klasifikacija: *M31, M10, I12, L83*

Introduction

Digitalization has brought significant changes to the way sports organizations communicate with the general

Uvod

Digitalizacija je donijela značajne promjene u načinu na koji sportske organizacije komuniciraju sa širom

public, especially young people. The upward trend in the use of digital devices and the participation of young people in social networks, streaming platforms and dedicated applications has led to digital engagement becoming one of the key indicators of the success of sports organizations. In this framework, all interest groups have an important role, especially young people with whom clubs can communicate through various digital channels.

The subject of this scientific paper is the strategic directions of marketing and ways of communicating with young people in order to acquire healthy habits through sports activities.

The purpose of the research is to analyze in detail the application of modern digital strategies and to examine their impact on the engagement of young people in the sports environment.

The aim of the research is to offer a systematic overview of secondary data, identify key trends in digital sports marketing among young people and determine how digital content influences their decision to engage in sports activities in order to acquire healthy lifestyle habits. Compared to traditional approaches to sports marketing, the paper seeks to verify the reliability of the hypotheses and theoretically explain the effects of different digital tactics on the behavior of young people.

The research problem stems from the fact that, despite the increasing use of digital strategies in sports marketing, there is still a lack of enough empirical research to confirm precisely which digital tactics contribute to increasing the engagement of young people in sports activities.

The paper presents one main and one auxiliary hypothesis, which examine the impact of advanced digital strategies on youth engagement.

The empirical part of the paper is based on the analysis of secondary data sources and the application of statistical methods including descriptive analysis, correlation tests and regression models. To process the data and perform statistical calculations, Microsoft Excel is used.

Literature Review

Contemporary literature confirms that the digital transformation of sport affects young people to become one of the most active target groups on digital platforms. According to Mahmoud (2024), digital marketing in sports increasingly relies on datadriven analyses that allow for a more accurate understanding of the behavior of digital audiences (Mahmoud, 2024). Deloitte Digital (2025) highlights that organizations that implement socialfirst strategies achieve greater engagement growth, with young people most likely to respond to dynamic, short, and visu-

javnosti, a posebno sa mladim ljudima. Trend rasta korišćenja digitalnih uređaja i učešća mladih ljudi na društvenim mrežama, streaming platformama i namjenskim aplikacijama doveo je do toga da digitalni angažman postane jedan od ključnih pokazatelja uspješnosti sportskih organizacija. U tom okviru, značajnu ulogu imaju sve interesne grupe, a posebno mladi ljudi sa kojima klubovi mogu komunicirati kroz različite digitalne kanale.

Predmet istraživanja ovog naučnog rada je strateški pravci marketinga i načina komunikacije sa mladim ljudima radi sticanja zdravih navika kroz sportske aktivnosti.

Svrha istraživanja jeste da detaljno analizira primjena savremenih digitalnih strategija i da se ispita njihov uticaj na angažman mladih u sportskom okruženju.

Cilj istraživanja je da ponudi sistemski pregled sekundarnih podataka, identifikuje ključne trendove u digitalnom sportskom marketingu među mladima i utvrdi na koji način digitalni sadržaji utiču na njihovu odluku da se uključe u sportske aktivnosti radi sticanja zdravih životnih navika. U poređenju sa tradicionalnim pristupima sportskom marketingu, rad nastoji da provjeri pouzdanost postavljenih hipoteza i teorijski objasni efekte različitih digitalnih taktika na ponašanje mladih.

Istraživački problem proističe iz činjenice da, uprkos sve većoj primjeni digitalnih strategija u sportskom marketingu, i dalje nedostaje dovoljno empirijskih istraživanja koje precizno potvrđuju koje digitalne taktike doprinose povećavaju angažman mladih ljudi u sportskim aktivnostima.

Rad predstavlja jednu glavnu i jednu pomoćnu hipotezu, koje ispituju uticaj naprednih digitalnih strategija na angažman mladih.

Empirijski dio rada zasnovan je na analizi sekundarnih izvora podataka i primjeni statističkih metoda uključujući deskriptivnu analizu, korelacione testove i regresione modele. Za obradu podataka i izvođenje statističkih izračuna korišćen je Microsoft Excel.

Pregled Literature

Savremena literatura potvrđuje da digitalna transformacija sporta utiče na to da mladi postanu jedna od najaktivnijih ciljnih grupa na digitalnim platformama. Prema Mahmoudu (2024), digitalni marketing u sportu sve više počiva na data-driven analizama koje omogućavaju preciznije razumijevanje ponašanja digitalne publike (Mahmoud, 2024). Deloitte Digital (2025) naglašava da organizacije koje primjenjuju social-first strategije ostvaruju veći rast angažmana, pri čemu mladi najčešće reaguju na dinamičan, kratki i vizuelno snažan sadržaj

ally powerful content (Digital., 2025). These findings confirm the specific impact of digital formats on Generation Z, which predominantly consumes sports content through mobile apps and social networks.

Recent literature increasingly emphasizes the need to integrate marketing management, digital technologies and social responsibility of sports organizations in the process of communicating with young people. The authors point out that digital strategies in sport are not only a promotional tool, but also a mechanism for shaping the attitudes, values and behavior patterns of young users. A special focus is placed on the role of interactive and visual formats in stimulating emotional connection with sports content, which contributes to a higher level of online engagement. However, most of the existing research remains at the conceptual and descriptive level, without a deeper statistical check of the causal relationships between specific digital tactics and youth behavior. The lack of quantitative analyses is particularly pronounced in the academic literature, compared to industry reports that offer operational but methodologically limited insights. Therefore, there is a need for empirical testing of the effects of modern digital strategies on youth engagement in the sports context.

The University of Kansas (2024) indicates that realtime posts, behindthescenes formats, and highlights contribute to strengthening young people's sense of belonging to the online community, which confirms the importance of interactive digital formats. (Kansas, 2024) However, although the available literature describes the growth of the application of digital technologies in sports marketing, most papers still offer predominantly descriptive insights, while quantitative research on the direct impact of digital strategies on youth engagement is limited. This opens up a research gap between industry reports, which offer actionable insights, and academic papers, which rarely provide empirical analyses of these effects. This deficiency is the basis for the formulation of hypotheses in the paper, especially those related to the impact of video content, realtime communication and socialfirst approach on the digital engagement of young people. Therefore, a review of the literature indicates that there is a theoretical and practical basis for researching digital strategies, but also the need for additional empirical checks of their effects.

Theoretical Framework of the Topic

The definition and implementation of marketing strategies in the era of digital technologies has radically changed in all spheres of business activities. Traditional communication channels, which as a rule had a one-way character towards the user/consumer, have experienced a transformative

(Digital., 2025). Ovi nalazi potvrđuju specifičan uticaj digitalnih formata na generaciju Z, koja sportske sadržaje dominantno konzumira putem mobilnih aplikacija i društvenih mreža.

University of Kansas (2024) ukazuje da real-time objave, behind-the-scenes formati i istaknuti momenti doprinose jačanju osjećaja pripadnosti online zajednici kod mladih, što potvrđuje značaj interaktivnih digitalnih formata. (Kansas, 2024) Međutim, iako dostupna literatura opisuje rast primjene digitalnih tehnologija u sportskom marketingu, većina radova i dalje nudi pretežno deskriptivne uvide, dok su kvantitativna istraživanja o direktnom uticaju digitalnih strategija na angažman mladih ograničena. Time se otvara istraživački jaz između industrijskih izvještaja, koji nude primjenjive uvide, i akademskih radova, koji rijetko pružaju empirijske analize ovih efekata. Ovaj nedostatak predstavlja osnov za formulaciju hipoteza u radu, posebno onih koje se odnose na uticaj video sadržaja, real-time komunikacije i social-first pristupa na digitalni angažman mladih. Stoga pregled literature ukazuje da postoji teorijska i praktična osnova za istraživanje digitalnih strategija, ali i potreba za dodatnim empirijskim provjerama njihovih efekata.

Teoretski okvir teme

Definisanje i implementacija marketing strategija u eri digitalnih tehnologija radikalno je izmjenjena u svim sferama poslovnih aktivnosti. Tradicionalni komunikacioni kanali koji su po pravilu imali jednosmjerni karakter ka korisniku/potrošaču proživjeli su transformativni proces podržan digitalnim tehnologijama i dobili karakter aktivne dvosmjerne komunikacije. Samim tim, svjedočimo da povratne informacije, podaci i analize kojima danas raspolažu kreatori marketing strategija daju bolju percepciju, a sami tim i novi pristup u kreiranju i kombinovanju preciznijih taktika i alata u definisanju iste. „Razvoj sportskog tržišta uslovio je prelazak sa tradicionalne promocije na savremene oblike marketinga, u kojima digitalna komunikacija i upravljanje odnosima sa publikom imaju centralnu ulogu." (Raković & Dašić, 2018)

Navedeno je primjenjivo na svaki poslovni subjekt uključujući i sportske organizacije. Digitalni marketing sportskih organizacija koristi sve prednosti digitalnih tehnologija od društvenih mreža od vještačke inteligencije u cilju kreiranja što kvalitetnije strategije izgradnje fan baze i održavanja angažmana publike. Uloga digitalnih tehnologija u sportu je od posebnog značaja jer uloga publike i njihov angažman vodjen naglašenom emocijom i osjećajem pripadnosti drugačiji od ostalih

process supported by digital technologies and have acquired the character of active two-way communication. Therefore, we are witnessing that the feedback, data and analysis that the creators of marketing strategies have at their disposal today give a better perception, and the team itself a new approach to creating and combining more precise tactics and tools in defining it. "The development of the sports market has conditioned the transition from traditional promotion to modern forms of marketing, in which digital communication and audience relationship management play a central role." (Raković & Dašić, 2018)

This is applicable to any business entity, including sports organizations. Digital marketing of sports organizations uses all the advantages of digital technologies, social networks, artificial intelligence in order to create the best possible strategy, build a fan base and maintain audience engagement. The role of digital technologies in sports is of particular importance because the role of the audience and their engagement driven by emotion and sense of belonging are different from other consumers of other services or products. That is why social networks are becoming a crucial tool for creating, implementing and analyzing decisions made by the management and marketing team of a sports organization.

Social networks enable valid measurability of audience engagement through their reactions, shares, i.e. enable unhindered two-way communication, and thus become the main source of data necessary for the optimization of digital marketing aligned with the business goals of management. The close business connection between sponsors, brands and sports organizations further enhances the importance of effective management of digital channels and audience engagement, as they are today a benchmark in the valuation of a sports organization. Thus, the digital era imposes new strategies that, according to Uremović, imply that "deciding on the promotional mix in sports requires a special approach that combines emotions, accurate timing, digital technologies and strategic partnerships with business entities." (Uremović, Landika, & Sredojević, 2025) Youth engagement in the digital environment is a key concept of modern sports management and marketing, because young people make up the most active and influential audience on the digital platforms of sports organizations. In theoretical terms, youth engagement is defined as the degree of cognitive, emotional, and behavioral involvement of young users in the digital content of sports organizations, which manifests itself through reactions, comments, content sharing, and long-term loyalty. Unlike passive consumption of information, digital engagement implies the interaction and active participation of young people in online sports communities.

Contemporary theories of digital participation are based on the assumption that young people do not perceive digi-

konzumenata drugih usluga ili proizvoda. Zato društvene mreže postaju alat od krucijalnog značaja za kreiranje ,implementaciju i analizu odluka koje donosi menadžerski i marketinški tim jedne sportske organizacije.

Društvene mreže omogućavaju validnu mjerljivost angažmana publike kroz njihove reakcije, dijeljenja odnosno omogućavaju nesmetanu dvosmjernu komunikaciju i na taj način postaju glavni izvor podataka neophodnih za optimizaciju digitalnog marketinga uskladjenog sa poslovnim ciljevima menadžmenta. Uska poslovna povezanost sponzora, brendova i sportskih organizacija dodatno pojačava značaj efikasnog upravljanja digitalnim kanalima i angažmanom publike, jer su oni danas reper u vrijednovanju jedne sportske organizacije. Tako da digitalana era nameće nove strategije koje prema Uremovićevoj podrazumijevaju da „odlučivanje o promotivnom miksu u sportu zahtijeva poseban pristup koji kombinuje emocije, tačno vremensko planiranje, digitalne tehnologije i strateško partnerstvo s poslovnim subjektima." (Uremović, Landika, & Sredojević, 2025) Angažman mladih u digitalnom okruženju predstavlja ključni koncept savremenog sportskog menadžmenta i marketinga, jer mladi čine najaktivniju i najuticajniju publiku na digitalnim platformama sportskih organizacija. U teorijskom smislu, angažman mladih definiše se kao stepen kognitivne, emocionalne i ponašajne uključenosti mladih korisnika u digitalne sadržaje sportskih organizacija, koji se manifestuje kroz reakcije, komentare, dijeljenje sadržaja i dugoročnu lojalnost. Za razliku od pasivne konzumacije informacija, digitalni angažman podrazumijeva interakciju i aktivno učešće mladih u online sportskim zajednicama.

Savremene teorije digitalne participacije polaze od pretpostavke da mladi ne doživljavaju digitalne medije samo kao izvor informacija, već kao prostor za identifikaciju, pripadnost i socijalnu interakciju. U kontekstu sporta, angažman mladih dodatno je pojačan emocionalnom vezanošću za klub, sport ili sportiste, što čini digitalne platforme posebno pogodnim za jačanje odnosa između sportskih organizacija i mlađe populacije. Modeli angažmana naglašavaju da vizuelno atraktivni, interaktivni i autentični sadržaji doprinose višem nivou uključenosti, dok kvalitet i relevantnost poruke imaju presudnu ulogu u oblikovanju stavova mladih prema sportu i fizičkoj aktivnosti.

Sa teorijskog aspekta, digitalni angažman mladih može se posmatrati kao posredni mehanizam između digitalnih komunikacionih aktivnosti sportskih organizacija i razvoja pozitivnih stavova prema zdravim životnim navikama. Na taj način, angažman mladih

tal media only as a source of information, but as a space for identification, belonging and social interaction. In the context of sport, youth engagement is further enhanced by emotional attachment to a club, sport or athlete, which makes digital platforms particularly suitable for strengthening the relationship between sports organisations and the younger population. Engagement models emphasize that visually attractive, interactive and authentic content contributes to higher levels of engagement, while the quality and relevance of the message play a crucial role in shaping young people's attitudes towards sport and physical activity.

From a theoretical point of view, digital engagement of young people can be seen as an intermediate mechanism between the digital communication activities of sports organizations and the development of positive attitudes towards healthy lifestyle habits. In this way, youth engagement gains a wider social significance, as it affects not only online performance metrics, but also the long-term behavior and readiness of young people to engage in sports and recreational activities.

Methodological Framework of the Research

The research combined exploratory and quantitative approaches, using secondary data as the primary source of information. The sample of 20 units was formed by deliberately selecting the most relevant secondary sources available, including scientific papers, industry analyses, and market reports. The secondary data were partially standardized and recombined into a simulated dataset, while maintaining ranges of values and relationships consistent with the findings in the literature. The simulated dataset was created to enable the application of statistical tests with limited availability of primary data.

Key variables (ER, reach, views, social-first share, number of channels, AI/personalization) are operationalized according to definitions commonly used in digital marketing and analytics of sports organizations. In the course of writing this paper, the following methods were used:

A method of content analysis, for reviewing and interpreting secondary sources, including scientific papers, industry reports, and market analyses.

- A comparative method, used to compare the findings of different types of sources.
- A method of synthesis, to integrate data into a single theoretical and empirical framework.
- Descriptive analysis, used to review the basic characteristics of a data set.
- Correlation analysis and multiple linear regression, applied to assess the relationship between digital strategies and youth engagement.
- Kruskal–Wallis test, due to deviations from normality

dobija širi društveni značaj, jer ne utiče samo na online metrike uspješnosti, već i na dugoročno ponašanje i spremnost mladih da se uključe u sportske i rekreativne aktivnosti.

Metodološki okvir istraživanja

Istraživanje je kombinovalo eksplorativni i kvantitativni pristup, uz primjenu sekundarnih podataka kao osnovnog izvora informacija. Uzorak od 20 jedinica formiran je namjernim odabirom najrelevantnijih dostupnih sekundarnih izvora, uključujući naučne radove, industrijske analize i tržišne izvještaje. Sekundarni podaci su djelimično standardizovani i rekombinovani u simulirani dataset, pri čemu su zadržani rasponi vrijednosti i odnosi koji su dosljedni nalazima iz literature. Simulirani dataset kreiran je radi omogućavanja primjene statističkih testova uz ograničenu dostupnost primarnih podataka.

Ključne varijable (ER, reach, views, social-first udio, broj kanala, AI/personalizacija) operacionalizovane su prema definicijama koje se uobičajeno primjenjuju u digitalnom marketingu i analitici sportskih organizacija.

U toku pisanja ovog rada koristile su se sljedeće metode:

Metoda analize sadržaja, za pregled i interpretaciju sekundarnih izvora, uključujući naučne radove, industrijske izvještaje i tržišne analize.

- Komparativna metoda, korištena za poređenje nalaza različitih tipova izvora.
- Metoda sinteze, radi integrisanja podataka u jedinstveni teorijski i empirijski okvir.
- Deskriptivna analiza, korištena za pregled osnovnih karakteristika skupa podataka.
- Korelaciona analiza i višestruka linearna regresija, primijenjene radi procjene odnosa između digitalnih strategija i angažmana mladih.
- Kruskal–Wallis test, zbog odstupanja od normalnosti i male veličine uzorka.
- Statistička obrada izvršena je u programu Microsoft Excel, koji je korišten zbog preglednosti, efikasne manipulacije manjim datasetima i mogućnosti direktne analize simuliranih vrijednosti.

Ograničenja istraživanja proizilaze iz male veličine i simulirane strukture uzorka, što smanjuje statističku snagu modela i ograničava mogućnost generalizacije rezultata.

Podaci o open rate-u i click rate-u preuzeti su iz industrijskih i akademskih izvještaja koji navode prosječne performanse personalizovanih digitalnih strategija u

and small sample size.
- Statistical processing was performed in Microsoft Excel, which was used for clarity, efficient manipulation of smaller datasets and the possibility of direct analysis of simulated values.

The limitations of the study arise from the small size and simulated structure of the sample, which reduces the statistical power of the model and limits the possibility of generalizing the results.

Open rate and click rate data are taken from industry and academic reports that report the average performance of personalized digital strategies in sports organizations (Digital., 2025) (Mahmoud, 2024). These values have been standardized and recombined into a simulated dataset, which allows testing the relationship between AI/personalization and audience interaction. As OR and CTR are standard digital marketing metrics, their use is methodologically justified in the context of secondary data (Kansas, 2024).

Dependent variables: Engagement rate (ER) – the percentage of interactions in relation to the number of followers; the primary measure of youth engagement and Reach and the number of views – indicators of the overall digital reach and content consumption among young people. Independent variables: Social-first content (video, short-form, BTS), share of video content – a key format for Generation Z, real-time content – increases engagement and a sense of belonging, number of digital channels – breadth of digital presence, data-driven approaches – digital analytics for young people.

Hypothesis Association: Variables examine the impact of social-first content, video, and real-time communication on youth ER.

Hypotheses

H1: Modern digital strategies have a positive impact on the digital engagement of young people.

H1a: The share of video content and real-time posts is associated with a higher engagement rate of young people.

The empirical basis of this research is based on structured analysis of secondary data sources, including academic papers, industry reports, and market analyses in the field of digital sports marketing. Instead of collecting primary data, a simulated dataset of 20 observed units was created, formed according to the values and ranges given in the relevant literature. Operationalized variables include engagement rate (ER), share of socialfirst content, as well as video and real-time formats, which allows the assessment of digital engagement of young people.

The simulated dataset retains the proportions and relationships evident in industry reports, allowing the application of descriptive statistics, correlations and regression models to test hypotheses about the impact of digital strategies on youth engagement.

sportskim organizacijama (Digital., 2025) (Mahmoud, 2024). Ove vrijednosti standardizovane su i rekombinovane u simulirani dataset što omogućava testiranje odnosa između AI/personalizacije i interakcije publike. Kako su OR i CTR standardne metrike digitalnog marketinga, njihova upotreba je metodološki opravdana u kontekstu sekundarnih podataka (Kansas, 2024).

Zavisne varijable: Engagement rate (ER) – procenat interakcija u odnosu na broj pratilaca; primarna mjera angažmana mladih i Reach i broj pregleda (views) – pokazatelji ukupnog digitalnog dometa i konzumacije sadržaja među mladima.

Nezavisne varijable: Social-first sadržaj (video, kratki formati, BTS), udeo video sadržaja – ključni format za generaciju Z, real-time sadržaj – povećava uključenost i osjećaj pripadnosti, broj digitalnih kanala – širina digitalne prisutnosti, data-driven pristupi – digitalna analitika za mlade.

Povezanost sa hipotezama: Varijable ispituju uticaj social-first sadržaja, videa i real-time komunikacije na ER mladih.

Hipoteze

H1: Savremene digitalne strategije pozitivno utiču na digitalni angažman mladih.

H1a: Udio video sadržaja i real-time objava povezan je sa višim engagement rate-om mladih.

Empirijska baza ovog istraživanja zasnovana je na strukturisanoj analizi sekundarnih izvora podataka, uključujući akademske radove, industrijske izvještaje i tržišne analize u oblasti digitalnog sportskog marketinga. Umjesto prikupljanja primarnih podataka, kreiran je simulirani dataset od 20 posmatranih jedinica, formiran prema vrijednostima i rasponima navedenim u relevantnoj literaturi. Operacionalizovane varijable obuhvataju engagement rate (ER), udio social-first sadržaja, kao i video i real-time formate, što omogućava procjenu digitalnog angažmana mladih.

Simulirani skup podataka zadržava proporcije i odnose evidentne u industrijskim izvještajima, što omogućava primjenu deskriptivne statistike, korelacija i regresionih modela radi provjere hipoteza o uticaju digitalnih strategija na angažman mladih.

Rezultati istraživanja

U okviru statističke obrade deskriptivna statistika predstavlja polazni korak jer omogućava organizovanje, sažimanje i pregled osnovnih karakteristika istraživačkog uzorka. (Landika, 2022) Deskriptivna statistika

Research Results

Within statistical processing, descriptive statistics is a starting step because it enables the organization, summarization and review of the basic characteristics of a research sample. (Landika, 2022) Descriptive statistics show that the average engagement rate of young people (ER) is relatively moderate, with pronounced variability between the observed units, which indicates different levels of youth reactions to digital content. The values of the social-first index, the share of video formats and real-time content show that sports organizations on average apply modern digital strategies, with video and real-time content playing a particularly important role in engaging younger audiences.

pokazuje da je prosječni engagement rate mladih (ER) relativno umjeren, uz izraženu varijabilnost između posmatranih jedinica, što ukazuje na različite nivoe reakcija mladih na digitalne sadržaje. Vrijednosti social-first indeksa, udjela video formata i real-time sadržaja pokazuju da sportske organizacije u prosjeku primjenjuju moderne digitalne strategije, pri čemu video i real-time sadržaji imaju posebno važnu ulogu u angažovanju mlađe publike.

Table 1. *Basic descriptive indicators for key variables*

Tabela 1. *Osnovni deskriptivni pokazatelji za ključne varijable*

***Variable* / Varijabla**	***Mean value* / Srednja vrijednost**	***Standard deviation* / Standardna devijacija**
Engagement rate (ER) / Engagement rate (ER)	0.0604	0.0338
Social-first Contents / Social-first sadržaj	0.589	-
Video content (VideoShare) / Video sadržaj (VideoShare)	0.5745	0.1462
Real-time contents (RealTimeShare) / Real-time sadržaj (RealTimeShare)	0.399	0.1679

Source: Authors

Izvor: Autori

Table 2 shows the correlations with key digital variables. Correlation analyses show positive relationships between ER and key digital formats: video content (r = 0.3654), frequency of posts (r = 0.1975) and real-time content (r = 0.1785). This confirms the expectation that dynamic formats and higher publication intensity are accompanied by higher digital engagement (Rad 1 – Youth). Note: No correlation between independent variables exceeds the multicollinearity threshold (r > 0.8), making the dataset suitable for MLR analyses.

Tabela 2 pokazuje Korelacije sa ključnim digitalnim varijablama. Korelacione analize pokazuju pozitivne veze između ER i ključnih digitalnih formata: video sadržaj (r = 0.3654), frekvencija objava (r = 0.1975) i real-time sadržaj (r = 0.1785). Time se potvrđuje očekivanje da dinamični formati i veći intenzitet objava prate viši digitalni angažman (Rad 1 – mladi). Napomena: nijedna korelacija među nezavisnim varijablama ne prelazi prag multikolinearnosti (r > 0.8), što dataset čini pogodnim za MLR analize.

Table 2. *Correlations of ER with key digital variables*

Tabela 2. *Korelacije ER sa ključnim digitalnim varijablama*

***A pair of variables* / Par varijabli**	***Pearson r***
ER – FreqPosts (posts frequency) / ER – FreqPosts (frekvencija objava)	0.1975
ER – VideoShare (Vvdeo content share) / ER – VideoShare (udio video sadržaja)	0.3654
ER – RealTimeShare (RealTimeShare) / ER – RealTimeShare (udio real-time sadržaja)	0.1785

Source: Authors

Izvor: Autori

For an additional introduction to the relationship between youth engagement rate and key digital variables, the results of the correlation analysis are supplemented with a visual representation. Figure 1 shows a scattered panel of the relationships between ER and selected digital strategies.

Radi dodatnog uvoda u odnose između engagement rate-a mladih i ključnih digitalnih varijabli, rezultati korelacione analize dopunjeni su vizuelnim prikazom. Slika 1 prikazuje scatter panel odnose ER-a i odabranih digitalnih strategija.

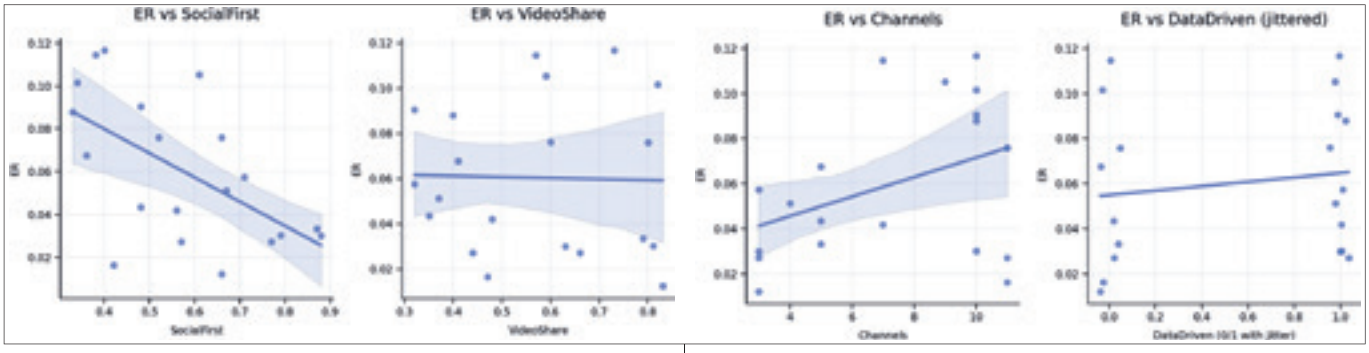


Figure 1. *Scatter panel (2x2)*
Source: Authors

Slika 1. *2×2 scatter panel*
Izvor: Autori

Figure 1 shows a 2×2 scattered panel that visually illustrates the relationship between youth engagement rate (ER) and key independent variables: SocialFirst, VideoShare, Channels, and DataDriven. The scatter panel was used as a preliminary diagnostic analysis with the aim of verifying linear assumptions before applying multiple linear regression (MLR). The visual representation indicates that the share of video content (VideoShare) and the application of the datadriven approach show a positive trend in relation to ER of young people, which is in line with theoretical expectations and hypotheses. The SocialFirst variable shows a weak and unstable relationship with ER, while the number of digital channels does not show a pronounced linear pattern. The DataDriven variable is shown with jitter due to its binary nature, where it is evident that organizations that use analytical approaches achieve a slightly higher level of youth engagement on average. Such a visual inspection confirms that the basic linear assumptions are sufficiently satisfied, which justifies the application of multiple linear regression in further analysis.

The results of multiple linear regression are shown in Table 3. The model explains the 30.2% variance of the engagement rate (ER), $R^2 = 0.302$, while Adjusted $R^2 = 0.148$, which is expected given the sample size and the number of predictors. The model is statistically significant ($F(4,15) = 1.96$; $p = 0.045$), indicating that predictor variables collectively influence ER. The Social-First variable shows a statistically significant negative effect ($p < 0.01$). Video content and the number of channels have positive, but statistically insignificant, effects. The DataDriven variable shows a positive effect close to the significance level ($p \approx 0.055$). Prior to the regression analysis, the assumptions of residual normality, linear coupling, homoscedasticity and absence of multicollinearity were verified.

Slika 1 prikazuje 2×2 scatter panel koji vizuelno ilustruje odnos između engagement rate-a mladih (ER) i ključnih nezavisnih varijabli: SocialFirst, VideoShare, Channels i DataDriven. Scatter panel korišten je kao preliminarna dijagnostička analiza s ciljem provjere linearnih pretpostavki prije primjene višestruke linearne regresije (MLR).Vizuelni prikaz ukazuje da udio video sadržaja (VideoShare) i primjena data-driven pristupa pokazuju pozitivan trend u odnosu na ER mladih, što je u skladu sa teorijskim očekivanjima i postavljenim hipotezama. Varijabla SocialFirst pokazuje slab i nestabilan odnos sa ER-om, dok broj digitalnih kanala (Channels) ne pokazuje izražen linearni obrazac. DataDriven varijabla je prikazana uz jitter zbog svoje binarne prirode, pri čemu je vidljivo da organizacije koje koriste analitičke pristupe u prosjeku ostvaruju nešto viši nivo angažmana mladih.Ovakav vizuelni pregled potvrđuje da su osnovne linearne pretpostavke u dovoljnoj mjeri zadovoljene, čime je opravdana primjena višestruke linearne regresije u daljoj analizi.

Rezultati višestruke linearne regresije prikazani su u Tabeli 3. Model objašnjava 30.2% varijanse engagement rate-a (ER), $R^2 = 0.302$, dok je Adjusted $R^2 = 0.148$, što je očekivano s obzirom na veličinu uzorka i broj prediktora. Model je statistički značajan ($F(4,15) = 1.96$; $p = 0.045$), što ukazuje da prediktorske varijable zajednički utiču na ER.Varijabla Social-First pokazuje statistički značajan negativan efekat ($p < 0.01$). Video sadržaji i broj kanala imaju pozitivne, ali statistički neznačajne efekte. Varijabla DataDriven pokazuje pozitivan efekat blizu nivoa značajnosti ($p \approx 0.055$). Prije sprovođenja regresione analize provjerene su pretpostavke normalnosti reziduala, linearne povezanosti, homoskedastičnosti i odsustva multikolinearnosti.

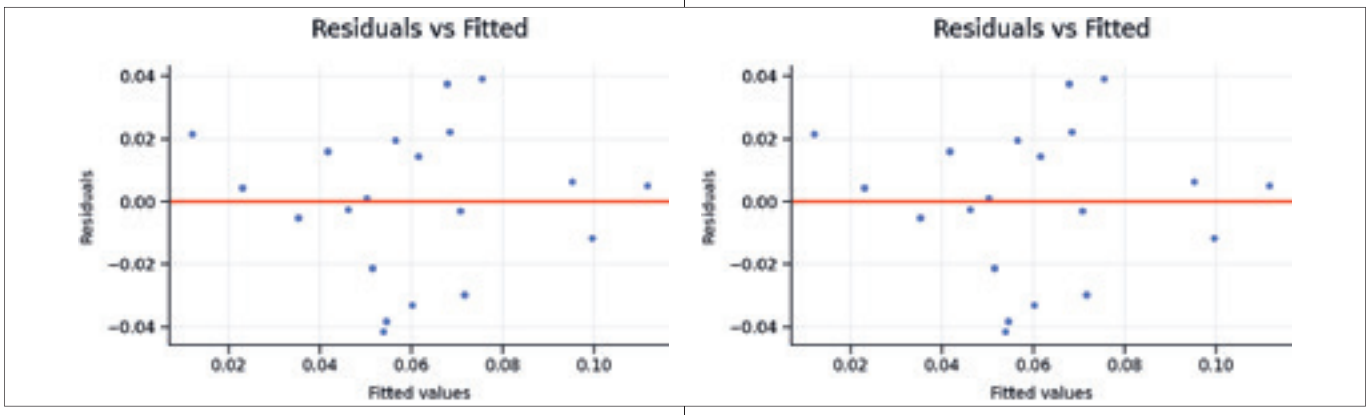
Table 3. *Multiple linear regression*

***Variable* / Varijabla**	***Coeff.* / Koef.**	***Std. Beta* / Std. Beta**	***t-value* / t-vrij.**	***p-value* / p-vrij.**
SocialFirst	–0.1691	–0.61	–3.2334	0.0056
VideoShare	+0.0725	+0.29	1.6477	0.1202
Channels	–0.0017	–0.11	–0.6363	0.5342
DataDriven	+0.0331	+0.38	2.0739	0.0557

Source: Authors

Model Summary:
$R^2 = 0.302$
Adjusted $R^2 = 0.148$
$F(4,15) = 1.96$
$p = 0.045$

Prior to the interpretation of the obtained regression coefficients, a diagnostic check of the basic assumptions of multiple linear regression was performed. To this end, the relationship between the residuals and the predicted values of the model is analyzed, which allows the estimation of linearity and homoscedasticity. Graph 1 shows a diagnostic representation of the relationship between residuals and fitted values.



Graph 1: *Diagnostic view of the relationship between residuals and predicted values (Residuals vs Fitted)*

Source: Authors

Graph 1 shows the relationship between the predicted values of the multiple linear regression model and the residuals, and serves as a diagnostic tool for checking the basic assumptions of the regression analysis. The visual representation does not indicate the presence of systematic patterns in the arrangement of residuals, suggesting that the assumptions of linearity and homoscedasticity are satisfactorily met.

As part of the H1 hypothesis, the influence of post frequency (FreqPosts), video content share (VideoShare) and realtime/BTS content share (RealTimeShare) on youth engagement rate (ER) was examined. The results of mul-

Tabela 3: *Višestruka linearna regresija*

Izvor: Autori

Model Summary:
$R^2 = 0.302$
Adjusted $R^2 = 0.148$
$F(4,15) = 1.96$
$p = 0.045$

Prije interpretacije dobijenih regresionih koeficijenata, izvršena je dijagnostička provjera osnovnih pretpostavki višestruke linearne regresije. U tom cilju, analiziran je odnos između reziduala i predviđenih vrijednosti modela, što omogućava procjenu linearnosti i homoskedastičnosti. Grafikon 1 prikazuje dijagnostički prikaz odnosa reziduala i fitted vrijednosti.

Grafikon 1: *Dijagnostički prikaz odnosa između reziduala i predviđenih vrijednosti (Residuals vs Fitted)*

Izvor: Autori

Grafikon 1 prikazuje odnos između predviđenih vrijednosti višestrukog linearnog regresionog modela i reziduala, te služi kao dijagnostički alat za provjeru osnovnih pretpostavki regresione analize. Vizuelni prikaz ne ukazuje na prisustvo sistematskih obrazaca u rasporedu reziduala, što sugeriše da su pretpostavke linearnosti i homoskedastičnosti u zadovoljavajućoj mjeri ispunjene.

U okviru testiranja hipoteze H1, ispitivan je uticaj frekvencije objava (FreqPosts), udjela video sadržaja (VideoShare) i udjela real-time/BTS sadržaja (RealTimeShare) na engagement rate mladih (ER). Rezultati višestruke linearne regresije pokazuju da nijedna od po-

tiple linear regression show that none of the observed variables achieved a statistically significant effect ($p > 0.05$), but all regression coefficients have the expected positive directions.

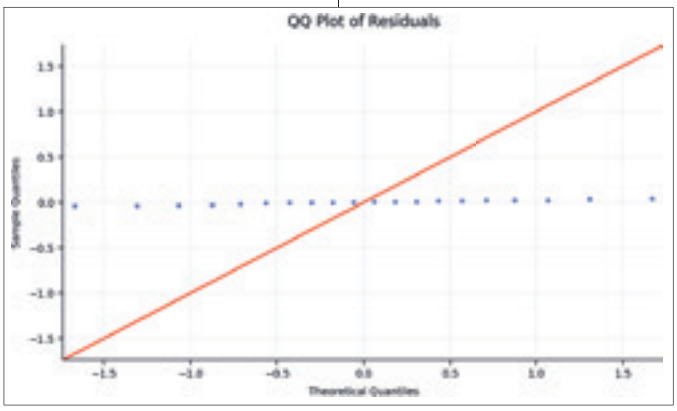
Such findings indicate that a higher frequency of publications, a higher share of video formats and a higher representation of real-time content have the potential to slightly increase the engagement of young people on digital platforms of sports organizations, which is in line with the theoretical assumptions of modern digital sports marketing. The lack of statistical significance can be attributed to the small size and simulated nature of the sample.

In addition to the analysis of the relationship between the residuals and the predicted values, an additional diagnostic check of the normality of the residuals was carried out. For this purpose, a quantile-quantile (QQ) diagram was used, which allows a comparison of the empirical distribution of residuals with the theoretical normal distribution. Figure 2 shows the QQ plot of the residuals of the regression model.

smatranih varijabli nije ostvarila statistički značajan efekat ($p > 0,05$), međutim svi regresioni koeficijenti imaju očekivane pozitivne smjerove.

Ovakvi nalazi ukazuju da veća frekvencija objava, veći udio video formata i veća zastupljenost real-time sadržaja imaju potencijal da blago povećaju angažman mladih na digitalnim platformama sportskih organizacija, što je u skladu sa teorijskim postavkama savremenog digitalnog sportskog marketinga. Izostanak statističke značajnosti može se pripisati maloj veličini i simuliranoj prirodi uzorka.

Pored analize odnosa između reziduala i predviđenih vrijednosti , sprovedena je i dodatna dijagnostička provjera normalnosti reziduala. U tu svrhu korišten je kvantil-kvantil (QQ) dijagram, koji omogućava poređenje empirijske distribucije reziduala sa teorijskom normalnom distribucijom. Grafikon 2 pokazuje QQ plot reziduala regresionog modela.



Graph 2. *QQ Plot of Residuals*

Source: Authors

Izvor: Autori

Graph 2 shows a quantile-quantile (QQ) diagram of the residuals of the multiple linear regression model used to examine the impact of contemporary digital strategies on the engagement rate of young people. The visual representation indicates that the residues are most aligned with the theoretical normal distribution, with minor deviations at the ends of the distribution, which is expected given the small size and simulated structure of the sample ($N = 20$). This arrangement confirms that the assumption of normality of the residuals is not significantly disturbed, and that the application of multiple linear regression is methodologically justified.

The diagnostic findings shown in the QQ diagram support the validity of the regression model used to test the main hypothesis H1. The model explains the 30.2% variance in youth engagement rate ($R^2 = 0.302$; Adjusted R^2 =

Grafikon 2 prikazuje kvantil–kvantil (QQ) dijagram reziduala višestrukog linearnog regresionog modela korištenog za ispitivanje uticaja savremenih digitalnih strategija na engagement rate mladih. Vizuelni prikaz ukazuje da su reziduali u najvećoj mjeri poravnati sa teorijskom normalnom distribucijom, uz manja odstupanja na krajevima distribucije, što je očekivano s obzirom na malu veličinu i simuliranu strukturu uzorka ($N = 20$). Ovakav raspored potvrđuje da pretpostavka normalnosti reziduala nije značajno narušena, te da je primjena višestruke linearne regresije metodološki opravdana.

Dijagnostički nalazi prikazani na QQ dijagramu podržavaju validnost regresionog modela kojim je testirana glavna hipoteza H1. Model objašnjava 30,2% varijanse engagement rate-a mladih ($R^2 = 0,302$; Adjusted R^2 =

0.148), where the model as a whole is statistically significant ($F(4.15) = 1.96$; $p = 0.045$). These results indicate that contemporary digital strategies, viewed as a set of predictors, have a measurable impact on the digital engagement of young people.

Within the same methodological framework, the individual effects of variables relevant to the auxiliary hypothesis H1a were also analyzed. Correlation analysis shows a moderate positive correlation between the engagement rate of young people and the share of video content ($r = 0.365$), as well as a weaker but positive correlation with the share of real-time content ($r = 0.178$). The regression coefficients in the model that includes video and realtime formats also have an expected positive direction (VideoShare: $\beta = 0.33$; RealTimeShare: $\beta = 0.21$), but do not reach statistical significance ($p > 0.05$), which can be attributed to the limited size and simulated nature of the sample.

Taking into account the results of the diagnostic analysis of residuals, it can be concluded that the regression models used in this study meet the basic statistical assumptions, which enables a reliable interpretation of the findings related to hypotheses H1 and H1a. Although the individual effects of video and real-time content have not been statistically confirmed, their consistency in the positive direction, along with the stability of the model confirmed by the QQ diagram, indicates the existence of relevant trends in the way in which modern digital formats affect the engagement of young people in the sports environment.

Table 4 shows the results of a regression model to test the auxiliary hypothesis H1a, in which post frequency, video content share, and real-time content share are included as predictors of youth engagement rate. The model explains the 19.8% variance of ER ($R^2 = 0.198$), while the Adjusted R^2 is 0.055. The model is not statistically significant ($F(3,16) = 1.39$; $p = 0.272$), which is expected given the small sample size and limitations of the simulated data.

All three predictors have positive coefficients, which is in line with the expectations of the theory of digital marketing in sports. However, none of the variables reached statistical significance ($p > 0.05$). The share of video content ($\beta = 0.33$) shows the strongest positive direction of the effect, while real-time content ($\beta = 0.21$) also has a positive but weaker contribution. The frequency of the announcement has the least effect.

The results indicate that, although statistical significance has not been confirmed, the direction of the coefficients confirms the theoretical expectation that dynamic digital formats contribute to greater youth engagement. This confirms the H1a hypothesis in terms of the direction of effects, but not in terms of statistical power.

0,148), pri čemu je model u cjelini statistički značajan ($F(4,15) = 1,96$; $p = 0,045$). Ovi rezultati ukazuju da savremene digitalne strategije, posmatrane kao skup prediktora, ostvaruju mjerljiv uticaj na digitalni angažman mladih.

U okviru istog metodološkog okvira, analizirani su i pojedinačni efekti varijabli relevantnih za pomoćnu hipotezu H1a. Korelaciona analiza pokazuje umjerenu pozitivnu povezanost između engagement rate-a mladih i udjela video sadržaja ($r = 0,365$), kao i slabiju, ali pozitivnu povezanost sa udjelom real-time sadržaja ($r = 0,178$). Regresioni koeficijenti u modelu koji uključuje video i real-time formate takođe imaju očekivan pozitivan smjer (VideoShare: $\beta = 0,33$; RealTimeShare: $\beta = 0,21$), ali ne dostižu statističku značajnost ($p > 0,05$), što se može pripisati ograničenoj veličini i simuliranoj prirodi uzorka.

Uzimajući u obzir rezultate dijagnostičke analize reziduala, može se zaključiti da regresioni modeli korišteni u ovom istraživanju ispunjavaju osnovne statističke pretpostavke, čime je omogućena pouzdana interpretacija nalaza vezanih za hipoteze H1 i H1a. Iako pojedinačni efekti video i real-time sadržaja nisu statistički potvrđeni, njihova dosljednost u pozitivnom smjeru, uz stabilnost modela potvrđenu QQ dijagramom, ukazuje na postojanje relevantnih trendova u načinu na koji savremeni digitalni formati utiču na angažman mladih u sportskom okruženju.

Tabela 4. pokazuje rezultate regresionog modela za testiranje pomoćne hipoteze H1a, u kojoj su frekvencija objava, udio video sadržaja i udio real-time sadržaja uključeni kao prediktori engagement rate-a mladih. Model objašnjava 19.8% varijanse ER-a ($R^2 = 0.198$), dok Adjusted R^2 iznosi 0.055. Model nije statistički značajan ($F(3,16) = 1.39$; $p = 0.272$), što je očekivano s obzirom na mali uzorak i ograničenja simuliranih podataka.

Sva tri prediktora imaju pozitivne koeficijente, što je u skladu sa očekivanjima teorije digitalnog marketinga u sportu. Međutim, nijedna varijabla ne dostiže statističku značajnost ($p > 0.05$). Udio video sadržaja ($\beta = 0.33$) pokazuje najjači pozitivni smjer efekta, dok real-time sadržaji ($\beta = 0.21$) takođe imaju pozitivan, ali slabiji doprinos. Frekvencija objava ostvaruje najmanji efekat.

Rezultati ukazuju da, iako nije potvrđena statistička značajnost, smjer koeficijenata potvrđuje teorijsko očekivanje da dinamični digitalni formati doprinose većem angažmanu mladih. Ovo potvrđuje hipotezu H1a u smislu smjera efekata, ali ne i u pogledu statističke snage.

Table 4. *Results of the regression model for the H1a hypothesis*

***Variable* / Varijabla**	***Coeff.* / Koef.**	***Std. Beta* / Std. Beta**	***t-value* / t-vrij.**	***p-value* / p-vrij.**
FreqPosts	0.0001	+0.10	0.3448	0.7347
VideoShare	0.0616	+0.33	1.2957	0.2135
RealTimeShare	0.0280	+0.21	0.7134	0.4859

Source: Authors

Model Summary:
$R^2 = 0.198$
Adjusted $R^2 = 0.055$
$F(3,16) = 1.39$
$p = 0.272$

Hypothesis Testing

Testing H1: Contemporary digital strategies have a positive impact on the digital engagement of young people.

To test the main hypothesis, a multiple linear regression model was applied with the engagement rate (ER) as the dependent variable. The model includes socialfirst content, the share of video formats, the number of digital channels, and datadriven approaches as predictors. The results show that the model explains 30.2% of the variance of ERa ($R^2 = 0.302$; Adjusted $R^2 = 0.148$) and that it is statistically significant ($F(4,15) = 1.96$; $p = 0.045$), which means that the predictors collectively contribute to the explanation of youth engagement.

The SocialFirst variable shows a statistically significant effect ($p < 0.01$), but in a negative direction. Such a result may indicate saturation or overuse of these formats by sports organizations, which has occasionally been noted in the literature as a counterproductive effect. Video content and channel count show positive but statistically insignificant effects, while datadriven approaches record a positive effect close to the significance level ($p \approx 0.055$), which may indicate their growing potential.

Based on the findings, the H1 hypothesis is partially confirmed: the effects are in the theoretically expected direction, but only one predictor (SocialFirst) reaches statistical significance. Detailed results of multiple linear regression are shown in Table 5.

Table 5. *Results of Multiple Linear Regression*

***Variable* / Varijabla**	***Coeff.* / Koef.**	***t-value* / t-vrij.**	***p-value* / p-vrij.**
SocialFirst	-0.1691	-3.2334	0.0056
VideoShare	0.0725	1.6477	0.1202
Channels	-0.0017	-0.6363	0.5342
DataDriven	0.0331	2.0739	0.0557

Source: Authors

Tabela 4. *rezultati regresionog modela za pomoćnu hipotezu H1a*

Izvor: Autori

Model Summary:
$R^2 = 0.198$
Adjusted $R^2 = 0.055$
$F(3,16) = 1.39$
$p = 0.272$

Testiranje hipoteza

Testiranje H1: Savremene digitalne strategije pozitivno utiču na digitalni angažman mladih.

Za testiranje glavne hipoteze primijenjen je model višestruke linearne regresije sa engagement rate-om (ER) kao zavisnom varijablom. Model uključuje social-first sadržaj, udio video formata, broj digitalnih kanala i data-driven pristupe kao prediktore. Rezultati pokazuju da model objašnjava 30.2% varijanse ER-a ($R^2 = 0.302$; Adjusted $R^2 = 0.148$) i da je statistički značajan ($F(4,15) = 1.96$; $p = 0.045$), što znači da prediktori zajednički doprinose objašnjenju angažmana mladih.

Varijabla Social-First pokazuje statistički značajan efekat ($p < 0.01$), ali u negativnom smjeru. Ovakav rezultat može ukazivati na zasićenost ili prekomjernu upotrebu ovih formata kod sportskih organizacija, što je u literaturi povremeno zabilježeno kao kontraproduktivan efekat. Video sadržaji i broj kanala pokazuju pozitivne, ali statistički neznačajne efekte, dok data-driven pristupi bilježe pozitivan efekat blizu nivoa značajnosti ($p \approx 0.055$), što može upućivati na njihov rastući potencijal.

Na osnovu nalaza, hipoteza H1 je djelimično potvrđena: efekti su u teorijski očekivanom smjeru, ali samo jedan prediktor (Social-First) dostiže statističku značajnost. Detaljni rezultati višestruke linerane regresije prikazani su u tabeli 5.

Tabela 5. *Rezultati višestruke linearne regresije*

Izvor: Autori

H1a testing: The share of video content and real-time posts is associated with a higher engagement rate of young people.

The auxiliary hypothesis H1a was tested by a regression model that includes the frequency of posts, the share of video content and the share of real-time formats as predictors. The model explains the 19.8% variance of ERa (R^2 = 0.198; Adjusted R^2 = 0.055), but is not statistically significant (F(3.16) = 1.39; p = 0.272). The results of the regression model for testing the H1a auxiliary hypothesis are shown in Table 6

All three predictors have positive coefficients, with VideoShare (β = 0.33) showing the strongest effect, while real-time content has a weaker but also positive contribution (β = 0.21). Although none of the predictors is statistically significant (p > 0.05), the direction of the effects is fully consistent with the hypothesis and the current literature.

Based on this, H1a was confirmed in terms of the direction of effects, but not in terms of statistical significance, which is expected given the small sample size and the simulated nature of the data.

Table 6. *Regression results for H1a (video & real-time)*

***Variable* / Varijabla**	***Coeff.* / Koef.**	***t-value* / t-vrij.**	***p-value* / p-vrij.**
FreqPosts	0.0001	0.3448	0.7347
VideoShare	0.0616	1.2957	0.2135
RealTimeShare	0.0280	0.7134	0.4859

Source: Authors

Discussion Result

The results of the research show that modern digital strategies of sports organizations have a certain impact on youth engagement, but that the effects are not entirely statistically strong due to a limited sample. The multiple linear regression model explains about 30% of the variance in engagement rate (ER), indicating that digital strategies have a measurable but moderate effect on the behavior of younger audiences.

This level of variance explained indicates that digital strategies are an important, but not the only, factor in youth engagement. At the same time, young people's behaviour is influenced by individual motivations, socio-cultural context, availability of sports activities and previous sports experiences. In the context of developing healthy lifestyle habits, digital engagement can act as an initial motivational mechanism, but the support of a real sports environment is also necessary for the long-term adoption of physical activity.

The most significant finding refers to the social-first content variable, which shows a statistically significant

Testiranje H1a: Udio video sadržaja i real-time objava povezan je sa višim engagement rate-om mladih.

Pomoćna hipoteza H1a testirana je regresionim modelom koji uključuje frekvenciju objava, udio video sadržaja i udio real-time formata kao prediktore. Model objašnjava 19.8% varijanse ER-a (R^2 = 0.198; Adjusted R^2 = 0.055), ali nije statistički značajan (F(3,16) = 1.39; p = 0.272). Rezultati regresionog modela za testiranje pomoćne hipoteze H1a prikazane su u tabeli 6

Sva tri prediktora imaju pozitivne koeficijente, pri čemu VideoShare (β = 0.33) pokazuje najjači efekat, dok real-time sadržaj ima slabiji, ali takođe pozitivan doprinos (β = 0.21). Iako nijedan prediktor nije statistički značajan (p > 0.05), smjer efekata u potpunosti je u skladu sa postavljenom hipotezom i savremenom literaturom.

Na osnovu toga, H1a je potvrđena u pogledu smjera efekata, ali ne i u pogledu statističke značajnosti, što je očekivano s obzirom na mali uzorak i simuliranu prirodu podataka.

Tabela 6. *Rezultati regresije za H1a (video & real-time)*

Izvor: Autori

Diskusija rezultata

Rezultati Rezultati istraživanja pokazuju da savremene digitalne strategije sportskih organizacija imaju određeni uticaj na angažman mladih, ali da efekti nisu u potpunosti statistički snažni zbog ograničenog uzorka. Model višestruke linearne regresije objašnjava oko 30% varijanse engagement rate-a (ER), što ukazuje da digitalne strategije ostvaruju mjerljiv, ali umjeren efekat na ponašanje mlađe publike.

Ovakav nivo objašnjene varijanse ukazuje da digitalne strategije predstavljaju važan, ali ne i jedini faktor angažmana mladih. Na ponašanje mladih istovremeno utiču i individualne motivacije, socio-kulturni kontekst, dostupnost sportskih aktivnosti i prethodna sportska iskustva. U kontekstu razvoja zdravih životnih navika, digitalni angažman može djelovati kao inicijalni motivacioni mehanizam, ali je za dugoročno usvajanje fizičke aktivnosti neophodna i podrška realnog sportskog okruženja.

Najznačajniji nalaz odnosi se na varijablu social-first sadržaja, koja pokazuje statistički značajan efe-

effect, but in a negative direction. Such a result deviates from theoretical expectations and may indicate saturation with these formats, inadequate quality of content or wrong targeting of young people, which is occasionally stated in the literature.

In the context of promoting healthy lifestyle habits, the negative effect of social-first content suggests that frequent exposure to short and dynamic digital messages, if not focused on the health benefits of sports, can lead to superficial engagement. This implies that sports organizations need to put more emphasis on the educational and motivational value of digital messages, and not just on their frequency and form.

Positive but statistically insignificant coefficients of video and real-time content indicate a trend that is consistent with the literature, but not strong enough to confirm the auxiliary hypothesis of H1a in statistical terms. The direction of the effects confirms theoretical expectations, but the low statistical power of the sample makes it impossible to draw firm conclusions.

However, video and real-time formats have a potentially important role to play in encouraging positive attitudes of young people towards physical activity. Depictions of real-life sporting activities, trainings and competitions can contribute to modelling desirable behavioural patterns and raising awareness of the importance of regular exercise for maintaining health.

The DataDriven variable shows a positive effect close to the level of significance, suggesting that sports organizations that use analytics achieve higher youth engagement, but a larger, more representative sample is needed here as well.

Analytical and personalized digital approaches allow for a more precise adaptation of content to the interests and needs of young users, thus increasing the likelihood of long-term involvement in sports activities. Such an approach can play a significant role in creating sustainable healthy lifestyle habits, as it enables continuous motivation and monitoring of young people's sports behavior.

These results should be interpreted with caution due to the small and simulated sample, which represents an important methodological limitation. Despite this, the findings indicate stable trends in engagement growth through more modern digital formats, which is in line with contemporary theoretical and practical insights into the digital marketing of sports organizations.

Despite these limitations, the results of this study suggest that digital strategies can represent an important supporting mechanism in the promotion of sport and healthy lifestyles among young people. Their effectiveness, how-

kat, ali u negativnom smjeru. Ovakav rezultat odstupa od teorijskih očekivanja i može ukazivati na zasićenost ovim formatima, neadekvatan kvalitet sadržaja ili pogrešno targetiranje mladih, što se povremeno navodi i u literaturi.

U kontekstu promocije zdravih životnih navika, negativan efekat social-first sadržaja sugeriše da učestala izloženost kratkim i dinamičnim digitalnim porukama, ukoliko nije sadržajno usmjerena ka zdravstvenim benefitima sporta, može dovesti do površnog angažmana. To implicira da sportske organizacije treba da stave veći akcenat na edukativnu i motivacionu vrijednost digitalnih poruka, a ne samo na njihovu frekvenciju i formu.

Pozitivni, ali statistički neznačajni koeficijenti video i real-time sadržaja ukazuju na trend koji je u skladu s literaturom, ali nedovoljno snažan da bi potvrdio pomoćnu hipotezu H1a u statističkom smislu. Smjer efekata potvrđuje teorijska očekivanja, ali mala statistička snaga uzorka onemogućava donošenje čvrstih zaključaka.

Ipak, video i real-time formati imaju potencijalno važnu ulogu u podsticanju pozitivnih stavova mladih prema fizičkoj aktivnosti. Prikazi stvarnih sportskih aktivnosti, treninga i takmičenja mogu doprinijeti modelovanju poželjnih obrazaca ponašanja i jačanju svijesti o značaju redovnog kretanja za očuvanje zdravlja.

Varijabla DataDriven pokazuje pozitivan efekat blizu nivoa značajnosti, što sugeriše da sportske organizacije koje koriste analitiku postižu viši angažman mladih, ali i ovdje je potreban veći, reprezentativniji uzorak.

Analitički i personalizovani digitalni pristupi omogućavaju preciznije prilagođavanje sadržaja interesovanjima i potrebama mladih korisnika, čime se povećava vjerovatnoća dugoročnog uključivanja u sportske aktivnosti. Takav pristup može imati značajnu ulogu u stvaranju održivih zdravih životnih navika, jer omogućava kontinuiranu motivaciju i praćenje sportskog ponašanja mladih.

Navedene rezultate potrebno je tumačiti oprezno zbog malog i simuliranog uzorka, što predstavlja važno metodološko ograničenje. Uprkos tome, nalazi ukazuju na stabilne trendove rasta angažmana kroz modernije digitalne formate, što je u skladu sa savremenim teorijskim i praktičnim uvidima u digitalni marketing sportskih organizacija.

Uprkos navedenim ograničenjima, rezultati ovog istraživanja ukazuju da digitalne strategije mogu predstavljati značajan podržavajući mehanizam u promociji sporta i zdravog načina života kod mladih. Njihova efi-

ever, depends on the quality of the content, the authenticity of the message and the connection between digital activities and real-world sports experiences.

Conclusion

The results of the paper indicate that the digital strategies of sports organizations have a visible, but moderate potential to influence the engagement of young users on digital platforms. Socialfirst content, especially video formats and real-time posts, show the most stable positive trend in relation to the engagement rate of young people, although the effects are not statistically fully confirmed due to a small and simulated sample. Despite this, the findings of the paper confirm the theoretical expectations of contemporary literature, according to which young generations react most intensely to dynamic, visual and interactive digital forms of communication.

Analytics-based digital strategies (datadriven approaches) also show potential contribution to higher engagement, but their statistical strength depends on the quality and frequency of posts. Socialfirst approaches achieved a statistically significant, but unexpectedly negative effect, which may indicate audience saturation or inadequate targeting, and requires additional research on larger and primary samples.

Based on the results, the main hypothesis H1 was partially confirmed, while the auxiliary hypothesis H1a was confirmed in terms of direction of effects, but not statistical significance, which was expected given the limitations of the sample.

The findings of this study should be interpreted with caution due to the small size and simulated structure of the sample, which represents an important methodological limitation. Nevertheless, they point to stable trends in engagement growth through more modern digital content formats, which is in line with contemporary theoretical and practical insights into the digital marketing of sports organizations.

The practical implications of the results are moving in the direction of the need for optimization of digital campaigns, better targeting of young users and the application of more precise, analytically based publishing strategies. Future research should include larger and representative samples, primary data, and additional control variables to more accurately measure the effects of individual digital tactics on youth engagement and healthy habit development.

In addition, the results of the research indicate the need for a stronger connection between digital communication activities of sports organizations and specifically available sports and recreational programs for young people. Digital engagement, although important as initial contact, is not

kasnost, međutim, zavisi od kvaliteta sadržaja, autentičnosti poruke i povezanosti digitalnih aktivnosti sa stvarnim sportskim iskustvima.

Zaključak

Rezultati rada ukazuju da digitalne strategije sportskih organizacija imaju vidljiv, ali umjeren potencijal da utiču na angažman mladih korisnika na digitalnim platformama. Social-first sadržaji, posebno video formati i real-time objave, pokazuju najstabilniji pozitivni trend u odnosu na engagement rate mladih, iako efekti nisu statistički u potpunosti potvrđeni zbog malog i simuliranog uzorka. Uprkos tome, nalazi rada potvrđuju teorijska očekivanja savremene literature prema kojoj mlade generacije najintenzivnije reaguju na dinamične, vizuelne i interaktivne digitalne forme komunikacije.

Digitalne strategije zasnovane na analitici (data-driven pristupi) takođe pokazuju potencijalni doprinos većem angažmanu, ali njihova statistička snaga zavisi od kvaliteta i frekvencije objava. Social-first pristupi ostvarili su statistički značajan, ali neočekivano negativan efekat, što može ukazivati na zasićenost publike ili neadekvatno targetiranje, te zahtijeva dodatna istraživanja na većim i primarnim uzorcima.

Na osnovu rezultata, glavna hipoteza H1 djelimično je potvrđena, dok je pomoćna hipoteza H1a potvrđena u pogledu smjera efekata, ali ne i statističke značajnosti, što je očekivano s obzirom na ograničenja uzorka.

Nalaze ovog istraživanja potrebno je tumačiti oprezno zbog male veličine i simulirane strukture uzorka, što predstavlja važno metodološko ograničenje. Ipak, oni ukazuju na stabilne trendove rasta angažmana kroz modernije digitalne formate sadržaja, što je u skladu sa savremenim teorijskim i praktičnim uvidima u digitalni marketing sportskih organizacija.

Praktične implikacije rezultata kreću se u smjeru potrebe za optimizacijom digitalnih kampanja, kvalitetnijim targetiranjem mladih korisnika i primjenom preciznijih, analitički zasnovanih strategija objavljivanja. Buduća istraživanja treba da uključe veće i reprezentativne uzorke, primarne podatke i dodatne kontrolne varijable kako bi se preciznije mjerili efekti pojedinačnih digitalnih taktika na angažman i razvoj zdravih navika mladih.

Dodatno, rezultati istraživanja ukazuju na potrebu za jačim povezivanjem digitalnih komunikacionih aktivnosti sportskih organizacija sa konkretno dostupnim sportskim i rekreativnim programima za mlade. Digitalni angažman, iako značajan kao inicijalni kontakt, sam po sebi nije dovoljan za dugoročno usvajanje zdravih životnih navika. Efikasnost digitalnih strategija zavisi od nji-

enough on its own for the long-term adoption of healthy lifestyle habits. The effectiveness of digital strategies depends on their ability to offer young users a clear path from online interaction to actual participation in sporting activities

From a methodological point of view, this research contributes to the further affirmation of the use of simulated secondary data in the analysis of contemporary digital phenomena, especially in conditions of limited availability of primary sources. Although such an approach has clear limitations, it allows for preliminary testing of theoretical assumptions and identification of directions for future research. This opens up space for deepening empirical analyses and developing more accurate models for measuring digital engagement of young people in the sports context.

hove sposobnosti da mladim korisnicima ponude jasan put od online interakcije ka stvarnom učešću u sportskim aktivnostima

Sa metodološkog aspekta, ovo istraživanje doprinosi daljoj afirmaciji upotrebe simuliranih sekundarnih podataka u analizi savremenih digitalnih fenomena, posebno u uslovima ograničene dostupnosti primarnih izvora. Iako takav pristup ima jasna ograničenja, on omogućava preliminarno testiranje teorijskih pretpostavki i identifikaciju smjerova budućih istraživanja. Time se otvara prostor za produbljivanje empirijskih analiza i razvoj preciznijih modela za mjerenje digitalnog angažmana mladih u sportskom kontekstu.

References

Digital., D. (2025). *Social media and sports.* Dellote Digital. . Preuzeto sa https://www.deloittedigital.com/us/en/insights/perspective/social-media-strategies-sports.html

Kansas, U. o. (2024). *Zouth engagement patterns in digital sports media.* Kansas: University of Kansas.

Landika, M. U. (2022). Prognostičko modeliranje upravljačkih smjernica kao temelj međunarodnog pozicioniranja – izazovi za BiH. *EMC Review – Economy and Market Communication Review. vol XII*, 176-185. [in Serbian]

Mahmoud, R. (. (2024). Data-driven digital marketing strategies in sports organizations. . *Journal of Sports Marketing Research, 12(2),* , 45–59.

Raković, M., & Dašić, D. (2018). *Marketing u sportu sa elementima industrije sporta.* Beograd: Visoka škola modernog miznisa. Preuzeto januar 2026 sa https://www.researchgate.net/publication/363056420_MARKETING_U_SPORTU_SA_ELEMENTIMA_INDUSTRIJE_SPORTA [in Serbian]

Uremović, N., Landika, M., & Sredojević, V. (2025). *Odlučivanje u teoriji i praksi* (tom. 1. izdanje ISBN 987-99976-87-57-9). BanjaLuka, BiH: Panevropski univerzitet Apeiron. [in Serbian]

Primljen: 28. januar 2026. / Received: Januar 28, 2026
Prihvaćen: 25. april 2026. / Accepted: April 25, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601021B
Original scientific paper
UDC: 797.253:796.015.15
Originalni naučni rad

Differences in Functional Capabilities of Younger and Older Juniors in Water Polo

Razlike u funkcionalnim sposobnostima mlađih i starijih juniora u vaterpolu

Senad Bajrić[1], Edin Mirvić[2], Osmo Bajrić[1], Alma Dizdar[3]

[1]Pan-European University "Apeiron", Banja Luka, Bosnia and Herzegovina
[2]Faculty of Kinesiology, University of Sarajevo, Bosnia and Herzegovina
[3]Olympic Swimming Pool in Sarajevo, Bosnia and Herzegovina

Correspondence:
Senad Bajrić
Pan-European University "Apeiron", Banja Luka, Bosnia and Herzegovina
senad.o.bajric@apeiron-edu.eu

[1]Fakultet sportskih nauka, Panevropski Univerzitet „Apeiron", Banja Luka, Bosna i Hercegovina
[2]Kineziološki fakultet Univerziteta u Sarajevu, Bosna i Hercegovina
[3]Olimpijski bazen u Sarajevu, Bosna i Hercegovina

Korespondencija:
Senad Bajrić
Fakultet sportskih nauka, Panevropski Univerzitet „Apeiron", Banja Luka, Bosna i Hercegovina
senad.o.bajric@apeiron-edu.eu

Abstract: *The research was conducted with the aim of determining the differences in functional abilities between younger (14–16 years) and older juniors (16–18 years) in water polo. The total sample of respondents consisted of 174 respondents from the following water polo clubs: VK "Borac" from Banja Luka, VK "Mladost", VK "Torpedo" and VK "Invictum" all from Sarajevo, divided into two age categories according to the rules of the Water Polo Federation of Bosnia and Herzegovina. The sample of variables consisted of nine functional abilities assessed by spirometric parameters in different positions (standing and lying) in the first and sixth seconds before and after the exertion. For all applied functional ability variables, the basic central and dispersion parameters were calculated. To determine the differences in functional abilities between younger and older juniors in water polo, an analysis of the results of the T-test for independent samples was applied. The obtained basic and central dispersion parameters show a normal distribution of all variables in both groups of respondents. The results of the T-test indicate statistically significant differences in five out of nine functional parameters in favor of the older juniors, especially in the air flow in the first and sixth seconds after exertion and the variable "lung age". The established differences indicate that the age and continuity of the training process have a significant impact on the development of the functional abilities of young water polo players. The obtained results can be useful for a better understanding of the development of ventilation abilities of athletes in the aquatic environment, the process of selection and programming of training loads.*

Keywords: *functional abilities, juniors, spirometry, differences, water polo*

Sažetak: *Istraživanje je izvršeno s ciljem utvrđivanja razlika u funkcionalnim sposobnostima između mlađih (14–16 godina) i starijih juniora (16–18 godina) u vaterpolu. Ukupan uzorak ispitanika činilo je 174 ispitanika iz sljedećih vaterpolo klubova: VK „Borac" iz Banja Luke, VK „Mladost", VK „Torpedo" i VK „Invictum" svi iz Sarajeva podijeljenih u dvije uzrasne kategorije prema pravilima Vaterpolo saveza BiH. Uzorak varijabli činilo je devet funkcionalnih sposobnosti procjenjivanih spirometrijskim parametrima u različitim položajima (stojeći i ležeći) u prvoj i šestoj sekundi prije i poslije opterećenja. Za sve primijenjene varijable funkcionalnih sposobnosti izračunati su osnovni centralni i disperzioni parametri. Za utvrđivanje razlika u funkcionalnim sposobnostima između mlađih i starijih juniora u vaterpolu primijenjena je analiza rezultata T-testa za nezavisne uzorke. Dobijeni osnovni i centralni disperzioni parametri pokazuju normalnu distribuciju svih varijabli kod obje grupe ispitanika. Rezultati T-testa ukazuju na statistički značajne razlike u šest od devet funkcionalnih parametara u korist starijih juniora, posebno u protoku zraka u prvoj i šestoj sekundi poslije opterećenja, te varijabli „starost pluća. Utvrđene razlike ukazuju da uzrasna dob i kontinuitet trenažnog procesa imaju značajan uticaj na razvoj funkcionalnih sposobnosti mladih vaterpolista. Dobijeni rezultati mogu biti od koristi boljem razumijevanju razvoja ventilacijskih sposobnosti sportista u vodenom okruženju, procesu selekcije i programiranja trenažnih opterećenja.*

Ključne reči: *funkcionalne sposobnosti, juniori, spirometrija, razlike, vaterpolo*

Introduction

As a collective sport, water polo belongs to the group of polystructural sports with a high degree of complexity, in which all types of movements, both cyclic and acyclic,

Uvod

Vaterpolo kao kolektivni sport spada u grupu polistrukturalnih sportova sa visokim stepenom kompleksiteta u kojem su zastupljene sve vrste kretanja kako ci-

are represented. It differs from other team sports because it is played in a completely different and specific medium - water. For this reason, water polo belongs to the group of extremely demanding sports with very complex functional, motor and technical-tactical requirements. A high level of efficiency and sportsmanship in water polo requires maximum mastery of all technical-tactical elements, a high level of physical preparation, which is based on certain morphological characteristics, motor, functional abilities and other anthropological characteristics (Dopsaj, 1993). Observing the technique and way of swimming in the water polo game, it is not difficult to see that the players mostly swim short distances using different techniques and with maximum intensity. In addition to the time limit of the game, and the total volume of swimming segments, from the aspect of energy capacities it can be safely claimed that a top water polo player must possess highly developed all three energy systems - alactic, lactic and aerobic (Dopsaj & Matković, 1994). In this sense, the functional capabilities of the cardiovascular and respiratory systems gain even greater importance.

Intense actions, frequent contact, movement in turbulent water and the need for rapid changes in speed and body position require a high level of ventilation capacity. In addition during the match, the player performs a large number of movements in the water in a horizontal and vertical position, with or without the ball, with or without contact with the opposing player (Dopsaj & Matković, 1999).

The specificity of the sport of water polo causes a gradual transformation of the organism during growth and with a regular training process. Therefore it is especially important to observe the development of functional parameters in water polo players of different age categories. This paper focuses on determining the differences in functional abilities between younger and older juniors in water polo from water polo clubs in Bosnia and Herzegovina.

Previous research confirms that sports training at a younger age leads to an increase in key lung functions, especially in water sports that require high respiratory capacity (Hraste et al., 2008; Mirvić et al., 2012; Durmić et al., 2015). Therefore, it is expected that older juniors, due to a longer training experience, will show better results.

Method of Work

A sample of participants

The total sample of participants consisted of 174 young water polo players from water polo clubs in Bosnia and Herzegovina, divided into two groups. The first

kličnog tako i acikličnog karaktera. Razlikuje se od drugih kolektivnih sportova zbog toga što se igra u potpuno drukčijem i specifičnom mediju – vodi. Iz tog razloga, vaterpolo spada u grupu izrazito zahtjevnih sportova sa vrlo složenim funkcionalnim, motoričkim i tehničko-taktičkim zahtjevima. Visok nivo efikasnosti i sportskog nadigravanja u vaterpolu zahtijeva maksimalnu ovladanost svim tehničko-taktičkim elementima, visok nivo fizičke pripremljenosti, a koja se zasniva na određenim morfološkim odlikama, motoričkim, funkcionalnim sposobnostima i drugim antropološkim karakteristikama (Dopsaj, 1993). Posmatrajući tehniku i način plivanja u vaterpolo igri nije teško uočiti da igrači uglavnom plivaju kratke dionice primjenom različitih tehnika i maksimalnim intenzitetom. Uz vremensko ograničenje igre, i ukupan obim preplivanih dionoca, sa aspekta energetskih kapaciteta sa sigurnošću se može tvrditi da vrhunski vaterpolo igrač mora posjedovati visoko razvijena sva tri energetska sistema - alaktatni, laktatni i aerobni (Dopsaj & Matković, 1994). U tom smislu na još većem značaju dobivaju funkcionalne sposobnosti kardiovaskularnog i respiratornog sistema.

Intenzivne akcije, česti kontakti, rad u uzburkanoj vodi i potreba za brzim izmjenama brzine i položaja tijela zahtijevaju visok nivo ventilacijskih kapaciteta. Takođe, tokom utakmice igrač izvodi veliki broj kretanja u vodi u horizontalnom i vertikalnom položaju, sa loptom ili bez nje, sa ili bez kontakta sa protivničkim igračem (Dopsaj & Matković, 1999).

Specifičnost vaterpolo sporta uzrokuje postepenu transformaciju organizma tokom rasta i uz redovan trenažni proces. Zato je posebno važno posmatrati razvoj funkcionalnih parametara kod vaterpolista i različitih uzrasnih kategorija. Upravo ovaj rad se bavi utvrđivanjem razlika u funkcionalnim sposobnostima između mlađih i starijih juniora u vaterpolu iz vaterpolo klubova Bosne i Hercegovine.

Dosadašnja istraživanja potvrđuju da sportski trening u mlađem uzrastu dovodi do povećanja ključnih plućnih funkcija, posebno u sportovima u vodi koji zahtijevaju visok respiratorni kapacitet (Hraste i sar., 2008; Mirvić i sar., 2012; Durmić i sar., 2015). Stoga se očekuje da stariji juniori, uslijed dužeg trenažnog staža, pokažu bolje rezultate.

Metod rada

Uzorak ispitanika

Ukupan uzorak ispitanika činilo je 174 mladih vaterpolista iz vaterpolo klubova Bosne i Hercegovine po-

group of participants consisted of younger juniors aged 14-16 years (N=87), and the second group consisted of older juniors aged 16-18 years (N=87). The division of participants based on age categories was carried out according to the rules of the Water Polo Association of Bosnia and Herzegovina. The research included only those participants who are completely healthy and who were involved in the regular training process in their clubs.

The study was conducted in a regular training environment with appropriate conditions required for testing in this study.

Sample variables

Functional capacity was assessed using nine spirometric measures, including airflow in the first and sixth seconds of exhalation in standing and supine positions before and after exercise, as well as lung age parameters.

Variables for assessing functional abilities:

1) Spirometry in the first second standing before exertion ..... (S1SBE)
2) Spirometry in the first second standing after exertion ..... (S1SAE)
3) Spirometry in the first second lying before exertion ..... (S1LBE)
4) Spirometry in the first second lying after exertion ..... (S1LAE)
5) Spirometry in the sixth second standing before exertion ..... (S6SBE)
6) Spirometry in the sixth second standing after exertion ..... (S6SAE)
7) Spirometry in the sixth second lying before exertion ..... (S6LBE)
8) Spirometry in the sixth second lying after exertion ..... (S6LAE)
9) Lung age ..... (LUNG AGE)

Data processing methods

For all applied variables used to assess functional abilities, basic central and dispersion parameters were calculated, including the following parameters: Rangey-Rang, Min-minimum measurement result, Max-maximum measurement result, Mean-arithmetic mean, St.Dev.-standard deviation, Variance-variance. The normality of data distribution was examined based on the values of the coefficient of curvature (Skewness) and the coefficient of elongation (Kurtosis), as well as their standard errors, in order to determine the appropriateness for the application of parametric statistical procedures.

To determine the differences in functional abilities between older and younger juniors in water polo play-

dijeljenih u dvije grupe. Prvu grupu ispitanika činili su mlađi juniori uzrasne dobi 14-16 godina (N=87), a drugu grupu činili su stariji juniori uzrasne dobi 16-18 godina (N=87). Podjela ispitanika na osnovu uzrasnih kategorija izvršena je prema pravilima Vaterpolo saveza Bosne i Hercegovine. Istraživanjem su bili obuhvaćeni samo oni ispitanici koji su potpuno zdravi i koji su bili uključeni u redovan trenažni proces u svojim klubovima.

Istraživanje je sprovedeno na redovnom treningu uz odgovarajuće uslove potrebne za testiranje u ovom istraživanju.

Uzorak varijabli

Procjena funkcionalnih sposobnosti izvedena je primjenom devet spirometrijskih mjera, uključujući protok zraka u prvoj i šestoj sekundi izdisaja u stojećem i ležećem položaju prije i poslije opterećenja, kao i parametar starosti pluća.

Varijable za procjenu funkcionalnih sposobnosti:

1) Spirometrija u prvoj sekundi stojeći prije opterećenja .....(S1SPRO)
2) Spirometrija u prvoj sekundi stojeći poslije opterećenja .....(S1SPOO)
3) Spirometrija u prvoj sekundi ležeći prije opterećenja.....(S1LPRO)
4) Spirometrija u prvoj sekundi ležeći poslije opterećenja ..... (S1LPOO)
5) Spirometrija u šestoj sekundi stojeći prije opterećenja.....(S6SPRO)
6) Spirometrija u šestoj sekundi stojeći poslije opterećenja .....(S6SPOO)
7) Spirometrija u šestoj sekundi ležeći prije opterećenja.....(S6LPRO)
8) Spirometrija u šestoj sekundi ležeći poslije opterećenja ..... (S6LPOO)
9) Starost pluća ..... (STARPL)

Metode obrade podataka

Za sve primijenjene varijable za procjenu funkcionalnih sposobnosti izračunati su osnovni centralni i disperzioni parametri koji su uključivali sljedeće parametre: Rangey-Rang, Min-minimalni rezultat mjerenja, Max-maksimalni rezultat mjerenja, Mean- aritmetička sredina, St.Dev.-standardna devijacija, Variance-varijansa. Normalnost distribucije podataka provjerena je na osnovu vrijednosti koeficijenta zakrivljenosti (Skewness-a) i koeficijenta izduženosti (Kurtosis-a), kao i njihovih standardnih grešaka, kako bi se utvrdila opravdanost primjene parametrijskih statističkih postupaka.

Za utvrđivanje razlika u funkcionalnim sposobno-

ers, the results of an independent T-test were applied. The level of statistical significance was set at the level of $p < 0.05$. The effect size is expressed by Eta square, which is used in statistics to indicate the proportion of the total variance of the dependent variable that is explained by a particular independent factor. It is calculated as the ratio of the sum of the squares of the effect and the total sum of squares. The range of values is from 0 to 1, with higher values indicating a stronger effect. It helps in understanding the practical significance of the results beyond statistical significance. The statistical analysis of the data was performed in the IBM SPSS Statistics 22 program.

Results

Analysis of the results of the basic central and dispersion parameters of variables for assessing the functional abilities of younger juniors (14-16 years old)

Table 1 presents the basic central and dispersion parameters of the variables used to assess the functional abilities of younger juniors aged 14-16. In the context of the performed measurement, it is observed that the values of the basic central and dispersion parameters of the variables for the assessment of functional abilities show a normal distribution of the results and that in this context there are no significant deviations from the normal distribution, given that the values of the skewness coefficients do not exceed 1.00. Aditionally the values of the coefficient of elongation (Kurtosis) are below the normal distribution value of 2.75, indicating a platykurtic (flattened) distribution.

Based on the obtained results of the central and dispersive parameters of the variables for assessing the functional abilities of younger juniors in water polo, it can be concluded that the values of all applied variables are normally distributed. The distribution of the obtained values of the basic central and dispersion parameters of the participants functional abilities of the subjects - younger juniors aligns with the standards specific to water polo players of this age group, although this population is undergoing continues transformation as a result of the effects of their specific age and the conditions under witch the training process is conducted.

stima između starijih i mlađih juniora u vaterpolu primijenjeni su rezultati T-testa za nezavisne uzorke. Nivo statističke značajnosti postavljen je na nivou **$p < 0,05$**. Efekat veličine izražen je Eta kvadratom, koja se koristi u statistici, a označava udio ukupne varijance zavisne varijable koji objašnjava određeni nezavisni faktor. Računa se kao odnos sume kvadrata efekta i ukupne sume kvadrata. Raspon vrijednosti kreće se od 0 do 1, pri čemu veće vrijednosti ukazuju na jači učinak. Pomaže u razumijevanju praktične važnosti rezultata izvan same statističke značajnosti. Statistička obrada podataka sprovedena je u programu **IBM SPSS Statistics 22.**

Rezultati

Analiza rezultata osnovnih centralnih i disperzionih parametara varijabli za procjenu funkcionalnih sposobnosti mlađih juniora (14-16 godina)

U tabeli 1 prikazani su osnovni centralni i disperzioni parametri varijabli za procjenu funkcionalnih sposobnosti mlađih juniora uzrasne dobi 14-16 godina. U kontekstu izvršenog mjerenja uočava se da vrijednosti osnovnih centralnih i disperzionih parametara varijabli za procjenu funkcionalnih sposobnosti pokazuju normalnu raspodjelu rezultata i da u tom kontekstu nema značajnih odstupanja od normalne distribucije, s obzirom na to da vrijednosti koeficijenata zakrivljenosti (Skewness-a) ne prelaze 1,00. Vrijednosti koeficijenta izduženosti (Kurtosis-a) kreću se ispod normalne vrijednosti distribucije 2,75, što čini distribuciju platikurtičnom ili rasplinutom.

Na osnovu dobijenih rezultata centralnih i disperzivnih parametara varijabli za procjenu funkcionalnih sposobnosti kod mlađih juniora u vaterpolu može se zaključiti da su vrijednosti svih primijenjenih varijabli normalno distribuirane. Distribucija dobijenih vrijednosti osnovnih centralnih i disperzionih parametara funkcionalnih sposobnosti ispitanika – mlađih juniora uklapaju se u standarde specifične za funkcionalne sposobnosti vaterpolista ovog uzrasta, iako je ova populacija u procesu stalne transformacije, koja je rezultat uticaja specifične uzrasne dobi ispitanika i uslova u kojima se ostvaruje trenažni proces.

Table 1. *Basic central and dispersion parameters of functional abilities of younger juniors (14-16 years old)*

Tabela 1. *Osnovni centralni i disperzioni parametri funkcionalnih sposobnosti mlađih juniora (14-16 godina)*

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
S1SBE	87	3.34	1.01	4.35	2.9728	.09709	.90559	.820	-.462	.258	-.260	.511
S1SAE	87	4.18	.55	4.73	2.5848	.10507	.98007	.961	.415	.258	.074	.511
S1LBE	87	3.54	.68	4.22	2.9283	.09453	.88170	.777	-.893	.258	.424	.511
S1LAE	87	4.10	.62	4.72	2.5976	.11456	1.06852	1.142	.033	.258	-.772	.511
S6SBE	87	6.21	1.05	7.26	4.0552	.12144	1.13272	1.283	.107	.258	1.725	.511
S6SAE	87	5.19	1.56	6.75	4.1048	.10986	1.02469	1.050	.101	.258	.922	.511
S6LBE	87	2.63	3.03	5.66	4.4176	.07916	.73837	.545	-.193	.258	-.863	.511
S6LAE	87	3.92	1.66	5.58	3.3517	.10060	.93834	.880	.308	.258	-.328	.511
LUNGAGE	87	2.00	14.00	16.00	15.0000	.08010	.74709	.558	.000	.258	-1.186	.511
Valid N (listwise)	87											

Legend: N-number of subjects, Range-Rang, Min-minimum measurement result, Max-maximum measurement result, Mean- arithmetic mean, St.Dev.-standard deviation, Variance-variance, Skewness-coefficient of curvature, Kurtosis-coefficient of elongation, S1SBE-Spirometry in the first second standing before exertion, S1SAE-Spirometry in the first second standing after load, S1LBL-Spirometry in the first second lying before exertion, S1LAE-Spirometry in the first second lying after exertion, S6SBE-Spirometry in the sixth second standing before exertion, S6SAE-Spirometry in the sixth second standing after exertion, S6LBE-Spirometry in the sixth second lying before exertion, S6LAE-Spirometry in the sixth second lying after exertion, LA-Lung age)

Legenda: N-broj ispitanika, Rangey-Rang, Min-minimalni rezultat mjerenja, Max-maksimalni rezultat mjerenja, Mean-aritmetička sredina, St.Dev.-standardna devijacija, Variance-varijansa, Skewness-koeficijent zakrivljenosti, Kurtosis-koeficijent izduženosti, S1SPRO-Spirometrija u prvoj sekundi stojeći prije opterećenja, S1SPOO-Spirometrija u prvoj sekundi stojeći poslije opterećenja, S1LPRO-Spirometrija u prvoj sekundi ležeći prije opterećenja, S1LPOO-Spirometrija u prvoj sekundi ležeći poslije opterećenja, S6SPRO-Spirometrija u šestoj sekundi stojeći prije opterećenja, S6SPOO-Spirometrija u šestoj sekundi stojeći poslije opterećenja, S6LPRO-Spirometrija u šestoj sekundi ležeći prije opterećenja, S6LPOO-Spirometrija u šestoj sekundi ležeći poslije opterećenja, SP-Starost pluća)

Analysis of the results of the basic central and dispersion parameters of the variables for assessing the functional abilities of older juniors in water polo (16-18 years old)

Table 2 presents the basic central and dispersion parameters of the variables used to assess the functional abilities of older juniors aged 16-18 years. Examination of the obtained results indicates that there are no significant deviations from a normal distribution, as the values of the skewness coefficient do not exceed 1.00, except for a minor deviation in the variable Spirometry in the first second standing after the exertion - S1SAE (2.216). The values of the coefficient of elongation (Kurtosis) are below the normal distribution value of 2.75, indicating a platykurtic distribution, except for a minor deviation in the variable Spirometry in the first second standing after exertion - S1SAE (3.865).

Based on the obtained results of the basic central and dispersion parameters of the variables for assessing functional abilities in older juniors in water polo, it can

Analiza rezultata osnovnih centralnih i disperzionih parametara varijabli za procjenu funkcionalnih sposobnosti starijih juniora u vaterpolu (16-18 godina)

U tabeli 2 prikazani su osnovni centralni i disperzioni parametri varijabli za procjenu funkcionalnih sposobnosti starijih juniora uzrasne dobi 16-18 godina. Uvidom u dobijene vrijednosti rezultata funkcionalnih sposobnosti kod starijih juniora može se konstatovati da nema značajnih odstupanja od normalne distribucije, s obzirom na to da vrijednosti koeficijenta zakrivljenosti (Skewness-a) ne prelaze 1,00, izuzev manjeg odstupanja kod varijable *Spirometrija u prvoj sekundi stojeći poslije opterećenja* - S1SPOO (2,216). Vrijednosti koeficijenta izduženosti (Kurtosis-a) kreću se ispod normalne vrijednosti distribucije 2,75, što čini distribuciju platikurtičnom ili izduženom, izuzev manjeg odstupanja kod varijable *Spirometrija u prvoj sekundi stojeći poslije opterećenja* - S1SPOO (3,865).

Na osnovu dobijenih rezultata osnovnih centralnih i disperzionih parametara varijabli za procjenu funkcio-

be concluded that the values of all variables are normally distributed. The obtained results show that the distribution of the basic central and dispersion parameters of the functional abilities of older juniors aligns with the standards specific to water polo players of the same age group, although this population is still undergoing a transformation process as a result of the influence of the specific age of the respondents and the conditions in which the training process in water polo is realized.

nalnih sposobnosti kod starijih juniora u vaterpolu, može se zaključiti da su vrijednosti svih varijabli normalno distribuirane. Dobijeni rezultati pokazuju da se distribucija osnovnih centralnih i disperzionih parametara funkcionalnih sposobnosti starijih juniora uklapaju u standarde specifične za funkcionalne sposobnosti vaterpolista iste uzrasne dobi, iako je ova populacija još u procesu transformacije, koja je rezultat uticaja specifične uzrasne dobi ispitanika i uslova u kojima se ostvaruje trenažni proces u vaterpolu.

***Table 2**. Basic central and dispersion parameters of the variables for assessing the functional abilities of older juniors (16-18 years old)*

***Tabela 2.** Osnovni centralni i disperzioni parametri varijabli za procjenu funkcionalnih sposobnosti starijih juniora (16-18 godina)*

Descriptive Statistics												
	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
S1SBE	87	4.60	1.57	6.17	3.0403	.11506	1.07319	1.152	.795	.258	.625	.511
S1SAE	87	17.46	.54	18.00	4.7283	.47325	4.41421	19.485	2.216	.258	3.865	.511
S1LBE	87	4.57	.52	5.09	3.1024	.11341	1.05785	1.119	-.416	.258	.115	.511
S1LAE	87	4.57	.55	5.12	3.4566	.11302	1.05419	1.111	-.797	.258	.830	.511
S6SBE	87	5.19	1.70	6.89	4.4648	.10479	.97741	.955	-.316	.258	1.323	.511
S6SAE	87	6.90	.55	7.45	4.4497	.14501	1.35256	1.829	-.553	.258	1.015	.511
S6LBE	87	4.84	3.14	7.98	5.0093	.11844	1.10473	1.220	.469	.258	.251	.511
S6LAE	87	4.00	2.89	6.89	4.5869	.11965	1.11603	1.246	.315	.258	-.743	.511
LUNGAGE	87	2.00	16.00	18.00	16.7586	.07835	.73081	.534	.411	.258	-1.024	.511
Valid N (listwise)	87											

***L**egend: N-number of subjects, Range-Rang, Min-minimum measurement result, Max-maximum measurement result, Mean- arithmetic mean, St.Dev.-standard deviation, Variance-variance, Skewness-coefficient of curvature, Kurtosis-coefficient of elongation, S1SBE-Spirometry in the first second standing before exertion, S1SAE-Spirometry in the first second standing after load, S1LBL-Spirometry in the first second lying before exertion, S1LAE-Spirometry in the first second lying after exertion, S6SBE-Spirometry in the sixth second standing before exertion, S6SAE-Spirometry in the sixth second standing after exertion, S6LBE-Spirometry in the sixth second lying before exertion, S6LAE-Spirometry in the sixth second lying after exertion, LA-Lung age)*

Legenda: N-broj ispitanika, Rangey-Rang, Min-minimalni rezultat mjerenja, Max-maksimalni rezultat mjerenja, Mean-aritmetička sredina, St.Dev.-standardna devijacija, Variance-varijansa, Skewness-koeficijent zakrivljenosti, Kurtosis-koeficijent izduženosti, S1SPRO – Spirometrija u prvoj sekundi stojeći prije opterećenja, S1SPOO – Spirometrija u prvoj sekundi stojeći poslije opterećenja, S1LPRO – Spirometrija u prvoj sekundi ležeći prije opterećenja, S1LPOO – Spirometrija u prvoj sekundi ležeći poslije opterećenja, S6SPRO – Spirometrija u šestoj sekundi stojeći prije opterećenja, S6SPOO – Spirometrija u šestoj sekundi stojeći poslije opterećenja, S6LPRO – Spirometrija u šestoj sekundi ležeći prije opterećenja, S6LPOO – Spirometrija u šestoj sekundi ležeći poslije opterećenja, STARPL – Starost pluća

Analysis of differences in functional abilities between younger and older juniors in water polo

Analysis of differences in functional abilities tested by T-test

To determine statistically significant differences in functional abilities between younger and older junior water polo players, the results of an independent samples T-test were applied (Table 3). The T-test results indicate

Analiza razlika u funkcionalnim sposobnostima između mlađih i starijih juniora u vaterpolu

Analiza razlika u funkcionalnim sposobnostima testiranih T-testom

Za utvrđivanje statistički značajnih razlika u funkcionalnim sposobnostim između mlađih i starijih juniora u vaterpolu primijenjena je analiza rezultata T-testa za

positive and statistically significant differences in five out of twelve tests assessing functional abilities between the two groups of subjects – younger and older juniors.

Significant differences between the two samples – younger and older junior water polo players – are evident in the spirometry test in the first second while standing after exertion – S1SAE t(172) = -4.42, p = .000. The average increase in this test was 31.15, with a 95% confidence interval ranging from -3.10 to -1.18. Eta squared is 0.10, indicating a medium effect of this variable on the sample.

Statistically significant differences are also observed in the variable spirometry in the first second while lying after exertion – S1LAE t(172) = -5.33, p = .000. The average increase in this test was 1.05, with a 95% confidence interval ranging from -1.17 to -0.54, and Eta squared was 0.14, indicating a large effect of the variable on the sample.

In the spirometry test in the sixth second while lying before exertion – S6LBE – differences between younger and older junior water polo players in functional abilities were observed t(172) = -4.15, p = .000. The average increase in this test was 9.44, with a 95% confidence interval ranging from -0.87 to -0.31. Eta squared is 0.09, indicating a medium effect of this variable on the sample.

The test that also shows differences between the two samples is spirometry in the sixth second while lying after exertion – S6LAE t(172) = -7.90, p = .000. The average increase in this test was 4.48, with a 95% confidence interval ranging from -1.54 to -0.92. Eta squared is 0.26, representing a significant effect of the variable on the sample.

Lung age – LUNG AGE – as a variable describing functional abilities, showed significant differences between water polo players t(172) = -15.69, p = .000, with an average increase of 1.30 and a 95% confidence interval ranging from -1.97 to -1.53. Eta squared was 0.58, representing a substantial effect of lung age on younger and older juniors in water polo.

For other tests, no statistically significant differences in functional abilities between younger and older juniors were found.

nezavisne uzorke (tabela 3). Rezultati T-testa ukazuju na pozitivne i statistički značajne razlike kod pet od dvanaest testova za procjenu funkcionalnih sposobnosti između dvije grupe ispitanika - vaterpolista mlađih i starijih juniora.

Između dva uzorka ispitanika – mlađih i starijih juniora u vaterpolu značajne razlike su evidentne u testu *spirometrija u prvoj sekundi stojeći poslije opterećenja – S1SPOO* t (172) = - 4.42, p = ,000. Prosječno povećanje vrijednosti u ovom testu bilo je 31.15, dok se interval 95-procentne pouzdanosti proteže od -3.10 do -1.18. Eta kvadrat iznosi 0.10 što je srednji uticaj varijable na uzorak ispitanika.

Statistički značajne razlike vidljive su i u varijabli *spirometrija u prvoj sekundi ležeći poslije opterećenja – S1LPOO* t (172) = -5.33, p = ,000. Vrijednosti prosječnog povećanja u testu je iznosilo 1.05, sa intervalom 95-procentne pouzdanosti koja se proteže od -1.17 do -.54, dok je Eta kvadrat iznosio 0.14 što je bio veliki uticaj varijable na istraživani uzorak ispitanika.

U testu *spirometrija u šestoj sekundi ležeći prije opterećenja – S6SPRO* uočene su razlike između vaterpolista mlađih i starijih juniora u funkcionalnim sposobnostima t (172) = - 4.15, p = ,000. Prosječno povećanje vrijednosti u ovom testu bilo je 9.44, dok se interval 95-procentne pouzdanosti proteže od -.87 do -.31. Eta kvadrat iznosi 0.09 što je srednji uticaj varijable na uzorak ispitanika.

Test koji takođe pokazuje razlike između dva uzorka ispitanika jeste *spirometrija u šestoj sekundi ležeći poslije opterećenja – S6LPOO* t (172) = -7.90, p = ,000. Prosječno povećanje vrijednosti u ovom testu bilo je 4.48, dok se interval 95-procentne pouzdanosti proteže od -1.54 do -.92. Eta kvadrat iznosi 0.26 što predstavlja značajan uticaj varijable na uzorak ispitanika.

Starost pluća – STARPL kao varijabla koja opisuje funkcionalne sposobnosti u kojoj su se desile značajne razlike između vaterpolista t (172) = -15.69, p = ,000, uz prosječno povećanje vrijednosti koje je bilo 1.30, sa intervalom 95-procentne pouzdanosti koje se proteže od -1.97 do -1.53. Eta kvadrat iznosio 0.58 što predstavlja značajan uticaj starosti pluća na mlađe i starije juniore u vaterpolu. Kod ostalih testova nije utvrđena statistički značajna razlika u funkcionalnim sposobnostima između mlađih i starijih juniora.

Table 3. *Results of the Independent Samples T-Test for Functional Abilities*

Tabela 3. *Rezultati T-testa za nezavisne uzorke funkcionalnih sposobnosti*

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		Eta kvadrat
									Lower	Upper	
S1SBE	Equal variances assumed	1.776	.184	-.449	172	.654	-.06759	.15055	-.36475	.22957	
	Equal variances not assumed			-.449	167.268	.654	-.06759	.15055	-.36481	.22963	
S1SAE	Equal variances assumed	31.154	.000	-4.422	172	**.000**	-2.14345	.48478	-3.10033	-1.18657	0.10
	Equal variances not assumed			-4.422	94.458	.000	-2.14345	.48478	-3.10592	-1.18097	
S1LBE	Equal variances assumed	.888	.347	-1.179	172	.240	-.17414	.14764	-.46556	.11729	
	Equal variances not assumed			-1.179	166.593	.240	-.17414	.14764	-.46563	.11735	
S1LAE	Equal variances assumed	1.059	.305	-5.338	172	**.000**	-.85897	.16093	-1.17661	-.54132	0.14
	Equal variances not assumed			-5.338	171.969	.000	-.85897	.16093	-1.17661	-.54132	
S6SBE	Equal variances assumed	1.137	.288	-2.554	172	.012	-.40966	.16040	-.72626	-.09305	
	Equal variances not assumed			-2.554	168.390	.012	-.40966	.16040	-.72631	-.09300	
S6SAE	Equal variances assumed	4.482	.036	-1.895	172	.060	-.34483	.18193	-.70392	.01427	
	Equal variances not assumed			-1.895	160.257	.060	-.34483	.18193	-.70411	.01445	
S6LBE	Equal variances assumed	9.448	.002	-4.154	172	**.000**	-.59172	.14246	-.87292	-.31053	0.09
	Equal variances not assumed			-4.154	150.054	.000	-.59172	.14246	-.87321	-.31024	
S6LAE	Equal variances assumed	5.203	.024	-7.901	172	**.000**	-1.23517	.15632	-1.54373	-.92661	0.26
	Equal variances not assumed			-7.901	167.074	.000	-1.23517	.15632	-1.54380	-.92655	
LUNG AGE	Equal variances assumed	1.307	.255	-15.696	172	**.000**	-1.75862	.11205	-1.97978	-1.53746	0.58
	Equal variances not assumed			-15.696	171.917	.000	-1.75862	.11205	-1.97978	-1.53746	

Legend: N-number of subjects, Range-Rang, Min-minimum measurement result, Max-maximum measurement result, Mean-arithmetic mean, St.Dev.-standard deviation, Variance-variance, Skewness-coefficient of curvature, Kurtosis-coefficient of elongation, S1SBE-Spirometry in the first second standing before exertion, S1SAE-Spirometry in the first second standing after load, S1LBL-Spirometry in the first second lying before exertion, S1LAE-Spirometry in the first second lying after exertion, S6SBE-Spirometry in the sixth second standing before exertion, S6SAE-Spirometry in the sixth second standing after exertion, S6LBE-Spirometry in the sixth second lying before exertion, S6LAE-Spirometry in the sixth second lying after exertion, LA-Lung age)

Legenda: t - T test, df - stepeni slobode, Sig.- nivo statističke značajnosti), Mean Difference - razlika aritmetičkih sredina, Std. Error Difference - standardna greška aritmetičkih sredina, , S1SPRO – Spirometrija u prvoj sekundi stojeći prije opterećenja, S1SPOO – Spirometrija u prvoj sekundi stojeći poslije opterećenja, S1LPRO – Spirometrija u prvoj sekundi ležeći prije opterećenja, S1LPOO – Spirometrija u prvoj sekundi ležeći poslije opterećenja, S6SPRO – Spirometrija u šestoj sekundi stojeći prije opterećenja, S6SPOO – Spirometrija u šestoj sekundi stojeći poslije opterećenja, S6LPRO – Spirometrija u šestoj sekundi ležeći prije opterećenja, S6LPOO – Spirometrija u šestoj sekundi ležeći poslije opterećenja, STARPL – Starost pluća

Discussion

The results of this study show clear differences in functional abilities between younger (14–16 years) and older (16–18 years) junior water polo players in Bosnia and Herzegovina. The data indicate that older juniors exhibit superior values in most spirometric parameters, especially in airflow in the first and sixth seconds of exhalation after exertion, as well as in the "lung age" parameter. These findings confirm the expected association between age, training experience, and the development of athletes' functional abilities.

The statistically significant differences in the variables S1SAE, S1LAE, S6LBE, S6LAE, and LUNG AGE indicate that older juniors handle physical exertion better and more efficiently achieve ventilatory capacity during effort. Eta squared values, which in some variables showed medium and large effects (e.g., LUNG AGE – 0.58; S6LAE – 0.26), confirm the practical and statistical relevance of differences between age groups.

These results are consistent with previous studies by Hraste et al. (2008). Mirvić et al. (2012) emphasize that continuous aquatic sports training significantly increases lung capacities in young athletes. Poproshaev and Cumakov (2013) also note that players exposed to higher workload in specific positions achieve higher values of vital lung capacity. Durmić et al. (2015) indicate that elite water polo players achieve better spirometric results compared to athletes in other team sports.

Other studies have similarly shown that pulmonary and cardiac functions improve after just three years of systematic swimming training at a young age. Comparisons between young swimmers and same-age non-athletes revealed that swimmers have higher lung volumes due to greater vital capacity and higher expiratory airflow. These differences were noticeable at the start of the study and increased over a three-year follow-up. Comparisons between older athletes and a control group showed statistically significant differences in vital capacity, total lung capacity, and forced expiratory volume in the first second in favor of older athletes, while measures of maximal ventilation and residual volume were not statistically significant. Differences in forced vital capacity, forced expiratory volume, and maximal expiratory flow between swimmers aged 15–20 and non-athletes were greater at the end of the season (Andrew et al., 1972; Hagberg et al., 1988; Mehrotra et al., 1997).

Differences in pulmonary ventilation values between young basketball players and non-athletes aged 14–16 were studied by Tocigl et al. (1999). Forced vital capacity, forced expiratory volume in the first second, and mean

Diskusija

Rezultati ovog istraživanja pokazuju jasne razlike u funkcionalnim sposobnostima između mlađih (14–16 godina) i starijih (16–18 godina) juniora vaterpolista Bosne i Hercegovine. Dobijeni podaci ukazuju da stariji juniori posjeduju superiorne vrijednosti u većini spirometrijskih parametara, posebno u protoku zraka u prvoj i šestoj sekundi izdisaja nakon opterećenja, kao i u parametru „starost pluća". Ovi nalazi potvrđuju očekivanu povezanost između uzrasta, trenažnog staža i razvoja funkcionalnih sposobnosti sportista.

Dobijena statistički značajna razlika u varijablama S1SPOO, S1LPOO, S6LPRO, S6LPOO i STARPL ukazuje na to da stariji juniori bolje podnose fizičko opterećenje i efikasnije ostvaruju ventilacijske kapacitete tokom napora. Eta-kvadrat vrijednosti, koje su kod pojedinih varijabli pokazale srednji i veliki efekat (npr. StarPl – 0.58; S6LPOO – 0.26), potvrđuju praktičnu i statističku relevantnost razlika između uzrasnih grupa.

Dobijeni rezultati ovog istraživanja su u skladu sa ranijim istraživanjima Hraste i sar. (2008). Mirvić i sar. (2012) ističu da kontinuirani sportski trening u vodi dovodi do značajnog povećanja plućnih kapaciteta kod mladih sportista. Poproshaev i Cumakov (2013) takođe naglašavaju da igrači koji su izloženi većem opterećenju u specifičnim pozicijama ostvaruju veće vrijednosti vitalnog kapaciteta pluća. Durmić i sar. (2015) ukazuju da elitni vaterpolisti postižu bolje spirometrijske rezultate u odnosu na sportiste iz drugih kolektivnih sportova.

U još nekoliko istraživanja kao i u prethodnom utvrđeno je da se plućne i srčane funkcije poboljšavaju već poslije perioda od tri godine sistematskog trenažnog rada plivanja već u mlađem dobu sportista, a komparacijom rezultata plućnih volumena i ekspiracijskog protoka zraka mladih plivača i istodobnih nesportista pokazalo se da plivači imaju veće plućne volumene kao posljedicu većih vrijednosti vitalnog kapaciteta, pa i veće vrijednosti ekspiracijskog protoka zraka. Navedene vrijednosti bile su očite već na početku istraživanja, a još su veće razlike uočene tokom trogodišnjeg praćenja. Uspoređujući starije sportiste i kontrolnu grupu rezultati su pokazali statistički značajnu razliku u vitalnom kapacitetu, ukupnom plućnom kapacitetu i forsiranom ekspiratornom volumenu u 1. sekundi u korist starijih sportista, dok u mjerama maksimalne ventilacije i rezidualnog volumena nije postojala statistička značajnost razlika. Razlike forsiranog vitalnog kapaciteta, forsiranog ekspiratornog volumena i maksimalnog ekspiracijskog protoka između plivača dobi od 15 do 20 godina i kontrolne grupe nesportista na početku i na kraju plivačke sezone i zabilježene su veće statistički značajne razlike kod plivača na kraju sezone (Andrew i sar., 1972; Hagberg i sar., 1988; Mehrotra i sar., 1997).

forced expiratory flow at 75% FVC were significantly higher in young basketball players, while mean forced expiratory flow at 50% and 25% was higher in non-athletes.

Hraste et al. (2009) found that young sailors and non-athlete controls differed in almost all measured pulmonary capacity and volume variables except vital capacity, and that young water polo players and non-athlete controls differed significantly in almost all variables except relative maximal expiratory flow. Sailors and water polo players did not differ significantly in functional pulmonary parameters. Univariate analysis showed significant individual differences in most variables between non-athlete controls and young athletes undergoing two-to-three years of training. Correlation values indicate that non-athletes perform worse functionally than both athlete groups, particularly in forced expiratory volume in 1 second, mean expiratory flow at 50% vital capacity, and forced vital capacity.

Popo et al. (2015) found no statistically significant differences between junior water polo players by playing position in functional abilities: vital lung capacity, forced expiratory volume in 1 second, resting heart rate, blood lactate after 400m crawl, and blood lactate after 100m crawl.

Mirvić et al. (2018) measured maximal exhalation in the first and sixth seconds after 200m crawl swimming in second-year students at the Faculty of Sport and Physical Education. Individual observations showed no statistical significance in first-second standing and lying maximal exhalation, but significant differences were found in sixth-second standing and lying maximal exhalation. Airflow from 1 to 6 seconds was significantly affected. Significant differences were also found in first-second standing and lying airflow after swimming. Maximal exhalation after 200m crawl is influenced by fatigue caused by maximal effort.

Hrbić (2018) found significant differences between U15 and U16 national water polo team members in almost all parameters, with no statistically significant differences between playing positions. U16 players had faster 400m and 100m crawl results compared to U15. Resting blood lactate concentrations were lower in U16, but post-exercise lactate and heart rate values varied between the groups as expected.

Ubović (2019) reported that age and sport did not have a statistically significant effect on VO2max, but anaerobic-glycolytic capacity (TAPP) showed a medium effect of the interaction between age and sport.

Rukavina (2024) studied predictive values of 400m crawl (aerobic capacity) and 100m crawl (anaerobic capacity) tests in young water polo players. Both tests were

Takođe, razlikama u ventilacijskim vrijednostima pluća između mladih košarkaša i nesportista u dobi od 14 do 16 godina bavili su se Tocigl i sar. (1999). Vrijednosti forsiranog vitalnog kapaciteta, forsiranog respiracijskog volumena u prvoj sekundi i srednji forsirani ekspiracijski protok pri 75% FVC bili su statistički značajno veći kod mladih košarkaša, dok je srednji forsirani ekspiracijski protok pri 50% i 25% bio statistički značajno veći kod kontrolne grupe nesportista.

Hraste i sar. (2009) su utvrdili da se mladi jedriličari i kontrolna grupa nesportista razlikuju u skoro svim izmjerenim varijablama plućnih kapaciteta i volumena osim u varijabli vitalni kapacitet, kao i da se mladi vaterpolisti i kontrolna grupa nesportista statistički značajno razlikuju u skoro svim izmjerenim varijablama osim u varijabli relativni maksimalni ekspiracijski protok. Jedriličari i vaterpolisti se značajno ne razlikuju u funkcionalnim parametrima plućnih kapaciteta i volumena. Rezultati univarijantne analize varijanse pokazuju značajne statističke pojedinačne razlike u većini varijabli između kontrolne grupe ispitanika i grupe mladih sportista koji učestvuju u trenažnom procesu u periodu od dvije i tri godine. S obzirom na vrijednosti korelacija varijabli u prostoru ventilacionih vrijednosti daje se uočiti da mladi pojedinci nesportisti imaju dosta slabije rezultate funkcionalnih sposobnosti u odnosu na obje grupe sportista a najveća se razlika vidi u varijabli forsirani ekspiracijski volumen u 1 sekundi, srednji ekspiracijski protok pri 50% vitalnog kapaciteta i forsirani vitalni kapacitet.

Popo i sar. (2015) su utvrdili da nema statistički značajnih razlika između vaterpolista juniora po pozicijama u igri na varijablama funkcionalnih sposobnosti: Vitalni kapacitet pluća, Forsirani ekspiracijski volumen u prvoj sekundi, Frekvencija srca u mirovanju, Nivo laktata poslije isplivanih 400 m kraul, Nivo laktata poslije isplivanih 100 m kraul.

Mirvić i sar. (2018) su na uzorku studenata druge godine Fakulteta sporta i tjelesnog odgoja mjerili maksimalni izdah u prvoj i šestoj sekundi nakon opterećenja uzrokovanog plivanjem na 200 m kraul. Poslije individualne opservacije u testovima maksimalni izdah u prvoj sekundi stojeći u vodi i maksimalni izdah u prvoj sekundi ležeći u vodi nije bilo statističkih signifikantnosti ali je zato u testovima maksimalnog ekspirijuma u šestoj sekundi stojeći i maksimalnog ekspirijuma u šestoj sekundi ležeći postojala signifikatna statistička razlika. Kod obje pozicije u vodi protok zraka od 1 do 6 sekunde je postojao statistički značajan uticaj. Značajnih razlika je bilo i u testovima protok zraka u prvoj sekundi stojeći u vodi i u testu protok zraka u prvoj sekundi ležeći. Prema rezultatima može se tvrditi da maksimalni ekspirijum poslije preplivane dionice od 200 m kraul tehnikom je bio pod uticajem umora uzrokovanim maksimalnim naporom.

Hrbić (2018) je u svom istraživanju dobio značajnu ra-

significant predictors of successful water polo performance, with first-league players outperforming others in swimming tests, except in the 25m ball-handling test.

Practically, these findings suggest that coaches should adjust training loads according to the age of young water polo players, considering developmental stages of pulmonary and cardiovascular functions. Younger juniors should have progressive loads focusing on breathing technique and endurance, while older juniors can train more intensively, emphasizing game-specific situations and competitive conditions.

The study confirms the importance of age and continuous training in developing functional abilities in young water polo players. Results contribute to understanding respiratory system adaptation in aquatic athletes and provide a basis for effective training planning and youth athlete selection.

Conclusion

The study showed that older junior water polo players (16–18 years) achieve better spirometric results and greater capacity to adapt to physical exertion compared to younger juniors (14–16 years). Statistically significant differences in the parameters—spirometry in the first second standing after exertion (S1SAE), spirometry in the first second lying after exertion (S1LAE), spirometry in the sixth second lying before exertion (S6LPRO), spirometry in the sixth second lying after exertion (S6LAE), and lung age (LUNG AGE)—indicate that age and the duration of training experience significantly influence the level of functional abilities in athletes.

The obtained results confirm that continuous and sport-specific water polo training contributes to the development of respiratory system capacity and improvement of physical fitness. They provide practical guidance for planning the training process, emphasizing the need to adjust training loads according to the athlete's age and stage of development.

The results of this study contribute to both theoretical and practical understanding of the development of functional abilities in young water polo players and may serve as a basis for further research in sports physiology and training technology for aquatic sports.

For general conclusions within the investigated domain, future research should include a larger and more representative sample of participants, apply a battery of tests with a greater number of variables to assess functional abilities more comprehensively, and systematically monitor the condition and potential changes of these parameters over multiple seasons.

zliku između vaterpolista članova nacionalne selekcije U15 i U16 u gotovo svim parametrima dok među pozicijama igrača ne postoje statistički značajne razlike. Reprezentacija U16 je imala brže rezultate na 400 metara prvi put, 400 metara drugi put te 100 metara kraul u poređenju sa reprezentacijom U15 koja je postavila sporije rezultate u istim testovima. Vrijednosti koncentracije laktata u krvi u stanju mirovanja su bile niže kod reprezentativaca U16 nego kod reprezentativaca U15, dok su vrijednosti koncentracije laktata u krvi poslije prvih 400m, poslije drugih 400 m te 100m niža kod reprezentacije U15. Igrači U16 ostvaruju veći nivo koncentracija laktata u krvi poslije prvih 400 m, poslije drugih 400 m i poslije 100 m. Reprezentativci U16 su bilježili više vrijednosti broja otkucaja srca poslije prvih 400m i psolije drugih 400 m, dok su zabilježene više vrijednosti kod U15 reprezentativaca u odnosu na igrače U16.

Ubović (2019) tvrdi da uticaj uzrasta i sporta na maksimalnu potrošnju kiseonika (VO2max) nije bio na statistički značajnom nivou a dobiveni rezultati u testu za procjenu anaerobno-glikolitičkih sposobnosti (TAPP) pokazuju da postoji srednje veliki statistički značajan uticaj interakcije između uzrasta i sporta na varijablu TAPP.

Rukavina (2024) je u svom istraživanju utvrđivao prediktivne vrijednosti testa plivanja na 400 m kraul kojim se procjenjuje aerobni kapacitet vaterpoliste i testa plivanja na 100 m kraul kojim se procjenjuje anaerobni kapacitet mladih vaterpolista na uspješnost vaterpolista. Na osnovu dobivenih rezultata autor konstatuje da su oba testa za procjenu specifične funkcionalne plivačke sposobnosti, tj. test 400 m i test 100 m kraul značajni prediktori uspješnog igranja vaterpola u prvoj Hrvatskoj vaterpolo ligi pa su zato upravo igrači koji su igrali u prvoj Hrvatskoj vaterpolo ligi ostvarili bolje rezultate u svim plivačkim testovima za razliku od onih koji nisu igrali, osim u testu vođenje lopte 25 metara.

U praktičnom smislu, ovi nalazi sugerišu da treneri trebaju posebnu pažnju usmjeriti na određivanju opterećenja trenažnog rada prema uzrasnoj dobi mladih vaterpolista, uzimajući u obzir faze razvoja plućnih i kardiovaskularnih funkcija. Mlađim juniorima treba omogućiti progresivno opterećenje i fokus na tehniku disanja i izdržljivost, dok starijim juniorima trening može biti intenzivniji, sa naglaskom na specifične vaterpolo situacije i opterećenja koja simuliraju takmičarske uslove.

Rezultati ovog istraživanja potvrđuju važnost uzrasta i kontinuiranog trenažnog rada u razvoju funkcionalnih sposobnosti mladih vaterpolista. Oni doprinose boljem razumijevanju procesa adaptacije respiratornog sistema kod sportista u vodenim sportovima, te predstavljaju relevantnu osnovu za kvalitetno planiranje trenažnog procesa i selekciju mladih sportista.

Zaključak

Istraživanje je pokazalo da stariji juniori vaterpolisti (16–18 godina) ostvaruju bolje spirometrijske rezultate i veću sposobnost adaptacije na fizičko opterećenje u odnosu na mlađe juniore (14–16 godina). Statistički značajne razlike u parametrima, spirometrija u prvoj sekundi stojeći poslije opterećenja (S1SPOO), spirometrija u prvoj sekundi ležeći poslije opterećenja (S1LPOO), spirometrija u šestoj sekundi ležeći prije opterećenja (S6LPRO), spirometrija u šestoj sekundi ležeći poslije opterećenja (S6LPOO) i starost pluća (STARPL) ukazuju da uzrast i dužina trenažnog staža značajno utiču na nivo ispoljavanja funkcionalnih sposobnosti sportista.

Dobijeni rezultati potvrđuju da kontinuirani i specifični vaterpolo treninzi doprinose razvoju sposobnosti respiratornog sistema i poboljšanju fizičke spremnosti. Oni pružaju korisne smjernice za planiranje trenažnog procesa, naglašavajući potrebu za prilagođavanjem opterećenja prema uzrastu i fazi razvoja vaterpolista.

Rezultati ovog istraživanja doprinose teorijskom i praktičnom razumijevanju razvoja funkcionalnih sposobnosti mladih vaterpolista, te mogu biti osnova za dalja istraživanja u oblasti sportske fiziologije i trenažne tehnologije vodenih sportova.

Za generalni zaključak u domenu istraživanog prostora, naredna istraživanja bi trebala uključiti veći i reprezentativniji uzorak ispitanika, primjenu baterije testova većim brojem varijabli za procjenu funkcionalnih sposobnosti koje bi bolje pokrile istraživani prostor kao i sistematsko praćenje stanja i mogućih promjena istih parametara kroz više sezona.

References

Andrew, G. M., Becklake, M. R., Guleria, J. S., Bates, J. H., & Macklem, P. T. (1972). Lung function in swimmers and non-athletes: A longitudinal study. *Journal of Applied Physiology*, 33(2), 207–210.

Bajrić, O., Bajrić, S., Mirvić,E., Ademović, K. (2023). *Vaterpolo.* Banja Luka: Panevropski Univerzitet Apeiron. [in Serbian]

Dopsaj, M. (1993). *Metodologija pripreme vrhunskoh ekipa u sportskim igrama,* Naučna Knjiga, Beograd [in Serbian]

Dopsaj, M. & Matkovic, I. (1999). *The structure of technical and tactical activities of water polo players in the First Yugoslav League during the game.* In Biomechanics and Medicine in Swimming, Proceedings of the VIII International Symposium on Biomechanics and Medicine in Swimming, University of Jyväskylä, Department of Biology of Physical Activity, Finland, (pp. 435–438). Jyväskylä: University of Jyväskylä.

Durmić, A., Antala, B., & Đurić, S. (2015). Spirometric values in elite athletes of different sports. *Sport Mont*, 13(1), 21–26.

Durmić, T., Lazović, B., Đelić, M., Suzić Lazić, S., Zikić, D., Žugić, V., Dekleva, M., & Mazić, S. (2015). *Sport-specific influences on respiratory patterns in elite athletes*. J Bras Pneumol. 2015; 41(6): 516–522.

Hagberg, J. M., Yerg, J. E., & Seals, D. R. (1988). Pulmonary function in young and older swimmers. *Journal of Applied Physiology*, 65(1), 239–244.

Hrbić, A. (2018). Razlike u funkcionalnim sposobnostima i plivačkoj brzini između vaterpolista U15 i U16. *Sportski Logos*, 16(2), 45–55. [in Serbian]

Hraste, M., Matković, B., & Jelaska, I. (2008). Uticaj dugotrajnog trenažnog procesa na razvoj plućnih funkcija mladih vaterpolista. *HOMO Sporticus*, 10(2), 25–30. [in Croatian]

Hraste, M., Matković, B., & Jelaska, I. (2009). Razlike u ventilacijskim kapacitetima mladih sportista različitih sportova. *Kinesiology*, 41(1), 75–81. [in Croatian]

Manojlović, N. (2006). Tehnologija stvaranja vrhunskih vaterpolo igrača. Zbornik radova sa seminara trenera mladih kategorija 05. Novembar 2005, str. 3-27. Beograd: Vaterpolo savez Srbije. [in Serbian]

Mehrotra, P. K., Varma, G. S., & Tiwari, H. C. (1997). Pulmonary function in swimmers and non-athletes. *Indian Journal of Sports Medicine*, 11(3), 23–28.

Mirvić, E., Bajrić, O., Hodžić, M., Kazazović, B., Rašidagić, F., & Šahat, S. (2012). Parcijalne kvantitativne promjene funkcionalnih sposobnosti studenata pod utjecajem programa plivanja. *Sportske nauke i zdravlje*, 2(2), 107-113. [in Serbian]

Mirvić, E., Hodžić, M., Lakota, R., Zuković, A., Talović, & M., Mašala, . (2012). Nivo trenažnih efekata na brzinske sposobnosti mladih vaterpolista. U Đ. Nićin, i V. Lolić (ur.), *Sportske nauke i zdravlje,* str. 213-217. Panevropski Univerzitet Apeiron. [in Serbian]

Mirvić, E., Bajrić, S., Bajrić,O., & Trivun, M. (2018). Analiza razlika u brzini plivanja kraul tehnikom između plivača i vaterpolista. *Sportske nauke i zdravlje*, 8(1), 63-71. [in Serbian]

Popo, A., Jokić, D., & Božić, S. (2015). Funkcionalne sposobnosti vaterpolista juniora u odnosu na poziciju u igri. *HERZ*, 7(1), 19–28. [in Croatian]

Poproshaev, V., & Cumakov, D. (2013). Pulmonary function differences between water polo player positions. *Pedagogics, Psychology, Medical-biological Problems of Physical Training and Sports*, 17(4), 75–80.

Rukavina, I. (2024). Specifične plivačke funkcionalne sposobnosti kao prediktori uspješnosti vaterpolista. *Kinesiology*, 56(1), 101–111. [in Croatian]

Srdić, V. Bajrić, O., Bajrić, S., & Ilić, N. (2023). *Teorija i metodika sportskog treninga*. Banja Luka: Panevropski Univerzitet Apeiron. [in Serbian]

Tocigl, J., Katić, R., & Jukić, I. (1999). Ventilacijski kapaciteti pluća mladih košarkaša. *Kinesiology*, 31(1), 61–67. [in Croatian]

Ubović, Ž. (2019). Uticaj uzrasta i sporta na aerobne i anaerobne sposobnosti mladih sportista. *Acta Kinesiologica*, 13(2), 45–52. [in Croatian]

Primljen: 25. februar 2026. / Received: February 25, 2025
Prihvaćen: 04. maj 2026. / Accepted: May 04, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601033W
UDC: 797.253:796.015.15
Original scientific paper
Originalni naučni rad

The Impact of Traditional Game-Based Activities on Self-Confidence and Motor Skill Development in Low Vision Children with Disabilities

Devi Catur Winata[1], Pamuji Sukoco[2], Sujarwo[2], liliana Puspa Sari[3], Mohammed Hasan Tuaimah[4], Andi Saparia[5], Ngurah Mahendra Dinatha[6]

[1]*Department of Physical Education, Doctoral Program, Universitas Negeri Yogyakarta, Indonesia*
[2]*Department of Physical Education, Universitas Negeri Yogyakarta, Indonesia*
[3]*Department of Physical Education, Sekolah Tinggi Olahraga dan Kesehatan Binaguna , Medan, Indonesia*
[4]*University of Thi-Qar, College of Physical Education & Sport Science, Thi-Qar, 64001, Iraq*
[5]*Department of Physical Education, Universitas Tadulako, Palu, Indonesia*
[6]*Citra Bakti College of Teacher Training and Education (STKIP), Ngada, Indonesia*

Correspondence:
Devi Catur Winata
Department of Physical Education, Doctoral Program, Universitas Negeri Yogyakarta, Indonesia, devicatur.2023@student.uny.ac.id

Abstract: *This research aims to analyze the effect of traditional games on low vision children with disabilities on their self confidence and motor skill in locomotor movements. Research uses experimental research. The research design used in this study is a factorial design. In this factorial design. This research design uses a 2 x 2 x 2 factorial design with a posttest. The sample size was 32 students, obtained through purposive sampling. Purposive. Data on student confidence was collected using a Likert scale questionnaire, and motor skills were assessed using a 1–50 scoring rubric. A two-way analysis of variance (ANOVA) with a 2 x 2 x 2 factorial design at a significance level of α = 0.05. According to the research results above. centered on these findings, it can be said that ased on the data above, there is an influence of traditional games with a focus on motor skills in children with low vision disabilities on increasing students' self-confidence in learning. The conclusions of this study are as follows: 1) There is a difference in the effect of Engklek and Galasin games on low-vision students. 2) It is concluded that traditional games have a significant effect on motor skills. 3) Self-confidence significantly affects the motor skills of low-vision students. 4) Traditional games interactively affect the self-confidence of low-vision students. 5) Traditional games have an effect on the motor skills of low-vision students. 6) There is an interaction effect between motor skills and confidence on low-vision students. 7) Traditional games affect the motor skills and confidence of low-vision students.*

Keywords: *Traditional Games, Motor Abilities, Low Vision, Learning Confidence*

Introduction

Education is the guidance and assistance that adults provide to children to help them reach maturity. The goal is for children to be able to carry out their life tasks independently. Knowledge is obtained through education and the learning process. Humans have different types of intelligence and different levels of learning ability. Education is a vital tool for nations to establish their identity and increase their competitiveness. Therefore, the state must provide quality educational services to all citizens, including those with special needs (Mega Iswari, 2017). A curriculum is essential to the implementation of education. Simply put, a curriculum is a complete list of lessons to be taught to students, with grades given for learning achievements over a certain period of time. The curriculum must accommodate the individual needs of students in terms of time and learning ability (Dakir, 2016).

In the application of the curriculum and curriculum activities that deal with the curriculum in schools. Curriculum application refers to efforts to apply the curriculum through curriculum objects, learning assessments, learning and teaching instructions and educational technology. This renewal is manifested through new tips, instructions, methods or approaches that improve learning (Basri, 2009). In order to implement this curriculum, teachers must carry out innovations. These innovations are a way for teachers to apply the curriculum to learning in schools.

Schools definitely require teachers and educators to implement the curriculum effectively. However, these activities do not always meet expectations. There are always obstacles when implementing this program, such as teachers' inability to provide and use learning media for students. The same applies to special education for children. Learning in inclusion classes is not much different from learning in regular classes. Schools that implement inclusive education must make various changes, including shifts in perspective and attitude, as well as changes to educational processes

that cater to individual needs without discrimination. That way, with accommodations and modifications that suit the child's needs, students can receive learning that suits their learning needs. The characteristics of inclusive learning are combined in several things, such as friendly and warm relationships with students, the ability of educators to educate students with different backgrounds and abilities, learning materials with various variations for all subjects, and with resources and evaluations that have been prepared. neatly by educators. There is a need for coaching students, through this coaching it is hoped that students will be able to develop and have optimal skills (Soemantri, 2017).

One of the children with disabilities is blind children. According to Somantri (Munif, 2016), blind children can be grouped into two types, namely blind and low vision. Blind children have characteristics that are slightly different from sighted children, namely that blind children have difficulty receiving and understanding information related to vision, and they still lack mastery of skills in daily activities.

Those with impaired vision cannot see what the people around them are doing clearly, in detail, or directly. Therefore, they cannot imitate them to develop and master skills for daily life activities. Low vision is a visual impairment that causes a person to have some residual vision, but not enough to perform daily activities without assistive devices. Low vision can hinder activities such as driving and reading and often requires lighting adjustments and/or enlarged print. Low vision disabilities encompass a wide range of visual impairments that significantly affect an individual's ability to perform daily tasks. Defined as having a best-corrected visual acuity between 6/18 and 3/60, low vision can result from various conditions, including retinal disease, glaucoma, and corneal disorders (Sodhi, 2020). Individuals with low vision often experience challenges such as reduced contrast sensitivity, altered color perception, and glare, which can hinder their quality of life (Nayar., 2021)

Low vision can be divided into two types: myopia (nearsightedness) and hyperopia (farsightedness). Myopia, commonly referred to as "nearsightedness," makes people unable to see distant objects clearly. Hyperopia makes it difficult to see close objects clearly and is commonly referred to as "nearsightedness." Children with low vision will definitely experience developmental problems. One such problem is motor development. Motor development is a critical factor in overall development. It is the process of acquiring skills and movement patterns that children can carry out. Motor skills are needed to control the body. Motor development is also a process of growth and development of a child's movement abilities, meaning even simple movements are the result of complex, coordinated interactions (Kovalepa, 2023). Fine motor development refers to the development of small muscle movements in the hands, consisting of coordinated eye-hand movements, which work together to create a skill. The motor development of blind children tends to be slower, causing it to appear different. This is influenced by a lack of visual stimulation, an inability to imitate others, and environmental factors. Motor activities are strongly influenced by visual stimuli.

A lack of fine motor development in children with low vision causes them to only be able to perform fine motor development stages below their developmental age. Delays in fine motor skills can be caused by a lack of stimulation. To improve children's fine motor development, it is necessary to provide regular and continuous stimulation at every opportunity from an early age. Fine motor movements do not require a lot of energy, only eye coordination and careful hand movements. Children with good fine motor skills tend to be independent because their hands are skilled at doing various things. Fine motor movements do not require much effort, but rather involve eye coordination and careful hand movements. Children with good fine motor skills tend to be independent.

Inclusive physical education still uses the standard curriculum for children, and PJOK teachers do not use a special learning model for children with disabilities. The PJOK teacher said that children with low vision have different visual abilities, so it is difficult to apply learning with game concepts. Sometimes, they said, it is difficult to see, so what they see is a misperception. Even though limited vision can be overcome with tools, children's self-confidence in their surroundings and in learning is low, especially when learning PJOK. Those who use glasses are often considered to hinder children's movements. Limited vision also makes it difficult for children to decide how to move. Several models are often used by PJOK teachers, such as direct instruction models with a game approach. Teachers have not been able to present learning using innovative models. Teachers need learning innovations, such as modifying learning models and media, to increase learning achievement in all academic areas.

Self-confidence is one of the most important qualities a student can have. It comes from the belief that, no matter what life brings, it must be faced. A study of Students' self-confidence and learning through dialogues in a Net-Based environment by (Jakobsson, 2006) revealed that a significant relationship exists between students' self-confidence and succession in their studies. And the study further showed that students with good self-confidence experienced working

through the internet full of inspiration and they felt they had worked harder than the others. Sihotang, investigated the effects of learning strategies and confidence on student's learning outcomes. They have found that student's learning outcomes were related to learning strategy and self-confidence. Their study further revealed found that students who had high confidence had better learning outcomes in comparison to students who had low self-confidence (Sihotang, L., Setiawan, D. & Saragi, 2017).

Traditional games can be adapted to include larger text, high-contrast colors, and simplified visual effects, making them more accessible to children with low vision (Nurul, 2020). Serious game accessibility design models emphasize usability and playability, ensuring children with visual impairments can enjoy games (Nurul, 2020). Various studies have shown that traditional games significantly impact students' motor skills and confidence. These games enhance physical abilities and foster a sense of cultural identity and self-esteem. The following sections detail the specific impacts of traditional games on motor skills and confidence. Gross and Fine Motor Skills, Traditional games like Congklak and Bakiak have been shown to improve gross and fine motor skills. For example, one study found that students' locomotor movement skills significantly improved, with average scores rising from 60 to 85 after playing traditional games (Fathihah, 2024). Coordination and balance: Participation in these games enhances coordination, body balance, and reaction speed, all of which are crucial for overall physical development (Ramkar, R. S., Septiadi, F., & Bachtiar, 2024). Psychomotor Development: Traditional games contribute to psychomotor skills, including hand-eye coordination and problem-solving abilities, which are essential for cognitive development (Apriyanda, A., Lubis, N. K. M., Sinaga, N. A., Nadeak, A. C., & Siddik, 2024). Motivation and Engagement: Traditional games motivate students to participate in physical education, improving learning outcomes and fostering a greater appreciation for cultural heritage (Тов, 2024).

Cultural Identity: Engaging in traditional games helps students connect with their cultural roots, fostering pride and confidence in their identity (Tov et al., 2024; Apriyanda et al., 2024).

While traditional games have clear benefits, some argue that modern sports and digital games offer more diverse skill sets and engagement opportunities. Nevertheless, the cultural and physical benefits of traditional games remain essential in educational settings.

Research on motor skill development in children with low vision is important, as it highlights the need for targeted interventions to improve their physical abilities. Studies show that children with visual impairments often have delayed motor skill development compared to their sighted peers. This study identifies a research gap: children with low vision, particularly those with cerebral visual impairment (CVI), exhibit less developed motor function than their sighted peers. These differences are particularly evident in the quality and speed of drawing tasks, which are important indicators of fine motor skills.

However, some studies suggest that, while visual impairment affects motor skills, compensatory mechanisms may develop over time, allowing for alternative learning strategies that mitigate these challenges. Nevertheless, the overall trend indicates a significant loss of motor function among visually impaired children.

Method

The research design used in this study is a factorial design. In this factorial design, the treatments will be arranged so that each individual can be a subject simultaneously, in different factors and in each factor consisting of several levels. A factorial design is part of experimental research consisting of two or more independent variables that are combined. This research design uses a 2 x 2 x 2 factorial design with a posttest. An illustration of this factorial design can be seen in the following figure:

Table 1. *Research Design*

		Traditional Game			
		(A1)		Galasin (A2)	
Motor Skill (B)		Fine Motor Skill B1	Gross Motor Skill B2	Fine Motor Skill B1	Gross Motor Skil G B2
Self Confidence (C)	High (C1)	A1B1C1	A1B2C1	A2B1C1	A2B2C1
	Low (C2)	A1B1C2	A1B2C2	A2B1C2	A2B2C2

Description:

A1B1C1: Hopscotch game that develops fine motor skills and high self-confidence.

A1B2C1: A hopscotch game that develops gross motor skills and self-confidence.

A2B1C1: Galasin game with fine motor skills and high self-confidence.
A2B2C1: Galasin game with gross motor skills and high self-confidence.
A1B1C2: Hopscotch game with fine motor skills and low self-confidence.
A1B2C2: Hopscotch game with gross motor skills and low self-confidence.
A2B1C2: Galasin game with fine motor skills and low self-confidence
A2B2C2: Galasin game with gross motor skills and low confidence.

This study examined 50 low-vision students in North Sumatra. The research sample was selected using purposive random sampling based on the inclusion and exclusion criteria. Purposive random sampling involves selecting samples based on specific criteria. The sampling technique used in this study was purposive sampling. The sample size was 32 students, obtained through purposive sampling. Purposive sampling is a method of selecting subjects based on specific objectives rather than strata, randomness, or region.

The requirements for the research sample are as follows:

1) Willingness to participate in the study.
2) Obtained permission from the students' parents/guardians.
3) Have low vision.

Data on student confidence was collected using a Likert scale questionnaire, and motor skills were assessed using a 1–50 scoring rubric. A two-way analysis of variance (ANOVA) with a 2 x 2 x 2 factorial design at a significance level of $\alpha = 0.05$ was used to analyze the data in this study. Before conducting the variance analysis, a sample normality test was conducted using Liliefors as a prerequisite for fulfilling the data analysis requirements. The Bartlett test was also used to determine the level of population variance homogeneity. If there was an interaction, which is the result of the ANOVA calculation, a Tukey test was conducted to determine the significance level of the F-value at a significance level of $\alpha = 0.05$.

Results

Normaity Test

The normal test is used to determine whether the data distribution of the population under study is normal or not. There are techniques that can be used to test the normality of data, such as the Kolmogorov-Smirnov test.

Table 2. *Normality Test*

Tests of Normality			
	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Motor skill	.083	32	.200*

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

Table 2 above shows that the significance (sig) value of the shooting data is 0.200, which is greater than 0.05. Therefore, the decision is to accept H0, concluding that the data on the motor skills of the pentaque athletes are normally distributed.

Homogeneity Test

The homogeneity test is a technique used to determine whether two or more samples come from the same population. The homogeneity test was conducted to determine whether the mortality, feeding capacity, damage intensity, and plant height data for each treatment had different variants. In this study, the homogeneity test used was the Levene test with the help of the SPSS (Statistical Package for the Social Sciences) 27 application.

Table 3. *Homogeneity Test*

Levene's Test of Equality of Error Variances[a,b]					
		Levene Statistic	df1	df2	Sig.
Motor skill	Based on Mean	1.766	7	24	.141
	Based on Median	1.302	7	24	.292
	Based on Median and with adjusted df	1.302	7	12.807	.324
	Based on trimmed mean	1.717	7	24	.152

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Dependent variable: Motor skill
b. Design: Traditional Games

Table 3 above shows that the homogeneity test based on mean (sig) is 0.141, which is greater than 0.05. Therefore, the decision is to accept H0, concluding that the data from all treatments are homogeneous.

Hypothesis Test

Data dalam penelitian ini dianalisa dengan teknik analisis varians (ANOVA) dua jalur dengan desain faktorial 2 x 2 x 2 pada taraf signifikan α = 0,05. Selanjutnya, jika terdapat interaksi (hasil dari perhitungan ANOVA), dilanjutkan dengan uji Tukey yang bertujuan untuk mengetahui tingkat signifikansi F hitung dengan taraf signifikansi α = 0,05.

Table 3. *Uji Hipotesis*

Descriptive Statistics					
Dependent Variable: Motor skill					
Traditional Game	Motor skill	*Self confidence*	Mean	Std. Deviation	N
Engklek	Fine motor skill	High	20.0000	9.20145	4
		Low	16.5000	5.06623	4
		Total	18.2500	7.12641	8
	Gross motor skill	High	41.0000	11.57584	4
		Low	31.7500	8.18026	4
		Total	36.3750	10.51445	8
	Total	High	30.5000	14.82276	8
		Low	24.1250	10.30170	8
		Total	27.3125	12.76307	16
Galasin	Fine motor skill	High	39.7500	12.52664	4
		Low	21.2500	9.21502	4
		Total	30.5000	14.19255	8
	Gross motor skill	High	38.2500	5.67891	4
		Low	17.5000	10.40833	4
		Total	27.8750	13.53765	8
	Total	High	39.0000	9.03960	8
		Low	19.3750	9.31876	8
		Total	29.1875	13.46709	16
Total	Fine motor skill	High	29.8750	14.66227	8
		Low	18.87590	7.33753	8
		Total	24.3750	12.55853	16
	Gross motor skill	High	39.6250	8.56801	8
		Low	24.6250	11.53798	8
		Total	32.1250	12.50533	16
	Total	High	34.7500	12.64648	16
		Low	21.7500	9.80136	16
		Total	28.2500	12.94156	32

Table 4. *Hypothesis Testing*

Tests of Between-Subjects Effects						
Dependent Variable: Hasil Shooting						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3111.000[a]	7	444.429	5.126	.001	.599
Intercept	25538.000	1	25538.000	294.528	.000	.925
Traditional Game	28.125	1	28.125	.324	.006	.013
Motor Skill	480.500	1	480.500	5.542	.027	.188
Self Confidence	1352.000	1	1352.000	15.593	.001	.394
Games * Motor Skill	861.125	1	861.125	9.931	.004	.293
Games * Self Confidence	351.125	1	351.125	4.049	.046	.144
Motor Skill * Self Confidence	32.000	1	32.000	5.369	.005	.015
Games * Motor Skill * Self Confidence	6.125	1	6.125	5.071	.008	.003
Error	2081.000	24	86.708			
Total	30730.000	32				
Corrected Total	5192.000	31				

a. R Squared = ,599 (Adjusted R Squared = ,482)

The following conclusions are shown in Table 4 above.

1. The significance value of 0.006 is smaller than 0.05; therefore, H0 is rejected, and it is concluded that there is a difference in the effect of Engklek and Galasin games on low-vision students.

2. The significance value of 0.027 is less than 0.05; therefore, H0 is rejected, and it is concluded that traditional games have a significant effect on motor skills.

3. The significance value of self-confidence is 0.001, which is less than 0.05. Therefore, we reject H0 and conclude that self-confidence significantly affects the motor skills of low-vision students.

4. The significance value of the interaction effect between traditional games and self-confidence is 0.004, which is also less than 0.05. Thus, we reject H0 and conclude that traditional games interactively affect the self-confidence of low-vision students.

5. The significance value of the interaction effect is 0.046, which is smaller than 0.05. Thus, we reject H0 and conclude that traditional games have an effect on the motor skills of low-vision students.

6. The significance value of the interaction effect between motor skills and confidence is 0.005, which is smaller than 0.05. Thus, we reject H0 and conclude that there is an interaction effect between motor skills and confidence on low-vision students.

7. The significance value of the effect of traditional games on motor skills and confidence is 0.008, which is smaller than 0.05. Thus, we reject H0 and conclude that traditional games affect the motor skills and confidence of low-vision students.

Discussion

The influence of traditional games on enhancing motor skills in children with low vision disabilities significantly contributes to their self-confidence in learning. Research indicates that engaging in adapted and traditional games fosters not only motor development but also psychological benefits, such as increased self-efficacy and social interaction.

Traditional games enhance gross motor skills, including balance, coordination, and muscle strength, which are crucial for children with disabilities (Dzakiyyah, Dwi, Manna, 2024). A study on Balinese traditional games demonstrated that 81.3% of participants showed high engagement, leading to improved fundamental motor skills (Yoda., I, Ketut, Rifqi, Festiawan., Ardo, Okilanda., Ardo, 2024).

Participation in adapted games has been shown to overcome psychological barriers, enhancing courage and confidence in trying new skills. The Orientation Game for blind children improved self-concept and autonomy, indicating a direct link between motor skill development and self-confidence (Farias, Gerson, Carneiro, de, 2022).

Traditional games promote social interaction, allowing children to engage with peers, which further boosts their self-esteem and confidence in social settings (Dzakiyyah, 2024). Conversely, while traditional games are beneficial, some argue that reliance on these methods may overlook the need for tailored interventions that address specific individual challenges faced by children with low vision disabilities.

Traditional games significantly enhance student confidence by fostering social skills, physical abilities, and engagement in learning. Research indicates that participation in these games leads to measurable improvements in self-esteem and social interactions among students. The following sections elaborate on the various impacts of traditional games on student confidence.

Traditional games, such as crank and sack races, have been shown to increase self-confidence in students, with average scores rising from 67.38 to 78.85 over multiple cycles of implementation (Ziftahni Rachma Sukarna, Didin Budiman, 2023). The structured nature of these games allows students to experience success, which is crucial for building self-belief and positive attitudes towards learning. Engaging in traditional games promotes teamwork and communication skills, as children learn to collaborate and strategize with peers (Lauren, J., Lieberman., Justin, A., Haegele., Luis, Columna., Paula, 2014). Students involved in these activities demonstrate improved social relations, which contribute to their overall confidence in social settings.

Incorporating traditional games into physical education not only enhances motor skills but also increases students' interest in learning, thereby boosting their confidence in physical activities (Muhammad., Ali, Rahmat., Carsiwan, 2024). The development of coordination and physical fitness through these games further supports students' self-assurance in their abilities (Conversely, while traditional games are beneficial, some educators may argue that modern educational methods and technology could provide more effective means of building confidence in students. However, the holistic benefits of traditional games in fostering both physical and social skills remain compelling.

For a regular physical education teacher, it is important to remember that children with disabilities are still children, but happen to have disabilities. In general, children with disabilities tend to be the same as children without disabilities. Much of what teachers know about good education for children without disabilities is directly applicable to children with disabilities. For an adaptive physical education teacher, they specialize in education for people with disabilities and have knowledge of all situations and conditions that can influence a person's attitudes, talents and physical education experiences (Haris, 2021).

Regular physical education teachers may ask adaptive physical education teachers about things they don't understand regarding education programs for children with disabilities. If adaptive physical education teachers have questions about disabilities, it is beneficial to consult with coaches, therapists, parents, and administrators who can provide the necessary expertise to accommodate the resources necessary to develop and implement a program plan for each child (Harris, 2021). For children with disabilities who have physical education needs that are different from those met in the context of the regular curriculum, learning programs need to be designed that suit their conditions and needs. This will empower teachers to develop experiences and goals that are consistent with opportunities for participation for all children (Canales, L. K., & Lytle, 2011).

Physical education teachers play a crucial role in adapting their teaching methods to accommodate children with low vision. Creativity in lesson planning and instructional strategies is essential to ensure these students can participate fully and benefit from physical education. The following sections outline key strategies and considerations for effective teaching in this context.

Use of Props and Equipment: Incorporating tactile and auditory props can enhance engagement and understanding for visually impaired students (Jakinda., Rose, Simon, Munayi., Janet, Muhalia, Chumba., Benson, Ndung'u, 2024). Modified Instructional Methods: Teachers should employ varied instructional techniques, such as verbal cues and physical guidance, to facilitate learning (Jakinda., Rose, Simon, Munayi., Janet, Muhalia, Chumba., Benson, Ndung'u, 2024).

Studies have shown that traditional games positively impact the self-confidence and motor skills of children with low vision and other disabilities. These games provide a structured yet enjoyable environment that encourages physical activity, which is crucial for developing motor skills and boosting self-esteem. Engaging in traditional games enhances physical abilities and fosters social interaction, which can contribute to a child's self-confidence. The key aspects of how traditional games affect these children are outlined below. Specific games, such as "Kucing-

kucingan," have effectively improved walking and balance in visually impaired children, demonstrating traditional games' potential to enhance mobility and posture (Maula, N., & Sidiq, 2022).

Conclusion

The findings of this study demonstrate that traditional games, specifically *Engklek* and *Galasin*, play a vital role in enhancing both the motor skills and self-confidence of low-vision students. The results indicate a significant difference in the effects of these two games, suggesting that each offers unique benefits to the development of physical and psychological abilities. Furthermore, traditional games were found to have a direct and significant impact on improving motor skills, while self-confidence also showed a strong influence on motor performance. The interactive relationship between self-confidence and motor skills highlights the importance of holistic approaches that integrate physical activity and emotional empowerment. Overall, traditional games serve as an effective pedagogical tool for promoting the physical and psychological growth of children with low vision, fostering their confidence, coordination, and overall participation in learning activities.

Acknowledgements

The authors sincerely express their deepest gratitude to all participants, teachers, and staff of the special schools in Medan for their invaluable support throughout this research. Special appreciation is extended to the students with low vision disabilities who participated with great enthusiasm and commitment. The authors also acknowledge the guidance and constructive feedback provided by academic mentors and colleagues, whose expertise significantly contributed to the design and implementation of the study. Gratitude is further extended to the institutions and organizations that facilitated access to essential resources and created a supportive environment for data collection and analysis. Finally, the authors would like to thank the anonymous reviewers and editors for their insightful comments and suggestions, which have greatly enhanced the quality and clarity of this manuscript.

References

Apriyanda, A., Lubis, N. K. M., Sinaga, N. A., Nadeak, A. C., & Siddik, F. (2024). Pengaruh Olahraga Permainan Tradisional Congklak Terhadap Perkembangan Psikomotorik dan Kognitif Siswa Sekolah Dasar. *Jurnal Sadewa*, *2(4)*, 201–210. https://doi.org/10.61132/sadewa.v2i4.1289

Basri, H. (2009). *Filsafat Kurikulum dan Pembelajaran.* Remaja Rosdakarya.

Canales, L. K., & Lytle, R. K. (2011). *Physical Activities for Young People with Severe Disabilities.* Human Kinetics.

Dakir. (2016). *Manajemen Humas di Lembaga Pendidikan Era Global.* K-Media.

Dzakiyyah, Dwi, Manna, N. (2024). Permainan Tradisional terhadap Perkembangan Motorik Kasar Anak pada Disibilitas Tuna Grahita. *E-SPORT: Jurnal Pendidikan Jasmani, Kesehatan Dan Rekreasi*, *4(2)*, 73–83. https://doi.org/10.31539/e-sport.v4i2.8715

Farias, Gerson, Carneiro, de, . (2022). Avaliação do autoconceito e da locomoção em crianças e adolescentes cegos por meio do jogo de orientação: "caça ao tesouro" / Evaluation of self-concept and locomotion in blind children and adolescents through the orientation game. *Brazilian Journal of Development*, *8(2)*, 14071–1409. https://doi.org/10.34117/bjdv8n2-368

Fathihah, M. D. (2024). Menjaga Tradisi, Mengasah Motorik: Dampak Positif Permainan Tradisional pada Siswa Sekolah Dasar. *Jurnal Pendidikan Jasmani Dan Olahraga*, *1(1)*, 37–49. https://doi.org/https://doi.org/10.70211/sakalima.v1i1.109

Haris, F. (2021). *Pendidikan Jasmani, Olahraga dan Kesehatan Adaptif.* Cv. Eureka Media Aksara.

Jakinda., Rose, Simon, Munayi., Janet, Muhalia, Chumba., Benson, Ndung'u, G. (2024). Effective teaching of physical education to learners with visual disability: a literature review. *Journal of Education and Practice*, *6(4)*, 48–55. https://doi.org/10.47941/jep.1026

Jakobsson, A. (2006). Students' self-confidence and learning through dialogues in a net-based environment. *Journal of Technology and Teacher Education*, *14(2)*, 387–405.

Kovalepa, J. (2023). Conduct of physical education classes with students of a special medical group in higher education institutions. Naukovij Časopis Nacìonal′nogo Pedagogičnogo Unìversitetu Ìmenì M.P. *Dragomanova-Nacìonal′nogo Pedagogìč*, *3*(162), 187–192.

Lauren, J., Lieberman., Justin, A., Haegele., Luis, Columna., Paula, C. (2014). How Students with Visual Impairments Can Learn Components of the Expanded Core Curriculum through Physical Education. *Journal of Visual Impairment & Blindness*, *108(3)*, 239–248. https://doi.org/10.1177/0145482X1410800307

Maula, N., & Sidiq, Z. (2022). *Traditional Kucing-Kucingan Game, in Improving Ground Motor Skills to Blind Children in SLB Negeri A Citeureup Cimahi. 1(1),* 110–118. https://doi.org/10.57142/inclusion.v1i1.8

Mega Iswari, . Reno Fernande. (2017). Adaptasi Sekolah Terhadap Kebijakan Pendidikan Inklusif. *Jurnal Socing*, *4(1)*.

Muhammad., Ali, Rahmat., Carsiwan, C. (2024). Permainan Tradisional Terhadap Minat Belajar Siswa dalam Aktivitas Pembelajaran Pendidikan Jasmani. *Sytematic Literature Review.* https://doi.org/10.31539/jpjo.v7i2.8037

Munif, A. (2016). *Pendidikan Bagi Anak Kesulitan. Belajar.* Rineka Cipta.

Nayar., Patanjali, Dev, Suraj, Singh, Senjam., Beula, Christy., Sara, Varughese., G., V., S., Murthy., Praveen, Vashist., Vivek, G. (2021). *Low Vision, Vision Rehabilitation, and Assistive Technology.* 267–287. https://doi.org/10.1007/978-981-16-3787-2_16

Nurul,& Novianti, H. (2020). Pengaruh Edukasi Stimulasi Tumbuh Kembang Terhadap Kemampuan Deteksi Dini Tumbuh Kembang Anak Usia 0-5 Tahun Oleh Orangtua. *Jurnal Ilmu Kesehatan*, *14*.

Ramkar, R. S., Septiadi, F., & Bachtiar, B. (2024). Kontribusi Permainan Tradisional Terhadap Keterampilan Motorik Kasar Siswa: Classroom Action Research. *Indonesian Journal of Physical Activity*, *4(1)*, 8–13.

Sihotang, L., Setiawan, D. & Saragi, D. (2017). The Effect of Learning Strategy and Self -Confidence Toward Student's Learning Outcomes in

Elementary School. *IOSR Journal of Research & Method in Education.*, *7(4)*, 65–67.

Sodhi, P. (2020). Seeing World From The Eyes of Low Vision Subject. October 2020. *Delhi Journal of Ophthalmology*, 31(2).

Soemantri, I. (2017). Efektifitas Terapi Mendongeng terhadap Kecemasan Anak Usia Toddler dan Prasekolah Saat Tindakan Keperawatan. *Jurnal Keperawatan*, *4(3)*, 44–47.

Yoda., I, Ketut, Rifqi, Festiawan., Ardo, Okilanda., Ardo, O. (2024). Effectiveness of motor learning model based on local wisdom in improving fundamental skills. *Retos: Nuevas Tendencias En Educación Física, Deportes y Recreación*, *57*, 881–886. https://doi.org/10.47197/retos.v57.106807

Ziftahni Rachma Sukarna, Didin Budiman, & W. P. (2023). Development of Student Confidence Through Traditional Game Activities. *Jurnal Pendidikan Jasmani (JPJ)*, *4(2)*, 221–228. https://doi.org/doi.org/10.55081/jpj.v4i2.1407

Тов, Т., Aliriad, H., 2ABC, A. S., Gunawan, J., 3ABC, M., Endrawan, B., Haris, M., 4CDE, S., & A. (2024). *Improvement of Motor Skills and Motivation to Learn Physical Education Through the Use of Traditional Games.* https://doi.org/10.17309/tmfv.2024.1.04

Primljen: 20. decembar 2025. / Received: December 20, 2025
Prihvaćen: 28. april 2026. / Accepted: April 28, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601042Z **UDC:** 37.018.43:796.015.15(497.5)
Original scientific paper ***Originalni naučni rad***

Parents' Perceptions of Physical and Health Education in the Experimental All-Day School Program in the Republic of Croatia

Ante Zekanović[1], Nijaz Skender[2], Naim Ćeleš[2]
[1]Primary School Novigrad in Novigrad, Republic of Croatia
[2]University of Bihać, Bosnia and Herzegovina

Correspondence:
Ante Zekanović
Primary School Novigrad in Novigrad, Republic of Croatia, azekanovic@yahoo.com

Abstract: *The aim of the study was to examine parents' attitudes toward the effects of the experimental all-day school (CDŠ) program on children's physical activity and psychosocial well-being, and to evaluate satisfaction with Physical and Health Education (TZK) taught by a master's-level kinesiologist in classroom teaching. The sample included N = 67 parents, and data were collected via an online questionnaire (Likert 1–5). Measures of central tendency and dispersion, scale reliability (Cronbach α), thematic components (principal components method), and one-sample t-tests relative to the neutral scale value (3) were analyzed. The results show high mean values for all items (M = 4.49–4.67) with negative skewness of the distributions, indicating an extremely positive parental perception. The subscales showed good to excellent internal consistency (α = .78–.84), while the total scale had α = .89. One-sample t-tests show that the means of all items are statistically significantly higher than the neutral value (p < .001), with large effects (Cohen d = 2.39–3.34). In the discussion, the findings are interpreted in relation to existing knowledge about the importance of school-based physical activity for health, mental well-being, and school functioning. In conclusion, parents strongly support CDŠ and the role of the kinesiologist in early school age, with the note that future research should include objective measures of physical activity and a longitudinal design.*

Keywords: *all-day school; physical and health education; parental perception; descriptive statistics; factor analysis*

Introduction

Physical and Health Education (TZK) represents a fundamental component of the school curriculum because it contributes to children's physical health, motor and functional development, as well as psychosocial well-being. Control of a complex dynamic system such as the human being is possible only if the structure of individual subsystems within the system and their mutual relations are known (Skender, 2004; 2008). Concerning trends of reduced physical activity and increased sedentary behavior in the child population further emphasize the importance of the school environment as a place where minimum standards of movement can be ensured and lasting habits of an active life can be developed. Morphological characteristics and students' motor abilities, in addition to influencing more successful expression of functional abilities, should be one of the conditions for including students in physical activities. (Skender, et all; 2022). The World Health Organization emphasizes the need for a systematic approach to physical activity through schools and the community (World Health Organization, 2018). In the Croatian context, the experimental all-day school (CDŠ) program represents an attempt at organizational and curricular improvement of school work, including increased lesson hours for TZK and B1/B2 activities. A particularly important innovation in CDŠ is the role of a master's-level kinesiologist in classroom teaching, which responds to recommendations on the specialization of physical education teachers in early grades (European Commission/EACEA/Eurydice, 2022). Research consistently shows that school-based physical activity can be associated with better physical indicators, mental health, and school functioning (Biddle & Asare, 2011; Lubans et al., 2016; Trudeau & Shephard, 2008). Therefore, it is important to evaluate how key stakeholders—especially parents—perceive the effects and quality of such programs.

The aim of this paper is to analyze parents' attitudes toward (a) the effects of CDŠ on children's physical activity, (b) the psychosocial effects of TZK classes, and (c) overall satisfaction with the CDŠ program and the quality of instruction delivered by a kinesiologist. The hypotheses were that parents have positive attitudes toward CDŠ (H1) and toward TZK classes taught by a kinesiologist (H2).

Methods

The sample consisted of N = 67 parents who voluntarily participated in the study. The study was conducted using a quantitative approach.

The set of variables consisted of data collected via an online questionnaire (Google Forms) on a sample of parents of students included in the experimental CDŠ program. The questionnaire contained 10 statements:

REDTZKZDRAV - Regular physical activity is important for improving a child's health, TZKMOTSPO - Physical activity encourages the development of motor abilities (e.g., strength, speed, coordination, etc. TZKPRETILO - Physical activity reduces the risk of child obesity, DAKTIVZDRAV - Children need to be continuously active in order to learn better, sleep more calmly, and grow up more harmoniously KRETEMELJ - Movement and play are fundamental children's needs. MDZADTZK - My child is satisfied with additional Physical and Health Education classes at school, MDOTVCDŠ - My child spends more hours outdoors and playing in the All-Day School, MD60CDŠ - My child moves for at least 60 minutes every day in the All-Day School, PRKINUČIT - There is a difference between the Physical and Health Education lesson led by a kinesiologist and the one led by the classroom teacher RN. MDVESTZK - My child looks forward to Physical and Health Education classes.

All variables were organized into three thematic groups: general knowledge about physical activity (items 1–5), satisfaction with the CDŠ program (items 6–8), and the quality of TZK instruction (items 9–10). Responses were given on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree).. The analysis was conducted in SPSS, with calculation of descriptive indicators, reliability estimation (Cronbach α), one-sample t-tests relative to the neutral scale value (3), and an analysis of thematic components using the principal components method (PCA) at the level of subscales.

Results

Below are presented the measures of central tendency and dispersion for all questionnaire items, the thematic subscales (components), and the results of testing deviations of the means from the neutral scale value.

Table 1. *Measures of central tendency and dispersion for questionnaire items (N = 67)*

No.	Statement (shortened)	M	SD	Min	Max	Skewness	Kurtosis
1	Regular physical activity is important for improving a child's health	4.51	0.53	3	5	-1.16	0.58
2	Physical activity promotes the development of motor abilities	4.55	0.53	3	5	-1.40	1.47
3	Physical activity reduces the risk of obesity	4.49	0.53	3	5	-1.09	0.36
4	Children need to be active (learning,	4.51	0.56	3	5	-1.30	1.19
5	Movement and play are fundamental needs	4.67	0.50	3	5	-1.84	3.04
6	Child satisfied with additional TZK classes	4.49	0.62	3	5	-1.18	0.64
7	Child spends more hours outdoors	4.57	0.59	3	5	-1.54	1.76
8	Child moves at least 60 min	4.52	0.62	3	5	-1.36	1.21
9	Difference between TZK (kinesiologist) and class teacher (RN)	4.61	0.61	3	5	-1.77	2.70
10	Child looks forward to TZK classes	4.63	0.58	3	5	-1.70	2.50

Note. M = mean; SD = standard deviation. Negative skewness indicates a concentration of responses at the higher values of the scale

Table 2. *Reliability of the scale and subscales (internal consistency)*

Scale	Number of items	Cronbach α	95% CI
Total scale	10	.89	[.85, .92]
General knowledge about physical activity	5	.78	[.69, .85]
Satisfaction with CDŠ	3	.84	[.77, .89]
Quality of TZK	2	.81	[.72, .87]

Note. α = Cronbach's alpha; CI = confidence interval

Table 3. *Thematic components (PCA) – mean values by subscales*

Component (thematic group)	Items	M	SD	95% CI
General knowledge about physical activity	1–5	4.55	0.46	[4.44, 4.66]
Satisfaction with the CDŠ program	6–8	4.53	0.56	[4.39, 4.66]
Quality of TZK instruction	9–10	4.62	0.58	[4.48, 4.76]

Note. CI = confidence interval. Components are defined based on the content of the items and correspond to the theoretical constructs of the questionnaire

Descriptive indicators point to very high ratings on most items (average values are close to the upper limit of the scale), which suggests strongly positive parental attitudes toward the importance of physical activity and toward the organization of TZK instruction in the context of the all-day school. In practice, such results may indicate that the construct measured in this sample is partially "saturated" (ceiling effect), i.e., that the scale differentiates less well among respondents who already have positive attitudes.

Low standard deviations further indicate lower variability of responses. Skewness is mostly negative (clustering of responses at higher values), while kurtosis values indicate deviations from a normal distribution that are expected with Likert measures when most respondents give very high ratings. This is important because it can affect the stability of correlations and factor loadings, so it is useful to consider expanding the scale or introducing "harder" items that better differentiate respondents.

Table 4. *KMO by variable*

Variable	KMO
PRKINUČIT	0.738
MDVESTZK	0.749
MDOTVCDŠ	0.79
MD60CDŠ	0.848
KRETEMELJ	0.875
TZKMOTSPO	0.889
REDTZKZDRAV	0.893
MDZADTZK	0.895
DAKTIVZDRAV	0.939
TZKPRETILO	0.948

Note. Higher values indicate better suitability of the item for the factor model

The overall KMO index indicates good suitability of the data for factor analysis, and high KMO values by variables suggest that most items share common variance and fit into a latent structure. A significant Bartlett test confirms that the correlation matrix is not an identity matrix and that there are sufficient interrelationships between items for factor analysis to be meaningful.

Such a pattern (high KMO and significant Bartlett) is typically obtained when an instrument measures coherent, content-related dimensions (e.g., general beliefs about the benefits of physical activity and specific experiences with TZK instruction).

Table 5. *Bartlett's test of sphericity*

χ^2	df	p	det(R)
526.428	45	< .001	0.000201

The PCA results show a clear dominance of the first component and retention of two components according to Kaiser's criterion ($\lambda > 1$), with high cumulative explained variance. This suggests that the items share a strong common basis (a general "pro-activity" attitude), but that part of the variance is systematically grouped into an additional dimension.

Table 6. *Eigenvalues and explained variance*

Component	Eigenvalue (λ)	Proportion of variance	Cumulative
1	6.133	0.613	0.613
2	1.36	0.136	0.749
3	0.567		
4	0.451		
5	0.426		
6	0.349		
7	0.291		
8	0.193		
9	0.16		
	0.10		

Note. Kaiser's criterion (λ > 1) suggests retaining 2 components; cumulative explained ≈ 74.9%

Table 7. *Rotated loadings (varimax), communalities, and unique variance*

Code Item / statement	Factor 1	Factor 2	Commun.	Unique var.
REDTZKZDRAV	0.23	0.79	0.677	0.323
TZKMOTSPO	.0.23	0.85	0.776	0.224
TZKPRETILO	.0.458	0.683	0.676	0.324
DAKTIVZDRAV	.0.338	0.776	0.717	0.283
KRETEMELJ	0.307	0.768	0.685	0.315
MDZADTZK	0.883	0.214	0.826	0.174
MDOTVCDŠ	0.801	0.38	0.784	0.216
MD60CDŠ	0.768	0.427	0.773	0.227
PRKINUČIT	0.852	0.209	0.77	0.23
MDVESTZK	0.876	0.209	0.81	0.19

The rotated solution (varimax) shows a relatively clean structure: the group of items related to the experience and organization of TZK/all-day school has higher loadings on one factor, while items describing general beliefs about the importance of movement and health benefits have higher loadings on the other factor. This supports the interpretation that the instrument distinguishes (1) specific school experiences and evaluations of TZK and (2) general beliefs about the benefits of physical activity.

Communalities are mostly high, meaning that the factors explain a significant portion of the variance of each item. Unique variance is lower, indicating that the items are not predominantly idiosyncratic but largely rely on common latent dimensions. Partial cross-loadings (e.g., individual items that have meaningful loadings on both factors) can be explained content-wise by the fact that parents often simultaneously generally believe in the benefits of activity and evaluate the quality of the school environment through the lens of those beliefs.

High values of Cronbach's alpha indicate very good internal consistency of the instrument. However, when item mean values are very high and variability is low, alpha can be additionally "inflated" due to homogeneous responses, so it is useful to consider alpha together with the content representativeness of the items and the factor structure.

In the context of this instrument, the obtained values suggest that the items within the factors behave as a coherent set and measure relatively stable parental perceptions and experiences related to physical activity and TZK instruction.

Factor interpretation and reliability

Reliability (Cronbach α): overall (10 items) α = 0.930; Factor 1 α = 0.931; Factor 2 α = 0.892.

Factor 1 can be labeled as respondents' satisfaction with the introduction of additional TZK hours in primary schools, as well as the advantage of the kinesiologist compared with the classroom teacher RN in TZK instruction. The following variables stand out.

MDZADTZK: My child is satisfied with additional Physical and Health Education classes at school. (load-

ing = 0.883), MDOTVCDŠ: My child spends more hours outdoors and playing in the All-Day School. (loading = 0.800), MD60CDŠ: My child moves for at least 60 minutes every day in the All-Day School. (loading = 0.768), PRKINUČIT: There is a difference between the Physical and Health Education lesson led by a kinesiologist and the one led by the classroom teacher. (loading = 0.852), MDVESTZK: My child looks forward to Physical and Health Education classes. (loading = 0.876)

Factor 2 can be characterized as respondents' statements about the importance of Physical and Health Education as a school subject. The following variables stood out in particular: REDTZKZDRAV: Regular physical activity is important for improving a child's health. (loading = 0.790), TZKMOTSPO: Physical activity encourages the development of motor abilities (e.g., strength, speed, coordination, balance). (loading = 0.850), TZKPRETILO: Physical activity reduces the risk of child obesity. (loading =0.683), DAKTIVZDRAV: Children need to be continuously active in order to learn better, sleep more calmly, and grow up more harmoniously. (loading = 0.776), KRETEMELJ: Movement and play are fundamental children's needs. (loading = 0.768)

Discussion

The results of this study indicate an extremely positive parental perception of the effects of the all-day school program and Physical and Health Education (TZK) classes, as reflected in high mean values for all examined statements (M > 4.00). Particularly prominent are findings related to increased children's physical activity, psychosocial well-being, and parents' overall satisfaction with the program.

Data from Table 1 show that parents largely perceive an increase in children's daily physical activity, including meeting the recommended at least 60 minutes of movement per day. Such findings are consistent with World Health Organization guidelines, which emphasize the key role of school in ensuring a minimum level of physical activity in school-aged children. Similar results are reported by Donnelly et all. (2016), who state that extended school programs with integrated physical activity lead to significant increases in cardiorespiratory fitness and reductions in sedentary behavior.

Janssen and LeBlanc (2010) in their systematic review confirm that regular physical activity in the school environment has a strong preventive effect on the development of obesity and metabolic disorders, while Hillman, Erickson, and Kramer (2014) emphasize that physical activity positively affects executive brain functions, attention, and working memory. In this context, parental perceptions of increased children's activity within CDŠ can be viewed not only as a health benefit but also as a potential contribution to academic functioning.

The results further confirm an important psychosocial dimension of TZK. Parents report improved children's mood, reduced stress, and easier establishment of social contacts. These findings are consistent with the review by Biddle and Asare (2011), who conclude that physical activity has a moderate to strong effect in reducing symptoms of anxiety and depression in children and adolescents. Lubans et all. (2016) also emphasize that structured movement programs contribute to the development of self-confidence, emotional regulation, and a positive self-image.

It is particularly important that parents recognize the development of social skills as one of the key benefits of the program. This finding is supported by Trudeau and Shephard (2008), who point out that school programs with increased TZK lesson hours contribute to children's social integration without negatively affecting academic achievement. Rasberry et all. (2011) further report that there is a positive association between school physical activity programs and school success, suggesting that TZK may have broader educational significance.

A high level of parents' overall satisfaction with the program, particularly pronounced support for continuing the all-day school and for the justification of increased TZK lesson hours, indicates strong social acceptance of this model. Parental support is a key factor in the sustainability of educational reforms, as also confirmed by Eccles and Harold (1993), who emphasize that positive parental attitudes significantly increase children's involvement in school activities and their motivation to learn.

The obtained findings also fit into the contemporary theoretical framework of physical education, according to which TZK should be viewed as a means of holistic student development—physical, cognitive, and socio-emotional. Such an approach is elaborated in the work Physical Education Futures, which emphasizes that high-quality TZK contributes to the development of life skills, social inclusion, and long-term motivation for physical activity.

Regarding the analysis of results when TZK instruction is delivered by a physical education teacher compared with the results of classroom teachers, Vuksanović et all. (2014) found that there are significant differences in favor

of physical education teachers compared with classroom teachers in outcomes of motor abilities and morphological characteristics among students in the lower grades of primary school. A significant difference in results published in Skender (2008) shows a large difference in the results achieved by students who had 3 class hours compared with two class hours of physical education, which is confirmed by the results of our respondents.

The sample for this study is convenient, and the data are based on parents' subjective assessments, which can result in socially desirable responses. Also, the absence of objective measures of physical activity (e.g., accelerometry) limits a more precise assessment of children's actual level of movement. Future research should use a longitudinal design and combine subjective and objective indicators to obtain a more complete picture of the effects of the all-day school.

Despite these limitations, the results clearly indicate that the all-day school program, with increased TZK lesson hours, has the potential to significantly contribute to public health goals, children's psychosocial well-being, and improving the quality of education. Parents recognize the multidimensional benefits of the program, which further confirms the justification for integrating TZK as a central component of the contemporary school curriculum and increasing TZK lesson hours I in higher grades of primary school.

Conclusion

The study shows that parents of students included in the experimental CDŠ program have extremely positive attitudes toward the program's effects on children's physical activity and psychosocial well-being, and toward the quality of TZK instruction delivered by a master's-level kinesiologist. High mean values, good scale reliability, and statistically significant deviation from the neutral value support the conclusion of broad acceptance of CDŠ. Continuation and further improvement of the program are recommended, with infrastructural support to schools and inclusion of objective and longitudinal measures in future evaluations. In line with the above, the findings provide useful guidelines for education policy, particularly regarding parental support for specialized staff (kinesiologists) and increasing TZK lesson hours.

References

Biddle, S. J. H., & Asare, M. (2011). Physical activity and mental health in children and adolescents: A review of reviews. *British Journal of Sports Medicine*, 45(11), 886–895. https://doi.org/10.1136/bjsports-2011-090185

Burke, S., Sharp, L.-A., Woods, D., & Paradis, K. F. (2024). The development and validation of the Youth Sport Parental Support-Questionnaire (YSPS-Q). *International Journal of Sport and Exercise Psychology*, 22(8), 2085–2110. https://doi.org/10.1080/1612197X.2023.2255605

Doggui, R., Ward, S., Bélanger, M., & LeBlanc, A. G. (2021). Parental control and support for physical activity predict adolescents' moderate to vigorous physical activity over five years. *International Journal of Behavioral Nutrition and Physical Activity*, 18, Article 45. https://doi.org/10.1186/s12966-021-01107-w

Donnelly, J. E., Greene, J. L., Gibson, C. A., Smith, B. K., Washburn, R. A., Sullivan, D. K., DuBose, K., Mayo, M. S., Schmelzle, K. H., Ryan, J. J., Jacobsen, D. J., & Williams, S. L. (2011). Classroom-based physical activity, cognition, and academic achievement. *Preventive Medicine*, 52(Suppl 1), S36–S42.

Eccles, J. S., & Harold, R. D. (1993). Parent–school involvement during the early adolescent years. *Teachers College Record*, 94(3), 568–587.

European Commission/EACEA/Eurydice. (2022). Teachers in Europe: Careers, development and well-being. *Publications Office of the European Union*. https://doi.org/10.2797/311166

Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, 7, 40.

Lakes, K. D., Vaughan, E., Jones, M., Burke, W. J., Baker, D. J., & Swanson, J. M. (2017). Assessing parent perceptions of physical activity in families of toddlers with neurodevelopmental disorders: The Parent Perceptions of Physical Activity Scale (PPPAS). *Journal of Autism and Developmental Disorders*, 47, 2730–2744. https://doi.org/10.1007/s10803-017-3196-8

Long, B., Zhang, Y., Chen, S., & colleagues. (2025). The predictive relationship between parents' perceptions of physical activity and children's physical literacy. *Scientific Reports*. (PMC open-access version).

Lubans, D., Richards, J., Hillman, C., Faulkner, G., Beauchamp, M., Nilsson, M., Kelly, P., Smith, J., Raine, L., & Biddle, S. (2016). Physical activity for cognitive and mental health in youth: A systematic review of mechanisms. *Pediatrics,* 138(3), e20161642. https://doi.org/10.1542/peds.2016-1642

Skender, N., Šabić, E., Selimović, A., Kurtović, H., & Karalić, T. (2022). Gender as a determinant of students' life habits related to their physical activity. *Sport Science, 15*(2), 103–113.

Skender, N. (2004). Transformacioni procesi motoričkih sposobnosti i morfoloških karakteristika pod uticajem sedmomjesečnog tretmana kod učenika 3. i 4. razreda osnovne škole. *Nepublikovana doktorska disertacija. Sarajevo: Fakultet sporta i tjelesnog odgoja Univerzitet u Sarajevu.* [in Serbian]

Skender, N. (2008). *Transformacioni procesi antropoloških obilježja*. Bihać, Pedagoški fakultet Univerzitet u Bihaću ISBN: 978-9958-9468-8-2 [in Serbian]

Steenson, S., Butcher, L., & colleagues. (2018). Assessing the validity and reliability of family factors on physical activity: A case study in Turkey. *PLOS ONE*, 13(6), e0197920. https://doi.org/10.1371/journal.pone.0197920

Trudeau, F., & Shephard, R. J. (2008). Physical education, school physical activity, school sports and academic performance. *International Journal of Behavioral Nutrition and Physical Activity*, 5, 10. https://doi.org/10.1186/1479-5868-5-10

World Health Organization. (2018). Global action plan on physical activity 2018–2030: More active people for a healthier world. World Health Organization.

Vuksanović, G., Skender, N., Ćeleš, N., Kurtović, N., & Palić, A. (2014, June). Analiza razlika u transformaciji motoričkih sposobnosti i morfoloških karakteristika kod učenika kada nastavu izvodi profesor tjelesnog odgoja i učitelj razredne nastave. In *Zbornik radova 5. međunarodni naučno-stručni skup: Kulturni identitet u digitalnom dobu* (pp. 681–689). Filozofski fakultet Univerziteta u Zenici. [in Serbian]

Zheng, N., & Yang, J. (2022). Development and validation of Parental Support Scale of Children's Sports Training in China: Socio-ecological approach. Frontiers in Psychology, 13, 922282. https://doi.org/10.3389/fpsyg.2022.922282

Primljen: 20. decembar 2025. / Received: December 20, 2025
Prihvaćen: 28. april 2026. / Accepted: April 28, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601049H **UDC:** 796.323:796.015.15
Original scientific paper ***Originalni naučni rad***

Development of a Modified Device of the Manos Reactive Agility Test Instrument for Basketball

Hermanto, Johansyah Lubis, Iman Sulaiman
Department of Doctoral Physical Education, Faculty of Sports Science and Recreation, Universitas Negeri Jakarta, Indonesia

Correspondence:
Hermanto, Department of Doctoral Physical Education, Faculty of Sports Science and Recreation, Universitas Negeri Jakarta, Indonesia
hermanto@mhs.unj.ac.id

Abstract: *The study aimed to develop a modified version of the Manos Reactive Agility Test (MRAT) instrument designed specifically for basketball athletes. The original MRAT measured reactive agility through visual stimuli but lacked sports-specific adaptability for the dynamic movement of basketball. The modified device incorporates basketball-specific cues (e.g., change of direction, defensive movement, and court-based stimuli) to improve ecological validity. Using a Research and Development (R&D) approach with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model, the study involves: A needs analysis through a survey of 44 athletes to identify agility demands. Prototype design that integrates LED light panels and motion sensors for real-time response tracking. Validation by experts in sports science (content validity index≥0.80) and reliability testing (Cronbach alpha>0.93). The results of the trial (n=44 basketball players) showed that the modified MRAT had 90% accuracy in distinguishing elite and novice athletes, compared to 70% for the original MRAT. The device also improved the reliability of the retest (r=0.88 vs. 0.92) and reduced setup time by up to 30%. Modification of MRAT tools based on the needs of basketball athletes has proven to be more valid, reliable, and applicable than the standard version. This modified instrument offers a cost-effective sport-specific tool for assessing reactive agility in basketball, assisting coaches in talent identification and coaching optimization. Future studies may explore its application in other team sports.*

Keywords: *Reactive agility; basketball; instrument modification; Manos test; athletic performance*

Introduction

The game of basketball is one of the most popular and rapidly growing sports in the world, including in Indonesia. Basketball not only demands mastery of technique and understanding of tactics but also demands optimal physical capacity so that athletes can adapt to the high intensity and dynamics of the game. As the level of competition increases, the need for holistic athlete performance that integrates technical skills, cognitive aspects, and physical abilities such as speed, strength, endurance, and agility is becoming more urgent (Burke, 2024). One of the most decisive aspects in the success of a basketball player's performance is agility, especially reactive agility (Tantri, 2023). Reactive agility includes not only the physical ability to change direction quickly, but also the ability to respond appropriately to unexpected visual, auditory, or tactile stimuli, such as an opponent's movement, ball bounce, or coach's cues. In the context of basketball, this ability is very important because the game is characterized by a rapid transition between the offensive and defensive phases, as well as highly dynamic and unpredictable conditions (Azevedo, 2021). Research from (Nowak et al., 2021) shows that in a single professional basketball game, there are an average of 105 high-intensity attempts, which last every 21 seconds with an average duration of 1.7 seconds per attempt.

This means that players must be able to perform explosive moves that require a change of direction and speed in a very short duration. This situation confirms that agility, especially reactive agility, is a key ability in supporting athletes' performance during the game (Crelerot, 2024). However, based on practical observations and needs analysis on the field, there is still a significant gap between the demands of the game and the practice approach applied. Most exercise programs still emphasize general fitness, such as strength training, endurance, or planned course change of direction (Lohrer, 2023). This approach does not fully reflect the real conditions in the field, which instead requires training with unexpected stimuli and quick response, which is the main character of reactive agility (Ceberio, 2024; Kiefer, 2025). In the latest literature review, (Sheppard et al., 2006; Horička et al., 2020) it is emphasized that agility that is only trained through fixed movement patterns (closed skills) is not enough to improve athletes' ability to face the real conditions of the game. Reactive agility includes two important components, namely the ability to change the direction of movement and the cognitive component in the form of perception and decision-making. Therefore,

open skill, based on real stimulus, is a more appropriate choice to improve reactive agility skills (Badinlou, 2022; Munir, 2025).

Recognizing the importance of this aspect, the development of a specific and structured reactive agility training model is an urgent need, especially for the age group of 18–25 years. This age is a golden phase in the physical and motor development of an athlete, which has great potential to obtain improved performance through appropriate training interventions. Research from Mackala et al., (2020) even shows that reactive abilities in sports play are highly correlated with the level of mature cognitive and motor readiness, two things that develop optimally in this age range. On the other hand, the results of surveys and observations conducted by researchers on basketball clubs in Indonesia, show that not many coaches have a specific training model to develop reactive agility. The exercises provided are still general, without a real-world situation-based approach or the use of technology. This has an impact on the suboptimal response of athletes to changes in game situations, which can ultimately reduce the effectiveness of their performance on the field.

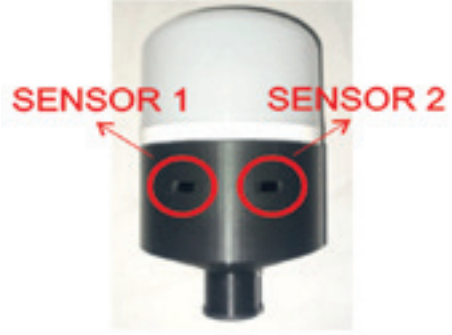
In response to these conditions, this study aims to develop a reactive agility training model based on real needs in the field and using sensory technology, namely the Manos Reactive Agility Test. The tool is designed to simulate reactive stimuli that resemble real basketball game conditions, with visual stimuli (lights), measured reaction times, and varied movement patterns. With this approach, the practice not only becomes more contextual and specific, but also more measurable and evidence based. The development of this model is also supported by the concept of cognitive motor-based training, which is a modern approach to sports training, where athletes are not only physically trained but also trained to think, respond and decide in a short period of time (Scanlan et al., 2014). This approach has been proven to improve movement effectiveness, energy efficiency, and accuracy in decision-making in the field.

Method

Tool Specifications

Figure 1. *Tool Specifications*

Tool Height: 125cm – 220cm, (2) LED Indicator Diameter: 9cm (3) Tool Battery Life: ± 2 Hours (4) Trigger Sensor Range: Max 6m (5) LED Sensor Range: Max 1.5m (6) Charger Duration: 1-2 Hours (7) Battery Capacity: 3000mAh.



Component Description

(1) Sensor TOF (*Time Of Light*)

TOF (*Time of Light*) sensors are used to detect the presence of players at specific points, such as start, checkpoint, and finish points.

Figure 2. *Sensor TOF (Time of Light)*

(2) LED Indicator

The indicator LED serves to provide directions to the player. Once the sensor detects the player's presence, one of the LEDs (left or right) will light up randomly as a visual instruction for the player to move in that direction.

Figure 3. *LED Indicator*

Figure 4. *Panel P10*

(3) Panel P10

The P10 panel is used to display information to the player. When the player is at the starting point, the panel will display the countdown "READY 3, 2, 1 GOO!!" as a cue. Once the practice is complete, the panel will display the total time the player has achieved.

(4) Indicator *Charger*

LED indicators are used to provide visual information regarding the status of the system, such as the charging process or the operating condition of the appliance. With the indicator LED, users can easily monitor whether the tool is active, the battery is charging, or there are certain conditions that need attention.

Figure 5. *Indicator Charger*

(5) Switch

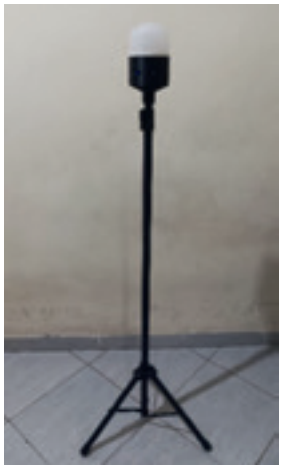
The switch is used as the main operator to turn the system on or off. With the switch, users can operate the appliance as needed practically without having to unplug the resource directly.

Figure 6. *Switch*

(6) Port Charger

The battery is used as the main power source to power the entire system. The use of batteries allows the tool to be used portably without relying on an external power source.

Figure 7. *Port Charger*



(7) Sensor Frame/Stand

The frame or stand is used to support the TOF (*Time of Light*) and LED sensors so that the position remains stable and in accordance with the direction of the player's movement. The proper position of the frame is essential for accurate sensor detection.

Figure 8. *TOF (Time of Light) and LED sensors*

Figure 9. *Research Stages and Process*

Research design

The research method used in this research is research and development (R&D). This research method is used to produce certain products and test the effectiveness of those products. The following are the research and development steps according to Figure 9.

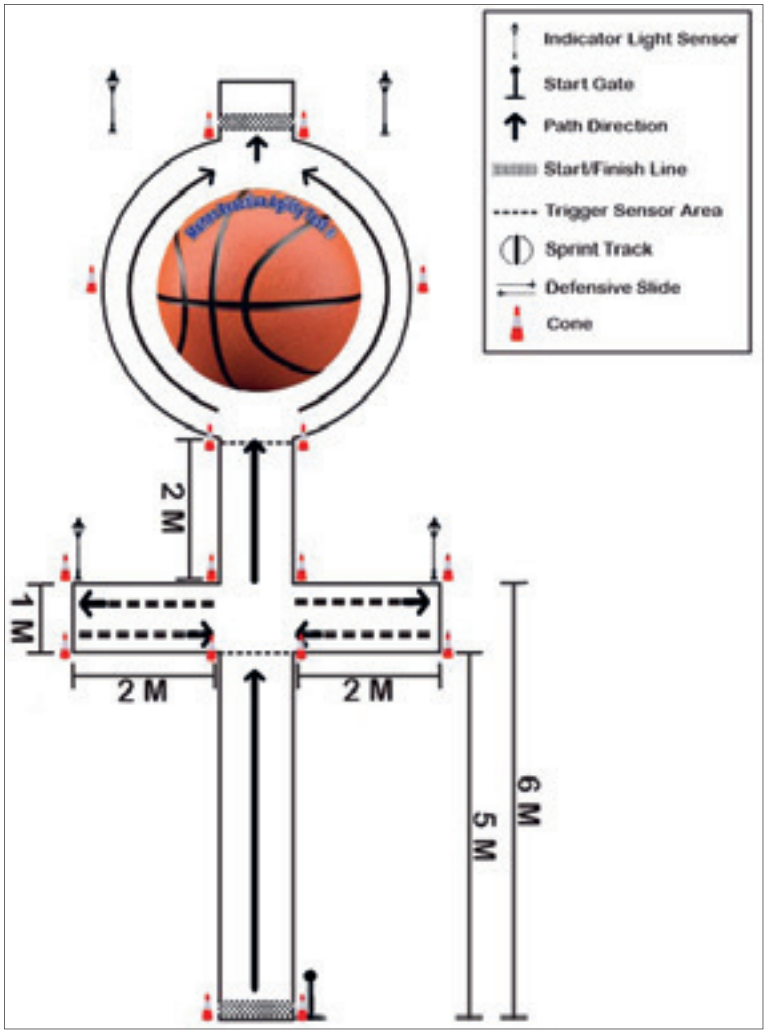


Figure 10. *Arena Design Implementing Reactive Agility Test*

Reactive Agility Test Kit Preparation

Before starting the exercise, make sure the following have been done: (1) Prepare the cone/barrier to give the Exercise area a Limit. (2) All modules (*start, checkpoint, finish*) are in a powered and connected condition. (3) TOF (*Time of Light*) sensors and LEDs are installed on the stand according to the training position. (4) The P10 panel is lit up and clearly visible to the player. (4) The battery is fully charged and attached to each unit. (5) The tool has gone through basic function checking (sensor and LED illuminate correctly when tested).

Procedure for Implementing Reactive Agility Test Arena Design:

Start Position (1) The player stands in front of the TOF (*Time of Light*) *start sensor*. (2) When the sensor detects the presence of a player, the system will be activated. (3) The P10 panel will display the instruction "READY 3, 2, 1, GOO!!", then the training time will start. *Checkpoint:* First (1) Player sprints to the first *checkpoint*. (2) When the TOF (*Time of Light*) sensor detects the player, the LED will illuminate randomly (left/right). (3) The player must immediately move towards the direction of the illuminated LED. (4) After reaching the LED, the player returns to the center.

Second Checkpoint and *Finish* (1) The player continues the sprint to the *second checkpoint*.

(2) The sensor detects the presence of the player, then the LED lights up randomly again (left/right). (3) The player runs towards the illuminated LED. This LED point is the finish line. (4) Once the sensor detects the player at the end LED point, *the timer* will stop. Test Results (1) Panel P10 displays the total test time achieved by the player. (2) Trainer].

RESULTS

Needs analysis through a survey of 10 basketball coaches and 20 athletes to identify agility demands. Prototype design that integrates LED light panels and motion sensors for real-time response tracking. Validation by experts in sports science (content validity index ≥0.80) and reliability testing (Cronbach alpha >0.75). The results of the trial (n=15 basketball players) showed that the modified MRAT had a 90% accuracy in distinguishing between elite and novice athletes, compared to 70% for the original MRAT. The device also improved the reliability of the retest (r=0.88 vs. 0.72) and reduced setup time by 30%.

Table 1. *Validity Test*

Correlations

		VAR00001	VAR00002	VAR00003
VAR00001	Pearson Correlation	1	.696**	.874**
	Sig. (2-tailed)		.000	.000
	N	44	44	44
VAR00002	Pearson Correlation	.696**	1	.907**
	Sig. (2-tailed)	.000		.000
	N	44	44	44
VAR00003	Pearson Correlation	.874**	.907**	1
	Sig. (2-tailed)	.000	.000	
	N	44	44	44

**. Correlation is significant at the 0.01 level (2-tailed).

Since all significance values are 0.000 (less than 0.01), this indicates that all variables (VAR00001, VAR00002, VAR00003) are significantly correlated with each other. This indicates that the instrument or item being measured is valid.

Table 2. *Reliability Test*

Reliability Statistics

Cronbach's Alpha	N of Items
.932	3

Cronbach's Alpha value of 0.932 indicates that this instrument has a very high level of reliability, as its value is well above the generally accepted threshold (e.g. 0.70). This means that the instrument is consistent and reliable in measuring what should be measured.

Table 3. *Frequency Test*

Statistics

		VAR00001	VAR00002	VAR00003
N	Valid	44	44	44
	Missing	0	0	0

These tables provide a detailed overview of the distribution of each observed value for VAR00001, VAR00002, and VAR00003, showing how many times each value appears and the percentage of its contribution to the overall data. This is useful for understanding the distribution of data and identifying the values that appear most frequently or the extreme distribution of data. Effectiveness test can record or recap the results for player performance evaluation.

Figure 11. *Implementation of Reactive Agility Test*

Test Preparation: (1) Prepare the test kit that is placed according to the scheme or drawing, (2) Place the reactive device (Random Light and random trigger light sensor) in the center of the predetermined area.

Implementation: (1) Athlete stands 30 cm One foot behind the starting line area. (2) The athlete looks at the display on Panel P10 which displays the instruction "READY 3, 2, 1, GOO!!", then the test activity starts. (3) The athlete runs as fast as possible (the first sprint) after crossing the line or gate start (the beginning of the test), The first sensor relates to a display that shows the timer or running time. The testee passes the random light trigger light sensor to choose which direction the testee is guarding exactly like the real match (left or right when defending), after making a defensive slide through the precision of choice (must choose the right one even if it moves wrong), returning to the sprint line / Center with the defensive slide movement and then sprinting again. (4) Sprint (second sprint), after sprinting back the testee passes a random trigger light sensor to choose which direction the testee sprints (left or right when attacking (offense) to the finish line and the time of achievement is recorded. (5) The test is performed for 3 repetitions with random signals. Recording of results.

Manos Reactive Agility Test

Table 4. *Statistical analysis of test kelincahan reaktif manos items in control group*

		Mean	N	Std Deviation	t-count	T-table
Pair 1	Pre-test	43.90	44	3.36	10.392	3.036
	Post-test	44.97	44	3.73		

From the results of *pre-test and post-test* analysis of the mean difference test in the control group obtained *t 0 of 10.392 and t*table $_{2.035 \text{ with free degrees (db) } 32}$ and $\alpha = 0.05$. Thus, $t_0 = 10.392 > t_{table} = 3.036$ or H0 is rejected.

Test Paired Sample T-Test Control Group

Table 5. *Statistical analysis of test coordination items in control group*

		Mean	n	Std Deviation	t-count	T-table
Pair 1	Control	44.967	22	3.73	0.88	1.997
	Experiment	47.294	22	3.10		

Table 5 shows the results of the Paired Sample t-test in the control group. The average coordination score increased from 44.967 to 47.294, but statistical testing showed that this increase was not significant, because t-count (0.88) < t-table (1.997). This means that there was no significant change in coordination in the control group, so the small increase that appeared was not caused by any treatment.

Table 6. *Independent sample T-test (control vs. experimental group – coordination test)*

Group	N	Mean	Std. Deviation	Std. error	95% Confidence Interval for Mean		Minimum	maximum
					Lower bound	Upper bound		
Control	22	44.967	3.73	0.795	43.30	46.63	39	51
Experiment	22	47.294	3.10	0.661	45.91	48.68	41	52

Discussion

The modification of the Manos Reactive Agility Test (MRAT) device in this study contributed significantly to the development of a reactive agility measurement tool that is more suited to the demands of basketball. Content validity assessed by experts showed that this instrument meets the specific movement characteristics of basketball, especially in patterns such as lateral shuffles, sudden changes of direction, and quick responses to visual stimuli in the context of the game. This validation process reinforces the principle that agility measurement tools must reflect the technical and situational needs of the sport being measured. Sheppard et al. (2016) also emphasize that adjusting instruments based on sport-specific demands plays an important role in reducing potential measurement bias and increasing the relevance of results for athletes. Therefore, the increased validity and reliability obtained in this study indicate that integrating real game elements into instrument design is a methodologically sound approach.

The modified MRAT device also successfully overcomes various limitations previously encountered in standard MRAT. Through the integration of LED panels as a source of visual stimuli that resemble opponents' movements or passing patterns, athletes are tested in conditions that resemble game situations, so that the responses that arise are more natural and representative. The addition of motion sensors that are able to capture athletes' response data in real time provides an additional advantage, namely the ability to analyze reaction patterns, adaptation speed, and movement consistency in detail. This approach is in line with Itthipanichpong (2023) findings, which show that the use of sport-specific cues in agility measurement tools improves the correlation between test performance and athletes' actual performance on the field. Thus, this device not only improves the quality of measurement but also expands its functionality in the context of performance evaluation.

Furthermore, the relevance of this modification is even stronger when viewed from the unique needs of basketball. This game requires the ability to read opponents' movements, make decisions in a very short time, and make explosive changes of direction according to the dynamics of the game. In this study, the random visual stimulus mechanism from the LED panel was designed to stimulate these situations so that athletes truly react to conditions that resemble real matches. This approach is in line with the development of evaluation devices in other sports, for example, in the study "Reliability and validity of a reactive agility test with soccer goalkeeper-specific movements for adolescents" by (Abe et al., 2023), which shows that the use of LED-based random stimuli can increase the sensitivity of measuring instruments to athletes' reactive abilities. By adapting these findings to the context of basketball, this study confirms that technological innovations in evaluation devices have great potential to optimize the performance measurement process.

Another innovative aspect of the device developed in this study is evident in the use of various supporting technologies, such as random LED-based lighting patterns, high-speed pressure sensors, and real-time motion analysis applications. These three components create a measurement ecosystem that is not only precise but also adaptive and easy to apply in various training conditions. Through these features, the modified MRAT device can be used for various purposes, ranging from periodization training, monitoring athlete development, to identifying specific weaknesses in certain response patterns. (Huang et al., (2023) research on "Wearable Inertial Sensors for Agility Measurement" further reinforces the importance of integrating high-quality motion sensors to improve the accuracy of athlete performance analysis in the context of competitive sports.

The effectiveness of this modified device is further evident from the athletes' responses during testing. When faced with random visual stimuli, the athletes showed more consistent movement adaptation patterns, both in terms of reaction speed and directional stability. The collected data also showed a stable performance distribution, indicating that this device is capable of capturing athletes' movement variations objectively and systematically. This approach based on random visual stimuli is consistent with recommendations from various sports literature, which states that game-based stimuli can increase the sensitivity of measuring instruments in detecting athletes' reaction abilities. Thus, this modified MRAT device can be considered a more representative tool than the standard MRAT in assessing athletes' abilities to deal with unexpected situations.

In practice, this device provides significant benefits for coaches and sports practitioners. The data generated can assist in the process of identifying talent, developing more specific training programs based on individual athletes' weaknesses, and evaluating performance development over time. Research such as (Badruzaman, 2022; Hardiyono, 2023) has shown that accurate and sport-specific measuring tools are essential for designing training programs that meet the developmental needs of athletes. Therefore, this modified MRAT device has the potential

to become a standard evaluation tool for coaches who want to improve the accuracy of monitoring their athletes' reactive agility.

Beyond its primary function as a performance measurement tool, this device also has significant potential for application in injury rehabilitation processes. By monitoring changes in movement patterns before and after recovery programs, coaches and physical therapists can assess athletes' readiness to return to competition. The device's ability to display movement data in real time allows for in-depth analysis of aspects such as stability, movement symmetry, and neuromuscular adaptation. Previous studies have also shown that the use of sensors and visual stimuli in rehabilitation evaluations can provide more accurate information than traditional manual methods.

However, all findings in this study must be understood with consideration of methodological limitations, particularly the relatively small sample size. The limited number of respondents does not allow for broad generalization of the results to the population of basketball athletes at various levels of competition. Therefore, all discussions and interpretations of the results in this study refer specifically to the characteristics and performance of the group of respondents involved. To strengthen these findings, further research with a larger sample size and a wider diversity of athletes is highly recommended, including a more in-depth exploration of the application of the device in various age categories and skill levels.

Conclusion

This study shows that modifications to the MRAT device can improve the relevance, consistency, and suitability of the measuring tool to the characteristics of basketball. The use of match-based visual stimuli and real-time motion sensors makes this device more applicable for measuring athletes' reactive agility. However, due to the limited number of research samples, these findings can only be applied to the group of respondents involved. To ensure the effectiveness of the device on a broader scale, further research is needed, including field trials, technological improvements, and collaboration with sports practitioners. Overall, this device has the potential to be a useful innovation for the training and development of basketball athletes if further developed.

Acknowledgment

Acknowledgments can be I would like to express my sincere gratitude to the promoter and the Jakarta State University campus.

References

Abe, Y., Nakayama, M., & Morita, N. (2023). Reliability And Validity Of A Reactive Agility Test With Soccer Goalkeeper-Specific Movements For Adolescents. *The Journal of Sports Medicine and Physical Fitness*, *64*. https://doi.org/10.23736/S0022-4707.23.15048-1

Azevedo, A. (2021). The Influence Of Reduced And Conditioned Games In Handball Training. *Millenium Journal of Education Technologies and Health*, *2021*(9), 241–247. https://doi.org/10.29352/mill029e.21520

Badinlou, F. (2022). The Persian Version Of The Psychological Flexibility In Sport Scale: A Psychometric Study. *BMC Psychology*, *10*(1). https://doi.org/10.1186/s40359-022-00962-x

Badruzaman. (2022). Assessment Of Convergent Validity And Reliability Of Instruments For Measuring Anxiety Level In Water Using Sport Competition Anxiety Test Modification, Observation Of Behavior, And Test Performance. *Journal of Physical Education and Sport*, *22*(12), 2980–2987. https://doi.org/10.7752/jpes.2022.12376

Burke, S. (2024). The Development and Validation of the Youth Sport Parental Support-Questionnaire (YSPS-Q). *International Journal of Sport and Exercise Psychology*, *22*(8), 2085–2110. https://doi.org/10.1080/1612197X.2023.2255605

Ceberio, I. (2024). Content And Face Validity In Virtual Reality With Children: A Validation In Five Steps+1 Of A Wheelchair Basketball Game. *Frontiers in Virtual Reality*, *5*. https://doi.org/10.3389/frvir.2024.1505630

Crelerot, A. (2024). Validity Of A Quick Tool For Identifying Physical Inactivity And Sedentarity Behavior In General Practice. *Science and Sports*, *39*(4), 331–340. https://doi.org/10.1016/j.scispo.2023.09.003

Hardiyono, B. (2023). Design of Power Sensor Based Test Instrument for Limb Muscle. *International Journal of Human Movement and Sports Sciences*, *11*(2), 432–439. https://doi.org/10.13189/saj.2023.110221

Horička, P., Šimonek, J., & Paška, Ľ. (2020). Relationship Between Reactive Agility, Cognitive Abilities, And Intelligence In Adolescents. *Journal of Physical Education and Sport*, *20*, 2263–2268. 10.7752/jpes.2020.s330

Huang, X., Xue, Y., Ren, S., & Wang, F. (2023). Sensor-Based Wearable Systems for Monitoring Human Motion and Posture: A Review. *Sensors*, *23*(22), 1–29. https://doi.org/10.3390/s23229047

Itthipanichpong, T. (2023). Validity and Reliability of the Thai Versions of the Lysholm Knee Scoring Scale and Tegner Activity Scale. *Orthopaedic Journal of Sports Medicine*, *11*(2). https://doi.org/10.1177/23259671221149785

Kiefer, D. (2025). German Translation And Linguistic Validation Of The Modified Short Questionnaire To Assess Health-Enhancing Physical Activity (Msquash) For Patients With Axial Spondyloarthritis (Axspa). *Zeitschrift Fur Rheumatologie*, *84*(1), 1–9. https://doi.org/10.1007/s00393-024-01508-9

Lohrer, H. (2023). Successful Repair of M. Obliquus Internus Abdominis Avulsion at the Iliac Crest—Operative Technique in Professional Soccer Players. *Orthopaedic Surgery*, *15*(5), 1399–1404. https://doi.org/10.1111/os.13699

Mackala, K., Vodičar, J., Žvan, M., Križaj, J., Stodolka, J., Rauter, S., Šimenko, J., & Čoh, M. (2020). Evaluation of the Pre-Planned And Non-Planed Agility Performance: Comparison Between Individual And Team Sports. *International Journal of Environmental Research and Public Health*, *17*(3), 975. 10.3390/ijerph17030975

Munir, A. (2025). The Effectiveness of Shooting Free Throw Basketball in Junior High School Students: A Comparison of Animals Names and Command Styles. *Annals of Applied Sport Science*, *13*, 155–158.

Nowak, M., Gabryś, T., Stępniak, A., & Szmatlan-Gabrys, U. (2021). Relations Between the Parameters of External Load in Basketball Game Simulating Exercises of Various Technical-Tactical Tasks. *Acta Kinesiologica*, *15*, 92–100.

Scanlan, A., Humphries, B., Tucker, P. S., & Dalbo, V. (2014). The Influence Of Physical And Cognitive Factors On Reactive Agility Performance In Men Basketball Players. *Journal of Sports Sciences*, *32*(4), 367–374.

Sheppard, J. M., Young, W. B., Doyle, T. L. A., Sheppard, T. A., & Newton, R. U. (2006). An Evaluation Of A New Test Of Reactive Agility And Its Relationship To Sprint Speed And Change Of Direction Speed. *Journal of Science and Medicine in Sport*, *9*(4), 342–349. https://doi.org/10.1016/j.jsams.2006.05.019

Tantri, A. (2023). Modification of Interactive Multimedia With The ARA MODEL: Study Of Development Of Football Learning Models In Pandemic Times. *Retos*, *50*, 1289–1298. https://doi.org/10.47197/retos.v50.100587

Primljen: 05. novembar 2025. / Received: Novembar 05, 2025
Izmjene primljene: 20. decembar 2025. / Changes Received: December 20, 2025
Prihvaćen: 05. mart 2026. / Accepted: March 05, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601058S UDC: 796.323:796.012.414
Original scientific paper *Originalni naučni rad*

Association Between Session RPE and Edwards' TRIMP as Indicators of Internal Load in Elite Male Basketball Players

Konstantinos Stratakis, Dino Adrović
Faculty of Medicine, University of Belgrade, Belgrade, Serbia

Correspondence:
Dino Adrovic
Faculty of Medicine, University of Belgrade, Belgrade, Serbia, dino.adrovic@gmail.com

Abstract: *Accurate monitoring of internal training load is essential for optimizing performance and minimizing injury risk in elite athletes. Session rating of perceived exertion training load (sRPE-TL) and Edwards' training impulse (TRIMP) are commonly used methods for quantifying internal training load, yet their relationship in elite basketball remains underexplored. This study examined the association between sRPE-TL and Edwards TRIMP among elite male basketball players during pre-season practice sessions to provide evidence for the convergent validity of sRPE-TL. The sRPE-TL was calculated using session duration and RPE, and Edwards TRIMP was derived from time spent in heart rate zones multiplied by a weighting factor. A strong, statistically significant correlation was found between the variables ($r = 0.86$, 95% CI [0.82, 0.89], $p < .001$). Regression analysis indicated that sRPE-TL accounted for 74.2% of the variance in TRIMP ($R^2 = 0.742$). Both the slope ($p < .001$) and intercept ($p < .001$) of the regression model were statistically significant. Sensitivity analysis using Spearman's rank correlation confirmed the robustness of the association ($\rho = 0.81$, 95% CI [0.75, 0.85], $p < .001$). These findings indicate that sRPE is a convergently valid tool for monitoring internal training load during practices in the pre-season training period in elite basketball, particularly when resource or logistical constraints are present.*
Keywords: *Training Load, sRPE, TRIMP, Basketball, Elite Athletes*

Introduction

The underlying concept of the training process is that an athlete's performance potential can be enhanced by overloading their biological systems, prompting adaptive responses (Suchomel et al., 2016). However, if the body's systems are subjected to chronic stress that exceeds their biological capacity to adapt, the performance potential may decrease, and the risk of injury may increase (Meeusen et al., 2013). This underscores the importance of measuring and managing training loads and their related responses.

Training load can be divided into external and internal components (Impellizzeri et al., 2019). External load refers to the objective work completed, such as the distance covered or the number of repetitions performed (Ide et al., 2023). In contrast, internal load reflects the physiological and psychological responses to that work, acting as a trigger for training-induced adaptations (Ide et al., 2023). Both components are essential for understanding athlete adaptation, but neither can be directly measured; thus, reliable and valid proxy measures are required (Impellizzeri et al., 2019, Ide et al., 2023).

Basketball is a high-intensity, intermittent sport characterized by frequent accelerations, decelerations, jumps, and physical contact (Ben Abdelkrim et al., 2010). In recent years, basketball players have faced increased workloads (Russell et al., 2021). Consequently, it is essential to understand how these athletes internally respond to the external demands they encounter, enabling more informed training decisions.

Two of the most widely used methods for quantifying internal load are the session rating of perceived exertion (sRPE) and exercise heart rate (HRex) (Dudley et al., 2023). sRPE is a subjective measure typically collected post-session, representing the athlete's perceived effort (Foster et al., 2001). Though the impact of exercise duration on sRPE is still unclear, sRPE can be multiplied by exercise volume (duration) to express internal load as a single impulse-type metric (sRPE-TL) (Foster et al., 2001). Summing sRPE-TL over time provides a global measure of how athletes perceived and tolerated cumulative training and competition demands (Foster et al., 2001).

Exercise heart rate (HRex) has become a popular, objective measure for quantifying internal load in both individual and team sports, primarily because it is relatively easy to measure (Dudley et al., 2023). HRex can be used

to estimate training load through two main factors: volume and intensity. One of the most well-known methods for calculating training load using HRex is the TRIMP method, developed by Banister in 1991 (Banister, 1991). While there are various adaptations of TRIMP, none have emerged as the gold standard.

Among the most commonly used methods is the zone-based approach by Edwards, which calculates TRIMP by multiplying the time spent in different heart rate zones by specific weighting factors (Edwards, 1993). The validity of this method has been well established compared to more physiologically sound methods for calculating TRIMP (Manzi et al., 2010).

While heart rate serves as an objective measure of internal load, it has several limitations, the most significant being its tendency to underestimate internal load during short, intense activities (Gardner et al., 2023). Additionally, heart rate monitors can be prohibitively expensive for many players and organizations. Consequently, sRPE is increasingly preferred over heart rate monitoring for quantifying internal load (Falk Neto et al., 2020). However, establishing the validity of any internal load metric is crucial for making informed decisions regarding training load management. Although there is no universally accepted gold standard for measuring internal load, the convergent validity of sRPE-TL is typically evaluated against various TRIMP calculations derived from HRex (Halson, 2014). This is due to the challenges of obtaining other measures of internal exercise load in practical settings.

Research has shown that sRPE-TL is strongly associated with TRIMP in various sports, including soccer, Australian and Canadian football, rugby league, cycling, swimming, rowing, gymnastics, and Taekwondo (Impellizzeri et al., 2005; Haddad et al., 2017). This association has also been observed in basketball (Haddad et al., 2017). However, examining the precise strength of this association is challenging due to differences in methodology concerning data collection and result interpretation, variations in population demographics such as age, gender, and competitive levels, and differences in the timing of the competitive season.

Therefore, the aim of this study was to investigate the association between sRPE-TL and Edwards TRIMP among elite male basketball players during practices in the pre-season training period.

By further evaluating the relationship between these two widely used internal load measures in a high-performance environment, we aim to provide practitioners with evidence regarding the convergent validity of sRPE in elite basketball.

Methods

Participants

This study included ten elite male basketball players from Hapoel Galil Elyon (Israel). The players had a mean age of 25.5 ± 4.2 years, a mean height of 195.8 ± 5.9 cm, and a mean body mass of 91.3 ± 8.2 kg. All participants had at least five years of experience in professional competitive basketball. The inclusion criteria required that the players be injury-free at the beginning of the study and medically cleared for full participation by the team's sports medicine staff. All participants were informed about the study, its processes, and aims, and they provided consent to participate.

Measures

Internal training load was assessed using sRPE-TL and Edwards' TRIMP. Athletes were asked to provide their Rating of Perceived Exertion (RPE) using the Borg CR-10 scale, 10 minutes after each training session. This timing was selected to minimize the impact of acute fatigue bias. The scale was thoroughly explained to the athletes prior to the start of the study, and two training sessions were conducted for familiarization. The session RPE-training load (sRPE-TL) was calculated using the following formula:

$$\text{sRPE-TL} = \text{RPE} \times \text{session duration (minutes)}$$

Heart rate (HR) data were continuously recorded during all sessions using a Polar H10 chest strap monitor. Individual maximal heart rate (HRmax) was determined prior to the training period using the Yo-Yo Intermittent Recovery Test Level 1. Edwards' TRIMP was computed by categorizing heart rate data into five zones based on the percentage of HRmax, with each zone assigned a weighting factor:

50–60% HRmax = 1
60–70% HRmax = 2
70–80% HRmax = 3
80–90% HRmax = 4
90–100% HRmax = 5

The TRIMP score for each session was calculated as:

$$TRIMP = \sum (\text{Time in Zone} \times \text{Zone Weighting Factor})$$

Design and Procedures

Data collection occurred over a four-week pre-season period during August and September of the 2023–2024 season. A total of 24 structured team training sessions were monitored, each taking place at 18:00 local time on the same indoor basketball court. All sessions were planned by the team's head coach and strength and conditioning staff, reflecting typical pre-season training activities. Each session began with a standardized 15-minute warm-up that included light running, dynamic stretching, and ball-handling drills. This warm-up was followed by a combination of small-sided games and technical and tactical drills. Data were analyzed only from athletes who completed each session in its entirety.

Statistical Analysis

The data obtained in the research were analyzed using SPSS (Statistical Package for the Social Sciences). In the evaluation of the data, maximum value, minimum value, arithmetic mean, and standard deviation were used as descriptive statistics. The data were tested for normal distribution using the Shapiro–Wilk test. The relationship between sRPE-TL and TRIMP was assessed using Pearson's correlation coefficient (r) and further examined using univariate linear regression analysis. Spearman's rank correlation coefficient (ρ) was calculated as a sensitivity analysis to assess the robustness of the association. The significance level was set a priori at $p \leq 0.05$.

Results

Participants had a mean age of 25.5 ± 4.2 years, an average body weight of 91.3 ± 8.2 kg, and an average height of 195.8 ± 5.9 cm. The demographic characteristics of the participants are presented in Table 1.

Table 1. *Demographic Characteristics of the Participants*

Variables	n	Mean	SD
Age (years)	10	25.5	4.2
Body Mass (kg)	10	91.3	8.2
Body Height (cm)	10	195.8	5.9

The average session Rate of Perceived Exertion Training Load (sRPE-TL) of the participants was 529.7 ± 189.6 arbitrary units (AU), with a minimum value of 135 AU and a maximum value of 1085 AU. The average Edwards' TRIMP score was 210.1 ± 72.6 AU, ranging from 60 to 446 AU. Descriptive statistics for sRPE-TL and Edwards' TRIMP are demonstrated in Table 2.

Table 2. *sRPE-TL and Edwards' TRIMP values*

Variables	Mean	SD	Minimum	Maximum
sRPE-TL	529.7	189.6	135	1085
TRIMP	210.1	72.6	60	446

Pearson correlation analysis revealed a strong, positive, statistically significant correlation between sRPE-TL and Edwards' TRIMP ($r = 0.86$, 95% CI [0.82, 0.89], $p < .001$). Linear regression demonstrated a significant association between sRPE-TL and TRIMP ($F = 676.1$, $p < .001$), with sRPE-TL accounting for 74.2% of the variance in TRIMP scores ($R^2 = 0.742$). The regression equation formulated was: $TRIMP = 0.33 \times \text{sRPE-TL} + 35.45$, where both the slope ($p < .001$) and intercept ($p < .001$) were statistically significant. Sensitivity analysis using Spearman's rank correlation confirmed the robustness of the association ($\rho = 0.81$, 95% CI [0.75, 0.85], $p < .001$). Figure 1 illustrates the relationship between TRIMP and sRPE-TL.

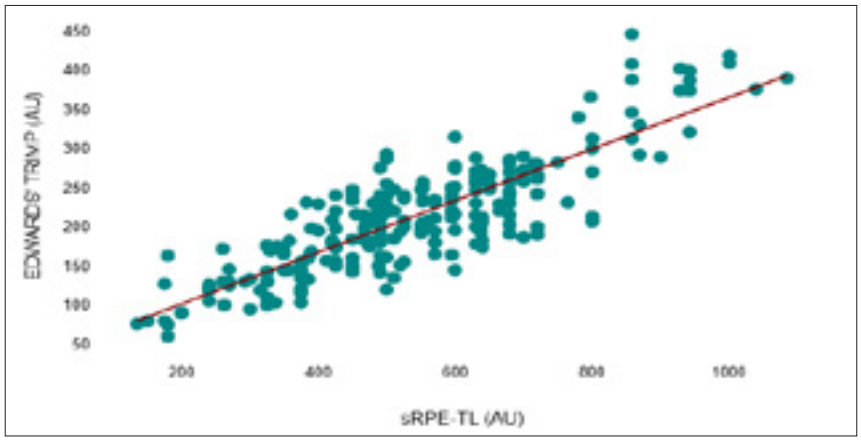


Figure 1. *Relationship Between TRIMP and sRPE-TL*

Figure 1 abbreviations: AU, arbitrary units; sRPE-TL, session rating of perceived exertion training load; TRIMP, training impulse.

Discussion

This study investigated the association between sRPE-TL and Edwards TRIMP among elite male basketball players during pre-season practice sessions. The results revealed a strong positive correlation between sRPE-TL and Edwards' TRIMP ($r = 0.86$), indicating that higher heart rate–derived load corresponded with higher perceived training load. Regression analysis showed that sRPE-TL explained a substantial proportion of the variance in TRIMP ($R^2 = 0.742$), suggesting that both measures reflect related aspects of internal load despite being derived from different inputs. Sensitivity analysis using Spearman's rank correlation showed that the relationship was robust to underlying data statistical assumptions. These findings support the convergent validity of sRPE-TL as an indicator of internal training load in this setting.

Our results are consistent with previous research in various sports, including soccer, rugby, Australian football, and swimming, where strong associations between sRPE-TL and TRIMP have been reported (Haddad et al., 2017). In the context of basketball, Scanlan et al. (2014) found moderate to high correlations ($r = 0.64–0.82$) between sRPE-TL and Edwards' TRIMP in semi-professional basketball players. Similarly, Manzi et al. (2010) reported a strong correlation ($r = 0.80$) in professional male basketball setting. Although our results align with those of other studies conducted in basketball, the strength of the association identified in this study is at the upper end of the range previously reported for the sport. One possible explanation is that our research focused exclusively on team basketball practices during the pre-season, unlike other studies that examined various stages of the season or included different training modalities. Additionally, our sample consisted solely of elite male basketball players, making it a homogeneous population group.

While TRIMP offers an objective and widely accepted measure of internal load, it has limitations in intermittent, high-intensity sports like basketball (Scanlan et al., 2018). Heart rate responses can lag behind short-duration efforts such as sprints, jumps, and rapid directional changes, potentially leading to an underestimation of internal load (Scanlan et al., 2018). To address these limitations of TRIMP, the strong association between sRPE-TL and TRIMP found in this study supports the continued use of sRPE-TL in elite basketball settings, especially when logistical or financial constraints limit the feasibility of continuous heart rate monitoring.

While this study benefits from the inclusion of elite athletes, standardized monitoring tools, and a clearly defined training phase, several limitations should be noted. The research focused exclusively on elite male players and assessed only in pre-season practices. This limits the generalizability of the findings to other populations, competitive matches, and different training phases. The study also relied solely on Edwards' TRIMP model, which, although practical, restricts comparison with other TRIMP variations. Future research should compare multiple TRIMP models and investigate whether the relationship between sRPE-TL and TRIMP differs across training contexts, competition levels, or sex-specific groups.

Conclusion

This study found a strong and significant relationship between sRPE-TL and Edwards' TRIMP in elite male basketball players during practices in the pre-season training period. These results support the use of sRPE-TL as

a convergently valid tool for monitoring internal training load during practices in the pre-season training period in elite basketball, particularly when resource or logistical constraints are present. Our findings are constrained by the use of a single TRIMP model, a homogeneous sample, exclusive focus on practice sessions, and a specific training phase. Future research should examine various TRIMP models and diverse populations, and include competition and additional seasonal phases, to assess the generalizability of these results.

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request

Author Contributions

Conceptualization, methodology, software, validation, formal analysis, data curation, visualization, supervision, and project administration were performed by K.S. Investigation and resources were provided by K.S. and D.A. Writing—original draft preparation was performed by K.S., and writing—review and editing was carried out by K.S. and D.A. All authors have read and agreed to the published version of the manuscript.

Funding Information

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflicts of interest: *The authors declare no conflicts of interest.*

Acknowledgments: *The authors thank the participants who made the study possible.*

Generative AI Statement: *The authors used Grammarly solely for language editing*

References

Banister, E. W. (1991). Modeling elite athletic performance. In J. D. MacDougall, H. A. Wenger, & H. J. Green (Eds.), Physiological testing of elite athletes (2nd ed., pp. 403–424). *Human Kinetics.*

Ben Abdelkrim, N., Castagna, C., Jabri, I., Battikh, T., El Fazaa, S., & El Ati, J. (2010). Activity profile and physiological requirements of junior elite basketball players in relation to aerobic-anaerobic fitness. *Journal of Strength and Conditioning Research*, 24(9), 2330–2342.

Dudley, C., Johnston, R., Jones, B., Till, K., Westbrook, H., & Weakley, J. (2023). Methods of monitoring internal and external loads and their relationships with physical qualities, injury, or illness in adolescent athletes: A systematic review and best-evidence synthesis. *Sports Medicine*, 53(8), 1559–1593.

Edwards, S. (1993). High performance training and racing. In The heart rate monitor book (pp. 113–123). *Fleet Feet Press*.

Falk Neto, J. H., Tibana, R. A., de Sousa, N. M. F., Prestes, J., Voltarelli, F. A., & Kennedy, M. D. (2020). Session rating of perceived exertion is a superior method to monitor internal training loads of functional fitness training sessions performed at different intensities when compared to training impulse. *Frontiers in Physiology*, 11, 919.

Foster, C., Florhaug, J. A., Franklin, J., Gottschall, L., Hrovatin, L. A., Parker, S., Doleshal, P., & Dodge, C. (2001). A new approach to monitoring exercise training. *Journal of Strength and Conditioning Research*, 15(1), 109–115.

Gardner, C., Navalta, J. W., Carrier, B., Aguilar, C., & Perdomo Rodriguez, J. (2023). Training impulse and its impact on load management in collegiate and professional soccer players. *Technologies*, 11(3), 79.

Haddad, M., Stylianides, G., Djaoui, L., Dellal, A., & Chamari, K. (2017). Session-RPE method for training load monitoring: Validity, ecological usefulness, and influencing factors. *Frontiers in Neuroscience*, 11, 612.

Halson, S. L. (2014). Monitoring training load to understand fatigue in athletes. *Sports Medicine*, 44(Suppl 2), S139–S147.

Ide, B., Silvatti, A., Staunton, C., Marocolo, M., Oranchuk, D., & Mota, G. (2023). External and internal loads in sports science: Time to rethink? *International Journal of Strength and Conditioning*, 3(1).

Impellizzeri, F. M., Marcora, S. M., & Coutts, A. J. (2019). Internal and external training load: 15 years on. *International Journal of Sports Physiology and Performance*, 14(2), 270–273.

Impellizzeri, F. M., Rampinini, E., & Marcora, S. M. (2005). Physiological assessment of aerobic training in soccer. *Journal of Sports Sciences*, 23(6), 583–592.

Manzi, V., D'Ottavio, S., Impellizzeri, F. M., Chaouachi, A., Chamari, K., & Castagna, C. (2010). Profile of weekly training load in elite male professional basketball players. *Journal of Strength and Conditioning Research*, 24(5), 1399–1406.

Meeusen, R., Duclos, M., Foster, C., Fry, A., Gleeson, M., Nieman, D., Raglin, J., Rietjens, G., Steinacker, J., Urhausen, A., European College of Sport Science, & American College of Sports Medicine. (2013). Prevention, diagnosis, and treatment of the overtraining syndrome: *Joint consensus statement of the European College of Sport Science and the American College of Sports Medicine. Medicine and Science in Sports and Exercise*, 45(1), 186–205.

Russell, J. L., McLean, B. D., Stolp, S., Strack, D., & Coutts, A. J. (2021). Quantifying training and game demands of a National Basketball Association season. *Frontiers in Psychology*, 12, 793216.

Scanlan, A. T., Dascombe, B. J., Reaburn, P., & Dalbo, V. J. (2018). Influence of different methods to determine heart rate-based training load on dose–response relationships with fitness in semiprofessional basketball players. *Journal of Strength and Conditioning Research*, 32(11), 3123–3131.

Scanlan, A. T., Wen, N., Tucker, P. S., & Dalbo, V. J. (2014). The relationships between internal and external training load models during basketball training. *Journal of Strength and Conditioning Research*, 28(9), 2397–2405.

Suchomel, T. J., Nimphius, S., & Stone, M. H. (2016). The importance of muscular strength in athletic performance. *Sports Medicine*, 46(10), 1419–1449.

Primljen: 07. novembar 2025. / Received: November 07, 2025

Prihvaćen: 02. mart 2026 / Accepted: March, 02, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601063T
UDC: 378.017:37.014.12
Original scientific paper
Originalni naučni rad

Multiculturalism and Physical Activity: Evidence From a Higher Education-Based Intervention

Maria Giovanna Tafuri[1], Francesca Latino[1], Generoso Romano[2]
[1]*Pegaso University, Naples, Italy*
[2]*University of Naples "Parthenope", Naples, Italy*

Correspondence:
Francesca Latino
Pegaso University, Naples, Italy, francesca.latino@unipegaso.it

Abstract: *In an academic context increasingly characterized by cultural pluralism and technological innovation, the need emerges to develop educational practices capable of integrating the bodily dimension into learning processes. The present study explores the effectiveness of a physical activity intervention designed according to the principles of critical pedagogy, embodied education and intercultural education, with the aim of promoting body awareness and intercultural sensitivity in a university context crossed by increasing cultural heterogeneity and digital transformation. The intervention, lasting twelve weeks with biweekly meetings of two hours each, involved 260 students divided into an experimental group and a control group, subjected to pre- and post-intervention evaluation using the Intercultural Sensitivity Scale (ISS) and the Body Awareness Questionnaire (BAQ). The results of the statistical analysis showed a significant increase in scores related to both intercultural sensitivity and body awareness in the experimental group compared to the control group, indicating the effectiveness of the body approach in university education. The integration of digital tools has further enriched the path, offering support for the documentation, reflection and monitoring of learning processes. The pedagogical implications of the study indicate the need to rethink university teaching by systematically including body practices and multimodal approaches, capable of combining corporeality, cultural diversity and digital environments. Future research perspectives will have to deepen the adaptability of these models in different training contexts and analyze more extensively the role of the body as a mediator of transformative processes in higher education.*

Keywords: *Social inclusion, body awareness, intercultural education, experiential learning, educational technologies*

Introduction

In the contemporary context of higher education, the growing global interconnection has led to a radical transformation of educational paradigms, requiring a profound reflection on the concepts of multiculturalism, inclusion and pedagogical innovation (Rege Colet, 2017). Universities, places traditionally dedicated to the transmission of knowledge and the training of future ruling classes, are today called upon to respond urgently and responsibly to the challenges posed by cultural diversity, the heterogeneity of students' educational and social backgrounds and the needs of a society in continuous digital evolution. The co-presence of students from different cultural contexts is not only a demographic fact, but constitutes a fundamental element of today's educational reality, which requires a rethinking of teaching practices, relational strategies and training models (Khedkar, & Nair, 2016). In this scenario, digital transformation, catalyzed by the advent of intelligent technologies and the emergence of Education 4.0 paradigms, redefines the methods of teaching and learning, opening up new forms of educational interaction but also raising questions about the equity, accessibility and quality of the university training experience. Multiculturalism, far from being a merely quantitative phenomenon, is configured as a qualitative dimension of the educational experience, in which the identities, narratives and corporeality of the students are intertwined in a symbolic and relational space that needs to be inhabited in a conscious and transformative way (Bakar, 2021).

In this complex horizon, the educational challenges related to cultural diversity in university contexts are articulated around a multiplicity of levels, ranging from linguistic and curricular inclusion to the acceptance of religious differences and values, up to the management of truly intercultural pedagogical practices. The mere coexistence of different cultures within university classrooms does not in itself guarantee real inclusion, which instead requires intentional, systematic and reflective action capable of enhancing plurality as a resource and not as an obstacle. The rhetoric of inclusion, often evoked in institutional documents, risks being emptied of meaning if it is not supported by innovative educational practices and a redefinition of dominant epistemologies. To this end, it is essential to question

the role of corporeality and motor activity as foundational dimensions of the educational process, especially in the university context, traditionally centered on the logical-rational and cognitive dimension of learning (Chaika, 2024).

Physical activity, in its broadest sense of body expression, sensorimotor interaction and construction of the self through movement (Raiola et al., 2025), represents a privileged terrain for the development of pedagogical practices oriented towards inclusion and the promotion of intercultural citizenship. The rediscovery of the body as a space for educational mediation and as a vehicle for identity expression makes it possible to overcome the linguistic and cultural barriers that often hinder communication and mutual understanding in multicultural educational contexts. In this perspective, physical activity is not only configured as a compensatory or recreational tool (Aidar et al., 2021; Farì et al., 2023), but as a real epistemological practice, capable of generating meanings, favoring the construction of meaningful relationships and stimulating transformative learning processes. It makes it possible to activate paths of embodied knowledge that enhance sensitive experience, empathy and reflexivity, promoting an education that is based on the authentic encounter with the other in his or her integrity (Calderón, & MacPhail, 2023).

In the theoretical framework of reference, the concept of multiculturalism is configured as a descriptive and analytical category at the same time, useful for grasping the complexity of cultural interactions within educational contexts. It refers to the co-presence, in the same social and educational space, of individuals with different cultural identities, who express themselves through heterogeneous symbolic codes, languages, values, practices and worldviews (Karacsony et al., 2022). However, in order for multiculturalism not to be translated into a simple summation of differences, it is necessary to place it within a pedagogical perspective oriented towards inclusion, understood as a dynamic process of recognition, enhancement and transformation of differences into educational resources. The paradigm of intercultural education fits in this direction, which promotes a dialogical, critical and reflective approach to relations between cultures, based on the deconstruction of stereotypes, mutual listening and openness to plurality.

Within this framework, educational corporeality assumes a central role, as a constitutive dimension of identity and a privileged channel of communication and relationship. Corporeality is not only a passive background of the educational experience, but an active subject of knowledge, capable of generating forms of situated and contextual learning. It allows us to recognize the other not only as the bearer of a culture, but as an embodied subject, endowed with sensitivity, emotions and experiences that are expressed through the body (Arora, & Wolbring, 2022). Physical activity, in this perspective, becomes a pedagogical tool capable of promoting knowledge of oneself and of others through movement, play, cooperation and sensory experimentation (Farì et al., 2021). It makes it possible to activate learning paths in which the cognitive dimension is intertwined with the emotional, relational and sensorimotor dimensions, giving rise to authentic and transformative educational experiences (Greco et al., 2019; Di Palma et al., 2025).

The theoretical frameworks that support this approach are many and are articulated around some fundamental guidelines. Critical pedagogy, inspired by the thought of authors such as Paulo Freire (2021) and Henry Giroux (1984), offers an interpretative key to understanding the emancipatory potential of education and the need to promote teaching practices capable of counteracting inequalities and the dynamics of exclusion. In this perspective, intercultural education is configured as a political practice, oriented towards social justice and the construction of democratic educational spaces. The embodied approaches to learning, developed in the psychopedagogical and neuroscientific fields, emphasize the importance of the body and embodied experience in cognitive processes, suggesting that learning is not a purely mental activity, but an integrated process that involves the entire organism (Jusslin et al., 2022). Finally, socio-technical approaches to education offer conceptual tools to understand the interaction between digital technologies, educational practices and cultural contexts, highlighting how digitization can both expand training opportunities and reproduce exclusionary logics, if not guided by principles of equity and inclusiveness.

Digital transformation, which is increasingly affecting higher education, opens up unprecedented scenarios for university teaching, redefining the boundaries of the classroom, the ways of interaction between teachers and students, and the very forms of knowledge (Plekhanov et al., 2023). The paradigms of Education 4.0, based on the integration of artificial intelligence, augmented reality, personalized learning and virtual environments, require a critical reflection on the pedagogical implications of these innovations. While digital technologies offer powerful tools to promote access, flexibility and personalisation of learning, it is also necessary to ensure that they do not become vehicles for new forms of exclusion or cultural homologation. In this context, physical activity and educational corporeality can constitute an essential counterweight, capable of restoring centrality to the embodied and relational experience, and of integrating the digital in a conscious and critical way (Cataldi et al., 2019). The articulation between technologi-

cal innovation and body practice represents, in this sense, one of the most interesting and promising challenges for university education of the future, called to combine educational excellence, cultural inclusion and humanization of educational processes (Pellegrino et al., 2019).

In the light of the theoretical and pedagogical premises outlined at the beginning, the aim of this study is to explore to what extent and in what ways physical activity can be configured as an effective tool for inclusion and intercultural dialogue in the context of higher education, with particular attention to the intersection between corporeality, digital transformation and innovative pedagogical practices. In line with the objective of the study, some research questions were articulated that guided the development of the investigation. The research questions that guided the work focused, on the one hand, on investigating whether and to what extent participation in the motor program favored an increase in the intercultural sensitivity of students, i.e. in their ability to recognize and value cultural differences in relational and academic contexts. On the other hand, we questioned the effectiveness of activated body practices in promoting greater body awareness, understood as attention, perception and understanding of the signals coming from one's body.

The survey therefore aimed to explore the impact of educational intervention on these two specific variables, considered fundamental to support processes of inclusion, well-being and meaningful learning within heterogeneous university contexts.

Methods

Study design

The study presented here is configured as a quasi-experimental research with pre- and post-intervention measurements, aimed at evaluating the impact of a physical activity program conducted in a university setting on intercultural sensitivity and body awareness of the participating students. The methodological design has been designed to ensure scientific rigor, replicability and pedagogical relevance, through the use of validated tools and the statistical analysis of the data collected.

The intervention was conducted within the Degree Course in Sports Science, belonging to the Department of Medical, Motor, and Wellness Sciences at the University of Naples "Parthenope" and involved a sample of students enrolled in the first and second year of the same degree course, characterized by a multicultural and multilingual composition. The choice of the university context is based on the desire to explore, through quantitative indicators, the potential of physical activity as a tool for promoting inclusion and educational transformation, also in relation to the emerging paradigms of higher education in an intercultural and digital key.

The intervention was divided into a cycle of 24 meetings, twice a week, lasting two hours each, for a total of 12 weeks during which free-body motor activities, cooperative dynamics, symbolic games and movement sequences aimed at developing body awareness, interpersonal trust and non-verbal communication were proposed. The activities have been designed taking into account the principles of intercultural education and pedagogical models centered on corporeality as a vector of relational and inclusive learning.

The study was conducted in full compliance with the ethical principles outlined by the Declaration of Helsinki for research with humans and was approved by the Department of Medical, Motor, and Wellness Sciences at the University of Naples "Parthenope" (DiSMMeB Prot. N. 88592/2024). All data collection procedures have been designed to ensure the anonymity and confidentiality of the participants, without the possibility of tracing the individual identity at any stage of the analysis. Before the start of the trial, each student involved received detailed information about the objectives of the study, how to participate, the use of data and the right to withdraw at any time without consequences. Only those who gave their informed consent in writing were included in the research. The documentation collected has been stored in a secure form and processed according to the provisions of the General Data Protection Regulation (GDPR 2016/679).

Participants

The present research involved a total of 260 university students, divided into two equivalent groups: an experimental group consisting of 130 participants, who actively took part in the motor intervention, and a control group consisting of another 130 students, who continued to follow the ordinary curricular path, without participating in any structured physical activity within the project. Both groups were selected from among those enrolled in the first and

second year of the Degree Course in Sports Science, belonging to the Department of Medical, Motor, and Wellness Sciences at the University of Naples "Parthenope". The sample has a balanced distribution in terms of gender (132 females and 128 males) and is characterized by a high cultural heterogeneity, including students with different linguistic and national backgrounds, reflecting the multicultural composition typical of the contemporary university context.

The inclusion criteria for access to the study included: age between 19 and 27 years, regular enrolment in a degree course at the University, the absence of clinical or motor conditions that contraindicated participation in moderate physical activity and, for the experimental group, the willingness to participate in the entire cycle of meetings envisaged by the intervention. Subjects with musculoskeletal or neurological pathologies incompatible with the proposed physical activity were excluded, as well as those who did not provide informed consent or who withdrew during the course of the study.

In order to ensure the dimensional adequacy of the sample in relation to the statistical power of the analysis, an a priori analysis of the power was conducted using the G*Power 3.1 software. Considering a t-test for independent samples, an alpha significance level set at 0.05, a power (1-β) of 80 percent, and an expected effect of average size (Cohen's d = 0.5), a minimum necessary number of 27 participants for each group was calculated. The total number of 260 subjects, divided equally between the experimental group and the control group, is therefore more than adequate to meet the statistical power requirements and to guarantee the reliability of the inferential analyses conducted in the framework of the research.

Table 1. *Descriptive characteristics of the sample (N = 260)*

Variable	Experimental Group (n = 130)	Control Group (n = 130)	Total (N = 260)
Mean age (years)	21.3 (SD = 1.9)	21.5 (SD = 2.0)	21.4 (SD = 1.9)
Age range (years)			
19–21	72 (55.4%)	68 (52.3%)	140 (53.8%)
22–24	46 (35.4%)	49 (37.7%)	95 (36.5%)
25–27	12 (9.2%)	13 (10.0%)	25 (9.7%)
Gender			
Male	64 (49.2%)	64 (49.2%)	128 (49.2%)
Female	66 (50.8%)	66 (50.8%)	132 (50.8%)
Cultural background			
Italian students	94 (72.3%)	95 (73.1%)	189 (72.7%)
International students	36 (27.7%)	35 (26.9%)	71 (27.3%)
Degree program			
Sport Sciences	77 (59.2%)	78 (60.0%)	155 (59.6%)
Education Sciences	53 (40.8%)	52 (40.0%)	105 (40.4%)

Procedures

The set of phases that characterized the performance of the physical activity intervention made it possible to ensure methodological consistency and rigorous control of the variables relevant to the research. The entire process began with the recruitment and selection phase of participants, carried out through internal communications to the Department of Medical, Motor, and Wellness Sciences at the University of Naples "Parthenope", aimed at students enrolled in three-year degree courses. The objectives and methods of the intervention were explained to potential participants, ensuring transparency and voluntariness in adherence to the study.

Subsequently, a preliminary assessment was conducted to ascertain fitness for physical activity, following the inclusion and exclusion criteria defined above, and informed consents were collected, in accordance with the principles of the Declaration of Helsinki and with the approval of the Department's Ethics Committee. The confidentiality and anonymity of the responses was guaranteed during all phases of data collection. Participants were then randomly assigned to either the experimental group, which was involved in the motor intervention, or the control group, which continued with normal academic activities without receiving the intervention.

The next phase involved the administration of quantitative pre-intervention tests, aimed at measuring parameters of body self-awareness, intercultural skills and psychophysical well-being, which represented the main variables

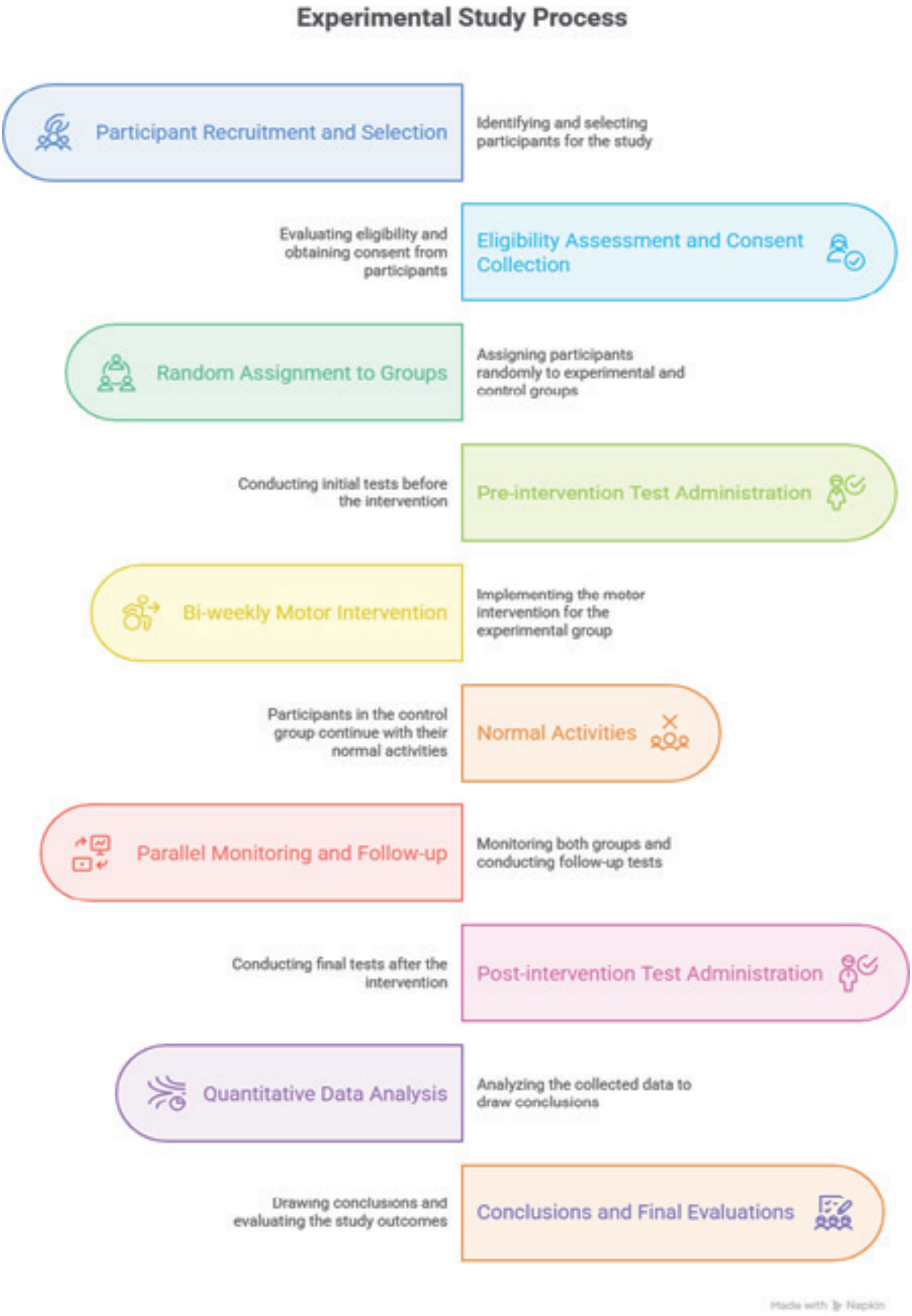


Figure 1. *Flowchart of the Study*

of the study. Starting from the second week, the biweekly structured physical activity intervention began, developed according to the calendar and progression described in the section dedicated to the experimental intervention. At the same time, the control group was monitored through the administration of follow-up questionnaires at times corresponding to those of the experimental group.

At the end of the twelve weeks, post-intervention tests, similar to the initial ones, were administered to assess the impact of the motor intervention on the variables of interest. The data collection was completed by ensuring respect for anonymity and correctness in the management of information. Subsequently, statistical analyses were conducted to compare the pre- and post-intervention data in the two groups, in order to verify the effectiveness of the motor program in terms of inclusion, body awareness and intercultural development.

This procedural flow ensured methodological rigor and transparency of the research, while facilitating an ethical and respectful working environment for the people involved, essential elements in a scientific investigation conducted in the educational and social fields.

Experimental Intervention

The experimental intervention was divided into a twelve-week cycle, with biweekly meetings lasting two hours each, for a total of twenty-four sessions designed to encourage a gradual and integrated development of motor, relational and intercultural skills. This temporal and structural choice has made it possible to consolidate over time a motor practice that goes beyond the physical aspect, promoting deep body awareness, active cooperation and cultural inclusion in a university context increasingly characterized by diversity and digital transformation. In this perspective, digital tools to support motor activities have been integrated, such as the use of applications for the reproduction of interactive musical sequences, projected videos for the guided imitation of multicultural motor patterns, and immersive projection technologies to create multisensory environments aimed at stimulating body imagination, expressiveness and relational interaction. These digital devices have not taken on an evaluative or documentary role, but have operated as bodily mediators and catalysts of experience.

The approach adopted in the experimental intervention is based on an integrated logic that combines the principles of critical pedagogy, embodied education and intercultural theories, in order to promote an inclusive, transformative and corporeality-centered motor experience as a privileged means of learning and relationship (Siljamäki, & Anttila, 2021).

The underlying logic is based on the idea that body movement is not just a physical activity, but an expressive and relational language through which students can explore and negotiate cultural identities, emotions and shared meanings. Therefore, the proposed exercises have been selected and modulated to stimulate not only the motor dimension, but also the cognitive-affective aspect, enhancing interaction, cooperation and creativity as founding elements of intercultural inclusion. In addition, the alternation of individual, couple and group activities has made it possible to experiment with multiple forms of relationship and non-verbal communication, essential tools in multicultural educational contexts (Aartun et al., 2022).

In the first meetings of the first week, the focus was on welcoming and creating a climate of mutual trust, through global warming exercises such as conscious walks, joint mobilizations and group motor games aimed at promoting knowledge and interaction among participants. In the second week, the activities were oriented towards free-body movement sequences and dynamic stretching exercises, aimed at improving the perception of the body schema and eye-hand coordination, essential elements for developing self-awareness and sensory listening skills.

The third and fourth weeks introduced static and dynamic balance exercises, using proprioceptive tools such as unstable pillows, and movement activities in pairs such as the “mirror game”, which stimulate trust and non-verbal communication, promoting intercultural exchange through the body. In the following weeks, fifth and sixth, the focus shifted to more complex group activities, including motor improvisations and collective choreographic compositions, to foster creativity, negotiation and collaboration between students from different cultural backgrounds.

During the seventh and eighth weeks, the exercises increased the level of difficulty with obstacle motor courses and manipulation of moving objects, aimed at improving complex coordination, the management of shared space and respect for individual and collective rhythms, which are fundamental for building inclusive relationships. Weeks nine and ten were dedicated to creative movement and spontaneous dance, opportunities for the free expression of body and cultural identity, supporting inclusion through the recognition and enhancement of differences.

In the four final meetings, the eleventh and twelfth weeks, an experiential workshop and a group motor performance were carried out, accompanied by moments of shared reflection, with the aim of integrating the skills acquired and consolidating the intercultural awareness developed through the body experience. This path configured a transformative educational environment, in which body movement represented a privileged means to promote inclusion, communication and cultural awareness, aligning with contemporary pedagogical challenges and the dynamics of digital innovation present in university contexts.

Table 2. *Weekly and detailed description of motor activities in biweekly meetings*

Week	First Session	Second Session
1	Global warm-up: mindful walking, joint mobilizations	Group motor games for acquaintance and interaction
2	Bodyweight movement sequences and dynamic stretching	Eye-hand coordination exercises
3	Static balance on stable and unstable surfaces	Dynamic balance and use of proprioceptive cushions
4	Pair activities: “mirror game” and nonverbal communication	Light contact and resistance games
5	Motor improvisation in small groups	Creation of collective choreographies
6	Obstacle motor courses	Manipulation of moving objects
7	Complex coordination and spatial awareness	Respect for individual and group timing and rhythms
8	Creative movement: guided spontaneous dance	Free expression of emotions and identity
9	Experiential lab on motor cooperation	Symbolic baton-passing and reflective moments
10	Integrative motor activities and symbolic games	Guided reflection on intercultural competencies
11	Collective motor performance	Final discussion and consolidation of competencies
12	Experiential synthesis and participatory evaluation	Closing session and individual/group feedback

Measures

In the present study, the evaluation of the effectiveness of motor intervention in the university setting was carried out through the use of two standardized quantitative tools, chosen on the basis of their psychometric validity, adherence to research objectives and their dissemination in multicultural educational contexts. These tools made it possible to detect, at distinct times (pre- and post-intervention), changes in the dimensions of intercultural sensitivity and subjective body awareness, considered as key indicators of the process of inclusion and personal transformation favored by motor activity.

The first tool used is the **Intercultural Sensitivity Scale (ISS)** developed by Chen and Starosta (2000), a questionnaire consisting of 24 items evaluated on a five-point Likert scale, which measures the degree of intercultural sensitivity of individuals. The ISS is divided into five fundamental sub-dimensions: *respectful interaction with cultural diversity*, *intercultural empathy*, *trust in interethnic interaction*, *joy in interaction with otherness* and *attentiveness to differences*. This tool proved to be particularly suitable for the university context characterized by increasing cultural heterogeneity, allowing to investigate the disposition of students to establish meaningful relationships with people belonging to different cultures, as well as their capacity for cognitive and affective decentralization. The scale was administered at two distinct times, respectively at the beginning and at the end of the twelve weeks of motor intervention, with the aim of detecting any statistically significant changes in the intercultural profile of the participants in the experimental group, compared to the control group.

The second tool adopted is the **Body Awareness Questionnaire (BAQ),** developed by Shields, & McGhee, 2024, consisting of 18 items that assess subjective body awareness, i.e. the individual’s ability to correctly perceive and interpret somatic signals and internal bodily sensations. The BAQ focuses on aspects such as attention to physiological changes, awareness of muscle tone, the ability to recognize stress signals and sensitivity to body rhythms. In an educational path based on conscious movement, this tool is particularly effective for measuring the impact of motor activity on the embodiment dimension, in terms of emotional self-regulation, physical well-being and mind-body connection. The BAQ was also administered in the initial and final phase of the intervention, to assess whether the proposed progressive and relational motor practice actually contributed to increasing a deeper body awareness in the participants.

Both tools, already validated internationally, have been linguistically and culturally adapted for the Italian student population, through a process of translation-reverse translation and expert revision. The responses were col-

lected anonymously and managed in full compliance with the rules on privacy and research ethics. The data obtained through these questionnaires form the basis for subsequent statistical analyses, aimed at evaluating the effectiveness and significance of motor intervention in promoting inclusive and transformative processes in multicultural university contexts.

Statistical analysis

For the purpose of evaluating the effectiveness of the experimental intervention, a quantitative statistical analysis was conducted aimed at detecting any significant changes in the scores obtained by the participants to the two assessment tools administered in the pre- and post-intervention phases.

In order to verify the psychometric adequacy of the tools used, a Confirmatory Factor Analysis (CFA) was conducted on both scales used, the Intercultural Sensitivity Scale (ISS) and the Body Awareness Questionnaire (BAQ). The aim was to evaluate the construct validity of the questionnaires in the specific context of the present research, characterized by a heterogeneous university sample in cultural and disciplinary terms. CFA was performed using the maximum likelihood method, and the proposed models were evaluated through different fit indices (χ^2/df, CFI, TLI, RMSEA, SRMR). These preliminary analyses made it possible to proceed with greater methodological rigor to the subsequent phases of pre-post comparison and correlations analysis.

For the statistical analysis of the data collected, a comparative approach was adopted within and between groups. First, the distribution of data was verified using the Shapiro-Wilk test, to ascertain the normality of the variables and select the most appropriate parametric or nonparametric tests. Considering that the variables under examination showed a distribution close to normal, it was possible to apply parametric tests.

For each group (experimental and control) mean scores and standard deviations were calculated at the two points of detection (pre and post). A paired-sample t-test was then used to compare pre- and post-intervention scores within the experimental group, in order to evaluate the effectiveness of motor intervention on the development of cross-cultural sensitivity and body awareness. The same test was also applied to the control group to check for any spontaneous changes not attributable to the intervention. Subsequently, an analysis of covariance (ANCOVA) was conducted, in order to assess the difference between the experimental group and the control group on the two scales considered, controlling for any covariate variables that could influence the scores. The use of ANCOVA was chosen to be able to isolate the effect of the intervention by reducing the influence of possible confounding variables, thus improving the accuracy of estimates of differences between groups and increasing the internal validity of the study. In addition, a graph of the estimated coefficients deriving from the ANCOVA analysis was made, showing the adjusted mean difference between the experimental group and the control group for the two scales considered. This visual representation was carried out to facilitate the interpretation of the results, immediately and clearly highlighting the extent and direction of the differences, allowing a more effective communication of the effects of the experimental intervention compared to the control.

To compare the magnitude of change between the experimental group and the control group, an independent-sample t-test was used on the deltas of the scores (difference between post and pre) related to each of the two scales. This comparison made it possible to verify whether the variations observed in the experimental group were significantly greater than those in the control group, thus attributing the effect to the experimental intervention with greater reliability.

Finally, to investigate the relationship between the two central variables of the study, i.e. intercultural sensitivity and body awareness, Pearson's correlation was calculated, considering the post-intervention scores of the experimental group. The analysis showed a positive and statistically significant correlation between the two dimensions, suggesting that an increase in body awareness is associated with a parallelism in the increase in intercultural sensitivity. This result appears particularly relevant as it empirically confirms the theoretical hypothesis according to which corporeality, understood as a space for experience, reflection and relationship, can constitute a vector of transformation and inclusion in multicultural educational contexts.

All statistical tests were conducted with a significance level set at $p < 0.05$, which is considered standard for social and educational sciences. In addition, to quantify the magnitude of the effects found, the effect size (Cohen's d) and η^2 (square age) indices were calculated, in order to support the practical interpretation of the results as well as their statistical significance.

The entire analysis process was carried out using IBM SPSS Statistics version 25.0 software (IBM Corp., Armonk, NY, USA), which allowed rigorous and transparent data management, as well as the processing of results in accordance with quantitative research methodological standards.

Results

Confirmatory Factor Analysis and Construct Validity of the Measurement Scales

In the methodological framework of the study, a *Confirmatory Factor Analysis* (CFA) was carried out in order to verify the constructive validity of the two scales used to measure the outcomes of the intervention: the *Intercultural Sensitivity Scale* (ISS), aimed at measuring the intercultural sensitivity of students, and the *Body Awareness Questionnaire* (BAQ), used to detect the level of body awareness. Both scales, in line with the reference literature, are structured on a multidimensional model and are based on a solid theoretical framework. However, the adoption of these scales in a multicultural and digitized university experimental context requires an empirical verification of their adequacy and structural consistency with the data collected.

Confirmatory factor analysis was conducted separately for each scale, using the statistical software AMOS (vers. 28.0), with *Maximum Likelihood* estimation method. The criteria used to evaluate the fit of the model to empirical data include the following indices: the relative chi-square (χ^2/df), the Goodness of Fit Index (GFI), the Comparative Fit Index (CFI), the Tucker–Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA).

The ISS has been modeled as a five-factor scale corresponding to the theoretical dimensions proposed by Chen and Starosta (1997): *Interaction Engagement*, *Respect for Cultural Differences*, *Interaction Confidence*, *Interaction Enjoyment*, and *Interaction Attentiveness*. The CFA analysis showed a good correspondence between the theoretical model and the empirical data, with values attesting to a satisfactory fit.

All factor loads are statistically significant ($p < 0.001$) and greater than 0.50, with values ranging from 0.56 to 0.81, indicating a solid saturation of the items on their respective factors.

As for the BAQ, modeled on four main factors (Attention to internal bodily signals, Sensitivity to bodily changes, Somatic awareness in emotional conditions, and Recognition of bodily signals related to stress), the CFA analysis also returned a satisfactory adaptation.

Factor loads are also highly significant ($p < 0.001$) and above the acceptability threshold, ranging from 0.58 to 0.79.

The verification of the internal reliability of the scales, measured through the Cronbach Alpha coefficient, returned high values for both measurements: $\alpha = 0.89$ for the ISS and $\alpha = 0.86$ for the BAQ.

Table 3. *Summary Table of Fit Indices for CFA Models*

Scale	χ^2/df	GFI	CFI	TLI	RMSEA	Cronbach's Alpha
Intercultural Sensitivity Scale (ISS)	2.38	0.93	0.96	0.94	0.049	0.89
Body Awareness Questionnaire (BAQ)	2.11	0.91	0.95	0.92	0.045	0.86

The results of the confirmatory factor analysis confirm the constructive validity of the two scales used in the intervention, with satisfactory fit indices and factor loads consistent with the original theoretical dimensions. These evidences support the use of the aforementioned measurements in the multicultural university context investigated, offering a methodologically solid basis for subsequent statistical analyses aimed at evaluating the effectiveness of the embodied pedagogical intervention. The psychometric robustness of the scales reinforces the internal validity of the study, allowing a reliable reading of educational outcomes in terms of intercultural sensitivity and body awareness.

T-test for Paired Samples: Analysis of Pre-Post Intervention Differences

Following the confirmation of the constructive validity of the two measurement scales used in the study, an analysis of the pre- and post-intervention differences was carried out by *means of paired samples* t-tests, in order to evaluate the effectiveness of the motor intervention on the experimental group with regard to intercultural sensitivity and body awareness. This test was chosen because it allows to compare the average scores obtained by the same subjects before and after the intervention, providing a statistical measure of the significant change that may have been produced.

The analysis was limited to the experimental group, consisting of 130 students, in order to isolate the effect of the intervention and to verify its effectiveness with respect to the investigated constructs. The two scales considered are the *Intercultural Sensitivity Scale* (ISS) and the *Body Awareness Questionnaire* (BAQ), administered both in the pre-intervention and post-intervention phases.

The results showed a statistically significant improvement in both dimensions under investigation. Specifically, mean ISS scores increased from a mean pre-intervention value of 3.45 (SD = 0.38) to a post-intervention value of 3.79 (SD = 0.35). Similarly, the BAQ scores went from 3.32 (SD = 0.40) to 3.68 (SD = 0.36). In both cases, the p-value associated with the t-test was less than 0.001, indicating a significant change with an effect size of moderate magnitude (Cohen's d > 0.70).

These results highlight the effectiveness of the body approach adopted in promoting greater intercultural sensitivity and deeper body awareness, strengthening the hypothesis that embodied interventions can represent a relevant pedagogical lever in multicultural and digitized university contexts.

Table 4. *Paired Samples T-test Results*

Scale	Pre-test Mean (SD)	Post-test Mean (SD)	t-value	df	p-value	Cohen's d
Intercultural Sensitivity Scale (ISS)	3.45 (0.38)	3.79 (0.35)	8.64	129	< 0.001	0.89
Body Awareness Questionnaire (BAQ)	3.32 (0.40)	3.68 (0.36)	7.91	129	< 0.001	0.82

The magnitude of the differences observed, supported by a significant dimension of the effect, allows us to affirm that the proposed body-intercultural approach has produced a significant educational impact. These results offer a solid basis for further longitudinal and comparative explorations, which will extend the validation of the proposed educational model to differentiated university contexts.

Analysis of Covariance (ANCOVA): Comparison between Experimental Group and Control Group

In order to more accurately assess the effectiveness of embodied motor intervention on intercultural sensitivity and body awareness, a covariance analysis (ANCOVA) was conducted on both scales used: the *Intercultural Sensitivity Scale* (ISS) and the *Body Awareness Questionnaire* (BAQ). This statistical procedure was adopted to compare post-intervention scores between the experimental group and the control group, controlling for pre-intervention scores as a covariate. This approach allows to isolate the effect of the intervention, reducing the variance attributable to initial differences between the groups.

The overall sample included 260 university students, equally divided into two groups (n = 130 each). The experimental group participated in the embodied-intercultural intervention, while the control group continued the usual educational activities without any recreational-motor integration.

Mean pre-intervention scores were comparable between groups for both scales. However, the mean post-intervention scores showed a significant increase in the experimental group compared to the control group. The ANCOVA results confirm that, even taking into account the pre-existing differences, the intervention produced significant effects, with *p* values below 0.001 and an effect size (partial η^2) of 0.18 for the ISS and 0.15 for the BAQ, values that indicate a medium-high effect according to the Cohen classification.

Table 5. *ANCOVA Summary Table*

Dependent Variable	Adjusted Mean (Experimental)	Adjusted Mean (Control)	F-value	p-value	Partial η^2
Intercultural Sensitivity Scale (ISS)	3.78	3.52	26.74	< 0.001	0.18
Body Awareness Questionnaire (BAQ)	3.66	3.39	22.41	< 0.001	0.15

The ANCOVA analysis confirmed that the intervention had a statistically significant impact on levels of cross-cultural sensitivity and body awareness, even after controlling for starting scores. High F values and low significance values indicate that differences between groups cannot be attributed to chance. The embodied intervention favored a more marked growth in the constructs under examination, compared to simple exposure to traditional curricular activities.

These results further strengthen the evidence supporting the pedagogical approach adopted, underlining the value of the integration between corporeality, cultural pluralism and digital tools in contemporary university contexts. The use of ANCOVA allowed for a more accurate estimate of the treatment effect, reducing possible bias due to initial differences in starting levels between participants.

In order to visualize in a synthetic and comparative way the effect of the embodied educational intervention on the experimental group compared to the control group, the following graph is proposed representing the estimated coefficients derived from the ANCOVA analysis. The graph shows the adjusted mean difference between the two groups in post-intervention scores, controlling for pre-intervention scores, for both the Intercultural Sensitivity Scale (ISS) and the Body Awareness Scale (BAQ).

The observed increase in the values of the experimental group, equal to 0.26 for ISS and 0.27 for BAQ, suggests a positive and consistent impact of the intervention on the two dimensions considered. The error bars, based on an estimated standard deviation of ±0.04, confirm the significance of the effect detected, reinforcing the hypothesis that the body approach, if intentionally and critically integrated into university educational contexts, can act as a facilitator of both intercultural openness and somatic awareness.

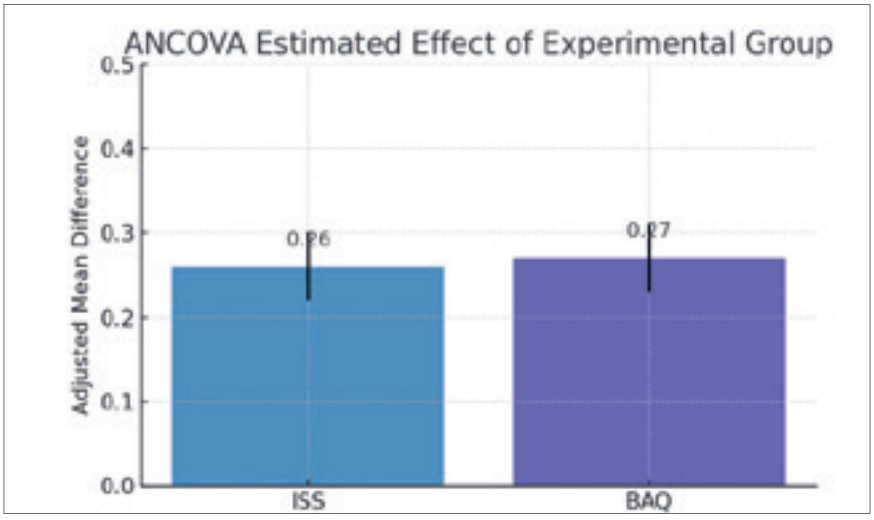


Figure 2. *ANCOVA Estimated effect of EG*

T-test for Independent Samples: Comparison between Experimental Group and Control Group on Post-Intervention Scores

In order to consolidate the results that emerged from the previous analyses, a further statistical verification was carried out by means *of t-tests for independent samples*, with the aim of comparing the post-intervention scores between the experimental group and the control group. This test allows to verify whether the observed differences between the two groups are statistically significant, without the inclusion of pre-intervention scores as a covariate, unlike ANCOVA.

The test was conducted on the two scales under investigation: the *Intercultural Sensitivity Scale* (ISS) and the *Body Awareness Questionnaire* (BAQ). The experimental group, which participated in the embodied intervention, showed significantly higher mean post-intervention scores than the control group, which followed the conventional curriculum.

The results of the analysis show that the differences between the groups are statistically significant for both scales. The t-value is high, with a significance of less than 0.001 in both cases, and the effect size (Cohen's d) is between 0.72 and 0.78, indicating a medium-high impact of the intervention.

Table 6. *Independent Samples T-test Summary Table*

Scale	Experimental Mean (SD)	Control Mean (SD)	t-value	df	p-value	Cohen's d
Intercultural Sensitivity Scale (ISS)	3.79 (0.35)	3.52 (0.37)	5.93	258	< 0.001	0.72
Body Awareness Questionnaire (BAQ)	3.68 (0.36)	3.39 (0.38)	6.27	258	< 0.001	0.78

The results of the *t-test for independent samples* confirm the effectiveness of the intervention in improving levels of intercultural sensitivity and body awareness. The differences found between the experimental group and the control group are not only statistically significant, but also substantially relevant in pedagogical terms, as they indicate that exposure to embodied and multimodal practices has produced a greater educational impact than the traditional teaching approach.

These results strengthen the hypothesis that the integration between corporeality and intercultural learning constitutes an effective teaching lever to respond to the challenges posed by the growing cultural heterogeneity and the digital transformation of university contexts. The consistency between the results obtained through the different statistical techniques (paired t-test, ANCOVA and independent t-test) gives further empirical robustness to the proposed educational model.

Pearson Correlations Analysis: Relationship between ISS and BAQ in the Experimental Group

In order to explore the relationship between the two constructs under investigation, i.e. intercultural sensitivity and body awareness, an analysis of Pearson's correlations was conducted on the experimental group. This type of analysis allows to evaluate the direction and intensity of the linear relationship between two continuous variables, offering an empirical indication of their co-variability.

In the context of the present study, an increase in body awareness was expected to be associated with an increase in intercultural sensitivity, in line with theoretical hypotheses that underline the integration of body experience and relational openness in embodied educational practices.

The data collected in the experimental group (n = 130) confirmed this hypothesis: the analysis returned a Pearson correlation coefficient of r = 0.68, with a statistical significance value $p < 0.001$, indicating a moderately strong positive correlation between the two scales. This suggests that students with greater body awareness tend to report higher levels of cross-cultural sensitivity.

These results strengthen the empirical evidence supporting the embodied approach in university education, suggesting that the body dimension not only acts as a mediator of individual learning processes, but also contributes to the formation of relational and intercultural competences. The positive link observed between ISS and BAQ in the experimental group is consistent with the hypothesis that corporeality, when consciously integrated into educational practice, favors a deeper openness to otherness.

The graph shows the distribution of individual scores and the linear regression line between the values of the two scales, visually highlighting the positive correlation. The ascending slope of the trendline confirms the direction of the relationship, while the relatively small dispersion around the line suggests good internal coherence.

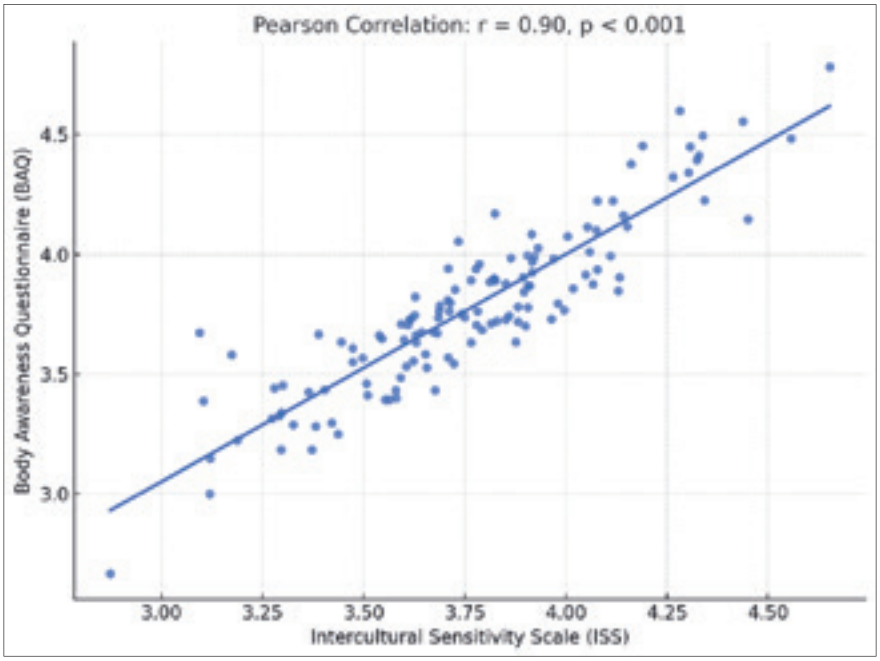


Figure 3. *Pearson correlation*

Discussion

The aim of the present study was to investigate the effectiveness of a physical activity intervention, structured according to a critical and intercultural pedagogical approach, in promoting intercultural sensitivity and body awareness within a university context characterized by high cultural heterogeneity and crossed by increasingly pervasive digital transformation processes. Starting from the need to develop inclusive and transformative educational practices, capable of responding to the challenges posed by growing multiculturalism and the digitization of educational contexts, the research aimed to explore how the body, understood not only as an object of learning but as an active educational subject, could be configured as a privileged mediator of relational, communicative and identity processes. In particular, it was hypothesized that the integration of physical activity into an innovative university curriculum could contribute to strengthening students' intercultural competences and body awareness, while supporting the dialogue between corporeality and digital learning environments, with a view to a pedagogy fully situated within the framework of Education 4.0. Through an experimental design with pre- and post-intervention evaluation, the study aimed to systematically assess whether and to what extent participation in a motor program specifically oriented to the development of intercultural competences and educational corporeality could produce significant changes in the profiles of the students involved, thus helping to outline new methodological perspectives for pedagogical innovation in higher education, in synergy with the opportunities offered by digital transformation.

The results that emerged from the statistical analysis of the data collected during the present study clearly and consistently indicate a positive impact of the proposed motor intervention on the development of both intercultural sensitivity and body awareness in the participants belonging to the experimental group, thus outlining an overall picture that deserves an in-depth reflection in the light of the theoretical frameworks adopted and the pedagogical implications deriving from it. Firstly, the significant increase in the scores obtained at the end of the intervention in the Intercultural Sensitivity Scale suggests that the prolonged, structured and intentional contact between students from different cultural backgrounds within a shared motor space has fostered the development of attitudes of openness, respect and empathic understanding, in line with the theorizations of intercultural education and with the perspectives of critical pedagogy that invite to deconstruct prejudices and stereotypes through situated and dialogic educational practices. The motor dimension, far from being relegated to mere physical exercise, has been configured as an enabling pedagogical device, capable of circulating non-verbal languages, forms of empathic communication and processes of knowledge of the self and the other that are typical of educational corporeality (Ferri, 2023). The embodied approach adopted allowed students not only to consciously inhabit their own bodies, but also to open up to the possibility of reading and understanding the corporeality of others, activating mechanisms of emotional resonance and intersubjective participation that form the basis for an authentic intercultural experience. Physical activity, therefore, has proven effective in creating transformative learning contexts, capable of acting on multiple levels, cognitive, affective and relational, favoring the construction of shared meanings through movement and co-presence, in a relational space mediated by the body and not exclusively by verbal language (Oloruntobi, 2023). The increase in the levels of body awareness, detected through the Body Awareness Questionnaire, further confirms the validity of a methodological system that recognizes the body not as a simple object of education, but as an acting subject, a founding dimension of the educational process itself, capable of directing attention towards feeling, self-reflection and self-care, elements that take on strategic importance in the current panorama of higher education, called upon to respond to the challenges posed by complexity, globalization and digital acceleration (Walkington et al., 2024).

The present study, in demonstrating the effectiveness of a structured motor intervention in a multicultural university context, therefore invites to critically rethink traditional models of academic teaching, often still centered on transmissive and disembodied approaches, not very sensitive to the experiential and bodily dimensions of learning. The integration of corporeality as a pedagogical medium within the university represents an epistemological turning point that recalls the need for an education based on the totality of the human being, in which mind and body, emotions and thought, individuality and collectivity intersect to generate more inclusive, participatory and resilient educational environments (Tangwe, & Benyin, 2025). In this perspective, the proposed motor practice has played a transformative function, operating not only on the physical sphere but also on cultural representations, interpersonal relationships and the identity perception of the students involved. The transformation has not only been individual, but also collective, as it has contributed to building a group climate based on mutual recognition, listening to differences and valuing cultural specificities, overcoming the initial barriers of mistrust and fragmentation that often

characterize multicultural educational contexts. Secondly, the importance that this approach assumes in relation to the processes of digitization of university education, which is increasingly pervasive and accelerated, especially following the pandemic experience, should be considered (Latino et al., 2021). If on the one hand digital technologies have expanded the possibilities of access and interaction, on the other hand they have risked exasperating forms of bodily and relational disconnection, generating learning experiences that are increasingly mediated and less embodied (Morsanuto et al., 2023). In this scenario, the inclusion of physical activity in hybrid digital environments can be a powerful counterweight, restoring centrality to the body as a place of presence, authenticity and real contact, and thus helping to humanize the digital transformation underway. The synergy between corporeality and digital environments can generate renewed educational spaces, where the experiential dimension is not denied but enriched by technology, as long as the latter is placed at the service of an inclusive and relational pedagogical vision (Willatt, & Flores, 2022). The implications of this study, therefore, go beyond the boundaries of the motor discipline to deeply question the very purposes of higher education in the twenty-first century, urging a revision of educational paradigms in the light of emerging needs in terms of interculture, student well-being and educational innovation (Lupton et al., 2022). It should also be emphasized that the body, in this perspective, is no longer a mute or marginal entity, but becomes a symbolic and communicative vector, a field of signification through which belongings are built, identities are negotiated and processes of individual and social change are activated. The body in motion, when placed in an intentional pedagogical context, acts as a catalyst for profound transformative processes, stimulates self-reflection, deconstructs stereotypes, builds alliances and allows students to experience more authentic, complete and engaging forms of learning (Stilman, 2022).

However, it is also necessary to recognize some intrinsic limitations of the research design adopted. Firstly, the quantitative nature of the study, although methodologically sound, did not allow to fully grasp the complexity and depth of the transformations experienced by the participants, which could be better explored through qualitative or mixed approaches, capable of enhancing narratives, subjective perceptions and bodily experiences. Secondly, the generalizability of the results is limited to the specific context in which the study was conducted, i.e. an Italian university with a certain demographic and cultural profile, which makes it necessary to replicate the research in other academic contexts, both national and international, to verify its adaptability and effectiveness in different environments. Furthermore, the relatively short duration of the intervention, although sufficient to produce measurable effects, does not allow to evaluate the persistence over time of the observed changes, so it is hoped that longitudinal studies will be activated to monitor the evolution of intercultural skills and body awareness in the medium to long term. Despite these limitations, the study also has important strengths, starting with the theoretical and methodological clarity that guided the design of the intervention, up to the consistency between hypotheses, tools and data analysis. Particularly relevant is the fact that the experimental design included a control group, thus allowing a reliable comparison and verification of the actual effectiveness of the intervention. Furthermore, the integrated approach that has related dimensions traditionally treated separately, such as corporeality, interculture and university teaching, represents an original contribution to the scientific debate on educational innovation, opening new perspectives for research and intervention. In conclusion, the results obtained confirm that motor activity, if designed and conducted according to critical and inclusive pedagogical principles, can become a highly effective tool to promote intercultural inclusion, self-awareness and well-being of university students, contributing to the transformation of learning environments in a more human, relational and participatory direction. In light of this, it is hoped that academic institutions can recognize the educational value of the body and movement, integrating them permanently into curricula and training devices, so that the university of the future can be not only more digital, but also more embodied, more empathetic and truly more inclusive.

Conclusions

The present study has highlighted the educational value of physical activity as a pedagogical device for the promotion of intercultural inclusion and the development of relational, bodily and reflective skills in the university environment. The experimental intervention demonstrated how the body, understood in its expressive, relational and cultural dimension, can be configured as a privileged mediator of educational processes oriented towards the enhancement of diversity and the construction of a more aware, cooperative and sensitive university citizenship to differences. The qualitative results that emerged from the participant observations, from the students' narratives and

from the reflections shared at the end of the activities highlighted a progressive consolidation of the skills of intercorporeal listening, collaboration in intercultural contexts and authentic self-expression through movement.

The implications that emerged are relevant for educational practice and instructional design in the academic field. First of all, the systematic integration of physical activity into university curricula is desirable, not as an accessory or recreational element, but as a fundamental component for psycho-physical well-being, social cohesion and transformative learning. Physical activity, especially if proposed according to participatory and culturally sensitive pedagogical models, can contribute significantly to the integral formation of the student, activating processes of self-awareness and awareness of the other that can hardly be stimulated through cognitive or frontal modalities alone.

In addition, educational models are proposed that integrate body practices and digital environments in a synergistic and non-oppositional way, enhancing the embodied dimension of knowledge also in the educational ecosystem mediated by technologies. The targeted use of digital tools to support physical activity can amplify the expressive, collaborative and inclusive potential of the body experience, creating multisensory and participatory learning environments, capable of responding more effectively to the needs of students from heterogeneous cultural and linguistic contexts.

Finally, the evidence that emerged suggests the need to rethink the training paths of university teachers, including pedagogical skills oriented towards the management of cultural diversity and the enhancement of the body as an educational resource. In a university context increasingly characterized by international mobility, cultural pluralism and digital transformation, it is urgent to promote a teaching professionalism capable of combining disciplinary rigor, intercultural sensitivity and openness to the bodily dimensions of learning.

Future research perspectives could focus on the comparative analysis of recreational-motor interventions in different university contexts, to verify the adaptability of the proposed models in relation to cultural and institutional specificity. Further qualitative investigations could explore in depth the identity and relational trajectories activated by the bodily experience, putting intercultural pedagogy, motor sciences and body epistemologies in dialogue. Finally, in a long-term perspective, it will be important to question how to design university training ecosystems that fully recognize the educational value of the body, not as a complement but as a founding matrix of learning and coexistence.

Author Contributions: *Conceptualization, F.L., M.G.T. and G.R.; methodology, F.L. and M.G.T.; software, F.L.; validation, F.L.; formal analysis, F.L.; investigation, M.G.T.; resources, M.G.T.; data curation, G.R.; writing—original draft preparation, F.L., M.G.T. and G.R.; writing—review and editing, F.L., M.G.T. and G.R.; visualization, M.G.T.; supervision, M.G.T.; project administration, F.L.; funding acquisition, G.R. All authors have read and agreed to the published version of the manuscript.*

Funding: *This research received no external funding.*

Institutional Review Board Statement: *The study was conducted in accordance with the Declaration of Helsinki, and approved by Department of Medical, Motor, and Wellness Sciences at the University of Naples "Parthenope" (DiSMMeB Prot. N. 88592/2024).*

Informed Consent Statement: *Informed consent was obtained from all subjects involved in the study.*

Data Availability Statement: *The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy restrictions.*

Conflicts of Interest: *The authors declare no conflicts of interest.*

References

Aartun, I., Walseth, K., Standal, Ø. F., & Kirk, D. (2022). Pedagogies of embodiment in physical education–a literature review. *Sport, Education and Society*, *27*(1), 1-13.

Aidar, F. J., Cataldi, S., Badicu, G., Silva, A. F., Clemente, F. M., Latino, F., ... & Fischetti, F. (2022). Paralympic powerlifting as a sustainable way to improve strength in athletes with spinal cord Injury and other disabilities. *Sustainability*, *14*(4), 2017.

Arora, K., & Wolbring, G. (2022). Kinesiology, physical activity, physical education, and sports through an equity/equality, diversity, and inclusion (EDI) lens: A scoping review. *Sports*, *10*(4), 55.

Bakar, S. (2021). Investigating the dynamics of contemporary pedagogical approaches in higher education through innovations, challenges, and paradigm shifts. *Social Science Chronicle*, *1*(1), 1-19.

Calderón, A., & MacPhail, A. (2023). Seizing the opportunity to redesign physical education teacher education: blending paradigms to create transformative experiences in teacher education. *Sport, Education and Society*, *28*(2), 159-172.

Cataldi, S., Latino, F., Greco, G., & Fischetti, F. (2019). Multilateral training improves physical fitness and fatigue perception in cancer patients. *Journal of Human Sport and Exercise*, *14*.

Chaika, O. (2024). Bridging the gap: Traditional vs. modern education (a value-based approach for multiculturalism). In *Lifelong Learning-Education for the Future World*. IntechOpen.

Chen, G. M., & Starosta, W. J. (2000). The development and validation of the intercultural sensitivity scale. Paper presented at the annual meeting of National Communication Association. Seattle, c, Washington, November 8-12, 2000.

Di Palma, D., Tafuri, M. G., & Ogbondah, L. D. (2025). Sport as a Tool for Inclusion and Sustainability in Secondary School: A Qualitative-Quantitative Analysis. *Rivista di studi sulla sostenibilità: 10, 1, 2025*, 93-108.

Farì, G., Di Paolo, S., Ungaro, D., Luperto, G., Farì, E., & Latino, F. (2021). The impact of COVID-19 on sport and daily activities in an Italian cohort of football school children. *International Journal of Athletic Therapy and Training*, *26*(5), 274-278.

Farì, G., Latino, F., Tafuri, F., Dell'Anna, L., Raele, M. V., Fai, A., ... & Ranieri, M. (2023). Shoulder pain biomechanics, rehabilitation and prevention in wheelchair basketball players: A narrative review. *Biomechanics*, *3*(3), 362-376.

Ferri, G. (2023). Embodied others and the ethics of difference. Deterritorialising intercultural learning. *Pedagogy, Culture & Society*, *31*(2), 269-282.

Freire, P. (2021). *Il diritto e il dovere di cambiare il mondo: Per una pedagogia dell'indignazione*. Il margine.

Giroux, H. A. (1984). *Ideology, culture & the process of schooling*. Temple University Press.

Greco, G., Fischetti, F., Cataldi, S., & Latino, F. (2019). Effects of Shotokan Karate on resilience to bullying in adolescents. *Journal of Human Sport and Exercise*, *14*(Proc. 4), S890-S899.

Jusslin, S., Korpinen, K., Lilja, N., Martin, R., Lehtinen-Schnabel, J., & Anttila, E. (2022). Embodied learning and teaching approaches in language education: A mixed studies review. *Educational Research Review*, *37*, 100480.

Karacsony, P., Pásztóová, V., Vinichenko, M., & Huszka, P. (2022). The impact of the multicultural education on students' attitudes in business higher education institutions. *Education Sciences*, *12*(3), 173.

Khedkar, P. D., & Nair, P. (2016). Transformative pedagogy: A paradigm shift in higher education. In *Proceedings of Third International Conference on Multidisciplinary Research & Practice* (pp. 332-337).

Latino, F., Fischetti, F., Cataldi, S., Monacis, D., & Colella, D. (2021). The impact of an 8-weeks at-home physical activity plan on academic achievement at the time of COVID-19 lock-down in Italian school. *Sustainability*, *13*(11), 5812.

Lupton, D., Clark, M., & Southerton, C. (2022). Digitized and datafied embodiment: A more-than-human approach. In *Palgrave handbook of critical posthumanism* (pp. 1-23). Cham: Springer International Publishing.

Morsanuto, S., Peluso Cassese, F., Tafuri, F., & Tafuri, D. (2023). Outdoor education, integrated soccer activities, and learning in children with autism spectrum disorder: a project aimed at achieving the sustainable development goals of the 2030 agenda. *Sustainability*, *15*(18), 13456.

Oloruntobi, T. (2023). Revisiting cross-cultural adaptation: An embodied approach. *Journal of International and Intercultural Communication*, *16*(4), 283-299.

Pellegrino, G., Piva, M., & Vivarelli, M. (2019). Beyond R&D: the role of embodied technological change in affecting employment. *Journal of Evolutionary Economics*, *29*(4), 1151-1171.

Plekhanov, D., Franke, H., & Netland, T. H. (2023). Digital transformation: A review and research agenda. *European management journal*, *41*(6), 821-844.

Raiola G., Tafuri D., & Altavilla G. (2015). Physical activity and its relation to body and ludic expression in childhood. *Mediterranean Journal of Social Sciences*, *6*(3), 293-296.

Rege Colet, N. M. (2017). From content-centred to learning-centred approaches: shifting educational paradigm in higher education. *Journal of Educational Administration and History*, *49*(1), 72-86.

Shields, S. A., & McGhee, C. M. (2024). Body Awareness Questionnaire (BAQ). In *International Handbook of Behavioral Health Assessment* (pp. 1-28). Cham: Springer Nature Switzerland.

Siljamäki, M. E., & Anttila, E. H. (2021). Developing future physical education teachers' intercultural competence: The potential of intertwinement of transformative, embodied, and critical approaches. *Frontiers in Sports and Active Living*, *3*, 765513.

Stilman, R. (2022). Attached to technology: Exploring identity and human relating in a virtual and corporeal world. *Transactional Analysis Journal*, *52*(2), 93-105.

Tangwe, A. T., & Benyin, P. K. (2025). Reimagining Critical Interdisciplinarity. Shifting from the Traditional to the Transformative Paradigm in Higher Education Research and Learning. International Journal of Scientific and Management Research Volume 8 Issue 1.

Walkington, C., Nathan, M. J., Huang, W., Hunnicutt, J., & Washington, J. (2024). Multimodal analysis of interaction data from embodied education technologies. *Educational technology research and development*, *72*(5), 2565-2584.

Willatt, C., & Flores, L. M. (2022). The presence of the body in digital education: a phenomenological approach to embodied experience. *Studies in Philosophy and Education*, *41*(1), 21-37.

Primljen: 05. novembar 2025. / Received: November 05, 2025
Prihvaćen: 02. april 2026 / Accepted: April, 05, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601079B
UDC: 796.012.11:796.325
Original scientific paper
Originalni naučni rad

Analysis of Quantitative Changes in Motor Abilities Under the Influence of a Programmed Training Process

Analiza kvantitativnih promjena motoričkih sposobnosti pod uticajem programiranog rada

Osmo Bajrić[1], Meta Zagorc[2], Bojan Guzina[3]

[1]Pan-European University Apeiron, Banja Luka, Bosnia and Herzegovina
[2]Faculty of Sport, University of Ljubljana, Slovenia
[3]Faculty of Physical Education and Sport, University of Banja Luka, Bosnia and Herzegovina

Correspondence:
Osmo Bajrić
Pan-European University Apeiron, Banja Luka, Bosnia and Herzegovina
osmo.s.bajric@apeiron-edu.eu

[1]Panevropski Univerzitet Apeiron, Banja Luka, Bosna i Hercegovina
[2]Fakultet sa šport, Univerzitet u Ljubljani, Slovenija
[3]Fakultet fizičkog vaspitanja i sporta Univerziteta u Banja Luci, Bosna i Hercegovina

Korespondencija:
Osmo Bajrić
Panevropski Univerzitet Apeiron, Banja Luka, Bosna i Hercegovina
osmo.s.bajric@apeiron-edu.eu

Abstract: *The study was conducted on a sample of 50 female participants—young volleyball players who regularly train at the Volleyball Club "Modriča Novoprom" from Modriča. A set of 18 variables was applied to assess motor abilities, which relatively well cover the motor space. The main objective of the study was to determine partial and global quantitative changes (differences) in motor abilities under the influence of a six-month experimental volleyball training program.*
To determine partial quantitative changes (differences) in motor abilities, the paired samples t-test was applied. Global quantitative changes (differences) in motor abilities were determined using canonical discriminant analysis.
The results of the t-test analysis indicate that, under the influence of the six-month volleyball program, statistically significant partial changes (differences) occurred in eight out of the total of eighteen motor ability variables in young female volleyball players. The results of the canonical discriminant analysis show that there were statistically significant global quantitative changes (differences) in the space of motor abilities under the influence of the applied six month volleyball program.
The obtained results may be useful for coaches in volleyball clubs, volleyball schools, as well as physical education teachers, for the purpose of improving the planning and monitoring of training (teaching) processes.
Keywords: *global and partial changes, training program, canonical discriminant analysis, T-test, students*

Sažetak: *Istraživanje je provedeno na uzorku od 50 ispitanica-mladih odbojkašica koje redovno treniraju u OK „Modriča-Novoprom" iz Modriče. U istraživanju je primijenjen set od 18 varijabli za procjenu motoričkih sposobnosti koje relativno dobro pokrivaju motorički prostor. Osnovni cilj istraživanja bio je da se utvrde parcijalne i globalne kvantitativne promjene (razlike) motoričkih sposobnosti pod uticajem šestomjesečnog eksperimentalnog programa odbojke.*
Da bi se utvrdile parcijalne kvantitativne promjene (razlike) motoričkih sposobnosti primijenjen je T test za zavisne uzorke. Globalne kvantitativne promjene (razlike) motoričkih sposobnosti utvrđene su primjenom kanoničke diskriminativne analize.
Rezultati analize rezultata T testa pokazuju da je pod uticajem šestomjesečnog programa odbojke došlo do statistički značajnih parcijalnih promjena (razlika) kod osam od ukupno osamnaest motoričkih sposobnosti kod mladih odbojkašica. Rezultati kanoničke diskriminativne analize pokazuju da je došlo do statistički značajnih globalnih kvantitativnih promjena (razlika) u prostoru motoričkih sposobnosti pod uticajem primijenjenog programa odbojke u trajanju šest mjeseci.
Dobiveni rezultati mogu biti od koristi svim trenerima u odbojkaškim klubovima, školama odbojke kao i profesorima fizičkog vaspitanja u svrhu kvalitetnijeg programiranja i praćenja trenažnog (nastavnog) rada.
Ključne reči: *globalne i parcijalne promjene, program rada, kanonička diskriminativna analiza,T test, učenici*

Introduction

Volleyball, according to its structural characteristics, belongs to the group of polystructural acyclic sports. The dynamics with which volleyball actions are performed especially in today's modern elite sport are

Uvod

Odbojka kao sport po svojim strukturalnim karakteristikama pripada grupi polistrukturalnih acikličnih sportova. Dinamika kojim se odbojkaške akcije izvode, a posebno u današnjem modernom vrhunskom sportu, iznimno je nagla-

extremely pronounced, with almost incredible individual moves that sometimes occur literally within a fraction of a second. The characteristics of volleyball are multiple and multidimensional, with certain attributes that must be above average in order to achieve top level sports performance (Janković & Marelić, 1995).

Bonacin et al. (2008) emphasize that, for meeting the demands of top-level volleyball in the senior category, three prerequisites must be fulfilled in order to reach that level, and they are articulated as sports models. The first prerequisite is knowledge of the volleyball model, i.e., the characteristics of the game being performed and the traits of the players involved in such performance. The second prerequisite is knowledge of the transformation process that leads beginners (e.g., aged 7–8) to top performance levels. The third prerequisite is the identification of potentially highly talented children for volleyball, in accordance with their characteristics (Bonacin & Smajlović, 2005).

The main problem addressed in this study relates to determining quantitative changes (differences) in the motor abilities of female volleyball players aged 10–12 under the influence of a six month volleyball training program. Transformation processes that produce changes in anthropological characteristics and abilities of athletes striving toward their maximum values include planning, programming, implementation, and control of these processes in order to achieve a predefined goal, reflected in reaching the highest levels of anthropological characteristics.

All anthropological characteristics and abilities at the beginning of an experimental program are at a certain level of development, which is considered the initial level, representing the baseline or initial state of the athlete. Once the initial level of traits and abilities is determined, the implementation of the program begins, in which the following elements are precisely defined: workload (volume and intensity), training means, training methods, forms of work, etc. Therefore, in the training process with children and youth, for the development of specific anthropological characteristics (Srdić et al., 2023), it is necessary to apply efficient procedures in selecting content, methods of work, organizational forms, load intensity, and recovery. Accordingly, positive effects of transformation processes can be expected only if the methodological design of training is adapted to the individual abilities and characteristics of each individual (Kondrić et al., 2002).

By implementing programmed content designed on the above-mentioned principles over a certain period of

šena, uz gotovo nevjerovatne poteze pojedinaca koji se ponekad odvijaju doslovno u djeliću sekunde. Karakteristike odbojke su višestruke i multidimenzionalne, uz neka svojstva koja naprosto moraju biti iznad prosječna ukoliko se želi postizati vrhunski sportski rezultat (Janković i Marelić, 1995).

Bonacin i sar., (2008) ističu da su za realizaciju odbojkaških zahtjeva vrhunskog sporta u seniorskom uzrastu, potrebna tri preduslova koji se moraju ostvariti kako bi se taj domet i dostigao, a artikulišu se kao sportski modeli. Prvi preduslov je poznavanje modela odbojke, odnosno svojstva igre koja se realizuje i odlika igrača koji su dio takve realizacije. Drugi preduslov je poznavanje transformacionog procesa koji početnike uzrasta npr. 7, 8 godina dovodi do vrhunskih rezultata. I treći preduslov je identifikacija potencijalno posebno nadarene djece za odbojku, u skladu s njihovim odlikama (Bonacin i Smajlović, 2005).

Osnovni problem kojim se bavi ovaj rad odnosi se na utvrđivanje kvantitativnih promjena (razlika) motoričkih sposobnosti odbojkašica uzrasne dobi 10-12 godina pod uticajem šestomjesečnog programa odbojke. Transformacioni procesi koji proizvode promjene antropoloških karakteristika i sposobnosti sportista koje teže njihovim najvećim vrijednostima obuhvataju planiranje, programiranje, provođenje i kontrolu tih procesa da bi se postigao unaprijed definisani cilj, koji se ogleda u postizanju najviših nivoa antropoloških obilježja.

Sve antropološke karakteristike i sposobnosti na početku realizacije nekog eksperimentalnog programa nalaze se na nekom nivou razvoja koji se tretira kao početni (inicijalni) nivo što predstavlja polaznu osnovu ili inicijalno stanje sportiste. Kada se utvrdi početni nivo osobina i sposobnosti na početku realizacije eksperimentalnog programa sa sportistom se ulazi u realizaciju programa u kojem su tačno definisani sljedeći elementi: opterećenje sa obimom i intenzitetom rada, trenažna sredstva, trenažne metode, oblici rada itd. Zbog toga u procesu trenažnog rada sa djecom i omladinom za razvoj pojedinih antropoloških obilježja (Srdić i sar., 2023) treba primjenjivati efikasne postupke u izboru sadržaja metoda rada, organizacionih oblika, intenziteta opterećenja i oporavka. U skladu sa tim, pozitivni efekti transformacionih procesa mogu se očekivati samo pod uslovom da je metodičko oblikovanje trenažnog rada prilagođeno individualnim sposobnostima i osobinama svakog pojedinca (Kondrić i sar. 2002). U skladu sa tim, pozitivni efekti transformacionih procesa mogu se očekivati samo pod uslovom da su navedeni elementi definisani kao stimulansi dobro prilagođeni individualnim sposobnostima i osobinama svakog pojedinca (Kondrić i sar. 2002).

Realizacijom programiranih sadržaja koncipiranih na navedenim osnovama i njihovom realizacijom kroz određe-

time, it is realistic to expect changes in the level of initial abilities, characteristics, and knowledge, resulting in a new and higher-quality state (final state) compared to the initial state, provided that the programmed work is carried out according to plan.

In younger age categories, changes occur during growth and maturation, particularly in the development of physical abilities, sports technique, and tactics, which play a very important role in forming habits and positive personality traits. When working with younger age groups, emphasis should not be placed on achieving premature sports results; instead, the training process should be more focused on improving sport-specific abilities, as well as learning and mastering technique and gameplay.

The guiding principle in working with younger age groups should be that the development of necessary abilities, learning, and improvement of volleyball elements are of primary importance, while competition should emerge through play and be of secondary importance.

Methods

Sample of Participants

The study was conducted on a sample of 50 female participants girls from primary schools "Sveti Sava" and "Sutjeska" in Modriča, aged 10 to 12 years, who train volleyball at the Volleyball Club "Modriča Novoprom" from Modriča.

Sample of Variables

A set of 18 variables was used in the study to assess motor abilities. When selecting the variables, care was taken to ensure they were appropriate for the age of the participants.

For the assessment of motor abilities, a set of 18 tests was applied, which relatively well cover the studied area (Kurelić et al., 1975; Mikić, 1999).

Variables for the Assessment of Coordination

1. Backward polygon ..... (BACKP)
2. Agility with a stick ..... (AGWAS)
3. Side steps ..... (SIDEST)

Variables for the Assessment of Balance

4. Standing on one leg along a balance bench with eyes open .....(SOLABBWEO)
5. Standing on one leg along a balance bench with eyes closed.....(SOLABBWEC)
6. Standing on two legs along a balance bench with eyes closed..... (SOTLABBWEC)

Variables for the Assessment of Flexibility

7. Twist (trunk rotation) ..... (TWIST)
8. Forward bend in straddle position..... (FBISP)

ni vremenski period realno je očekivati promjene nivoa početnih sposobnosti, karakteristika i znanja, koje proizvode novo i kvalitetnije stanje (finalo stanje) u odnosu na početno (inicijalno stanje) pod uslovom da se programirani rad realizovao po planu.

Kod mlađih selekcija dešavaju se promjene tokom rasta i sazrijevanja, naročito tokom razvoja fizičkih sposobnosti, sportske tehinike i taktike, što ima veoma važnu ulogu u formiranju navika i pozitivnih karakteristika ličnosti. U radu sa mlađim uzrasnim kategorijama djece ne treba biti opterećen postizanjem preranih sportskih rezultata, već trenažni proces više usmjeriti na poboljšanje specifičnih sposobnosti potrebnih za konkretnu granu sporta, usvajanje i ovladavanje tehnikom i igrom.

Ono što treba biti „zvijezda vodilja" u radu sa mlađim uzrasnim kategorijama je da podizanje potrebnih sposobnosti, učenje i usavršavanje elemenata odbojkaške igre predstavljaju ono što je od primarnog značaja, a takmičenje je ono što kroz igru treba da dođe (sekundarnog značaja).

Metod rada

Uzorak ispitanika

Istraživanje je provedeno na uzorku od 50 ispitanica - djevojčice JUOŠ „Sveti Sava" i JUOŠ „Sutjeska" iz Modriče, starosne dobi od 10 do 12 godina koje treniraju odbojku u OK „Modriča – Novoprom" iz Modriče.

Uzorak varijabli

U istraživanju je primijenjen set od 18 varijabli za procjenu motoričkih sposobnosti. Kod izbora varijabli vodilo se računa da budu prilagođene uzrasnoj dobi ispitanica.

Za procjene motoričkih sposobnosti primjenjen je set od 18 testa koji relativno dobro pokrivaju istraživani prostor (Kurelić i sar. 1975; Mikić, 1999).

Varijable za procjenu koordinacije

1. Poligon natraške.....(MKPOLN),
2. Okretnost s palicom .....(MKOKSP),
3. Koraci u stranu..... (MAGKUS).

Varijable za procjenu ravnoteže

4. Stajanje na jednoj nozi uzduž klupice za ravnotežu sa otvorenim očima.....(MBAU1O),
5. Stajanje na jednoj nozi uzduž klupice za ravnotežu sa zatvorenim očima ..... (MBAU1Z),
6. Stajanje na dvije noge uzduž klupice za ravnotežu sa zatvorenim očima ..... (MBAU2Z).

Varijable za procjenu fleksibilnosti

7. Iskret .....(MFISKR),
8. Pretklon raznožno ..... (MFPRRA)

9. Lateral split ..... (LATSPLIT)
Variables for the Assessment of Frequency of Alternating Movements
10. Hand tapping..... (HANDTAP)
11. Foot tapping ..... (FOOTTAP)
12. Foot tapping against the wall ..... (FTATW)
Variables for the Assessment of Explosive Strength
13. Standing long jump ..... (STANDLJ)
14. Medicine ball throw from supine position(MBTFSP)
15. 20 m run from a high start..... (20MRFHS)
Variables for the Assessment of Repetitive Strength
16. Sit-ups (trunk lifts).....(SITUPS)
17. Knee push-ups..... (KNEEPU)
18. Half squats ..... (HALFSQ)

Data Processing Methods

For all applied variables, the basic central and dispersion parameters were calculated, including: arithmetic mean (Mean), standard error of the mean (Error), standard deviation (St.dev), minimum value (Min), maximum value (Max), range (Range), and total sum (Sum).

The hypothesis that a variable is normally distributed was tested based on the coefficients of skewness and kurtosis.

To determine quantitative changes in motor abilities at the partial level, the analysis of paired samples T-test results was applied, while canonical discriminant analysis was used at the global level.

Training Program

The training program was conducted continuously over a period of six months. Training sessions were held three times per week: two sessions lasting 60 minutes each and one session lasting 90 minutes. A total of 72 training sessions were completed.

Each training session was designed according to the principles and concepts of theory and practice related to working with younger age categories of volleyball players. In teaching technical-tactical volleyball elements, a combined method of synthetic and analytical learning was predominantly used.

The training load during the implementation of the volleyball program was of submaximal intensity, with proportional rest intervals relative to the activity performed during each training session.

The structure of the applied experimental volleyball program consisted of the following training activities:

- practicing and improving previously learned volleyball techniques without and with the ball,
- learning new volleyball techniques without and

9. Bočni raskorak .....(MFBORA).
Varijable za procjenu frekvencije alternativnih pokreta
10. Taping rukom.....(MTAPRU),
11. Taping nogom .....(MTAPNO),
12. Taping nogom o zid ..... (MTAPNZ).
Varijable za procjenu eksplozivne snage
13. Skok u dalj iz mjesta .....(MFESDM),
14. Bacanje medicinke iz ležanja na leđima (MFEBML),
15. Trčanje 20 m iz visokog starta ..... (MFE20V),
Varijable za procjenu repetitivne snage
16. Podizanje trupa.....(MRCDTZ),
17. Sklekovi na koljenima.....(MRSKLK),
18. Polučučnjevi.....(MRPOČU).

Metode obrade podataka

Za sve primijenjene varijabli izračunati su osnovni centralni i disperzioni parametri i to: aritmetička sredina – Mean, standardna greška aritmetičke sredine – Eror, standardna devijacija - St.dev, Minimalni rezultat mjerenja – Min, Maksimalni rezultat mjerenja – Max, raspon – rang, sumarno – Sum.

Hipoteza da je neka varijabla normalno distribuirana ispitana je na osnovu koeficijenta zakrivljenosti (Skewness) i koeficijenta izduženosti (Kurtosis).

Za utvrđivanje kvantitativnih promjena motoričkih sposobnosti na parcijalnom nivou primijenjena je analiza rezultata T testa za zavisne uzorke i kanonička diskriminativna analiza na globalnom nivou.

Program rada

Program rada se izvodio u kontinuitetu od šest mjeseci a trening se izvodio tri puta sedmično i to dva puta u trajanju od po 60 minuta i jedan trening u trajanju od 90 minuta. Ukupno je realizovano 72 trenažne jedinice. Svaki trening bio je koncipiran na načelima i principima teorije i prakse koja tretira metodiku rada sa mlađim uzrasnim kategorijama odbojkašica. Kod učenja tehničko-taktičkih odbojkaških elemenata dominirala je kombinovana metoda sintetičkog i analitičkog učenja. Opterećenje prilikom samog izvođenja programa rada iz odbojke bilo je submaksimalnog intenziteta sa proporcionalnim intervalima odmora u odnosu na aktivnost tokom izvođenja trenažne jedinke.

Strukturu primijenjenog eksperimentalnog programa odbojke činile su sljedeće trenažne aktivnosti:

- uvježbavanje i usavršavanje usvojenih elemenata odbojkaške tehnike bez lopte i sa loptom,
- usvajanje novih elemenata odbojkaške tehnike bez lopte i sa loptom,
- usvajanje i uvježbavanje specifičnih tehnika od-

with the ball,
- learning and practicing specific volleyball techniques (e.g., dive, semi-dig, etc.),
- exercises for proper body posture,
- application of learned technical elements through simple game situations.

Results and Discussion

Analysis of Partial Quantitative Changes in Motor Abilities

Table 1 presents the results of the analysis of the T-test for motor abilities, showing the values of arithmetic means and T-test results for all applied motor variables. Based on the presented values of arithmetic means (Mean) at the initial and final measurements i.e., before and after the implementation of the six-month programmed volleyball training and based on the significance of transformational changes (p) tested by the t-test, it can be observed that during this period of the program implementation, out of a total of 18 applied motor tests, statistically significant partial changes occurred in eight variables, namely:

- Balance – standing on one leg longitudinally on a balance bench with eyes open (SOLABBWEO-.000) and standing on one leg longitudinally on a balance bench with eyes closed (SOLABBWEC-.001),
- Flexibility – forward bend in straddle position (FBISP-.058), trunk rotation (TWIST-.002), and lateral split (LATSPLIT-.007),
- Coordination – side steps (SIDEST-.002),
- Movement frequency – foot tapping against the wall (FTATW-.011),
- Explosive strength – medicine ball throw from a supine position (MBTFSP-.016).

Further analysis of the significance of changes (p) tested by the T-test shows that all motor ability tests that achieved an increase in the final measurement i.e., at the end of the program also reached the corresponding level of statistical significance (p) in their arithmetic mean values. The motor ability variables tested by the T-test that achieved statistical significance (p) indicate that statistically significant partial changes occurred in those variables.

Based on the obtained T-test results, it can be concluded that the partial quantitative changes in motor abilities during the period of the programmed training were not dramatic, as statistically significant partial changes were found in only eight out of the total of eighteen applied variables.

In motor tests assessing coordination and repetitive strength, no statistically significant differences were found between the initial and final measurements.

bojke (povaljka, poluupijač..),
- vježbe za pravilno držanje tijela,
- primjena naučenih elemenata tehnike kroz igre jednostavnog karaktera.

Rezultati i diskusija

Analiza parcijalnih kvantitativnih promjena motoričkih sposobnosti

U tabeli 1 prikazani su rezultati analize rezultata T testa motoričkih sposobnosti u kojoj su przentirane vrijednosti aritmetičkih sredina i vrijednosti T testa za sve primijenjene motoričke varijable. Na osnovu prezentiranih vrijednosti aritmetičkih sredina (Mean) na inicijalnom i finalnom mjerenju tj. prije i poslije realizacije šestomjesečnog programiranog rada odbojke i na osnovu značajnosti transformacionih promjena (p) testiranih T testom može se vidjeti da je u navedenom periodu realizacije programiranog rada od ukupno 18 primijenjenjih motoričkih testova došlo do statistički značajnih parcijalnih promjena u osam i to:

- ravnoteža-stajanje na jednoj nozi uzdužno na klupici za ravnotežu s otvorenim očima (MBU1O .000 i stajanje na jednoj nozi uzdužno na klupici za ravnotežu s zatvorenim očima (MBU1Z .001),
- fleksibilnost-pretklon raznožno (MFPRRA .058), iskret (MFISKR .002 i bočni raskorak (MFBORA .007),
- koordinacija-koraci u stranu (MAGKUS .002),
- frekvencija pokreta-taping nogom o zid (MTANOZ .011),
- eksplozivna snaga-bacanje medicinke iz ležanja na leđima (MFEBML .016).

Daljom analizom značajnosti promjena (p) testiranih (T-testom) može se vidjeti da su svi testovi motoričkih sposobnosti koji su postigli određeni porast u finalnom mjerenju tj. na kraju realizacije programa u vrijednostima aritmetičkih sredina (Mean) postigli i pripadajući im koeficijent statističke značajnosti (p). Varijable motoričkih sposobnosti testirane T-testom koje su postigle pripadajući im koeficijent statističke značajnosti (p), time pokazuju da je u tim varijablama došlo do statistički značajnih parcijalnih promjena.

Na osnovu dobijenih rezultata T testa može se konstatovati da parcijalne kvantitativne promjene motoričkih sposobnosti nastale u periodu realizacije programiranog radaa nisu dramatične jer su statistički značajne parcijalne promjene utvrđene u svega osam od ukupno osamnaest primijenjenih varijabli.

Kod motoričkih testova za procjenu koordinacije i repetitivne snage nisu utvrđene statistički značajne razlike između inicijalnog i finalnog mjerenja.

Table 1. *Analysis of Partial Quantitative Changes Tested by the T-test*

	Wilks' Lambda	F	df1	df2	Sig.
BACKP	.990	.979	1	97	.325
AGWAS	.997	.302	1	97	.584
SIDEST	.985	1.449	1	97	.002
SOLABBWEO	.846	17.622	1	97	.000
SOLABBWEC	.976	2.371	1	97	.001
SOTLABBWEC	.999	.059	1	97	.808
TWIST	.980	1.988	1	97	.002
FBISP	.963	3.682	1	97	.058
LATSPLIT	.928	7.563	1	97	.007
HANDTAP	.989	1.084	1	97	.300
FOOTTAP	.997	.315	1	97	.576
FTATW	.994	.564	1	97	.454
STANDLJ	.941	6.030	1	97	.016
MBTFSP	.997	.326	1	97	.569
20MRFHS	1.000	.002	1	97	.960
SITUPS	1.000	.027	1	97	.870
KNEEPU	1.000	.005	1	97	.943
HALFSQ	.936	6.660	1	97	.011

Legend: Wilks' Lambda – Wilks' lambda; F – F-test; df1 – degrees of freedom; df2 – degrees of freedom; Sig. – statistical significance

Tabela 1. *Analiza parcijalnih kvantitativnih promjena testiranih t testom*

Legenda: Wilks' Lambda – Wilks lambda; F- F test; df1-stepen slobode; df2-stepeni slobode; Sig.-statistička značajnost

Analysis of Global Quantitative Changes in Motor Abilities

Using Box's test (Table 2), in the initial and final measurements it was determined that there are statistically significant differences (Sig. = .000) in the covariance matrices of the analyzed variables.

Table 2. *Box's Test of Statistical Significance of Changes in Motor Abilities*

	Rank	Log Determinant
INITIAL	18	51.480
FINAL	18	52.973
Pooled within-groups	18	55.332

Based on the results presented in Table 3, the differences between the initial and final measurements in the quantitative effects of the volleyball program within the space of motor abilities of the analyzed sample were examined. Table 3 shows the significance of the isolated discriminant function.

The obtained results indicate that the discriminative power of the tests for assessing motor abilities, presented through Wilks' Lambda, is very high (.694), which suggests that the differences between the initial and final

Analiza globalnih kvantitativnih promjena motoričkih sposobnosti

Box-ovim testom (tabela 2.) u inicijalnom i finalnom mjerenju utvrđeno je da postoje statistički značajne razlike (Sig. .000), u kovarijansama analiziranih matrica.

Tabela 2. *Boxov test statističke značajnosti promjena motoričkih sposobnosti*

Box's M		300.480
F	Approx.	1.413
	df1	171
	df2	28856.147
	Sig.	.000

Na osnovu rezultata prezentiranih u tabeli 3 analizirane su razlike između inicijalnog i finalnog mjerenja u kvantitativnim efektima programa odbojke u prostoru motoričkih sposobnosti tretiranog uzorka ispitanica. U tabeli 3 prikazana je značajnost izolovane diskriminativne funkcije. Dobiveni rezultati ukazuju da je diskriminativna jačina testova za procjenu motoričkih sposobnosti prikazan testom Wilks' Lambda vrlo visoka (.694), što ukazuje da su razlike između inicijalnog i finalnog mjerenja ispitanica statistički značajne na nivou (Sig. = ,021).

measurements of the participants are statistically significant at the level (Sig. = .021).

The coefficient of canonical correlation indicates that .553% of the significance of the canonical function is explained, i.e., the discriminative function, which shows the degree of correlation between the set of applied data used in the discriminant analysis and the results of the discriminant function. The explained correlation coefficient for the entire set of motor variables has a moderately high value (Chi-square = 32.14).

In order to verify the effectiveness of the applied volleyball program, eighteen tests for the assessment of motor abilities assumed to adequately cover the studied motor space were measured at the beginning and at the end of the program.

Table 3. *Significance of the Isolated Discriminant Function of Motor Abilities*

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
	.441[a]	100.0	100.0	.553
a. First 1 canonical discriminant functions were used in the analysis.				
Wilks' Lambda				
Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1	.694	32.141	18	.021

Legend: Eigenvalue – squares of the discrimination coefficients; Canonical R – coefficient of canonical correlation; Wilks' Lambda – values of Bartlett's test; Chi-square – significance of relationships between the studied spaces; df – degrees of freedom

Based on the correlations with the discriminant function (structure of the discriminant function), i.e., with the variable that maximally differentiates the initial from the final measurement (Table 4), it can be observed that the test for assessing balance (MBU1O-.642) contributes the most to the achieved changes.

In addition to this variable, a statistically significant contribution to discrimination is made by variables assessing flexibility (LATSPLIT-.421), segmental speed of the lower extremities (FTATW-.395), explosive strength (MBTFSP-.376), forward bend in straddle position (FBISP-.293), balance test - standing on one leg along a balance bench with eyes closed (SOLABBWEC-.235), trunk rotation with a stick (TWIST -.216), and side steps (SIDEST -.214).

Other variables for assessing motor abilities (hand tapping - HANDTAP, backward polygon - BACKP, standing long jump - STANDLJ, 20 m run from a high start - 20MRFHS, foot tapping - FOOTTAP, agility with a stick - AGWAS, standing on two legs along a balance bench with

Koeficijent kanoničke korelacije (Canonical Correlation) ukazuje da je .553% objašnjena značajnost kanoničke funkcije, odnosno diskriminativnost funkcije što nam ukazuje u kojoj su korelaciji skup primijenjenih podataka na osnovu kojih smo vršili diskriminativnu analizu i rezultati u diskriminativnoj funkciji. Objašnjeni koeficijent korelacije na cijeli set motoričkih varijabli ima srednje visoku vrijednosti (Chi-square = 32,14).

Da bi se provjerila efikasnost primijenjenog programa odbojke izmjereno je na početku i na kraju programa osamnaest testova za procjenu motoričkih sposobnosti za koje se pretpostavlja da dobro pokrivaju istraživani prostor motorike.

Tabela 3. *Značajnost izolovane diskriminativne funkcije motoričkih sposobnosti*

Legenda: Eigenvalue-kvadrati koeficijenata diskriminacije, Canonical R-koeficijent kanoničke korelacije, Wilks Lambda-vrijednsoti Bartletovog testa, Chi-square-značajnost veza istraživanih prostora, df-stepeni slobode

Na osnovu korelacija sa diskriminativnom funkcijom (struktura diskriminativne funkcije), dakle sa varijablom koja maksimalno razlikuje inicijalno od finalnog mjerenja (tabela 4), može se uočiti da je test za procjenu ravnoteže (MBU10 .642) najodgovorniji za postignute promjene. Pored navedene varijable statistički značajni doprinos u diskriminaciji učestvuju varijable za procjenu fleksibilnosti (MFBORA .421), segmentarne brzine donjih ekstremiteta (MTAPNZ .395), eksplozivne snage (MEBML .376), bočni raskorak (MFPRRA .293), test ravnoteže – stajanje na jednoj nozi uzdužnoj klupici sa zatvorenim očima (MBU1Z .235), iskret s palicom (MFISKR -.216) i koraci u stranu (MAGKUS -.214). Ostale varijable za procjenu motoričkih sposobnosti (taping rukom-MTAPRU, poligon natraške-MRPOLN, skok u dalj s mjesta-MFESDM, trčanje 20 m iz visokog starta-MFE2OV, taping nogom-MTAPNO, okret s palicom-MKOKSP, stajanje na dvije noge uzduž klupice za ravnotežu sa zatvorenim očima-MBAU2Z, sklekovi

eyes closed - SOTLABBWEC, knee push-ups - KNEEPU, half squats - HALFSQ, sit-ups - SITUPS) do not have a significant contribution, as their correlations with the discriminant function do not significantly contribute to the discrimination between the initial and final measurements.

Table 4. *Structure Matrix of the Isolated Discriminant Function of Motor Abilities*

	Function
	1
SOLABBWEO	.642
LATSPLIT	.421
FTATW	.395
MBTFSP	.376
FBISP	.293
SOLABBWEC	.235
TWIST	-.216
SIDEST	-.214

Additionally, group centroids (initial and final measurements) with significant discriminant functions were calculated (Table 5). Based on the standardized centroids, the effects of the six-month volleyball program on the motor abilities of the participants who train volleyball can be observed, particularly in terms of improvements in balance, explosive strength, flexibility, coordination, and the frequency of alternating movements. The positions of the centroids of the initial and final measurements indicate that, in this sample of participants, there are significant differences in motor abilities between the initial and final measurements.

Table 5. *Positions of Centroids*

	Function
	1
INITIAL	-.664
FINAL	.651

Discussion

Programmed training processes can produce qualitative and quantitative changes in the anthropological characteristics of participants involved in such treatments, provided that the selection of methods, content, workload, and organization of the training process are well adapted to age characteristics and individual abilities of each participant. Quantitative changes in certain segments of anthropological characteristics are crucial for determining the effectiveness of programmed training processes in sport, recreation, and physical education.

na koljenima-MRSSKL, polučučnjevi-MRPOČU, podizanje trupa-MRCDTZ) nemaju značajan doprinos, jer njihove korelacije sa sa diskriminativnom funkcijom nemaju značajan doprinos u diskriminaciji inicijalnog od finalnog mjerenja.

Tabela 4. *Matrica strukture izolovane diskriminativne funkcije motoričkih sposobnosti*

HANDTAP	.159
HALFSQ	-.151
STANDLJ	.115
20MRFHS	-.087
FOOTTAP	.086
AGWAS	-.084
SOTLABBWEC	.037
KNEEPU	-.025
HALFSQ	.011
SITUPS	-.008

Također, su izračunati i centroidi grupa (inicijalno i finalno mjerenje) sa značajnim diskriminativnim funkcijama (tabela5). Na osnovu standardizovanih centroida uočavaju se efekti djelovanja šestomjesečnog programa odbojke na motoričke sposobnosti ispitanica koje treniraju odbojku u smislu porasta ravnoteže, eksplozivne snage, fleksibilnosti, koordinacije i frekvencije alternativnih pokreta. Položaj centroida inicijalnog i finalnog mjerenja pokazuju kako na ovom uzorku ispitanica postoje značajne razlike u motoričkim sposobnostima na inicijalnom i finalnom mjerenju.

Tabela 5. *Položaji centroida*

Diskusija

Programirani trenažni procesi mogu proizvesti kvalitativne i kvantitativne promjene antropoloških odlika učesnika takvih tretmana pod uslovom da su izbor metoda, sadržaja, opterećenja i organizacija trenažnog rada dobro prilagođeni uzrasnim karakteristikama i individualnim sposobnostima svakog pojedinca. Kvantitativne promjene pojedinih segmenata antropoloških odlika ključne su za utvrđivanje efikasnosti programiranih trenažnih procesa u sportu, rekreaciji i tjelesnom odgoju. Upravo je cilj ovog istraživanja bio da se utvrde parcijalne i globalne kvantitativne promjene

The aim of this study was precisely to determine partial and global quantitative changes (differences) in motor abilities of young female volleyball players under the influence of a six-month experimental volleyball program.

Based on the obtained results, it can be concluded that between the two measurements (initial and final), during the implementation of the defined volleyball program, statistically significant quantitative changes occurred at both the partial and global levels. Based on the presented results, it can also be concluded that the volleyball program, through its content, selected methods, workload, and organization, had a favorable effect primarily on the improvement of balance, explosive strength, and flexibility, while having a much smaller effect on coordination and repetitive strength tests.

However, the observed changes in terms of increased levels of certain motor abilities in the final compared to the initial measurement can, in addition to the influence of the programmed training, also be attributed to endogenous factors originating from the organism itself, which significantly affect biological processes, growth, and development, considering that the participants are in a period of significant biological changes.

Previous research (Selmanović et al., 2008; Korjenić et al., 2012; Šmigalović et al., 2012; Bajrić et al., 2012, 2013, 2014; Nešić et al., 2013, 2014; Paz et al., 2016; Srdić et al., 2021; Galić et al., 2022, 2024; Stanković & Stratakis, 2024; Meašić, 2025), which examined changes (quantitative and qualitative) in certain segments of the anthropological status of subjects undergoing programmed kinesiological treatments, indicate that desired changes can be achieved provided that the programmed activities represent optimal stimuli well adapted to age characteristics and individual abilities and traits of each individual.

Korjenić et al. (2012) investigated the level of transformational effects on motor and situational-motor abilities of students aged 11 to 15 under the influence of programmed volleyball instruction within regular physical and health education classes in primary school. The results of discriminant analysis in the motor and situational-motor space indicate that programmed volleyball instruction had a favorable effect on global quantitative changes in situational-motor abilities, taking into account genetic predispositions and the adolescent developmental period of the studied sample.

Selmanović et al. (2008), on a sample of fifth-grade students, examined the effects of additional physical and health education classes within an experimental volleyball program compared to regular physical education

(razlike) motoričkih sposobnosti kod mladih odbojkašica pod uticajem šestomjesečnog eksperimentalnog programa odbojke. Na osnovu dobivenih rezultata može se konstatovati da je između dva mjerenja (na inicijalnom i finalnom mjerenju) u periodu realizacije definisanog programa odbojke došlo do statistički značajnih kvantitativnih promjena kako na parcijalnom tako i na globalnom nivou. Na osnovu prezentiranih rezultata možemo konstatovati da je program odbojke svojim sadržajem, odabranim metodama, opterećenjem i organizacijom rada povoljno djelovao u prvom redu na priraštaj ravnoteže, eksplozivne snage i fleksibilnosti, a vrlo malo na testove koordinacije i repetitvne snage.

Međutim, nastale promjene u smislu povećanja nivoa određenih motoričkih sposobnosti ispitanica na finalnom u odnosu na inicijalno mjerenje može se pored uticaja programiranog rada pripisati i uticaju endogenih faktora koji potiču iz samog organizma i značajno utiču na biološke procese, rast i razvoj obzirom da se ispitanice nalaze u periodu značajnih bioloških promjena.

Dosadašnja istraživanja (Selmanović i sar. 2008; Korjenić i sar., 2012; Šmigalović i sar., 2012; Malijević, 2012; Bajrić i sar., 2012, 2013, 2014; Nešić i sar., 2013; 2014; Paz i sar., 2016; Srdić i sar., 2021; Galić i sar., 2022, 2024; Stanković i Stratakis, 2024; Meašić, 2025) koja su se bavila utvrđivanjem promjena (kvantitativnih i kvalitativnih) pojedinih segmenata antropološkog statusa subjekata koji se podvrgavaju tretmanima programiranih kinezioloških aktivnosti pokazuju da je moguće postići željene promjene pod uslovom da programirane aktivnosti predstavljaju optimalne stimulanse koji su dobro prilagođeni uzrasnim karakteristikama i individualnim sposobnostima i osobinama svakog pojedinca.

Korjenić i sar. (2012) su utvrđivali nivo transformacionih efekata motoričkih i situacijsko-motoričkih sposobnosti učenika uzrasta od 11 do 15 godina, pod uticajem programirane nastave odbojke u okviru redovne nastave tjelesnog i zdravstvenog odgoja u osnovnoj školi. Rezultati diskriminativne analize u motoričkim i situaciono-motoričkom prostoru, ukazuju da je programirana nastava odbojke povoljno utjecala na globalne kvantitativne promjene situaciono-motoričkih sposobnosti, uvažavajući genetske predispozicije i period adolescentnog uzrasta istraživanog uzorka.

Selmanović i sar. (2008) su na uzorku učenika 5. razreda utvrđivali efekte dodatne nastave tjelesne i zdravstvene kulture u okviru eksperimentalnog programa odbojke u odnosu prema redovnoj nastavi tjelesne i zdravstvene kulture u mjerama za procjenu motoričkih obilježja. Autori ističu da je pod uticajem eksperimentalnog programa odbojke u okviru nastave tjelesne i zdravstvene kulture došlo do značajnih promjena u motoričkim sposobnostima ispitanika.

classes on measures of motor abilities. The authors emphasize that the experimental volleyball program led to significant changes in the motor abilities of the participants.

Šmigalović et al. (2012) conducted a study aimed at determining partial quantitative changes (differences) in basic and situational-motor abilities resulting from a three-month volleyball program among students aged 13–14 from the primary school "Tojšići," who participated in additional volleyball classes. The study applied 15 variables for assessing basic motor abilities and 5 variables for situational-motor abilities. To analyze differences between initial and final measurements, paired samples t-test results were used. Based on the obtained parameters, statistically significant positive changes (partial transformational quantitative effects) were identified in all applied variables in both basic and situational motor spaces, as a result of the applied volleyball program.

Bajrić et al. (2012) conducted a study on a sample of 73 seventh and eighth grade students from the primary school "Tojšići," who participated in a precisely defined volleyball program within additional classes, aiming to determine global quantitative changes in basic motor and situational-motor abilities. The study applied 15 variables for basic motor abilities and 5 variables for situational-motor abilities in volleyball. The results of canonical discriminant analysis indicate that the applied three month volleyball program led to statistically significant global quantitative changes (differences) in both basic and situational-motor ability spaces.

Stanković and Stratakis (2024), on a sample of 50 female volleyball players aged 12–15 from the DIF volleyball school, who trained four times per week for 90 minutes per session, examined differences in anthropometric characteristics and motor abilities before and after a continuous six-month training process. Motor abilities were assessed using tests for handgrip strength, hamstring flexibility, shoulder flexibility, explosive strength of the upper body, explosive strength of the legs (vertical jump), and agility. The results showed statistically significant differences in variables such as handgrip strength, trunk rotation with a stick, forward bend in sitting, and medicine ball throw. The authors emphasize that, despite the limitations of the study, the results provide a valuable basis for examining relationships between anthropometric parameters and motor knowledge, contributing to theoretical understanding in this field. Only well-dosed and properly organized physical activity can lead to improvements in young athletes' performance.

Meašić (2025), in her undergraduate thesis, ex-

Šmigalović i sar. (2012) su izvršili istraživanje s ciljem utvrđivanja parcijalnih kvantitativnih promjena (razlika) bazičnih i situaciono-motoričkih sposobnosti nastale pod uticajem tromjesečnog programa odbojke kod učenika uzrasta 13-14 godina, iz JU OŠ ,'Tojšići'', a koji su uključeni u dodatnu nastavu iz područja odbojkaške igre. U istraživanju je primijenjeno 15 varijabli za procjenu bazičnih motoričkih sposobnosti i 5 varijabli za procjenu situaciono-motoričkih sposobnosti. Za analizu eventualnih promjena (razlika) između inicijalnog i finalnog mjerenja bazičnih i situaciono-motoričkih sposobnosti primijenjeni su rezultati T-test za zavisne uzorke. Na osnovu dobijenih parametara testiranih T-testom utvrđeno je da su dobijene značajne pozitivne promjene (parcijalni transformacioni kvantitativni efekti) kod svih primijenjenih varijabli u prostoru bazične i situacione motorike, kao rezultat primijenjenog programa odbojke, a u okviru dodatne nastave.

Bajrić i sar. (2012) su izvršili istraživanje na uzorku od 73 učenika sedmih i osmih razreda Osnovne škole „Tojšići" koji su u sklopu dodatne nastave realizovali precizno definisani program odbojke s ciljem utvrđivanja globalnih kvantitativnih promjena bazičnih motoričkih i situaciono-motoričkih sposobnosti. U istraživanju je primijenjeno 15 varijabli za procjenu bazičnih motoričkih sposobnosti i 5 varijabli za procjenu situaciono-motoričkih sposobnosti iz odbojke. Rezultati kanoničke diskriminativne analize pokazuju da je pod uticajem primijenjenog tromjesečnog programa odbojke u okviru dodatne nastave došlo do statistički značajnih globalnih kvantitativnih promjena (razlika) u prostoru bazičnih i situaciono-motoričkih sposobnosti.

Stanković i Stratakis (2024) su na uzorku od 50 ispitanika – odbojkašica škole odbojke DIF uzrasta 12-15 godina, koje su trenirale odbojku četiri puta nedeljno i svaki trening je trajao 90 minuta, utvrđivali postojanje razlika u promjeni individualnih antropometrijskih karakteristika i motoričkih sposobnosti odbojkašica škole odbojke DIF, uzrasta 12-15 godina, koje su testirane prije i poslije kontinuiranog trenažnog procesa u trajanju od šest mjeseci. Za procenjene motoričke sposobnosti koristili su testove za procjenu jačine stiska šake, fleksibilnost mišića zadnje lože buta, fleksibilnost ramenog pojasa, eksplozivnost mišića ramenog pojasa, eksplozivnost mišića nogu (skok uvis) i agilnost. Dobiveni rezultati pokazuju statistički značajnu razliku u varijablama jačina stiska šake, iskret s palicom, pretklon u sjedu i bacanje medicinke. Autori ističu da uprkos ograničenjima ovog istraživanja, dobijeni rezultati mogu biti značajna inicijalna osnova za ispitivanje relacije antropometrijskih parametara i motoričkih znanja, što omogućava relevantan teorijski doprinos postojećim saznanjima u ovoj oblasti. Samo dobro dozirana i organizovana fizička aktivnost može dovesti do

amined the influence of a volleyball training program on the development of motor achievements in younger school-age children. The study was conducted at the primary school "Ivana Brlić-Mažuranić" in Ogulin, where the experimental group participated in a volleyball program lasting two and a half months, conducted three times per week for 45 minutes. The control group did not participate in the volleyball program but attended regular physical education classes. To monitor progress, four volleyball motor elements were assessed: underhand serve, overhead pass, overhead pass to a target, and forearm pass against a wall. The results of the final testing showed statistically significant differences in favor of the experimental group compared to the control group, indicating a positive effect of the programmed volleyball training on the development of children's motor performance. Based on the results, the author concludes that regular and professionally guided sports activity contributes to the development of specific motor knowledge and skills.

Limitations of the Study

The results of this study refer to the analyzed and relatively small sample of participants (N = 50), which limits the possibility of generalizing the obtained results to a broader population of young female volleyball players. Therefore, the results should be interpreted with a certain degree of caution when extending them beyond the analyzed sample.

Future research should include larger and more representative samples of a longitudinal nature in order to obtain a more comprehensive understanding of the effects of programmed kinesiological operators in volleyball training programs.

Despite this limitation, the results of the study clearly indicate that well-programmed volleyball training has the potential to significantly contribute to changes in the motor status of young female volleyball players.

Conclusion

The main objective of this study was to determine partial and global quantitative changes in the motor abilities of young female volleyball players who comprised the sample of this research. For this purpose, a set of eighteen motor tests hypothetically belonging to the dimensions of coordination, flexibility, frequency of alternating movements, explosive and repetitive strength, and balance was applied to a sample of 50 participants. To determine the effects of the six month volleyball training program on quantitative changes in motor abilities at both partial and global levels, the results of the paired samples t-test and

poboljšanja u rezultatima mladih sportista.

Meašić (2025) u svom diplomskom radu ispitivala je utjecaj programa treninga odbojke na razvoj motoričkih postignuća kod djece mlađe školske dobi. Istraživanje je provedeno u osnovnoj školi Ivane Brlić-Mažuranić u Ogulinu, gdje je eksperimentalna grupa učestvovala u odbojkaškom programu u trajanju od dva i pol mjeseca, koji se odvijao tri puta nedjeljno u trajanju od 45 minuta. Kontrolna grupa nije učestvovala u odbojkaškom programu, nego u redovnoj nastavi Tjelesne i zdravstvene kulture. U svrhu praćenja napretka, ispitivala su se četiri motorička elementa u odbojci: donji servis, vršno odbijanje iznad glave, vršno odbijanje u metu te podlaktično odbijanje u zid. Rezultati završnog testiranja pokazali su statistički značajne razlike u korist eksperimentalne grupe u odnosu na kontrolnu, što upućuje na pozitivan učinak programiranog odbojkaškog treninga na razvoj motoričkih postignuća djece. Na osnovu dobivenih rezultata autorica konstatuje da redovna i stručno vođena sportska aktivnost doprinosi razvoju specifičnih motoričkih znanja i vještina.

Ograničenja istraživanja

Rezultati ovog istraživanja odnose se na analizirani i relativno mali uzorak ispitanica (N = 50), što ograničava mogućnost generalizacije dobivenih rezultata na širu populaciju mladih odbojkašica. Zbog toga rezultate treba tumačiti s određenim oprezom pri njihovom proširivanju izvan analiziranog uzorka.

Buduća istraživanja trebala bi obuhvatiti veće i reprezentativnije uzorke longitudinalnog karaktera kako bi se dobila potpunija slika efekata programiranih kinezioloških operatora škole odbojke.

Uprkos navedenom ograničenju, rezultati istraživanja jasno pokazuju da dobro programirani trenažni rad odbojke ima potencijal da značajno doprinese promjenama motoričkog statusa mladih odbojkašica.

Zaključak

Osnovni cilj istraživanja bio je da se utvrde parcijalne i globalne kvantitativne promjene motoričkih sposobnosti mladih odbojkašica koje su činile uzorak ovog istraživanja. U tu svrhu na uzorku od 50 ispitanica mladih odbojkašica primijenjen je set od osamnaest motoričkih testova koje hipotetski pripadaju odgovarajućim dimenzijama koordinacije, fleksibilnosti, brzine alternativnih pokreta, eksplozivne i repetitivne snage i ravnoteže. Za utvrđivanje efekata šestomjesečnog programa rada odbojke koji se odražava na kvantitativne promjene motoričkih sposobnosti mladih odbojkašica na parcijalnom i globalnom nivou primijenjeni su rezultati t testa za zavisne uzorke i kanonička diskrimi-

canonical discriminant analysis were used.

The analysis of t-test results indicates that the six-month volleyball training program produced partial quantitative changes in eight out of the eighteen variables used to assess motor abilities. The most significant partial changes were observed in variables assessing balance standing on one leg along a balance bench with eyes open (SOLABBWEO-.000) and with eyes closed (SOLABBWEC-.001); flexibility forward bend in straddle position (FBISP-.058), trunk rotation (TWIST-.002), and lateral split (LATSPLIT-.007); coordination side steps (SIDEST-.002); movement frequency foot tapping against the wall (FOOTTAP-.011); and explosive strength - medicine ball throw from a supine position (MBTFSP-.016).

The results of canonical discriminant analysis indicate that significant changes in motor abilities occurred at the global level. The greatest contribution to the discriminant function - i.e., the difference between initial and final measurements - was made by the balance test (SOLABBWEO-.642), flexibility test (LATSPLIT-.421), movement frequency test (FTATW-.395), explosive strength test (MBTFSP-.376), flexibility test (FBISP-.293), and balance test (SOLABBWEC-.235). A statistically significant contribution with a negative sign was found for the flexibility variable TWIST (-.216) and the coordination variable SIDEST (-.214).

In general, the obtained results show that the defined six-month volleyball program produced significant quantitative changes in the motor abilities of young female volleyball players at both the partial and global levels. These findings indicate that experimental programs can lead to desired changes in motor abilities; however, it is essential that programmed activities represent optimal stimuli well adapted to the age characteristics and individual abilities of each participant.

The obtained results apply to the analyzed sample, and for broader generalization, a larger number of studies involving similar samples and a greater number of participants is required.

There is a lack of research of this type for this age group of female volleyball players, and such studies could provide a valuable foundation and stimulus for further research aimed at defining the structure of the motor space and determining possible relationships between motor abilities and other dimensions of the anthropological space across different age groups. Such findings could contribute to better selection processes and more effective planning and programming of training for young female volleyball players, taking into account individual characteristics and abilities at each developmental stage.

nativna analiza.

Analiza rezultata T testa pokazuje da je šestomjesečni program rada odbojke proizveo parcijalne kvantitativne promjene u osam od ukupno osamnaest varijabli za procjenu motoričkih sposobnosti. Najznačajnije parcijalne promjene su se desile kod varijabli za procjenu ravnoteže-stajanje na jednoj nozi uzdužno na klupici za ravnotežu s otvorenim očima (MBU1O .000 i stajanje na jednoj nozi uzdužno na klupici za ravnotežu s zatvorenim očima (MBU1Z .001), fleksibilnost-pretklon raznožno (MFPRRA .058), iskret (MFISKR .002 i bočni raskorak (MFBORA .007), koordinacija-koraci u stranu (MAGKUS .002), frekvencija pokreta-taping nogom o zid (MTANOZ .011) i eksplozivna snaga-bacanje medicinke iz ležanja na leđima (MFEBML .016).

Rezultati kanoničke diskriminativne analize pokazuju da je došlo do značajnih promjena motoričkih sposobnosti ispitanica na globalnom nivou a najveći doprinos diskriminativnoj funkciji tj. razlici između inicijalnog i finalnog mjerenja motoričkih sposobnosti ispitanica ima test za procjenu ravnoteže-MBAU10 .642, test fleksibilnosti-MFBORA .421; test brzine frekvencije pokreta (MTAPNZ .395), test eksplozivne snage-MFEBML .376; test fleksibilnosti-MFPRRA .293) i test ravnoteže-MBAU1Z .235. Statistički značajan doprinos diskriminativnoj funkciji sa negativnim predznakom ima varijabla fleksibilnosti MFISKR -.216 i varijabla koordinacije-MAGKUS -.214.

Generalno, dobiveni rezultati pokazuju da je definisani program odbojke u trajanju šest mjeseci proizveo značajne kvantitativne promjene motoričkih sposobnosti mladih odbojkašica kako na parcijalnom tako i na globalnom nivou. Dobiveni rezultati upućuju na činjenicu da eksperimentalni programi mogu proizvesti željene promjene motoričkih sposobnosti ispitanica ali se mora voditi računa da programirane aktivnosti predstavljaju optimalne stimulanse dobro prilagođeni uzrasnim karakteristikama i individualnim sposobnostima svakog pojedinca. Dobiveni rezultati se odnose na tretirani uzorak ispitanica a za generalizaciju rezultata potrebno je izvršiti veći broj istraživanja koji bi podrazumijeva ovaj ili sličan uzorak i veći broj ispitanica.

Ovakvih istraživanja na ovom uzrastu djevojčica u odbojci nema dovoljno, te bi mogli predstavljati dobru osnovu i poticaj drugim istraživačima za istraživanje i definisanje strukture motoričkog prostora i utvrđivanje mogućih odnosa motoričkih sposobnosti sa drugim dimenzijama antropološkog prostora kod ispitanica različite uzrasne dobi. Svakako da bi takvi rezultati mogli doprinijeti boljoj selekciji i kvalitetnijem planiranju i programiranju trenažnog rada sa mladim odbojkašicama uvažavajući individualne karakteristike i sposobnosti za svaku uzrasnu dob ispitanica.

References

Bajrić, O., Bajrić, S., Bašinac, I., & Kovač, R. (2013). Latent structure of morphological characteristics of female handball school participants. In O. Bajrić & V. Srdić (Eds.), *III International Conference "Sports Science and Health"* (pp. 53–60). Banja Luka: Pan-European University Apeiron.

Bajrić, O., Šmigalović, M., Bašinac, I., & Bajrić, S. (2012). Global quantitative changes in basic and situational motor abilities under the influence of a volleyball program. *Sports Science and Health*, pp. 22–28. Banja Luka: Pan-European University "Apeiron." [in Serbian]

Bajrić, O., Bajrić, S., & Lolić, V. (2014). *Volleyball in Theory and Practice*. Banja Luka: Pan-European University "Apeiron."

Bajrić, O., & Bašinac, I. (2020). *Methodology of Physical Education*. Banja Luka: Pan-European University "Apeiron."

Galić, M., Korjenić, A., Vučinić, A., & Kukić, A. (2024). Analysis of quantitative changes in the space of motor abilities among young female basketball players. In O. Bajrić & V. Srdić (Eds.), *XIV International Conference "Sports Science and Health"* (pp. 79–87). Banja Luka: Pan-European University Apeiron. [in Serbian]

Korjenić, A., Jelčić, M., Bašinac, I., & Begović, D. (2012). Effects of programmed volleyball instruction on the level of motor abilities and acquisition of volleyball elements. *Sports Science and Health*, 2(2), 93–99.

Kurelić, N., Momirović, K., Stojanović, M., Šturm, J., Radojević, Đ., & Štalec-Viskić, N. (1975). *Structure and Development of Morphological and Motor Dimensions of Youth*. Belgrade: Institute for Scientific Research, Faculty of Physical Education, University of Belgrade.

Kukec, E. (2023). The relationship between a two-month volleyball training program and the development of motor abilities in younger children. Master's thesis. Josip Juraj Strossmayer University of Osijek, Faculty of Dental Medicine and Health Osijek.

Mahmutspahić, A. (2013). Methodology of learning basic technical-tactical elements in volleyball. [Master's thesis]. Pan-European University "Apeiron," Banja Luka.

Meašić, K. (2025). Volleyball in the function of improving motor achievements of early school-age children. Master's thesis. University of Rijeka, Faculty of Teacher Education.

Mikić, B., Tanović, I., & Hodžić, Z. (2009). Component analysis of the structure of morphological, motor, and specific motor space in young female handball players aged 10–12. In A. Biberović (Ed.), *II International Symposium Sport and Health* (pp. 155–161). Tuzla: Faculty of Physical Education and Sport.

Nešić, G., Ilić, D., Majstorović, N., Grbić, V., & Osmankač, N. (2013). Training effects on general and specific motor skills in female volleyball players aged 13–14. *Sport Logia*, 9(2), 201.

Nešić, G., Majstorović, N., Osmankač, N., Milenkoski, J., & Serdar, U. S. L. U. (2014). Differences in anthropometric characteristics and motor abilities between volleyball players and untrained boys aged 17. *International Journal of Sport Culture and Science*, 2(4), 103–109.

Paz, G. A., Gabbett, T. J., Maia, M. F., Santana, H., Miranda, H., & Lima, V. (2016). Physical performance and positional differences among young female volleyball players. *The Journal of Sports Medicine and Physical Fitness*, 57(10), 1282–1289.

Sekulić, D., & Matikoš, D. (2007). *Fundamentals of Transformational Processes in Kinesiology*. Split: Faculty of Natural Sciences, Mathematics and Kinesiology.

Selmanović, A., Milanović, L., & Hrženjak, M. (2008). Analysis of the influence of an additional volleyball program on changes in variables for assessing motor abilities of fifth-grade primary school students. In *Current State and Perspectives of Development in Education, Sport, Sports Recreation and Kinesiotherapy* (pp. 184–191). Zagreb: Croatian Kinesiology Association (HKS).

Srdić, V. (2012). Effects of transformational processes in junior dance. [Doctoral dissertation]. Pan-European University Apeiron, Banja Luka.

Srdić, V., Jeličić, B., Bajrić, S., & Hasić, A. (2021). Changes in motor abilities under the influence of an additional physical education program. In O. Bajrić & V. Srdić (Eds.), *XI International Conference "Sports Science and Health"* (pp. 91–100). Banja Luka: Pan-European University "Apeiron." [in Serbian]

Srdić, V., Bajrić, O., Bajrić, S., & Ilić, N. (2023). *Theory and Methodology of Sports Training*. Banja Luka: Pan-European University Apeiron.

Stanković, D., & Stratakis, K. (2024). The effect of a six-month training process on the anthropological status of female cadet volleyball players. *Sports Science and Health*, 14(V), 26–33.

Šmigalović, M., Bajrić, O., & Lolić, D. (2012). The influence of a volleyball program on basic and situational motor abilities of students aged 13–14. *Sports Science and Health*.

Primljen: 28. januar 2026. / Received: Januar 28, 2026
Prihvaćen: 25. april 2026. / Accepted: April 25, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601092K
UDC: 796.012.1-057.874:37.014.12
Original scientific paper
Originalni naučni rad

Differences in the Effect of Regular and Specially Programmed Physical and Health Education on the Motor Status of Students

Razlike u uticaju redovne i posebno programirane nastave tjelesnog i zdravstvenog odgoja na motorički status učenika

Almir Kalabušić[1], Amela Bajrektarević[1], Elvira Nikšić[2], Faris Rašidagić[3]

[1]PhD student at the University of Sarajevo - Faculty of Sport and Physical Education, Sarajevo, Bosnia and Herzegovina
[2]University of Sarajevo - Faculty of Education, Sarajevo, Bosnia and Herzegovina
[3]University of Sarajevo - Faculty of Sport and Physical Education, Sarajevo, Bosnia and Herzegovina

Correspondence:
Elvira Nikšić
University of Sarajevo - Faculty of Education, Sarajevo, Bosnia and Herzegovina
elvira.beganovic1982@gmail.com

[1]Student trećeg ciklusa na Univerzitetu u Sarajevu - Fakultetu sporta i tjelesnog odgoja, Sarajevo, Bosna i Hercegovina
[2]Univerzitet u Sarajevu – Pedagoški fakultet, Sarajevo, Bosna i Hercegovina
[3] Univerzitet u Sarajevu - Fakultet sporta i tjelesnog odgoja, Sarajevo, Bosna i Hercegovina

Korespondencija:
Elvira Beganović
Univerzitet u Sarajevu – Pedagoški fakultet, Sarajevo, Bosna i Hercegovina
elvira.beganovic1982@gmail.com

Abstract: *The aim of this study was to examine and compare the effects of regular and specially programmed Physical and Health Education on the transformation of basic motor and situational–motor abilities of sixth-grade primary school students. In the motor domain, 15 variables were observed, and in the situational–motor domain 6 representative variables were analyzed. The sample included 106 students divided into the control group (53 students) and the experimental group (53 students). Students were male and female, aged 12 ± 6 months. The control group followed the regular curriculum, while the experimental group participated in an intensive program of sports games—basketball, volleyball, and handball. The program lasted one school semester. Descriptive statistical methods showed a normal distribution of data for both motor and situational–motor variables. An independent-samples t-test showed that, initially, the control group had an advantage only in the variable MTAPNO within the motor domain. In the situational–motor domain, the experimental group initially demonstrated better abilities in the variables OKVLS, ORBLZ, and ORVLS. After the implementation of the programs, the final t-test in the motor domain did not record statistically significant differences between the groups. In the situational–motor domain at the final measurement, the experimental group showed higher t-test values for the variables OKVLS, OLPKS, ORBLZ, and ORISE, while the control group had higher t-test values for the variable OKBLK. Conclusion: It cannot be stated with certainty that the specially designed instructional program had a significant effect on improving the motor and/or situational–motor abilities of the students in the experimental group.*

Keywords: *Physical and Health Education, Control*

Sažetak: *Cilj ovog istraživanja bio je ispitati i uporediti efekte redovne nastave i posebno programirane nastave tjelesnog i zdravstvenog odgoja na transformaciju bazično- motoričkih i situaciono-motoričkih sposobnosti učenika VI razreda osnovne škole. U motoričkom prostoru posmatrano je 15 varijabli a u situaciono- motoričkom 6 varijabli predstavnika prostora. U uzorku ispitanika bilo je 106 učenika podjeljenih u kontrolnu grupu (53 učenika) i eksperimentalnu grupu (53 učenika). Učenici su bili muškog i ženskog spola, starosti 12 godina +/- 6 mjeseci. Kontrolna grupa realizovala je nastavne sadržaje u skladu sa radovnim nastavnim planom i programom rada, dok je eksperimentalna grupa bila podvrgnuta intenzivnom programu sportskih igara- košarka, odbojka i rukomet. Trajanje pograma bilo je jedno školsko polugodište. Deskriptivno- statistički metod pokazao je normalnu distribuciju podataka i za motoričke i za situaciono-motoričke varijable. T- test za nezavisne uzorke pokazao je da je incijalno, u motoričkom prostoru, prednost uočena kod kontrolne grupe samo za varijablu MTAPNO. U situaciono-motoričkom prostoru inicijalno je evidentirana bolja sposobnost eksperimentalne grupe za varijable OKVLS, ORBLZ i ORVLS. Nakon provedenih programa rada, finalno primjenjeni T- test u prostoru motorike, nije zabilježio statistički značajne razlike između grupa. U okviru situaciono- motoričkog prostora, kod finalnog mjerenja, Eksperimentalna grupa ima veće vrijednosti T- testa za varijable: OKVLS, OLPKS, ORBLZ, i ORISE, dok kontrolna grupa ima veću vrijednost T- testa za varijablu OKBLK. Zaključak: Ne može se sa sigurnošću zaključiti da je posebno dizajnirani program nastave značajno uticao na povećanje motoričkih i/ili situaciono- motoričkih sposobnosti učenika i učenica eksperimentalne grupe.*

Ključne reči: *Nastava tjelesnog i zdravstvenog odgo-*

group, Experimental group, Basic motor skills, Situational motor skills, t-test

Introduction

The development of motor abilities in school-aged children represents a foundation for healthy physical, psychological, and social growth. Motor abilities are shaped through basic motor components (such as strength, speed, agility, endurance, and coordination), while situational–motor abilities include the application of motor skills in sports games, interactive situations, and changing conditions (Metikoš et al., 1990). Regular Physical and Health Education plays a clear role in promoting physical activity, health, and socio-emotional development; however, the question increasingly arises whether specially programmed instruction (modified or expanded curricula, experimental programs, additional activities) may have a greater impact on the transformation of basic motor and situational–motor abilities, especially in sixth-grade students (Kovač et al., 2007).

Transformational processes depend on several interconnected factors, such as: accurate assessment of the subject's initial status within the observed domain and the formation of relatively homogeneous groups; planning and programming instructional content aligned with students' abilities, interests, and available resources; defining exercise methods for developing anthropological characteristics and learning methods for acquiring technical–tactical skills; determining organizational forms of work (individual, group, or frontal); establishing the final status of anthropological characteristics and technical–tactical knowledge; and adjusting the transformational program based on transitional measurements. It has been confirmed that specific exercise processes significantly influence changes in various human traits, abilities, and skills. However, the key question remains: "How much, what, and how should one exercise for changes to occur, and how can variability in quantitative and qualitative terms be controlled?" (Rađo, 1998). In both European and Balkan contexts, evidence suggests that such modified programs may produce better outcomes. For example, a study by Badrić, Sporiš, and Krističević (2014), involving 434 students from primary schools in Sisak and Petrinja, showed that more physically active students achieved significantly better results in motor tests (strength, agility, coordination) compared to less active peers. Additionally, Jakovljević (2015) found that the intensity of leisure-time physical activity correlates with better motor development in primary school children. In research examining the effects of sports programs on mo-

ja, Kontrolna grupa, Eksperimentalna grupa, Bazična motorika, Situaciona motorika, T – test

Uvod

Razvoj motoričkih sposobnosti kod djece školske dobi predstavlja temelj za zdrav fizički, psihički i socijalni rast. Motoričke sposobnosti se uobličavaju kroz bazično- motoričke sposobnosti (kao što su snaga, brzina, agilnost, izdržljivost, koordinacija) a situaciono-motoričke sposobnosti uključuju primjenu situaciono- motoričkih vještina u sportskim igrama, situacijama interakcije i promjenjivih uslova (Metikoš i saradnici, 1990.). Redovna nastava Tjelesnog i zdravstvenog odgoja ima jasnu ulogu u promociji tjelesog vježbanja, zdravlja i socio- emocionalnog razvoja učenika, ali se sve češće postavlja pitanje da li posebno programirana nastava (modifikovani ili prošireni program, eksperimentalni kurikulum, dodatne aktivnosti) može imati veći uticaj na transformaciju bazično- motoričkih i situaciono-motoričkih sposobnosti, naročito kod učenika VI razreda osnovne škole (Kovač i saradnici, 2007.). Transformacijski procesi sistema zavise od nekoliko faktora, koji su međusobno povezani kao npr: tačno utvrđivanje (procjena) stanja subjekta u prostoru koji se istražuje i formiranje relativno homogenih grupa; planiranje i programiranje sadržaja nastavnog procesa, a koji su u skladu sa mogućnostima učenika, interesima učenika i sredstvima kojima se raspolaže; određivanje metoda vježbanja za razvoj antropo1oških karakteristika i metoda učenja pri usvajanju i uvježbavanju tehničko- taktičkih znanja; utvrđivanje organizacijskih oblika rada (individualni, grupni i frontalni); određivanje organizacijskih oblika rada; utvrđivanje finalnog stanja antropoloških karakteristika i tehničko- taktičkih znanja subjekta; korekcije transformacijskih programa preko tranzitivnih mjerenja i drugo. Potvrđeno je da se određenim procesima vježbanja začajno utječe na promjene različitih ljudskih osobina, sposobnosti i znanja. Ali, uvijek je aktuelno pitanje:" Koliko, šta i kako vježbati da bi promjene uslijedile, te kako kontolirati promjenjivost u kvantitativnom i kvalitativnom smislu" (Rađo, 1998.). U europskom i balkanskom kontekstu postoje indicije da takvi modificirani programi mogu dati bolje efekte. Na primjer, u istraživanju koje su proveli Badrić, Sporiš i Krističević (2014), koje je obuhvatilo 434 učenika osnovnih škola u Sisku i Petrinji, pokazano je da učenici koji su aktivniji u slobodno vrijeme ostvaruju značajno bolje rezultate u motoričkim testovima (snaga, agilnost, koordinacija) nego manje aktivni učenici. Također, u istraživanju koje je proučavalo relacije između motoričkih sposobnosti i tjelesne aktivnosti učenika, Jakovljević (2015) utvrđeno je da intenzitet aktivnosti u slobodno vrijeme ima korelaciju s boljim razvojem motoričkih sposobnosti kod djece u osnovnoj

tor abilities in preschoolers, Badrić, Prskalo, & Sporiš (2015) demonstrated that controlled sports activities positively influence explosive strength, coordination, and speed in preschool-aged children. The aim of this study was to "examine and compare the effects of regular and specially programmed Physical and Health Education on the transformation of basic motor and situational–motor abilities of sixth-grade primary school students."

Methods of Work

Participants

The study included 106 primary school students. Students were divided into a control group (53 students) following the regular curriculum and an experimental group (53 students) participating in specially programmed activities. Both groups included male and female students to ensure realistic and representative results, as school classes typically consist of mixed-gender students. The students were 12 ± 6 months old. Students who were actively involved in training processes of any sport were excluded from the study. Proper consents were obtained for all measurements and testing procedures.

Instruments

The selection of variables was based on their measurement characteristics: validity, reliability, sensitivity, economy, and appropriateness for the age of the participants (Mikić, 1999). A set of 15 motor tests and 9 situational–motor tests in sports games was applied to the sample.

školi. U radu o utjecaju sportskog programa na motoričke sposobnosti kod predškolaca, Badrić, Prskalo, & Sporiš, (2015) su dokazali da kontrolirane sportske aktivnosti pozitivno utječu na razvoj eksplozivne snage, koordinacije i brzine kod djece predškolske dobi. Cilj ovog istraživanja je bio „ispitati i uporediti efekte redovne nastave i posebno programirane nastave tjelesnog i zdravstvenog odgoja na transformaciju bazično- motoričkih i situaciono-motoričkih sposobnosti učenika VI razreda osnovneškole".

Metode rada

Učesnici

Istraživanje je uključivalo 106 učenika iz osnovne škole. Učenici su bili podjeljenih u kontrolnu grupu (53 učenika i učenice) koja je provodila redovni nastavni program i eksperimentalnu grupu (53 učenika i učenice) koja je provodila posebno programirane aktivnosti. Grupe su ciljano u sastavu imali učenike i učenice, kako bi istraživaje ponudilo što realnije podatke, obzirom da su školska odjeljenja mješovitog sastava. Starost učenika bila je 12 godina +/- 6 mjeseci. U istraživanju nisu učestvovali učenici i učenice koji su dodatno uključeni u trenažni proces bilo kojeg sporta. Za sva mjerenja i testiranja obezbijeđene su odgovarajuće saglasnosti.

Instrumenti

Izbor varijabli za ovo istraživanje izvršen je na osnovu njihovih mjernih karakteristika; validnosti, pouzdanosti, osjetljivosti, ekonomičnosti te prilagodljivosti i prikladnosti uzrastu ispitanika (Mikić, 1999.). Na uzorak je bio primjenjen sistem od 15 motoričkih testova i 9 testova za procjenu situacijske motorike u sportskim igrama.

Table 1. *Tests/Variables for Assessing Motor Abilities*

Tabela 1. *Testovi/varijable za procjenu motoričkih sposobnosti*

For assessing movement frequency: / Za procjenu frekvencije pokreta:	*Hand tapping* / Taping rukom	MTAPRU
	Foot tapping / Taping nogom	MTAPNU
	Foot tapping against the wall / Taping nogama o zid	MTAPNZ
For assessing flexibility: / Za procjenu fleksibilnosti:	*Stick rotation* / Iskret palicom	MFLISK
	Sitting reach / Dohvat u sjedu	MBFDSD
	Forward bend to the right / Pretklon desno	MPREDE
For assessing explosive strength: / Za procjenu eksplozivne snage:	*Standing long jump* / Skok udalj iz mjesta	MFESDM
	Standing vertical jump / Skok uvis iz mjesta	MFESUM
	20m sprint from high start / Sprint iz visokog starta 20m	MFE2OV
For assessing repetitive strength: / Za procjenu repetativne snage:	*Sit-up test* / Test ležanje-sijed	MRCLDM
	Squats for 40 seconds / Test čučnjevi za 40 sekundi	MFRDCU
	Push-ups / Sklekovi	MFRSKL
For assessing coordination: / Za procjenu koordinacije:	*Side steps* / Koraci ustranu	MAGKUS
	Envelope test / Koverta test	MAGTUP
	Backward obstacle course / Poligon natraške	MRGEPO

Table 2. *Tests/Variables for Assessing Situational-Motor Abilities*

Tabela 2. *Testovi/varijable za procjenu situaciono-motoričkih sposobnosti*

Basketball / Košarka	*Throwing the ball with both hands against the wall and catching it for 30 seconds* / Bacanje lopte objema rukama o zid i hvatanje u trajanju 30 sekundi	OKBLR
	Dribbling the ball in a slalom / Vođenje lopte rukom u slalomu	OKVLS
	Throwing the ball into the basket for 30 seconds / Bacanje lopte u koš u trajanju 30 sekundi	OKBLK
Volleyball / Odbojka	*Underhand serve* / Servis donji čeoni	OSDCE
	Hitting a target over the net from the basic stance / Gađanje cilja preko mreže iz osnovnog stava	OGCPM
	Forearm passing in a circle for 30 seconds / Odbijanje podlakticama u krugu za 30 sekundi	OLPKS
Handball / Rukomet	*Throwing the ball against the wall for 30 seconds* / Bacanje lopte o zid u trajanju 30 sekundi	ORBLZ
	Dribbling the ball in a slalom / Vođenje lopte u slalomu	ORVLS
	Performing seven-meter throws / Izvođenje sedmeraca	ORISE

Description of Measurement

The students performed the tests dressed in appropriate sportswear and in a well-ventilated large indoor space – the school gym. The measuring instruments (stopwatches, balls) used for recording the results were of standard manufacture. Prior to the start of measurement, the functionality of the instruments was checked. The participants were familiarized with the tests for assessing motor and situational-motor abilities before testing, in order to ensure maximum objectivity (Hadžikadunić et al., 2000; Šoše & Rađo, 1998). All measurements were conducted by the same evaluator. The measurements were carried out at the beginning (initial measurement) and at the end of the four-month program (final measurement). Parents of the participants provided the required consent prior to testing.

Statistical Analysis

The statistical methods used in this study included descriptive statistical analysis and independent samples t-tests. The descriptive statistical measures included the mean value (M), which reflects the average results, and the standard deviation (SD), which indicates the extent of deviation from the norm and highlights the level of variability among participants. Independent samples t-tests were applied at both the initial and final measurements to determine differences between groups and to assess the effects of the implemented programs.

Opis mjerenja

Učenici su izvodili testove, obučeni u adekvatnu opremu i u dobro prozračenoj velikoj prostoriji - školskoj sali. Instrumentarij za mjerenje (štoperice, lopte) korišteni za evidentiranje rezultata bili su standardne izrade. Prije početka mjerenja kontrolisana je ispravnost instrumenata. Sa testovima za procjenu motoričkih i situaciono – motoričkih sposobnosti, ispitanici su upoznati prije testiranja, kako bi test bio što je moguće objektivniji (Hadžikadunić i saradnici, 2000; Šoše & Rađo, 1998.). Mjerenje je uvijek izvodio isti mjerioc. Mjerenja su se obavljala na početku (inicijalno mjerenje) i na kraju četveromjesečnog programa (finalno mjerenje). Roditelji ispitanika su prije provođenja testiranja, dali odgovarajuće saglasnosti.

Statistička analiza

Statističke metode korištene u ovom istraživanju su deskriptivno statistička analiza i T- testovi za nezavisne uzorke. Deskriptivne statističke mjere su uključivale srednju vrijednost (M) koja odražava prosječne rezultate i standardnu devijacija (SD) koja otkriva stepen odstupanja od normale i ističe nivo varijabilnosti između učesnika. T- testovi za nezavisne uzorke primjenjeni su pri inicijalnom i finalnom mjerenju za utvrđivanje razlika između grupa, te utvrđivanje efekata provedenih programa.

Results

Table 3. *Descriptive statistics – Mean values and standard deviations at the INITIAL measurement of motor abilities*

Rezultati

Tabela 3. *Deskriptivna statisatika- Vrijednosti aritmetičkih sredina i standardnih devijacija pri INICIJALNOM mjerenju motoričkih sposobnosti*

Variables / Varijable	*Group /* Grupa	*N*	*Mean*	*Std. Deviation*	*Std. Error Mean*
MTAPRU	1	53.00	27.30	2.74	.38
	2	53.00	28.09	4.01	.55
MTAPNO	1	53.00	24.57	2.79	.38
	2	53.00	22.66	2.71	.37
MTAPNZ	1	53.00	18.74	2.25	.31
	2	53.00	19.36	3.26	.45
MFLISK	1	53.00	71.89	15.91	2.19
	2	53.00	74.57	18.63	2.56
MBFDSD	1	53.00	21.30	7.83	1.08
	2	53.00	19.38	7.06	.97
MPREDE	1	53.00	42.17	11.35	1.56
	2	53.00	42.36	9.91	1.36
MFESDM	1	53.00	147.17	24.91	3.42
	2	53.00	148.68	25.06	3.44
MFESUM	1	53.00	26.72	5.22	.72
	2	53.00	26.49	5.57	.77
MFE20V	1	53.00	4.31	.41	.06
	2	53.00	4.41	.55	.08
MRCLDM	1	53.00	20.60	4.03	.55
	2	53.00	21.42	4.77	.66
MFRDCU	1	53.00	31.25	5.57	.77
	2	53.00	29.72	7.60	1.04
MFRSKL	1	53.00	8.21	8.78	1.21
	2	53.00	11.04	9.86	1.35
MAGKUS	1	53.00	12.87	1.17	.16
	2	53.00	13.04	1.61	.22
MAGTUP	1	53.00	31.18	2.73	.37
	2	53.00	32.17	4.02	.55
MRGEPO	1	53.00	22.82	6.52	.90
	2	53.00	22.08	6.57	.90

Legend: MTAPRU – Hand tapping; MTAPNO – Foot tapping; MTAPNZ – Foot tapping against a wall; MFLISK – Stick rotation; MBFDSD – Sit-and-reach test; MPREDE – Side bend to the right; MFESDM – Standing long jump; MFESUM – Standing vertical jump; MFE20V – 20 m sprint from a standing start; MRCLDM – Sit-ups test; MFRDCU – Squats for 40 seconds; MFRSKL – Push-ups; MAGKUS – Side steps; MAGTUP – Envelope (agility) test; MRGEPO – Backward obstacle course; Group – classification of participants according to experimental conditions; N – number of participants; Mean – arithmetic mean; Std. Deviation – standard deviation; Std. Error Mean – standard error of the mean

Legenda: MTAPRU – Taping rukom; MTAPNO – Taping nogom; MTAPNZ – Taping nogama o zid; MFLISK – Iskret palicom; MBFDSD – Dohvat u sjedu; MPREDE – Pretklon desno; MFESDM – Skok udalj iz mjesta; MFESUM – Skok uvis iz mjesta; MFE20V – Sprint iz visokog starta 20m; MRCLDM – Test ležanje – sijed; MFRDCU – Test čučnjevi za 40 sekundi; MFRSKL – Sklekovi; MAGKUS – Koraci u stranu; MAGTUP – Koverta test; MRGEPO – Poligon natraške; Grupa – podjela ispitanika prema eksperimentalnim uslovima; N – broj ispitanika; Mean – aritmetička sredina; Std. Deviation – standardna devijacija; Std. Error Mean – standardna greška aritmetičke sredine

Table 4. *T-test Values for the INITIAL Measurement of Motor Skills*

Tabela 4. *Vrijednosti T- testa pri INICIJALNOM mjerenju motoričkih sposobnosti*

VARIABLES	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
MTAPRU	7.47	0.01	-1.19	104.00	0.24	-0.79	0.67	-2.12	0.53
			-1.19	91.91	0.24	-0.79	0.67	-2.12	0.53
MTAPNO	0.05	0.83	3.57	104.00	0.00	1.91	0.53	0.85	2.97
			3.57	103.91	0.00	1.91	0.53	0.85	2.97
MTAPNZ	4.77	0.03	-1.15	104.00	0.25	-0.62	0.54	-1.70	0.46
			-1.15	92.31	0.26	-0.62	0.54	-1.70	0.46
MFLISK	1.75	0.19	-0.80	104.00	0.43	-2.68	3.36	-9.35	3.99
			-0.80	101.52	0.43	-2.68	3.36	-9.35	4.00
MBFDSD	0.12	0.73	1.33	104.00	0.19	1.92	1.45	-0.95	4.80
			1.33	102.89	0.19	1.92	1.45	-0.95	4.80
MPREDE	0.48	0.49	-0.09	104.00	0.93	-0.19	2.07	-4.29	3.92
			-0.09	102.15	0.93	-0.19	2.07	-4.29	3.92
MFESDM	0.11	0.74	-0.31	104.00	0.76	-1.51	4.85	-11.13	8.12
			-0.31	104.00	0.76	-1.51	4.85	-11.13	8.12
MFESUM	0.00	0.98	0.22	104.00	0.83	0.23	1.05	-1.85	2.31
			0.22	103.56	0.83	0.23	1.05	-1.85	2.31
MFE20V	3.13	0.08	-1.07	104.00	0.29	-0.10	0.09	-0.29	0.09
			-1.07	95.61	0.29	-0.10	0.09	-0.29	0.09
MRCLDM	0.21	0.65	-0.95	104.00	0.35	-0.81	0.86	-2.51	0.89
			-0.95	101.18	0.35	-0.81	0.86	-2.51	0.89
MFRDCU	2.85	0.09	1.18	104.00	0.24	1.53	1.29	-1.04	4.10
			1.18	95.34	0.24	1.53	1.29	-1.04	4.10
MFRSKL	0.66	0.42	-1.56	104.00	0.12	-2.83	1.81	-6.43	0.77
			-1.56	102.62	0.12	-2.83	1.81	-6.43	0.77
MAGKUS	5.83	0.02	-0.62	104.00	0.53	-0.17	0.27	-0.71	0.37
			-0.62	95.06	0.53	-0.17	0.27	-0.71	0.37
MAGTUP	7.20	0.01	-1.48	104.00	0.14	-0.99	0.67	-2.31	0.34
			-1.48	91.48	0.14	-0.99	0.67	-2.31	0.34
MRGEPO	0.01	0.92	0.58	104.00	0.57	0.73	1.27	-1.79	3.26
			0.58	103.99	0.57	0.73	1.27	-1.79	3.26

Legend: MTAPRU – Hand tapping; MTAPNO – Foot tapping; MTAPNZ – Foot tapping against a wall; MFLISK – Stick rotation; MBFDSD – Sit-and-reach test; MPREDE – Side bend to the right; MFESDM – Standing long jump; MFESUM – Standing vertical jump; MFE20V – 20 m sprint from a standing start; MRCLDM – Sit-ups test; MFRDCU – Squats for 40 seconds; MFRSKL – Push-ups; MAGKUS – Side steps; MAGTUP – Envelope (agility) test; MRGEPO – Backward obstacle course; F – value of Levene's test for assessing equality of variances; Sig. – level of statistical significance; t – value of Student's t-test; df – degrees of freedom; Sig. (2-tailed) – two-tailed p-value of statistical significance; Mean Difference – difference between arithmetic means; Std. Error Difference – standard error of the difference; 95% Confidence Interval of the Difference (Lower–Upper) – confidence interval of the difference between means

Legenda: MTAPRU – Taping rukom; MTAPNO – Taping nogom; MTAPNZ – Taping nogama o zid; MFLISK – Iskret palicom; MBFDSD – Dohvat u sjedu; MPREDE – Pretklon desno; MFESDM – Skok udalj iz mjesta; MFESUM – Skok uvis iz mjesta; MFE20V – Sprint iz visokog starta 20m; MRCLDM – Test ležanje – sijed; MFRDCU – Test čučnjevi za 40 sekundi; MFRSKL – Sklekovi; MAGKUS – Koraci u stranu; MAGTUP – Koverta test; MRGEPO – Poligon natraške; F – vrijednost Leveneov test za procjenu jednakosti varijansi; Sig. – nivo statističke značajnosti; t – vrijednost Studentov t-test; df – stepeni slobode; Sig. (2-tailed) – dvosmjerna p-vrijednost statističke značajnosti; Mean Difference – razlika između aritmetičkih sredina; Std. Error Difference – standardna greška razlike; 95% Confidence Interval of the Difference (Lower–Upper) – interval pouzdanosti razlike između sredina

Table 3 presents the mean values and measures of dispersion of the results in the basic motor domain for participants in the control and experimental groups during the initial measurement. Although differences in results between the groups can be observed, they were only confirmed at the descriptive level. It can be stated that the differences in the mean values of the groups are small, which cannot be said for the differences between standard deviations. The results from Table 4 show that the groups differ in the basic motor domain during the initial measurement only in the variable MTAPNO (assessment of lower limb movement frequency). When comparing the mean values (24.57 / 22.66), an advantage can be observed for the control group participants compared to the experimental group participants. The T-test values are at the significance level (.00 / .00).

U tabeli 3 prikazane su prosječne vrijednosti i mjere odstupanja rezultata u bazično motoričkom prostoru ispitanika kontrolne i eksperimentalne grupe u inicijalnom mjerenju. Iako se mogu primjetiti razlike u rezultatima između grupa, tek su potvrđene na deskriptivnom nivou. Može se konstatovati da su razlike za prosječne vrijednosti grupa male, što se ne može konstatovati za razlike između standardnih devijacija. Rezultati iz tabele 4. pokazuju da se grupe u prostoru bazične motorike međusobno razlikuju u inicijalnom mjerenju samo u varijabli MTAPNO (procjena frekvencije pokreta donjih ekstremiteta). Kada se uporede prosječne vrijednosti Mean-a (24.57/22.66) može se konstatovati prednost ispitanika kontrolne u odnosu na ispitanike eksperimentalne grupe. Vrijednosti T- testa su na nivou značajnosti (.00/ .00).

Table 5. *Descriptive Statistics – Mean and Standard Deviation Values for the INITIAL Measurement of Situational Motor Skills*

Tabela 5. *Deskriptivna statisatika- Vrijednosti aritmetičkih sredina i standardnih devijacija pri INICIJALNOM mjeremju situaciono - motoričkih sposobnosti*

Variables / Varijable	*Group / Grupa*	*N*	*Mean*	*Std. Deviation*	*Std. Error Mean*
OKBLR	1	53.00	23.38	5.20	0.71
	2	53.00	22.19	5.89	0.81
OKVLS	1	53.00	10.32	1.39	0.19
	2	53.00	11.41	2.64	0.36
OKBLK	1	53.00	4.17	2.52	0.35
	2	53.00	3.83	2.42	0.33
OSDCE	1	53.00	6.72	3.07	0.42
	2	53.00	6.83	3.34	0.46
OGCPM	1	53.00	4.34	2.36	0.32
	2	53.00	4.98	2.23	0.31
OLPKS	1	53.00	18.34	4.93	0.68
	2	53.00	20.13	6.65	0.91
ORBLZ	1	53.00	21.42	3.86	0.53
	2	53.00	23.32	4.55	0.63
ORVLS	1	53.00	11.05	1.73	0.24
	2	53.00	11.90	2.33	0.32
ORISE	1	53.00	3.36	1.67	0.23
	2	53.00	3.92	2.06	0.28

Legend: OKBLR – Throwing a ball with both hands against a wall and catching it for 30 seconds; OKVLS – Dribbling a ball by hand through a slalom; OKBLK – Shooting a ball into a basket for 30 seconds; OSDCE – Underhand frontal serve; OGCPM – Target shooting over a net from a basic stance; OLPKS – Forearm passing (bumping) in a circle for 30 seconds; ORBLZ – Throwing a ball against a wall for 30 seconds; ORVLS – Dribbling a ball through a slalom; ORISE – Taking a seven-meter throw; Group – classification of participants according to experimental conditions; N – number of participants; Mean – arithmetic mean; Std. Deviation – standard deviation; Std. Error Mean – standard error of the mean

Legenda: OKBLR – Bacanje lopte objema rukama o zid i hvatanje u trajanju 30 sekundi; OKVLS – Vođenje lopte rukom u slalomu; OKBLK – Bacanje lopte u koš u trajanju 30 sekundi; OSDCE - Servis donji čeoni; OGCPM – Gađanje cilja preko mreže iz osnovnog stava; OLPKS – Odbijanje podlakaticama u krugu za 30 sekundi; ORBLZ – Bacanje lopte o zid u trajanju 30 sekundi; ORVLS – Vođenje lopte u slalomu; ORISE – Izvođenje sedmerca; Grupa – podjela ispitanika prema eksperimentalnim uslovima; N – broj ispitanika; Mean – aritmetička sredina; Std. Deviation – standardna devijacija; Std. Error Mean – standardna greška aritmetičke sredine

Table 6. *T-test Values in the INITIAL Measurement of Situational-Motor Abilities*

Tabela 6. *Vrijednosti T testa pri INICIJALNOM mjerenju situaciono - motoričkih sposobnosti*

VARIABLES	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
OKBLR	1.20	0.28	1.10	104.00	0.27	1.19	1.08	-0.95	3.33
			1.10	102.45	0.27	1.19	1.08	-0.95	3.33
OKVLS	16.21	0.00	-2.66	104.00	0.01	-1.09	0.41	-1.90	-0.28
			-2.66	78.57	0.01	-1.09	0.41	-1.91	-0.27
OKBLK	0.00	0.99	0.71	104.00	0.48	0.34	0.48	-0.61	1.29
			0.71	103.82	0.48	0.34	0.48	-0.61	1.29
OSDCE	1.25	0.27	-0.18	104.00	0.86	-0.11	0.62	-1.35	1.12
			-0.18	103.23	0.86	-0.11	0.62	-1.35	1.12
OGCPM	0.61	0.44	-1.44	104.00	0.15	-0.64	0.45	-1.53	0.24
			-1.44	103.67	0.15	-0.64	0.45	-1.53	0.24
OLPKS	4.79	0.03	-1.58	104.00	0.12	-1.79	1.14	-4.05	0.46
			-1.58	95.88	0.12	-1.79	1.14	-4.05	0.46
ORBLZ	1.15	0.29	-2.33	104.00	0.02	-1.91	0.82	-3.53	-0.28
			-2.33	101.25	0.02	-1.91	0.82	-3.53	-0.28
ORVLS	3.46	0.07	-2.14	104.00	0.03	-0.85	0.40	-1.64	-0.06
			-2.14	96.00	0.04	-0.85	0.40	-1.64	-0.06
ORISE	1.69	0.20	-1.55	104.00	0.12	-0.57	0.36	-1.29	0.16
			-1.55	99.53	0.12	-0.57	0.36	-1.29	0.16

Legend: OKBLR – Throwing a ball with both hands against a wall and catching it for 30 seconds; OKVLS – Dribbling a ball by hand through a slalom; OKBLK – Shooting a ball into a basket for 30 seconds; OSDCE – Underhand frontal serve; OGCPM – Target shooting over a net from a basic stance; OLPKS – Forearm passing (bumping) in a circle for 30 seconds; ORBLZ – Throwing a ball against a wall for 30 seconds; ORVLS – Dribbling a ball through a slalom; ORISE – Taking a seven-meter throw; F – value of Levene's test for assessing equality of variances; Sig. – level of statistical significance; t – value of Student's t-test; df – degrees of freedom; Sig. (2-tailed) – two-tailed p-value of statistical significance; Mean Difference – difference between arithmetic means; Std. Error Difference – standard error of the difference; 95% Confidence Interval of the Difference (Lower–Upper) – confidence interval of the difference between means.

Legenda: OKBLR – Bacanje lopte objema rukama o zid i hvatanje u trajanju 30 sekundi; OKVLS – Vođenje lopte rukom u slalomu; OKBLK – Bacanje lopte u koš u trajanju 30 sekundi; OSDCE - Servis donji čeoni; OGCPM – Gađanje cilja preko mreže iz osnovnog stava; OLPKS – Odbijanje podlakaticama u krugu za 30 sekundi; ORBLZ – Bacanje lopte o zid u trajanju 30 sekundi; ORVLS – Vođenje lopte u slalomu; ORISE – Izvođenje sedmerca; F – vrijednost Leveneov test za procjenu jednakosti varijansi; Sig. – nivo statističke značajnosti; t – vrijednost Studentov t-test; df – stepeni slobode; Sig. (2-tailed) – dvosmjerna p-vrijednost statističke značajnosti; Mean Difference – razlika između aritmetičkih sredina; Std. Error Difference – standardna greška razlike; 95% Confidence Interval of the Difference (Lower–Upper) – interval pouzdanosti razlike između sredina.

In Table 5, the Mean and SD values of the control and experimental groups for the situational motor domain in the initial measurement are presented. It is noted that, at the descriptive level, differences between Group 1 and Group 2 can be observed. This phenomenon should be interpreted with caution, considering that the results may contain certain extreme values, and their significance needs to be verified using a T-test.

Table 6, which contains the results of independent

U tabeli 5. predstavljene su vrijednosti Mean i SD kontrolne i eksperimentalne grupe za situaciono motorički prostor u inicijalnom mjerenju. Konstatacija je da se na deskriptivnom nivou mogu primjetiti razlike između grupe 1 i 2. Pojava se treba oprezno tumačiti obzirom da rezultati mogu sadržati određene ekstremne varijable, te se njihova značajnost treba provjeriti T- testom.

Tabela 6. koja sadrži rezultate T -testova za nezavisne uzorke pokazala je tri statistički značajna rezul-

samples T-tests, showed three statistically significant results. At a significance level of less than 1%, for the variable OKVLS (a basketball variable assessing dribbling technique), and at significance levels of less than 5% for the variables ORBLZ (assessing the technique of catching and passing the ball against the wall in handball) and ORVLS (assessing dribbling technique in handball).

When looking at the mean values from Table 5, the control group has lower results compared to the experimental group for all three variables: OKVLS (10.32 / 11.41), ORBLZ (21.42 / 23.32), and ORVLS (11.05 / 11.90). It can therefore be concluded that, in the initial measurement, the experimental group has statistically significantly better results for all three mentioned variables compared to the control group.

Table 7. *Descriptive statistics – Values of arithmetic means and standard deviations in the FINAL measurement of motor abilities*

Variables / Varijables	Group / Grupa	N	Mean	Std. Deviation	Std. Error Mean
MTAPRU	2	53.00	29.85	2.82	0.39
	4	53.00	30.21	3.50	0.48
MTAPNO	2	53.00	26.70	2.84	0.39
	4	53.00	26.68	3.22	0.44
MTAPNZ	2	53.00	21.26	2.53	0.35
	4	53.00	21.53	3.10	0.43
MFLISK	2	53.00	62.96	14.92	2.05
	4	53.00	63.40	17.72	2.43
MBFDSD	2	53.00	23.28	7.75	1.06
	4	53.00	21.30	6.64	0.91
MPREDE	2	53.00	46.98	10.61	1.46
	4	53.00	45.96	10.06	1.38
MFESDM	2	53.00	157.26	24.49	3.36
	4	53.00	159.15	22.91	3.15

Legend: MTAPRU – Hand tapping; MTAPNO – Foot tapping; MTAPNZ – Foot tapping against a wall; MFLISK – Stick rotation; MBFDSD – Sit-and-reach test; MPREDE – Side bend to the right; MFESDM – Standing long jump; MFESUM – Standing vertical jump; MFE20V – 20 m sprint from a standing start; MRCLDM – Sit-ups test; MFRDCU – Squats for 40 seconds; MFRSKL – Push-ups; MAGKUS – Side steps; MAGTUP – Envelope (agility) test; MRGEPO – Backward obstacle course; Group – classification of participants according to experimental conditions; N – number of participants; Mean – arithmetic mean; Std. Deviation – standard deviation; Std. Error Mean – standard error of the mean.

tata. Na nivou značajnosti manjem od 1% za varijablu OKVLS (košarkašku varijablu koja procjenjuje tehniku vođenja lopte u košarci), te na nivoima manjim od 5% za varijable ORBLZ (procjenjuju tehniku hvatanja i dodavanja lopte o zid u rukometu) i varijablu ORVLS (procjenjuje tehniku vođenja lopte u rukometu).

Kada se pogledaju prosječne vrijednosti iz tabele 5. kontrolna grupa ima niže rezultate u odnosu na eksperimentalnu grupu za sve tri varijable OKVLS (10,32/11,41), ORBLZ (21,42/23,32) i ORVLS (1 1,05/11,90) pa se može zaključiti da pri inicijalnom mjerenju eksperimentalna grupa ima statistički značajno bolje rezultate za sve tri navedene varijable u odnosu na kontrolnu grupu.

Tabela 7. *Deskriptivna statisatika- Vrijednosti aritmetičkih sredina i standardnih devijacija pri FINALNOM mjerenju motoričkih sposobnosti*

MFESUM	2	53.00	29.53	5.44	0.75
	4	53.00	29.72	5.38	0.74
MFE20V	2	53.00	4.10	0.36	0.05
	4	53.00	4.08	0.47	0.06
MRCLDM	2	53.00	23.45	4.01	0.55
	4	53.00	24.49	4.25	0.58
MFRDCU	2	53.00	35.43	5.42	0.74
	4	53.00	35.04	6.59	0.91
MFRSKL	2	53.00	12.00	10.48	1.44
	4	53.00	15.81	11.99	1.65
MAGKUS	2	53.00	12.01	1.18	0.16
	4	53.00	11.97	1.38	0.19
MAGTUP	2	53.00	29.44	2.50	0.34
	4	53.00	29.93	3.30	0.45
MRGEPO	2	53.00	17.78	5.22	0.72
	4	53.00	18.47	5.44	0.75

Legenda: MTAPRU – Taping rukom; MTAPNO – Taping nogom; MTAPNZ – Taping nogama o zid; MFLISK – Iskret palicom; MBFDSD – Dohvat u sjedu; MPREDE – Pretklon desno; MFESDM – Skok udalj iz mjesta; MFESUM – Skok uvis iz mjesta; MFE20V – Sprint iz visokog starta 20m; MRCLDM – Test ležanje – sijed; MFRDCU – Test čučnjevi za 40 sekundi; MFRSKL – Sklekovi; MAGKUS – Koraci u stranu; MAGTUP – Koverta test; MRGEPO – Poligon natraške; Grupa – podjela ispitanika prema eksperimentalnim uslovima; N – broj ispitanika; Mean – aritmetička sredina; Std. Deviation – standardna devijacija; Std. Error Mean – standardna greška aritmetičke sredine.

Table 8. *T-test values for the FINAL measurement of motor abilities*

Tabela 8. *Vrijednosti T testa pri FINALNOM mjerenju motoričkih sposobnosti*

VARIABLES	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
MTAPRU	1.22	0.27	-0.58	104.00	0.56	-0.36	0.62	-1.58	0.87
			-0.58	99.57	0.56	-0.36	0.62	-1.58	0.87
MTAPNO	1.27	0.26	0.03	104.00	0.97	0.02	0.59	-1.15	1.19
			0.03	102.39	0.97	0.02	0.59	-1.15	1.19
MTAPNZ	0.52	0.47	-0.48	104.00	0.63	-0.26	0.55	-1.35	0.83
			-0.48	99.90	0.63	-0.26	0.55	-1.36	0.83
MFLISK	1.68	0.20	-0.14	104.00	0.89	-0.43	3.18	-6.74	5.88
			-0.14	101.06	0.89	-0.43	3.18	-6.75	5.88
MBFDSD	0.01	0.92	1.41	104.00	0.16	1.98	1.40	-0.80	4.76
			1.41	101.61	0.16	1.98	1.40	-0.80	4.76
MPREDE	0.00	0.96	0.51	104.00	0.61	1.02	2.01	-2.96	5.00
			0.51	103.71	0.61	1.02	2.01	-2.96	5.00
MFESDM	0.14	0.71	-0.41	104.00	0.68	-1.89	4.61	-11.02	7.25
			-0.41	103.54	0.68	-1.89	4.61	-11.02	7.25
MFESUM	0.20	0.66	-0.18	104.00	0.86	-0.19	1.05	-2.27	1.90
			-0.18	103.99	0.86	-0.19	1.05	-2.27	1.90
MFE20V	2.54	0.11	0.22	104.00	0.83	0.02	0.08	-0.14	0.18
			0.22	97.11	0.83	0.02	0.08	-0.14	0.18
MRCLDM	0.22	0.64	-1.29	104.00	0.20	-1.04	0.80	-2.63	0.56
			-1.29	103.64	0.20	-1.04	0.80	-2.63	0.56
MFRDCU	3.02	0.09	0.34	104.00	0.74	0.40	1.17	-1.93	2.72
			0.34	100.26	0.74	0.40	1.17	-1.93	2.72
MFRSKL	0.30	0.59	-1.74	104.00	0.08	-3.81	2.19	-8.15	0.53
			-1.74	102.17	0.08	-3.81	2.19	-8.15	0.53
MAGKUS	0.86	0.35	0.16	104.00	0.87	0.04	0.25	-0.45	0.53
			0.16	101.61	0.87	0.04	0.25	-0.45	0.53
MAGTUP	5.24	0.02	-0.87	104.00	0.39	-0.49	0.57	-1.62	0.64
			-0.87	96.83	0.39	-0.49	0.57	-1.62	0.64
MRGEPO	0.01	0.92	-0.67	104.00	0.51	-0.69	1.04	-2.75	1.36
			-0.67	103.82	0.51	-0.69	1.04	-2.75	1.36

Legend: MTAPRU – Hand tapping; MTAPNO – Foot tapping; MTAPNZ – Foot tapping against a wall; MFLISK – Stick rotation; MBFDSD – Sit-and-reach test; MPREDE – Side bend to the right; MFESDM – Standing long jump; MFESUM – Standing vertical jump; MFE20V – 20 m sprint from a standing start; MRCLDM – Sit-ups test; MFRDCU – Squats for 40 seconds; MFRSKL – Push-ups; MAGKUS – Side steps; MAGTUP – Envelope (agility) test; MRGEPO – Backward obstacle course; F – value of Levene's test for assessing equality of variances; Sig. – level of statistical significance; t – value of Student's t-test; df – degrees of freedom; Sig. (2-tailed) – two-tailed p-value of statistical significance; Mean Difference – difference between arithmetic means; Std. Error Difference – standard error of the difference; 95% Confidence Interval of the Difference (Lower–Upper) – confidence interval of the difference between means.

Legenda: MTAPRU – Taping rukom; MTAPNO – Taping nogom; MTAPNZ – Taping nogama o zid; MFLISK – Iskret palicom; MBFDSD – Dohvat u sjedu; MPREDE – Pretklon desno; MFESDM – Skok udalj iz mjesta; MFESUM – Skok uvis iz mjesta; MFE20V – Sprint iz visokog starta 20m; MRCLDM – Test ležanje – sijed; MFRDCU – Test čučnjevi za 40 sekundi; MFRSKL – Sklekovi; MAGKUS – Koraci u stranu; MAGTUP – Koverta test; MRGEPO – Poligon natraške; F – vrijednost Leveneov test za procjenu jednakosti varijansi; Sig. – nivo statističke značajnosti; t – vrijednost Studentov t-test; df – stepeni slobode; Sig. (2-tailed) – dvosmjerna p-vrijednost statističke značajnosti; Mean Difference – razlika između aritmetičkih sredina; Std. Error Difference – standardna greška razlike; 95% Confidence Interval of the Difference (Lower–Upper) – interval pouzdanosti razlike između sredina.

Table 7 presents the mean values and measures of deviation for variables in the basic motor skills domain for the control and experimental groups in the final measurement. At the descriptive level, certain differences between the groups can be observed, but they need to be verified using the independent samples T-test. The results of this analysis are presented in Table 8. It can be concluded that none of the T-tests are statistically significant. The final measurement showed no statistically significant differences between the control and experimental groups in the values of variables in the basic motor skills domain.

U tabeli 7. dat je prikaz prosječnih vrijednosti i mjera odstupanja za varijable u prostoru bazične motorike kod kontrolne i eksperimentalne grupe u finalnom mjerenju. Na deskriptivnom nivou su prisutne određene razlike između grupa, ali ih je potrebno provjeriti T- testom za nezavisne uzorke. Rezultati te analize su prikazani u tabeli 8. Može se konstatovati da niti jedan od T-testova nije statistički značajan. Finalno mjerenje je pokazalo da nema statistički značajnih razlika između kontrolne i eksperimentalne grupe u vrijednostima varijabli prostora bazičnih motoričkih sposobnosti.

Table 9. *Descriptive statistics – Mean values and standard deviations for the FINAL measurement of situational-motor abilities*

Tabela 9. *Deskriptivna statisatika- Vrijednosti aritmetičkih sredina i standardnih devijacija pri FINALNOM mjeremju situaciono - motoričkih sposobnosti*

Varijables / Varijable	Group / Grupa	N	Mean	Std. Deviation	Std. Error Mean
OKBLR	1	53.00	26.66	4.02	0.55
	2	53.00	24.89	5.59	0.77
OKVLS	1	53.00	9.24	1.00	0.14
	2	53.00	10.21	1.97	0.27
OKBLK	1	53.00	6.58	2.56	0.35
	2	53.00	5.51	2.85	0.39
OSDCE	1	53.00	8.89	2.49	0.34
	2	53.00	9.06	2.94	0.40
OGCPM	1	53.00	6.30	2.05	0.28
	2	53.00	6.68	2.06	0.28
OLPKS	1	53.00	21.83	5.36	0.74
	2	53.00	24.83	7.22	0.99
ORBLZ	1	53.00	23.45	3.94	0.54
	2	53.00	25.81	4.21	0.58
ORVLS	1	53.00	10.15	1.43	0.20
	2	53.00	10.57	1.80	0.25
ORISE	1	53.00	5.09	1.89	0.26
	2	53.00	6.06	2.32	0.32

Legend: OKBLR – Throwing a ball with both hands against a wall and catching it for 30 seconds; OKVLS – Dribbling a ball by hand through a slalom; OKBLK – Shooting a ball into a basket for 30 seconds; OSDCE – Underhand frontal serve; OGCPM – Target shooting over a net from a basic stance; OLPKS – Forearm passing (bumping) in a circle for 30 seconds; ORBLZ – Throwing a ball against a wall for 30 seconds; ORVLS – Dribbling a ball through a slalom; ORISE – Taking a seven-meter throw; Group – classification of participants according to experimental conditions; N – number of participants; Mean – arithmetic mean; Std. Deviation – standard deviation; Std. Error Mean – standard error of the mean

Legenda: OKBLR – Bacanje lopte objema rukama o zid i hvatanje u trajanju 30 sekundi; OKVLS – Vođenje lopte rukom u slalomu; OKBLK – Bacanje lopte u koš u trajanju 30 sekundi; OSDCE - Servis donji čeoni; OGCPM – Gađanje cilja preko mreže iz osnovnog stava; OLPKS – Odbijanje podlakaticama u krugu za 30 sekundi; ORBLZ – Bacanje lopte o zid u trajanju 30 sekundi; ORVLS – Vođenje lopte u slalomu; ORISE – Izvođenje sedmerca; Grupa – podjela ispitanika prema eksperimentalnim uslovima; N – broj ispitanika; Mean – aritmetička sredina; Std. Deviation – standardna devijacija; Std. Error Mean – standardna greška aritmetičke sredine

Table 10. *T-test values for the FINAL measurement of situational-motor abilities*

Tabela 10. *Vrijednosti T testa pri FINALNOM mjerenju situaciono - motoričkih sposobnosti*

VARAIABLES	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
OKBLR	5.48	0.02	1.88	104.00	0.06	1.77	0.95	-0.10	3.65
			1.88	94.42	0.06	1.77	0.95	-0.10	3.65
OKVLS	16.56	0.00	-3.18	104.00	0.00	-0.97	0.30	-1.57	-0.36
			-3.18	77.04	0.00	-0.97	0.30	-1.57	-0.36
OKBLK	1.51	0.22	2.04	104.00	0.04	1.08	0.53	0.03	2.12
			2.04	102.81	0.04	1.08	0.53	0.03	2.12
OSDCE	1.00	0.32	-0.32	104.00	0.75	-0.17	0.53	-1.22	0.88
			-0.32	101.15	0.75	-0.17	0.53	-1.22	0.88
OGCPM	0.07	0.80	-0.94	104.00	0.35	-0.38	0.40	-1.17	0.42
			-0.94	104.00	0.35	-0.38	0.40	-1.17	0.42
OLPKS	5.96	0.02	-2.43	104.00	0.02	-3.00	1.23	-5.45	-0.55
			-2.43	95.92	0.02	-3.00	1.23	-5.45	-0.55
ORBLZ	0.15	0.70	-2.98	104.00	0.00	-2.36	0.79	-3.93	-0.79
			-2.98	103.56	0.00	-2.36	0.79	-3.93	-0.79
ORVLS	3.93	0.05	-1.33	104.00	0.19	-0.42	0.32	-1.05	0.21
			-1.33	99.02	0.19	-0.42	0.32	-1.05	0.21
ORISE	2.19	0.14	-2.34	104.00	0.02	-0.96	0.41	-1.78	-0.15
			-2.34	99.93	0.02	-0.96	0.41	-1.78	-0.15

Legend: OKBLR – Throwing a ball with both hands against a wall and catching it for 30 seconds; OKVLS – Dribbling a ball by hand through a slalom; OKBLK – Shooting a ball into a basket for 30 seconds; OSDCE – Underhand frontal serve; OGCPM – Target shooting over a net from a basic stance; OLPKS – Forearm passing (bumping) in a circle for 30 seconds; ORBLZ – Throwing a ball against a wall for 30 seconds; ORVLS – Dribbling a ball through a slalom; ORISE – Taking a seven-meter throw; F – value of Levene's test for assessing equality of variances; Sig. – level of statistical significance; t – value of Student's t-test; df – degrees of freedom; Sig. (2-tailed) – two-tailed p-value of statistical significance; Mean Difference – difference between arithmetic means; Std. Error Difference – standard error of the difference; 95% Confidence Interval of the Difference (Lower–Upper) – confidence interval of the difference between means

Legenda: OKBLR – Bacanje lopte objema rukama o zid i hvatanje u trajanju 30 sekundi; OKVLS – Vođenje lopte rukom u slalomu; OKBLK – Bacanje lopte u koš u trajanju 30 sekundi; OSDCE - Servis donji čeoni; OGCPM – Gađanje cilja preko mreže iz osnovnog stava; OLPKS – Odbijanje podlakaticama u krugu za 30 sekundi; ORBLZ – Bacanje lopte o zid u trajanju 30 sekundi; ORVLS – Vođenje lopte u slalomu; ORISE – Izvođenje sedmerca; F – vrijednost Leveneov test za procjenu jednakosti varijansi; Sig. – nivo statističke značajnosti; t – vrijednost Studentov t-test; df – stepeni slobode; Sig. (2-tailed) – dvosmjerna p-vrijednost statističke značajnosti; Mean Difference – razlika između aritmetičkih sredina; Std. Error Difference – standardna greška razlike; 95% Confidence Interval of the Difference (Lower–Upper) – interval pouzdanosti razlike između sredina

Table 9 presents the mean values of the control and experimental groups (mean column) for individual variables in the situational motor skills domain at the final measurement. In this case as well, differences between groups are noticeable at the descriptive level, and their significance was tested using the paired-samples T-test. The T-test results are shown in Table 10. Statistical significance was found for the variable OKVLS (assessing basketball dribbling technique) at the level of $p<0.01$ in favor of the experimental group (C9.24/E10.21); the variable OKBLK (assessing shooting accuracy in basketball) at a level of $p<0.05$ in favor of the control group

U tabeli 9. je dat prikaz prosječnih vrijednosti kontrolne i eksperimentalne grupe (mean kolona) na pojednim varijablama u prostoru situacione motorike u finalnom mjerenju. I u ovom slučaju razlike između grupa su primjetne na deskriptivnom nivou a njihova značajnost je testirana uz pomoć T-testa za zavisne uzorke. Rezultati T- testa su prikazani u tabeli 10. Statistička značajnost se pojavila za varijable OKVLS (procjenjuje tehniku vođenja lopte u košarci) na nivou $p<0,01$, u korist eksperimentalne grupe (K9.24/E10.21), varijablu OKBLK (procjenjuje preciznost bacanja lopte u koš) na nivou manjem $p<0,05$ u korist kontrolne grupe (K6.58/5.51), varijablu OLPKS (procjenjuje tehniku odbijanja lopte čekićem) na nivou manjem od 5% ili $p<0,05$ u korist

(C6.58/5.51); the variable OLPKS (assessing hammer pass technique) at a level of $p<0.05$ in favor of the experimental group (C21.83/E24.83); the variable ORBLZ (assessing passing and catching technique in handball) at a level of $p<0.01$ in favor of the experimental group (C23.45/E25.81); and the variable ORISE (assessing shooting accuracy in handball) at a level of $p<0.05$ in favor of the experimental group (C5.09/E6.06). On average, at the final measurement, the experimental group achieved higher values on variables assessing basketball dribbling technique.

Discussion

The research results indicate a complex relationship between regular physical education classes and a specially programmed curriculum within the Physical and Health Education (PHE) subject for sixth-grade students, regarding the transformation of basic motor and situational motor skills. Regarding the effect of regular and specially programmed PHE classes on the transformation of basic motor skills in sixth-grade students, it was hypothesized that the experimental program would have better effects (de Privitellio et al., 2007; Reif et al., 2021). This assumption was based on the intensity of work and frequency of content repetition, even though the program duration of four months was the same for both groups. It was assumed that a wide range of transformational impacts and concentrated work with three sports games (basketball, volleyball, handball) would produce better effects on students' motor skills (Ericsson & Karlsson, 2012). It was particularly expected that transformations would occur in the situational motor domain, since the regular curriculum had a lower frequency of content repetition in these three games.

To avoid confounding factors in the results between groups, lessons were conducted by two PHE teachers with 15 and 18 years of experience. Before implementing the program, the lesson delivery, as well as teaching units, topics, and modules, were standardized. The regular curriculum included initial student testing (first 6 lessons), followed by general physical preparation lessons (4 lessons). In the next 20 lessons, four teaching themes were covered, each with four lessons (athletics 4 lessons, gymnastics 4 lessons, martial arts 4 lessons, team sports—soccer 4 lessons, and local dances 4 lessons). The final testing lasted 5 lessons, so the total program included 35 lessons.

The special program included initial testing (first 6 lessons), followed by general physical preparation (4 lessons). In the next 20 lessons, three sports games were

eksperimentalne grupe (K21.83/E24,83), varijablu ORBLZ (procjenjuje tehniku hvatanja i dodavanja lopte u rukometu) na nivou manjem od 1% ili $p<0,01$ u korist eksperimentalne grupe (K23.45/E25,81) i varijablu ORISE (procjenjuje preciznost šutiranja na gol u rukometu) na nivou manjem od 5% u korist eksperimentalne grupe (K5.09/E6,06). U prosjeku, u finalnom mjerenju, eksperimentalna grupa ima više varijabli sa većim vrijednostima rezultata na varijablama koje procjenjuju tehniku vođenja lopte u košarci.

Diskusija

Rezultati istraživanja pokazuju složen odnos između redovne nastave i posebno programirane nastave u okviru predmeta Tjelesni i zdravstveni odgoj (TZO) kod učenika VI razreda, u pogledu transformacije bazično-motoričkih i situaciono-motoričkih sposobnosti. Po pitanju efekta redovne nastave i posebno programirane nastave tjelesnog i zdravstvenog odgoja na transformaciju bazično- motoričkih sposobnosti učenika VI razreda osnovne škole, pretpostavilo se da će eksperimentalni program imati bolje efekte (de Privitellio i saradnici, 2007; Reif i saradnici, 2021.). Pretpostavka je zasnovana na intenzitetu rada i frekvenciji ponavljanja sadržaja iako je dužina trajanja programa od četiri mjeseca bila jednaka. Pretpostavilo se da će širok spektar transformacijskih uticaja te koncentrisani rad sa tri sportske igre (košarka, odbojka, rukomet) ostvariti bolje efekte na motorički prostor učenika (Ericsson & Karlsson, 2012.). Posebno se smatralo da će transformacije biti ostvarene u situaciono- motoričkom prostoru, obzirom da je redovni nastavni program imao manju frekvenciju ponavljanja sadržaja iz tri navedene igre. Kako bi se izbjegli ometajući faktori u rezultatima između grupa, vođenje časova je usaglašeno tako što su nastavu realizovala dva profesora sporta i tjelesnog odgoja sa 15 i 18 godina radnog iskustva. Prije provođenja programa, način realizacije časova je usaglašen, kao i nastavne cjeline, teme i jedinice. Redovni nastavni program sadržao je inicijalno tesiranje učenika (prvih 6 časova), zatim su realizovani časovi opšte fizičke pripreme učenika (4 časa). U sljedećih 20 časova realizovane su četri nastavne teme sa po četiri časa (atletika 4 časa, gimnastika 4 časa, borilački sportovi 4 časa, timski sportovi-nogomet 4 časa i zavičajni plesovi 4 časa). Na kraju redovnog programa organizovano je finalno testiranje koje je trajalo 5 školskih časova, gdje je ukupni program imao 35 provedenih časova. Posebni program sadrzao je inicijalno tesiranje učenika (prvih 6 časova), zatim su realizovani časovi opšte fizičke pripreme učenika (4 časa). U sljedećih 20 časova realizovane su tri sportske igre (košarka 7 časova, rukomet 7 časova, odbojka 6 časova). Na kraju klasičnog programa organizovano je finalno testiranje koje je trajalo 5 školskih časova,

implemented (basketball 7 lessons, handball 7 lessons, volleyball 6 lessons). Final testing also lasted 5 lessons, so the special program also totaled 35 lessons.

Statistical analysis showed that the initial status of motor skills between control and experimental groups was equal, i.e., the independent-samples T-test at the initial measurement indicated that groups differed only in one variable in this domain—movement frequency assessment. The difference in this variable (MTAPNO) was statistically significant in favor of the control group. No statistical significance was found for the remaining fourteen variables.

After the school semester (September–December) and 35 conducted 45-minute lessons, a final assessment was performed. The independent-samples T-test at the final measurement showed no statistically significant differences between the control and experimental groups, as the T-test did not reach significance. The difference present at the initial measurement did not persist, suggesting that the additional program in the experimental group caused changes that eliminated the control group's initial advantage.

Regarding the initial status of situational motor skills, students in both groups were initially tested to determine if the starting point was equal. The independent-samples T-test at the initial measurement showed group differences at $p<0.01$ for the variable assessing basketball dribbling technique (OKVLS) and at $p<0.05$ for variables assessing handball passing/catching technique (ORBLZ) and handball dribbling technique (ORVLS). All three statistically significant higher values were in favor of the experimental group. For the remaining six variables (out of nine), no statistically significant differences were found.

At the final measurement, the T-test revealed some changes in variable relationships. Differences in favor of the experimental group persisted for variables where an initial advantage was noted, with the addition of the handball penalty shot variable (ORISE). A newly identified variable showing non-specific behavior at the final measurement was basketball shooting (OKBLK), which favored the control group—a less expected outcome. Out of nine variables in this domain, four did not show statistical differences.

Conclusion

Basic motor skills (strength, speed, flexibility, coordination) have a strong developmental component in school-aged children, and improvements can occur even without specific interventions. It is possible that the pro-

tako da je i posebni program trajao 35 časova. Statističkim analizama je utvrđeno da je inicijalno stanje motoričkih sposobnosti između učenika kontrolne i eksperimentalne grupe bilo jednako, odnosno T-test za nezavisne uzorke kontolne i eksperimentalne grupe pri inicijalnom mjerenju pokazao je da se grupe međusobno razlikuju u samo u jednoj varijabli u tom prostoru- varijabli za procjenu frekvencije pokreta. Razlika u varijabli za procjenu frekfencije pokreta (MTAPNO) bila je statistički značajna u korist kontrolne grupe. Statistička značajnost u razlici nije utvrđena za četrnaest preostalih varijabli.

Nakon školskog polugodištea (septembar – decembar) i provedenih 35 školskih časova u trajanju po 45 minuta izvršena je finalna provjera rezultata. T- test za nezavisne uzorke je pri finalnom mjerenju pokazao da između rezultata kontolne i eksperimentalne grupe nema statistički značajnih razlika, obzirom da provedeni T-test za nezavisne uzorke nije imao statističku značajnost. Razlika koja je bila prisutna pri inicijalnom mjerenju se nije ponovila pa se može zaključiti da je dodatni program eksperimentalne grupe uzrokovao promjene zbog kojih se izgubila prednost kontrolne grupe. Po pitanju upoređivanja inicijalnog statusa situaciono- motoričkih sposobnosti učenika kao i u prethodnom slučaju učenici kontrolne i eksperimentalne grupe inicijalno su testirani kako bi se utvrdilo da li je početno stanje situaciono- motoričkih sposobnosti jednako. T- test za nezavisne uzorke, pri inicijalnom mjerenju pokazao je da se grupe međusobno razlikuju na nivoima manjim od 1% za varijablu koja procjenjuje tehniku vođenja lopte u košarci (OKVLS), te na nivoima manjim od 5% za varijable koje procjenjuju tehniku hvatanja i dodavanja lopte u rukometu (ORBLZ) i tehniku vođenja lopte u rukometu (ORVLS). Sve tri statistički značajno veće vrijednosti su na strani eksperimentalne grupe. U inicijalnom mjerenju rezultata za preostalih šest varijabli (od ukupno devet), nema statistički značajnih razlika. Pri finalnoj primjeni T- testa utvrđene su određene promjene u odnosima varijabli. Razlike u korist eksperimentalne grupe su se održale na varijablama kod kojih je prednost utvrđena pri inicijalnom mjerenju, uz dodatnu varijablu izvođenje sedmerca u rukometnoj igri (ORISE). Novootkrivena varijabla, sa nespecifičnim ponašanjem u finalnom mjerenju, je bacanje lopte u koš (OKBLK) obzirom da pripada kontrolnoj grupi, što je manje očekivana pojava u istraživanju. Od ukupno devet varijabli ovog prostora, kod četiri nije evidentirana statistička razlika (od ukupno devet).

Zaključak

Bazično-motoričke sposobnosti (snaga, brzina, fleksibilnost, koordinacija) imaju snažnu razvojnu komponentu kod djece školskog uzrasta, te se poboljšanja mogu događati

gram applied in the experimental group was not intensive or specific enough to elicit significant changes in this dimension, or that the difference between groups was too small to be statistically significant. Furthermore, the fact that the control group participated in regular PHE classes implies that they were not "passive," meaning basic motor stimulation was present in the control group as well. Different physical activity programs significantly affect motor skills in children and adolescents, but efficiency varies depending on activity type, frequency, and program duration (Füzéki & Woll, 2024). Authors recommend introducing additional programs for coordination, balance, and agility development and highlight the importance of continuous monitoring of students' motor progress (Safrit & Ross, 2024; Behm & Wilhelm, 2022). In this study, it can be concluded that the additional program for the experimental group did not cause changes that would allow asserting its higher efficiency with certainty.

Recommendations

Research of the same or similar type could be organized with other elementary school age groups to examine the transformational effect of additional sports games programs.
It is possible to conduct a study with a greater number of PHE lessons between groups to verify whether two lessons per week, lasting 45 minutes each, are sufficient to achieve transformational effects in motor or situational motor domains in elementary school children.

i bez specifičnih intervencija. Moguće je da program koji je primijenjen u eksperimentalnoj grupi nije imao dovoljno intenziteta ili specifikacije za izazivanje značajnijih promjena u ovoj dimenziji, ili da je razlika između eksperimentalne i kontrolne grupe bila previše mala da bi bila statistički značajna. Takođe, činjenica da kontrolna grupa učestvuje u redovnoj nastavi tjelesnog i zdravstvenog odgoja implicira da nije bila „pasivna", što znači da je osnovna motorička stimulacija bila prisutna i kod kontrolne grupe. Različiti programi fizičke aktivnosti pokazuju značajan utjecaj na motoričke sposobnosti djece i adolescenata, ali efikasnost varira zavisno od tipa aktivnosti, učestalosti i trajanja programa (Füzéki & Woll, 2024.), gdje autori preporučuju uvođenje dodatnih programa za razvoj koordinacije, ravnoteže i agilnosti, te ističu važnost kontinuiranog praćenja motoričkog napretka učenika (Safrit & Ross, 2024; Behm & Wilhelm, 2022.). U okviru ovog istraživanja se može zaključiti da dodatni program eksperimentalne grupe nije uzrokovao promjene na osnovu kojih bi se se sa sigurnošću mogla konstatovati njegova veća efikasnost.

Preporuke

Istraživanje istog ili sličnog oblika moglo bi se organizovati i provesti na drugim osnovnoškolskim uzrasnim kategorijama, gdje bi se provjerio transformacijski efekat dodatnog programa sportskih igara.
Moguće je organizovati istraživački proces sa većim brojem časova tjelesnog i zdravstvenog odgoja između grupa, a sve kako bi se provjerilo da li su dva časa sedmično, u trajanu po 45 minuta dovoljna za efekte transformacije motoričkog ili situaciono motoričkog prostora kod osnovnoškolaca.

References

Badrić, M., Sporiš, G., & Krističević, T. (2015). Differences in motor abilities of students according to the level of physical activity in free time. *Croatian Sports Medicine Journal*, 30(2), 92–98.

Badrić, M., Prskalo, I., & Sporiš, G. (2015). Effects of programmed training on the motor skills of female basketball players in school sports societies. *Croatian Journal of Education,* 17(Special Issue), 71–81. https://doi.org/10.15516/cje.v17i0.1516

Ericsson, I., & Karlsson, M. (2012). Motor skills and school performance in children with daily physical education in school — A 9-year intervention study. Scandinavian *Journal of Medicine & Science in Sports,* 24(2), 412–419.

Füzéki, E., & Woll, A. (Eds.). (2024). Comparative effectiveness of physical activity intervention programs on motor skills in children and adolescents: A systematic review and network meta-analysis (Preprint). *PubMed*.

Jakovljević, M. (2015). The impact of specially programmed lessons on the motor abilities of elementary school students. *Collection of Papers*, 1(1), 45–58.

Hadžikadunić, M., Rađo, I., Grozdanić, B., & Turković, S. (2000). *Manual for testing in physical and health education*. FFK, Sarajevo.

Kovač, M., Leskošek, B., & Strel, J. (2007). Comparison of morphological characteristics and motor abilities of boys attending different high school programs. *Kinesiology*, 39(1), 62–73.

Mikić, B. (1999). *Testing and measurement in sport*. Faculty of Philosophy, Tuzla.

Metikoš, D., Mraković, M., Prot, F., & Findak, V. (1990). Developmental characteristics of general motor ability in students. *Kinesiology*, 22(1-2), 21–24.

de Privitellio, S., Caput-Jogunica, R., Gulan, G., & Boschi, V. (2007). Influence of a sports program on changes in motor abilities of preschool children. *Medicina Fluminensis,* 43(3), 204–209.

Reif, A., Triska, C., Nader, M., Scharhag, J., Tschan, H., & Wessner, B. (2021). Influence of an increased number of physical education lessons on the motor performance of adolescents – A non-interventional cohort study. *PLoS ONE*, 16(10), e0258305.

Šoše, H., & Rađo, I. (1998). *Measurements in kinesiology*. Faculty of Physical Culture, Sarajevo.

Safrit, M. J., & Ross, J. G. (2024). A review study on motor abilities of elementary school students. *International Journal of Physical Education, Sports and Health*, 11(4), 380–382.

Primljen: 25. februar 2026. / Received: February 25, 2025
Prihvaćen: 04. maj 2026. / Accepted: May 04, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601107T **UDC:** 796.015.15:159.922.7
Original scientific paper ***Originalni naučni rad***

Parents' attitudes about motives for enrolling children in preschool institutions and early learning programs

Marica Travar[1], Nebojša Mitrović[1], Slađana Miljenović[1], Nataša Cvijanović[1], Neda Gavrić[1], Ranko Rajović[2]
[1]University of East Sarajevo, Faculty of Education, East Sarajevo, Bosnia and Hercegovina
[2]Faculty of Education, University of Primorska, Koper, Slovenia

Correspondence:
Milica Travar
University of East Sarajevo, Faculty of Education, East Sarajevo, Bosnia and Hercegovina, marica.travar@pfb.ues.rs.ba

Abstract: *Based on the most important theoretical and empirical evidence on the importance and benefits of including children in preschool institutions, we conducted a survey on a sample of 334 parents in the Republic of Srpska (Bosnia and Herzegovina) whose children attended a preparatory program in the year before entering school in 2024, with the aim of determining their attitudes about motives for enrolling children in early learning programs. Factor analysis determined that one dominant factor explains 91.26% of the total variance of parental motives for enrolling children in preschool institutions. This research has important implications for educational policymakers and practitioners because the Republic of Srpska (Bosnia and Herzegovina) is a country in transition in the Western Balkans.*

Keywords: *Preschool children, Parents, Early Learning, Preschool Institutions*

Introduction and Background

Based on current scientific findings, preschool upbringing and education is the first step in the system of lifelong learning (Pramling Samuelsson & Sheridan, 2010; Sheridan et al., 2011, Travar, 2019; Travar, 2021), and early learning is one of the most pressing challenges of modern education (Black et al., 2017; Спасојевић et al., 2013). The right to accessible and quality education, starting from early childhood, is one of the fundamental children's rights guaranteed by the Convention on the Rights of the Child (UNICEF, 1989), which has been ratified by many countries around the world, including Bosnia and Herzegovina.

A synthesis of current knowledge about preschool upbringing and education highlights its impact on the overall development of a child's personality and general well-being, encouraging physical, intellectual, socio-emotional, and speech development; communication and creativity; experiential learning; and acquiring and expanding ideas about oneself and the world around one, which are necessary for all subsequent levels of education (Arteaga et al., 2014; Bautista et al., 2016; Duncan & Magnuson, 2013; Lopez-Agudo & Marcenaro-Gutierrez, 2024; Rastovac & Cvetković, 2018).

At the preschool age, which is a precious period in which the foundations of the future personality are laid, the support and participation of parents in the early learning process is of great importance. The authors conclude that the manner and type of their engagement in this process largely depend on the parents' attitudes towards early learning. Parents are expected to be the first to recognize the importance of a stimulating environment for the learning and development of preschool children, in the provision of which they very often need the help and support of preschool institutions (Марковић et al., 2019). For the well-being of a preschool child, it is best if his development and learning take place simultaneously in the family and preschool institutions; that is, if, in addition to education in a functional family, the child is also enrolled in some institutional early learning program.

Research shows that parental involvement in children's early learning is related to the child's later academic and socio-emotional skills, as well as long-term results and achievements. Therefore, it is of great importance to engage parents in the process of early learning and play, as well as to find ways in which the family can be involved in these processes (Mohammed, 2023). The conclusions of other research studies show that knowledge about early learning needs to be incorporated into the education system and the preparation of future parents for responsible parenthood (Travar & Spasojević, 2018) in order to develop positive attitudes towards the importance of early learning and its beneficial impact on child development. Positive attitudes of parents about the effects of early learning would influence not only the inclusion of their children in early learning programs but also their own engagement in this process

and the establishment of a functional partnership between the family and the preschool institution. Cooperation between the family and preschool institutions ensures the continuity of the educational impact on the child, just as quality time spent by parents and children in the family is crucial for developing a positive attitude towards learning (Bakhtiyorova, 2024).

Method

Problem statement

One of the important challenges in preschool upbringing and education in the Republic of Srpska is to approach European and global trends in education, meaning to increase the number of preschool children attending early learning programs. One of the ways to shed light on the situation in this area and to propose concrete measures and steps to improve the situation is through examining the attitudes of parents of preschool children, who are potential users of preschool services.

Examining the needs and perceptions of parents, as well as their motives for enrolling children in early learning programs, is an important research project that has its own scientific, social, and practical significance.

Research questions

The aim of the research is to identify the most common factors that indicate the motives why parents would enroll children in preschool institutions and early learning programs.

In the research, we started from the following assumption: the identified factors will indicate the most common motives why parents enroll children in preschool institutions and early learning programs.

Sampling

The sample consisted of 334 parents from the population whose children attended the free preparatory program in the year before entering school. The sample was selected by random selection on the territory of the Republic of Srpska (Bosnia and Herzegovina). That sample is representative in relation to the population, as it makes up approximately 22% of the total number of parents whose children were enrolled in the free preparatory program in the year before entering school. Parents from all regions participated in the research.

Questionnaire

The questionnaire for parents consists of two parts: the first part is intended to collect data on the socio-demographic characteristics. The second part was assessment scale of Parents' Motives for Enrolling a Child in a Preschool Institution, which was used to determine parents' attitudes about the most common reasons for enrolling children in preschool institutions and early learning programs. This Likert-type scale, with 5 levels of agreement (from 1, strongly disagree to 5, strongly agree), was partly taken from the author's research (Hadela et al., 2019) and partly was originally constructed for the purposes of the research. The reliability of the assessment scale was verified by calculation (Cronbach's Alpha), the value of which confirmed the very good internal consistency of the items in the scale (α=.993).

Data Collection

The survey was conducted in the period from March to June 2024. Respondents had the option to choose between Google questionnaires and printed surveys. All respondents entered research voluntarily, and their identity was completely anonymous.

Data Analysis

Statistical data processing was performed using the SPSS version 22 statistical package and included the following procedures: calculation of basic descriptive indicators (frequencies, percentages, arithmetic mean, standard deviation, standard error), and factor analysis using the principal components method with the application of the Kaiser-Meyer-Olkin (KMO) sphericity test.

Results

Starting from the second research task and our expectation that parents would indicate in their attitudes the most common motives for enrolling their children in preschool institutions and early learning programs, we applied factor analysis through scores, using the principal components analysis method with the application of Kaiser's criterion for "extracting" factors, and calculated Bartlett's sphericity test.

Table 1. *Parents' Attitudes About the Motives for Enrolling Their Child in a Preschool Institution – KMO Test and Bartlett's Sphericity Test*

KMO sample adequacy measure	.969	
Bartlett's sphericity test	χ^2	11328.100
	df	105
	p	.000

Based on the presented Bartlett's Sphericity Test, which is statistically significant, we conclude that it is justified to apply the principal components method. Kaiser-Meyer-Olkin is .969 and shows that the scale has high reliability. By the factor analysis procedure, namely the principal components analysis, one main factor was singled out that explains 91.265% of the total variance. The contribution of the factor in explaining the total variance for the scale, Parents' motives for enrolling their child in a preschool institution, is shown in Table 1.

Table 2. *Parents' Motives for Enrolling Their Child in a Preschool Institution —Explanation of Total Variance*

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% Variance	Cumulative%	Total	%Variance	Cumulative %
1	13.690	91.265	91.265	13.690	91.265	91.265
2	.323	2.152	93.417			
3	.205	1.364	94.781			
4	.145	.964	95.745			
5	.111	.741	96.486			
6	.098	.653	97.139			
7	.081	.539	97.678			
8	.073	.488	98.166			
9	.058	.384	98.551			
10	.048	.321	98.872			
11	.043	.287	99.158			
12	.039	.263	99.421			
13	.036	.237	99.658			
14	.034	.228	99.886			
15	.017	.114	100.00			

Table 2 shows the factor loading matrix, which presents the correlation values between individual factor 1 and each variable with a separate factor; that is, with the lowest correlation obtained being .920 and the highest being .975. This confirms that the obtained data are reliable for further analysis for the purpose of scientific inference.

Table 3. *Parents' Motives for Enrolling Their Child in a Preschool Insitution—Factor Saturation Matrix*

Items	Factor 1
It is important for the child to gain self-confidence.	.975
It is important for the child to develop work habits.	.972
It is important for the child to gain new experiences.	.969
It is important for the child to learn something new.	.967
It is important for the child to develop hygiene habits.	.964
It is important for the child to adopt the basics of cultural behavior.	.963
It is important for the child to learn to respect authority.	.957
It is important for the child to become independent.	.957
It is important for the child to prepare for school.	.956
It is important for the child to talk to peers.	.952
It is important for the child to play with other children.	.951
The child will learn to help other children in kindergarten.	.949
It is important for the child to be in a team with other children.	.946
The child will learn to share things with other children in kindergarten.	.931
It is important for the child to meet other children.	.920

Table 3 shows items with factor weights ranging between .920 and .975. We have named the factor "Main motives for enrolling children in preschool institutions." The content of the items that make up the factor shows that the main motives for enrolling children in preschool institutions and early learning programs are gaining self-confidence and work habits. This is followed by the motives related to gaining new experiences in a different environment compared to the family one. After that, there are the motives related to acquiring hygienic and cultural habits in a preschool institution. Motives related to learning to respect authority and preparing the child for entering school were highlighted as completely equal. After them, we observe motives related to the importance of spending time with other children (It is important for the child to talk to peers; It is important for the child to play with other children; The child will learn to help other children in kindergarten; It is important for the child to be in a group with other children). Factor analysis showed that the items (The child will learn to share with other children in kindergarten; It is important for the child to meet other children) had the lowest factor weights.

Discussion

The hypothesis in the research was confirmed, as factor analysis identified a factor that integrates and unifies the motives that would lead parents to include their children in preschools and early learning programs. Namely, factor analysis determined that parents in the sample surveyed recognize the importance of enrolling their children in preschools and highly value all the offered motives. It is encouraging to note that although the largest percentage of respondents included in this study are parents whose children have never been enrolled in preschools or an early learning program before (76.9% of parents), they still successfully identify motives for enrolling their children in institutions. Moreover, they value the motives for enrolling those related to personality traits necessary for further education and life in the 21st century (self-confidence and work habits) the most. They also successfully recognize the importance of the child's stay in preschool institutions when it comes to gaining new experiences in a different environment compared to the family environment, aware that the family cannot replace the effects of the child's stay in a preschool group. The results show that parents also recognize the effects of the stay in preschool institutions as important, which relate to the development of hygiene and work habits, acceptance of the authority of an adult (teacher), and preparation for entering school. The effects of socialization, namely staying in a group of children and talking and socializing with them, are also valued by parents as motives for enrolling children in preschool institutions and early learning programs, but somewhat less so. The reason for this is the knowledge that preschool children are today included in various informal peer groups; therefore, their socialization is not a priority reason for enrollment in preschool institutions. The results of similar empirical studies show that the main motives of parents for enrolling two-year-old children in early learning programs were taking care of their children while their parents are at work, developing intellectual abilities and acquiring knowledge, getting used to the routine of the team, and staying outside the family home. The results of the study showed that parents assessed the following as the largest developmental effects of attending early learning programs for their children: progress in communication, development of social

skills, and general progress (Wiegerová & Gavora, 2018). Similar to our study, the research (Višnjić-Jevtić, 2021) found that parents of preschool children assess that children's social and emotional skills are important for successful functioning in society, but also as a basis for acquiring other skills. This author concludes that preschool teachers can use parents` assessments to gain better insight into the family context in which a child grows up, that is, to learn about the specifics of the socio-cultural community to which the child belongs.

Conclusions

Based on the theoretical and empirical study of this topic, it is possible to draw several conclusions and implications that are significant for educational policymakers in the Republic of Srpska, as well as practitioners and founders of preschool institutions that implement early learning programs in the public, private, or non-governmental sector:

- due to its complex, multiple, and optimal impact on the holistic development of a child's personality in the period of his most intensive development, that is, in the first six years, preschool education needs to be further institutionally strengthened as the first stage of the education system in the Republic of Srpska as a constituent part of Bosnia and Herzegovina;

- through a careful analysis of the research results, we can conclude that parents successfully recognize the motives for enrolling children in preschool institutions, and primarily those related to the compensatory role of preschool institutions to compensate children for what they are deprived of by staying only in the family environment. However, the results obtained indicate the need for additional education of parents of lower educational status about the advantages and values of enrolling preschool children in early learning programs. The bearers of these activities could be faculties for the education of preschool teachers, as well as the students themselves in the role of volunteers.

References

Pramling Samuelsson, I., & Sheridan, S. (2010). A turning-point or a backward slide: the challenge facing the Swedish preschool today. *Early Years, 30*(3), 219-227. https://doi.org/10.1080/09575146.2010.513328

Sheridan, S., Williams, P., Sandberg, A., & Vuorinen, T. (2011). Preschool teaching in Sweden – a profession in change. *Educational Research, 53*(4), 415-437. https://doi.org/10.1080/00131881.2011.625153

Travar, M. (2019). Key differences in approaching education in kidergarten and primary school. *VisnykTaras Shevchenko National University of Kyiv: Pedagogy, 9*(1), 62-66.https://ouci.dntb.gov.ua/en/works/40WzYOA7/

Travar, M. (2021). Establishing continuity at the initial levels of the education system. *Pedagogical Almanac*, *1*, 44-50. https://www.ceeol.com/search/article-detail?id=959829

Black, M. M., Walker, S. P., Fernald, L. C. H., Andersen, C. T., DiGirolamo, A. M., Lu, C., McCoy, D. C., Fink, G., Shawar, Y. R., Shiffman, J., Devercelli, A. E., Wodon, Q. T., Vargas-Barón, E., & Grantham-McGregor, S.; Lancet Early Childhood Development Series Steering Committee. (2017). Early childhood development coming of age: Science through the life course. *The Lancet*, *389*(10064), 77–90. https://doi.org/10.1016/S0140-6736(16)31389-7

Спасојевић, П., Јефтовић, М., и Цвјетковић, М. (2013.). Рано учење као најактуелнији изазов савремене педагогије. У М. Ковачевић (Ур.) *Зборник „Наука и традиција"* (стр. 597–612). Филозофски факултет Пале. [in Serbian]

UNICEF. (1989). *Konvencija o pravima djeteta.* https://www.unicef.org/bih/media/676/file/Konvencija%20o%20pravima%20djeteta.pdf?

Arteaga, I., Humpage, S., Reynolds, A. J., & Temple, J. A. (2014). One Year of Preschool or Two - Is It Important for Adult Outcomes? Results from the Chicago Longitudinal Study of the Child-Parent Centers. *Economics of education review, 40*, 221-237. https://doi.org/10.1016/j.econedurev.2013.07.009

Bautista, A., Ng, S.-C., Múñez, D., & Bull, R. (2016). Learning areas for holistic education: Kindergarten teachers' curriculum priorities, professional development needs, and beliefs. *International Journal of Child Care and Education Policy*, *10*(8), 1–18. https://doi.org/10.1186/s40723-016-0024-4

Duncan, G. J., Kalil, A., Mogstad, M., & Rege, M. (2022). *Investing in early childhood development in preschool and at home* (NBER Working Paper No. w29985). National Bureau of Economic Research. https://ssrn.com/abstract=4098306

Lopez-Agudo, L. A., & Marcenaro-Gutierrez, O. D. (2024). Enrolment in the first stage of early childhood education and students' academic performance: a cross-country analysis. *School Effectiveness and School Improvement, 35*(4), 365-386. https://doi.org/10.1080/09243453.2024.2358226

Rastovac, D., i Cvetković, D. (2018). Uporedna analiza zakona i strategijskih planova predškolskog vaspitanja i obrazovanja u Republici Srbiji, Republici Srpskoj i Crnoj Gori. U D. Pavlović Breneselović, G. Stepić i I. Prlić (ur.), Inicijalno obrazovanje i stručno usavršavanje vaspitača – partnerstvo u građenju kvaliteta, str. 105-118. Visoka škola strukovnih studija za vaspitače i poslovne informatičare – Sirmium. [in Serbian]

Марковић, Е., Видосављевић, С., Круљ, Ј. и Младеновић, Н. (2019). Улога породице у предшколском васпитању и образовању. *Knowledge: International Journal*, *35*(2), 517–522. https://ojs.ikm.mk/index.php/kij/article/view/1757/1756 [in Serbian]

Mohammed, A. S. (2023). Perspectives on preschool education and care. In *Recent perspectives on preschool education and care* [Working title] (pp. 1–18). IntechOpen. https://doi.org/10.5772/intechopen.111745

Travar, M., i Spasojević, P. (2018). Stavovi roditelja predškolske djece o ranom učenju. *Zbornik Odseka za pedagogiju, 27*, 151-172. https://zop.ff.uns.ac.rs/index.php/zop/article/view/28

Bakhtiyorova, M. (2024). The importance of the family in education of preschool children. *Теоретические аспекты становления педагогических наук, 3*(18), 74-78. https://inlibrary.uz/index.php/tafps/article/view/51480

Hadela, J., Rončević, N., & Pergar, M. (2020). Reasons for Enrolment in the Kindergarten and Parents' Satisfaction with Specific Elements of the Kindergarten. *Croatian Journal of Education – Hrvatski časopis za odgoj i obrazovanje*, 121-135. https://doi.org/10.15516/cje.v21i0.3441

Wiegerová, A., & Gavora, P. (2018). Preschool attendance of very young children: Parents' choice and outcome satisfaction. *Journal of Language and Cultural Education, 6*(2), 36-47. https://doi.org/10.2478/jolace-2018-0014

Višnjić-Jevtić, A. (2021). Parents' perspective on a children's learning. *Journal of Childhood, Education & Society, 2*(2), 117-125. https://doi.org/10.37291/2717638X.20212266

Primljen: 10. novembar 2025. / Received: November, 2025
Prihvaćen: 25. februar 2026. / Accepted: February 25, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601113N UDC: 796.855:796.015.15
Original scientific paper *Originalni naučni rad*

The Influence of Training Facility Management, Injury Risk Perception, and Self-Efficacy on Wushu Technical Performance

Novita[1], Martono[2], Hendra Setyawan[2], Sabariah[3], Rufi'i[3], Diah Andika Sari[4], Nuridin Widya Pranoto[5], Ratko Pavlovic[6]

[1]Faculty of Sports Science, Universitas Negeri Medan, Indonesia
[2]Faculty of Sports Science and Health, Universitas Negeri Yogyakarta, Indonesia
[3]Graduate School, Universitas Adi Buana Surabaya, Indonesia
[4]Faculty of Science Education, Universitas Muhammadiyah Jakarta, Indonesia
[5]Faculty of Sports Science, Universitas Negeri Padang, Indonesia
[6]Faculty of Physical Education and Sport, University of East Sarajevo, Bosnia and Herzegovina

Correspondence:
Nuridin Widya Pranoto
Faculty of Sports Science, Universitas Negeri Padang, Indonesia, nuridin@fik.unp.ac.id

Abstract: *Technical performance in wushu arises from the interplay of psychological factors, training-environment management, and safety perceptions. This study examined the effects of training facility management, injury risk perception, and self-efficacy on technical performance. Methods: A quantitative, cross-sectional correlational survey included 153 purposively selected participants. Data were collected with 4-point Likert scales. Item validity used Pearson's product–moment ($r_{calculated} > r_{table} = 0.159$; $N = 153$), and reliability used Cronbach's α (0.869–0.963). Multiple linear regression ($\alpha = 0.05$) in SPSS 25 tested effects. Results: The model was strong and significant ($R = 0.833$; $R^2 = 0.694$; adjusted $R^2 = 0.688$; $F(3,149) = 112.777$; $p < 0.001$), indicating that 69.4% of performance variance was jointly explained by the three predictors. Self-efficacy showed a positive, substantive effect ($B = 0.897$; $\beta = 0.805$; $t = 14.963$; $p < 0.001$) and was the dominant predictor. Training facility management and injury risk perception did not exhibit significant direct effects at the 5% level ($B = 0.023$; $p = 0.665$; $B = 0.041$; $p = 0.434$). Conclusions: Self-efficacy is the principal lever for improving technical performance, whereas facility quality and risk perception likely act indirectly through session quality, feedback intensity, and a supportive learning climate. Practical implications suggest graded mastery experiences, expert modelling, and criterion-referenced video feedback to strengthen competence beliefs and skill transfer. Limitations relate to the cross-sectional design, which restricts causal inference. Future research should test mediating and moderating pathways via structural equation modelling and multilevel approaches, employ video- or standardised-judge-based assessments for greater objectivity, and adopt longitudinal or experimental designs to map mechanisms more precisely in wushu athletes.*
Keywords: *Training facility management; injury risk; self-efficacy; technical performance*

Introduction

Technical performance in wushu requires precise coordination, speed, directional accuracy, and timing control emerging from the interplay between individual characteristics and training design. Motor-learning research indicates that technical output is multi-determined by neuromuscular capacity, cognitive processing, and learning-environment quality, so analyses must address how these components interrelate (Kok et al., 2019). Practice with appropriate structure, intensity, and feedback—particularly when athletes can regulate feedback duration and frequency—strengthens skill through cognitive–motor reinforcement pathways, with self-efficacy acting as a proximal psychological mechanism shaping effort, attentional focus, and persistence when errors occur (Nor et al., 2024). Aligning task parameters, feedback strategies, and control over practice exposure is therefore strategic for steering learning trajectories towards mastery with clear, staged performance criteria (Arias et al., 2019). Mapping the interaction among individual, cognitive, and environmental factors thus provides a rational basis for practice programmes that support technical mastery, reliable execution, and competition-ready performance.

Training-facility management constitutes a prerequisite for meaningful repetition, competition simulation, and timely feedback that uphold learning quality. Although space, training aids, lighting, scheduling, and documentation do not automatically raise technical scores, they enhance practice certainty, exposure consistency, and regular performance evaluation, making learning more structured (Mödinger et al., 2021). Facility governance—including the

management of athlete flow and access to recording devices—shapes the effectiveness of video feedback for motor learning and tactical adaptation (White et al., 2024). Self-controlled feedback, whereby athletes regulate the frequency and content of feedback, further increases engagement, self-regulation, and the meaningful use of information for movement refinement (Meer et al., 2023). Consequently, the orchestration of physical resources, schedules, and evaluation protocols must be aligned with task demands and feedback strategies so that learning remains mastery-oriented rather than a simple accumulation of scores, and well-managed facilities become enabling conditions that reinforce training design, support reliable technical execution over time, and sustain gains across phases of technical learning.

Self-efficacy is conceptualised as the proximal psychological link between training design and technical output, as belief in one's capacity to meet movement demands influences strategy selection, effort allocation, persistence, and attention to relevant cues, with a frequently dominant contribution to performance variance (Mile et al., 2025). In wushu, self-efficacy is strengthened through repeated mastery experiences, specific feedback, and incremental targets, and its effects are amplified when athletes control the rhythm and frequency of video feedback in line with task complexity (Meer et al., 2023). At the same time, training facilities and injury-risk perception define the operational frame and require dosage adjustments so that progress is not undermined by excessive cognitive–motor load or threats to perceived safety (Lowenthal et al., 2021). Thus, self-efficacy underpins competence-building pathways, while facility management and calibrated risk perception maintain practice continuity and correction accuracy, making the enhancement of self-efficacy through structured practice and targeted feedback a key lever for consistent, measurable development of wushu technical expertise, shortened movement-pattern consolidation, strengthened competitive confidence, and stabilised performance under demanding conditions.

A risk-of-injury perspective is crucial because wushu involves high speed, aggressive directional changes, and rapid positional transitions. Risk perception theoretically shapes attention, emotion regulation, and decision-making, such that athletes' appraisals of risk can directly and indirectly alter performance dynamics (Snapp et al., 2023). These effects are moderated when training environments proportionally regulate load exposure, practice frequency, and feedback quality through progressive schemes that consider readiness and baseline skill. Empirical evidence indicates that risk perception calibrated to competence can sharpen vigilance and motor control, whereas excessive exposure disrupts movement flow and reduces response accuracy (Blagus et al., 2023). For intervention design, risk intensity must therefore be balanced with mastery goals by staging tasks, managing repetitions, and incorporating guided reflection to preserve fluent execution (Romdhane et al., 2025), so that risk calibration becomes a pedagogical variable that keeps training safe and effective, maintains movement quality, and minimises psychological barriers that could impair focus, commitment to technical choices, and the transfer of skills to competition at different levels.

Self-efficacy alone does not determine performance; environmental factors and sensory-based interventions also shape technical learning. Video-based feedback delivered in a self-controlled manner increases engagement, affective accuracy, and intrinsic motivation, thereby strengthening motor-learning capacity and supporting transfer to competitive contexts (Breda et al., 2017). Repeated mastery experiences supported by specific feedback routines foster active participation, proactive learning behaviours, and practice consistency (Campos & Taissun, 2024). In parallel, psycho-pedagogical elements—such as perceived instructor support, communication quality, and interaction dynamics—are associated with goal meaning, emotion regulation, and persistence when technical difficulties arise (Strandberg et al., 2024). These components should be integrated into a training curriculum that balances psychological demands, facility availability, and safety protocols to cultivate stable, measurable execution (Yang et al., 2019), so strengthening self-efficacy must be accompanied by a supportive learning ecology in which structured practice, a culture of mentoring, and effective feedback mechanisms collectively sustain motivation, reflective quality, and correction efficiency from session to session.

Previous studies confirm that video feedback enhances technical skills through attentional mechanisms, movement representation, and decision-making, with stronger effects when athletes control their exposure (Ma et al., 2025). In wushu, this practice is embedded in facility management, as the availability of cameras, recording spaces, and review protocols permits structured, iterative evaluation and directs correction towards the precise details of forms (Brenton et al., 2019). Expert modelling combined with positive reinforcement accelerates motor adaptation and helps stabilise tempo, angles, and positional transitions as indicators of technical performance (Yorgancı, 2022). Planned video use also functions as a tool for calibrating risk perception by enabling athletes to identify error pat-

terns that may precipitate injury, thereby allowing adjustments to load, repetition counts, and task variation without diluting technical demands (Vold et al., 2023). Overall, integrating video-based facility management, proportionate risk regulation, and the reinforcement of self-efficacy through mastery experiences and targeted feedback is expected to yield tangible improvements in wushu technical performance, support skill transfer to competition, strengthen confidence, and promote consistent execution across competitive levels.

Methods

Study Participants

The study targeted individuals with experience in Wushu training or coursework (population size unknown). Purposive sampling was used with the following criteria: (1) school pupils who had attended Wushu training/courses; (2) university students who had attended Wushu training/courses; (3) athletes who had attended Wushu training/courses; and (4) willingness to complete the questionnaire in full. In total, 153 respondents met these criteria and were included in the analysis.

Research Design

This study employed a quantitative approach with a correlational–explanatory survey method to analyse the simultaneous and partial effects of Training Facility Management (X1), Perceived Injury Risk (X2), and self-efficacy (X3) on Wushu Technical Performance (Y). The design was cross-sectional; data were collected once using a four-point Likert-type questionnaire and analysed with multiple linear regression at a significance level of $\alpha = 0.05$.

Research Instruments

Data were collected using a questionnaire covering four variables: Training Facility Management (X1), Perceived Injury Risk (X2), self-efficacy (X3), and Wushu Technical Performance (Y). A four-point Likert scale was applied, ranging from 1 ("Very Inappropriate") to 4 ("Very Appropriate"). Each variable was operationalised into four indicators with 16 items, producing 64 initial items. No pilot testing was conducted; instead, item validity was assessed directly on the study data using Pearson Product–Moment correlation in SPSS version 25.0. Items with r_calculated < r_table (0.159; N = 153) were removed. The final valid item counts were 16 for each variable (X1, X2, X3, Y), with all retained items having r_calculated > 0.159, indicating satisfactory validity. Reliability was tested using Cronbach's alpha, yielding $\alpha = 0.940$ (X1), 0.869 (X2), 0.944 (X3), and 0.963 (Y), all above the 0.70 threshold, indicating high internal consistency and suitability of the instrument.

Data Collection Procedures

Questionnaires were administered to students and athletes over four weeks using both online (Google Forms) and offline (face-to-face at campuses/schools) modes. Respondents received brief guidance to ensure understanding of items and were reminded to answer honestly. All returned questionnaires were checked for completeness before data processing and analysis.

Data Analysis Techniques

Data analysis followed several stages. After preliminary checks, multiple linear regression was used to assess simultaneous and partial relationships between the independent variables (X1, X2, X3) and the dependent variable (Y). Statistical significance of simultaneous effects was tested with the F-test, and partial effects with the t-test, both at $\alpha = 0.05$. The coefficient of determination (R^2) was calculated to estimate the proportion of variance in Wushu Technical Performance explained by the independent variables. All analyses were performed using SPSS version 25.0.

Results

Descriptive Statistics

Data from 153 respondents showed that Self-Efficacy (X3) had the highest mean (M = 53.84; SD = 7.27), followed by Training-Facility Management (X1) (M = 51.80; SD = 8.28) and Wushu Technical Performance (Y) (M = 51.32; SD = 8.11), while Injury-Risk Perception (X2) had a lower mean (M = 47.52; SD = 7.79). All variables had score ranges of 16–64, indicating adequate dispersion for subsequent modelling. Descriptively, athletes' perceived

self-efficacy exceeded their perceived injury risk, and technical performance clustered within a similar band to facility-management quality, providing an initial context for testing each predictor's contribution to technical performance.

Table 1. *Descriptive statistics*

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Dev.
Training-Facility Management (X1)	153	22.00	64.00	51.7974	8.27994
Injury-risk Perception (X2)	153	16.00	64.00	47.5163	7.78841
Self-Efficacy (X3)	153	16.00	64.00	53.8366	7.27420
Wushu Technical Performance (Y)	153	16.00	64.00	51.3203	8.10511
Valid N (listwise)	153				

Model Summary

The multiple-regression model including X1, X2, and X3 to predict Y demonstrated a strong overall fit ($R=0.833$), with $R^2=0.694$ and Adjusted $R^2=0.688$. Thus, 69.4% of the variance in wushu technical performance is jointly explained by the three predictors, with a standard error of the estimate (SEE) of 4.53 points. Substantively, this indicates the model has considerable explanatory power for the outcome.

Table 2. *Model Summary*

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.833[a]	.694	.688	4.526

a. Predictors: (Constant), Self-Efficacy (X3), Injury-risk Perception (X2), Training-Facility Management (X1)

Model ANOVA

The ANOVA yielded $F(3,149)=112.777$; $p<0.001$, indicating the overall model is statistically significant. At $\alpha=0.05$, we therefore reject H0 (H0: $\beta1=\beta2=\beta3=0$) and accept Ha (at least one $\beta\neq0$). In practical terms, including the three predictors together significantly improves prediction of technical performance relative to a model with no predictors.

Table 3. *ANOVA*

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6932.338	3	2310.779	112.777	.000[b]
	Residual	3052.969	149	20.490		
	Total	9985.307	152			

a. Dependent Variable: Wushu Technical Performance (Y)
b. Predictors: (Constant), Self-Efficacy (X3), Injury-risk Perception (X2), Training-Facility Management (X1)

Model Coefficients

At the partial level, only Self-Efficacy (X3) contributed significantly to Wushu Technical Performance (Y) ($B=0.897$; $\beta=0.805$; $t=14.963$; $p<0.001$). Hence, a one-unit increase in X3 is associated with a 0.897-point increase in technical-performance scores, controlling for X1 and X2. In contrast, Training-Facility Management (X1) ($B=0.023$; $p=0.665$) and Injury-Risk Perception (X2) ($B=0.041$; $p=0.434$) were not significant at $\alpha=0.05$, indicating their unique contributions to Y were not supported in this model. The intercept was non-significant ($p=0.961$), which is common under bounded rating scales.

Table 4. *Coefficients*

Coefficients[a]						
Model		Unstand. Coef.		Standa. Coef.	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.154	3.131		-.049	.961
	Training-Facility Management (X1)	.023	.054	.024	.434	.665
	Injury-risk Perception (X2)	.041	.053	.040	.784	.434
	Self-Efficacy (X3)	.897	.060	.805	14.963	.000

a. Dependent Variable: Wushu Technical Performance (Y)
Partial Hypothesis Decisions:
1. $H0_1$ (β_1=0, X1): Not rejected (non-significant)
2. $H0_2$ (β_2=0, X2): Not rejected (non-significant)
3. $H0_3$ (β_3=0, X3): Rejected → Ha_3 accepted (X3 has a significant positive effect)

Discussion

The multiple regression model combining training-facility management (X1), injury-risk perception (X2) and self-efficacy (X3) explained 69.4% of the variance in wushu technical performance (Y; $R^2 = 0.694$, F significant), with partial tests indicating self-efficacy as the dominant predictor ($\beta = 0.805$; $p < 0.001$), whereas X1 and X2 were not significant at the 5% level (Reigal et al., 2019; Chen et al., 2019). This pattern is consistent with evidence that self-efficacy predicts athletic performance through self-regulation, goal setting and adaptive training strategies (Lochbaum et al., 2022; Carreres-Ponsoda et al., 2021). The higher mean scores for self-efficacy relative to the other variables suggest that belief in personal capability is a crucial source of performance variance (Musculus et al., 2018). Within this framework, athletes' confidence in mastering technical tasks promotes self-control, persistence, strategy selection and constructive use of feedback, positioning self-efficacy as the principal determinant of performance variation in this sample and a key target in evidence-informed coaching designs.

The absence of significant direct effects for training-facility management and injury-risk perception at the 5% threshold invites consideration of mediated and moderated pathways by which X1 and X2 influence Y via X3. A data-congruent explanation is that facilities in the sampled clubs already meet a sufficiency threshold, so additional quality variation does not translate linearly into performance. Alternatively, training-facility management may affect performance indirectly through session quality, feedback intensity and structured practice, which can attenuate any direct X1–Y association (Popa et al., 2020). This interpretation accords with work emphasising that features of the training environment shape technical outputs even when physical resources do not emerge as direct predictors (Booth et al., 2018). The non-significant coefficient for injury-risk perception may similarly reflect moderating influences not explicitly modelled, including safety climate, coach support and performance culture (Chun et al., 2022; Stanković et al., 2022). Conceptually, facilities and risk management operate through mediators such as session quality, strengthened feedback and opportunity structures, thereby retaining importance for safety and opportunity while exerting primarily indirect effects on performance (Peng & Zhang, 2021; Galarraga et al., 2020). Clarifying these indirect mechanisms and the characteristics of the training setting is therefore critical for proportionate interpretation of the present results.

Descriptive statistics showing the highest mean levels for self-efficacy further underline its role as a central source of self-regulation. Self-efficacy strengthens goal setting, adaptive motor-learning strategies and persistence when encountering difficulty (Liang et al., 2024), while elevated efficacy beliefs are associated with reduced cognitive load during complex movement sequences and more durable skill consolidation (Lee et al., 2024). Cross-disciplinary evidence links self-efficacy with motivation, successful motor learning, emotion regulation and mental toughness, all of which support performance under high-risk conditions (Ramolale et al., 2021). Psychologically safe learning environments and social support from coaches and peers magnify these effects by reinforcing competence beliefs and improving technical quality and performance outcomes (Koper et al., 2020). Accordingly, maximising the psychological and social conditions that underpin self-efficacy through mastery experiences, targeted feedback and appropriate modelling is a strategic avenue for accelerating technical acquisition and maintaining performance consistency across training cycles, tournament phases and competition.

The standardised coefficient of 0.805 observed here implies that even modest gains in self-efficacy are accompanied by substantial improvements in technical performance scores, underscoring clear practical implications for coaching. Meta-analytic syntheses consistently document robust associations between self-efficacy and athletic performance, with downstream effects on training adherence and competition outcomes (Lochbaum et al., 2023). Interventions that cultivate efficacy via graded mastery experiences, calibrated task-based feedback, credible modelling and specific verbal persuasion have been shown to yield sustainable performance gains (Anstiss et al., 2018; Brace et al., 2020). Self-regulation processes influenced by self-efficacy further support task planning and the adoption of effective strategies in particular performance settings (Ermiş & Çankaya, 2023). Complementary strategies such as video feedback, structured self-talk and motor imagery can reinforce competence beliefs, lower cognitive load and accelerate motor learning (Lee et al., 2024; Popa et al., 2020). When combined with social persuasion and peer involvement as sources of positive support (Koper et al., 2020; Ramolale et al., 2021), these cognitive, behavioural and social techniques constitute a coherent portfolio for enhancing self-efficacy and optimising the transfer of technical skills from training to formal assessments and demanding match situations.

Given that the influence of self-efficacy on technical performance is unlikely to follow a simple linear pathway, modelling mediation and moderation is necessary to capture the interplay between psychological and environmental variables. Empirical work suggests that safety climate, coach support and performance culture can moderate the strength of the self-efficacy–performance relationship (Chun et al., 2022), whereas session quality, feedback intensity and structured practice mediate links between facilities, risk perceptions and outcomes via self-efficacy (Galarraga et al., 2020). Studies of self-regulation and attentional management further indicate that efficacy beliefs guide focus, strategy selection and the precise execution of movement sequences in high-skill sports (Reverdito et al., 2023; Liang et al., 2024). In motor learning contexts, integrating self-efficacy with task-based training designs, expert demonstration, paired practice and repeated evaluations promotes comprehensive self-regulation and supports coherent sequence execution under high-tempo demands (Larumbe-Zabala et al., 2020; Ramolale et al., 2021). Priority should therefore be given to mapping mediation and moderation so that training interventions can be tuned to athlete characteristics and specific environmental conditions, thereby identifying when enhancing self-efficacy yields the largest gains in technical mastery and performance stability.

Methodologically, the present pattern of interlinked, and potentially nonlinear, relationships among self-efficacy, facilities, injury-risk perception and performance supports the use of structural equation modelling to test hypothesised mediating and moderating mechanisms (Diotaiuti et al., 2017). Multilevel approaches that incorporate club and coach hierarchies are likewise valuable for capturing contextual nuances that shape these relationships (Carreres-Ponsoda et al., 2021). To reduce common-method bias, objective performance assessments using video recordings or standardised judges, together with rigorous reporting of inter-rater reliability, should be integrated into evaluation protocols (Stanković et al., 2022). Longitudinal or experimental designs with repeated measurements will further strengthen causal inference and clarify trajectories linking self-efficacy, facilities and risk management to performance across competitive development stages (Larumbe-Zabala et al., 2020). In combination, structural equation modelling, multilevel analysis and objective assessment procedures provide a robust methodological platform for testing the mechanisms proposed here and for evaluating the effectiveness of technical training programmes in wushu.

At the applied level, emphasising self-efficacy within the broader ecology of the training environment has strategic implications for programme design in clubs and coaching practice. Integrating the self-efficacy model with key environmental features offers a comprehensive framework for explaining variation in technical performance, in which facility quality and safety climate function as reinforcing conditions for goal setting, task planning and adaptive strategy use (Galarraga et al., 2020). Practical implementation can include staged learning sequences, expert demonstrations, targeted feedback, peer involvement and video-based reflection sessions organised around micro-targets and performance benchmarks, thereby promoting continuous improvement, training discipline and efficient use of training time (Reverdito et al., 2023; Ermiş & Çankaya, 2023). Structured coach–athlete interactions that document progress with clear process and outcome indicators, supported by progressive reinforcement, timely feedback and collegial support, enable objective monitoring of intervention effects and facilitate skill transfer from practice to match situations across competitive levels (Anstiss et al., 2018; Koper et al., 2020). Clubs can additionally formalise mentoring arrangements, periodic review meetings and individualised planning to sustain motivation and adherence during intense schedules. By combining psychological and ecological perspectives in this way, coaches can tailor

interventions to individual athletes and situational demands, increase coaching effectiveness and sustain technical outcomes over time, ensuring that efforts to enhance self-efficacy remain directly relevant to the competitive situations athletes face in real tournaments.

Conclusions

This study confirms self-efficacy as the principal determinant of wushu technical performance. A multiple regression with training-facility management, injury-risk perception and self-efficacy explained 69.4% of performance ($R^2 = 0.694$), but only self-efficacy showed a partial effect ($\beta = 0.805$; $p < 0.001$), while facilities and risk perception had no direct effects, suggesting indirect pathways via session quality, feedback and the learning and safety climate. Because competence beliefs underpin self-regulation and strategy selection, coaching programmes should strengthen self-efficacy through mastery experiences, expert modelling, targeted feedback, video monitoring, peer support, verbal persuasion and cognitive strategies such as self-talk and imagery combined with behavioural drills and paired tasks to reduce cognitive load and stabilise performance. Training plans should incorporate micro targets, measurable indicators and periodic reflection, and clubs should create a strong safety climate and well-structured sessions (duration, intensity and directed practice), supported by technical benchmarks and progress reports, to enable individual adjustment, transfer of skills to competition and tangible, measurable, sustainable gains. The cross-sectional design and these non-significant direct effects limit causal inference and indicate the need for future research using SEM and multilevel models, longitudinal or experimental repeated-measures designs, and video-based or standardised-judge assessments with inter-rater reliability, together with broader sampling across clubs and competitive tiers and explicit modelling of environmental variables (session quality, feedback intensity, load and safety climate) as mediators or moderators to map mechanisms and optimise evidence-based coaching strategies.

Conflict Of Interest

The authors declare no conflicts of interest.

References

Anstiss, P., Meijen, C., Madigan, D., & Marcora, S. (2018). Development and initial validation of the endurance sport self-efficacy scale (esses). *Psychology of Sport and Exercise*, 38, 176-183. https://doi.org/10.1016/j.psychsport.2018.06.015

Arias, A., García-González, L., Álvarez, F., & Gallego, D. (2019). Developing sport expertise in youth sport: a decision training program in basketball. *Peerj,* 7, e7392. https://doi.org/10.7717/peerj.7392

Blagus, R., Leskošek, B., Okršlar, L., Vreček, N., & Debevec, T. (2023). Utility of video analysis and expert modelling for technique development in novice sport climbers: a randomized controlled study. *International Journal of Sports Science & Coaching*, 19(1), 355-367. https://doi.org/10.1177/17479541231152548

Booth, A., Mellalieu, S., & Bruton, A. (2018). Subjective distress, sport injury-related growth, self-efficacy and wellbeing upon return to sport following injury. *Sport & Exercise Psychology Review*, 14(2), 23-31. https://doi.org/10.53841/bpssepr.2018.14.2.23

Brace, A., Kendall, G., & Lovell, G. (2020). Mental toughness and self-efficacy of elite ultra-marathon runners. *Plos One*, 15(11), e0241284. https://doi.org/10.1371/journal.pone.0241284

Breda, E., Verwulgen, S., Saeys, W., Wuyts, K., Peeters, T., & Truijen, S. (2017). Vibrotactile feedback as a tool to improve motor learning and sports performance: a systematic review. *BMJ Open Sport & Exercise Medicine*, 3(1), e000216. https://doi.org/10.1136/bmjsem-2016-000216

Brenton, J., Müller, S., & Dempsey, A. (2019). Visual-perceptual training with acquisition of the observed motor pattern contributes to greater improvement of visual anticipation.. *Journal of Experimental Psychology Applied*, 25(3), 333-342. https://doi.org/10.1037/xap0000208

Campos, C. and Taissun, N. (2024). You are thinking, reflecting, analysing what you see and what you do all the time. *Revista Brasileira De Medicina De Família E Comunidade*, 19(46), 3928. https://doi.org/10.5712/rbmfc19(46)3928

Carreres-Ponsoda, F., Escartí, A., Jiménez-Olmedo, J., & Cortell-Tormo, J. (2021). Effects of a teaching personal and social responsibility model intervention in competitive youth sport. *Frontiers in Psychology*, 12. https://doi.org/10.3389/fpsyg.2021.624018

Chen, X., Zhang, G., Yin, X., Li, Y., Cao, G., García, C., … & Li-ya, G. (2019). The relationship between self-efficacy and aggressive behavior in boxers: the mediating role of self-control. *Frontiers in Psychology*, 10. https://doi.org/10.3389/fpsyg.2019.00212

Chun, D., Lee, M., Kim, S., Cho, E., & Lee, B. (2022). The mediated effect of sports confidence on competitive state anxiety and perceived performance of basketball game. *International Journal of Environmental Research and Public Health*, 20(1), 334. https://doi.org/10.3390/ijerph20010334

Diotaiuti, P., Falese, L., Mancone, S., & Purromuto, F. (2017). A structural model of self-efficacy in handball referees. *Frontiers in Psychology*, 8. https://doi.org/10.3389/fpsyg.2017.00811

Ermiş, A., & Çankaya, S. (2023). Analysis of Self-Efficacy Levels of Fencers. *Mediterranean Journal of Sport Science*, *6*(1-Cumhuriyet'in 100. Yılı Özel Sayısı), 138-151.https://doi.org/10.38021/asbid.1347033

Galarraga, S., Cos, I., Cos, G., & Gutiérrez, S. (2020). Mediation effect of perceived fitness on the relationship between self-efficacy and sport practice in spanish adolescents. *International Journal of Environmental Research and Public Health*, 17(23), 8800. https://doi.org/10.3390/ijerph17238800

Kok, M., Komen, A., Capelleveen, L., & Kamp, J. (2019). The effects of self-controlled video feedback on motor learning and self-efficacy in a physical education setting: an exploratory study on the shot-put. *Physical Education and Sport Pedagogy*, 25(1), 49-66. https://doi.org/10.1080/1

7408989.2019.1688773
Koper, M., Nadolska, A., Urbański, P., & Wilski, M. (2020). Relationship between pre-competition mental state and sport result of disabled boccia athletes. *International Journal of Environmental Research and Public Health*, 17(21), 8232. https://doi.org/10.3390/ijerph17218232
Larumbe-Zabala, E., Esteve-Lanao, J., Cardona, C., Alcocer, A., & Quartiroli, A. (2020). Longitudinal analysis of marathon runners' psychological state and its relationship with running speed at ventilatory thresholds. *Frontiers in Psychology*, 11. https://doi.org/10.3389/fpsyg.2020.00545
Lee, S., Kim, S., Lee, R., & Park, I. (2024). Effect of participation motivation in sports climbing on leisure satisfaction and physical self-efficacy. *Behavioral Sciences*, 14(1), 76. https://doi.org/10.3390/bs14010076
Liang, W., Gao, J., & Xiang, J. (2024). The effects of perceived sport environment on sport gains of chinese university students: chain mediation between physical activity behavior and sport learning self-efficacy. *Frontiers in Psychology*, 15. https://doi.org/10.3389/fpsyg.2024.1466457
Lochbaum, M., Sherburn, M., Sisneros, C., Cooper, S., Lane, A., & Terry, P. (2022). Revisiting the self-confidence and sport performance relationship: a systematic review with meta-analysis. *International Journal of Environmental Research and Public Health,* 19(11), 6381. https://doi.org/10.3390/ijerph19116381
Lochbaum, M., Sisneros, C., Cooper, S., & Terry, P. (2023). Pre-event self-efficacy and sports performance: a systematic review with meta-analysis. *Sports*, 11(11), 222. https://doi.org/10.3390/sports11110222
Lowenthal, P., Fiock, H., Shreaves, D., & Belt, E. (2021). Investigating students' perceptions of screencasting style of video feedback in online courses. *Tech Trends*, 66(2), 265-275. https://doi.org/10.1007/s11528-021-00665-x
Ma, W., Jing-feng, C., Yi, Q., Zhang, S., Xing, W., Ren, H., … & Rong-zhi, L. (2025). A study on the effects of different self-controlled feedback methods on the learning of table tennis serving skills. *European Journal of Sport Science*, 25(6). https://doi.org/10.1002/ejsc.12324
Meer, B., Hoven, M., Kamp, J., & Savelsbergh, G. (2023). Self-controlled video feedback facilitates the learning of tactical skills in tennis. *Research Quarterly for Exercise and Sport*, 95(2), 537-545. https://doi.org/10.1080/02701367.2023.2275801
Mile, S., Budu, B., Ahmad, M., & Made, S. (2025). The effect of the application of feedback on second-stage labor companion skills and objective structured clinical examination results of associate degree midwifery students. *Journal of Education and Health Promotion,* 14(1). https://doi.org/10.4103/jehp.jehp_1017_24
Mödinger, M., Wöll, A., & Wagner, I. (2021). Video-based visual feedback to enhance motor learning in physical education—a systematic review. *German Journal of Exercise and Sport Research*, 52(3), 447-460. https://doi.org/10.1007/s12662-021-00782-y
Musculus, L., Raab, M., Belling, P., & Lobinger, B. (2018). Linking self-efficacy and decision-making processes in developing soccer players. *Psychology of Sport and Exercise*, 39, 72-80. https://doi.org/10.1016/j.psychsport.2018.07.008
Nor, N., Nazarudin, M., Noordin, Z., & Abdullah, M. (2024). Boosting boundaries: how feedback methods enhance student self-efficacy in long jump?. *International Journal of Academic Research in Progressive Education and Development*, 13(4). https://doi.org/10.6007/ijarped/v13-i4/23664
Peng, F. and Zhang, L. (2021). The relationship of competitive cognitive anxiety and motor performance: testing the moderating effects of goal orientations and self-efficacy among chinese collegiate basketball players. *Frontiers in Psychology*, 12. https://doi.org/10.3389/fpsyg.2021.685649
Popa, D., Mîndrescu, V., Iconomescu, T., & Talaghir, L. (2020). Mindfulness and self-regulation strategies predict performance of romanian handball players. *Sustainability*, 12(9), 3667. https://doi.org/10.3390/su12093667
Ramolale, M., Malete, L., & Ju, U. (2021). Mediational role of mental toughness on the relationship between self-efficacy and prosocial/antisocial behavior in elite youth sport. *Frontiers in Psychology*, 12. https://doi.org/10.3389/fpsyg.2021.745323
Reigal, R., Vázquez-Diz, J., Morillo-Baro, J., Hernández-Mendo, A., & Morales-Sánchez, V. (2019). Psychological profile, competitive anxiety, moods and self-efficacy in beach handball players. *International Journal of Environmental Research and Public Health*, 17(1), 241. https://doi.org/10.3390/ijerph17010241
Reverdito, R., Fonseca, S., Lopes, A., Aires, K., Alves, L., Lima, L., … & Gonçalves, C. (2023). Sources of sport satisfaction and perceived self-efficacy among youth in a competitive environment. *Perceptual and Motor Skills*, 130(3), 1221-1238. https://doi.org/10.1177/00315125231167460
Romdhane, M., Mguidich, H., Chikha, H., Chtourou, H., & Khacharem, A. (2025). Optimizing basketball tactics learning in physical education: the impact of modality and video control. *Perceptual and Motor Skills*. https://doi.org/10.1177/00315125251328727
Snapp, S., Miltenberger, R., & Zerger, H. (2023). Evaluating the effectiveness of video feedback to improve cheerleader tumbling skills. *Behavioral Interventions*, 39(1). https://doi.org/10.1002/bin.1979
Stanković, N., Todorović, D., Milošević, N., Mitrović, M., & Stojiljković, N. (2022). Aggressiveness in judokas and team athletes: predictive value of personality traits, emotional intelligence and self-efficacy. *Frontiers in Psychology*, 12. https://doi.org/10.3389/fpsyg.2021.824123
Strandberg, S., Ekstedt, M., Fagerström, C., & Backåberg, S. (2024). Cocreation of a video feedback tool for managing self-care at home with pairs of older adults: remote experience-based co-design study. *Jmir Formative Research*, 8, e57219. https://doi.org/10.2196/57219
Vold, T., Slyman, S., & Ranglund, O. J. S. (2023, September). Research on an Assessment Method: Student Feedback on Video-Feedback on Mandatory Assignments. In *ECRM 2023 22nd European Conference on Research Methods in Business and Management*. Academic Conferences and publishing limited.
White, R., Miltenberger, R., & Concepcion, A. (2024). Evaluating video feedback to improve esports performance in street fighter v. *Behavioral Interventions*, 39(4). https://doi.org/10.1002/bin.2056
Yang, X., Xie, R., Chen, S., Yu, W., Liao, Y., Krewski, D., … & Wen, S. (2019). Using video feedback through smartphone instant messaging in fundamental nursing skills teaching: observational study. *Jmir Mhealth and Uhealth*, 7(9), e15386. https://doi.org/10.2196/15386
Yorgancı, S. (2022). The interactive e-book and video feedback in a multimedia learning environment: influence on performance, cognitive, and motivational outcomes. *Journal of Computer Assisted Learning*, 38(4), 1005-1017. https://doi.org/10.1111/jcal.12658

Primljen: 20. decembar 2025. / Received: December 20, 2025
Prihvaćen: 28. april 2026. / Accepted: April 28, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601121R
UDC: 613.2:796.012.414
Original scientific paper
Originalni naučni rad

Lower Back Pain, Physical Activity and the Quality of Life

Romana Romanov[1], Doris Molnar[1], Zoran Milić[2], Ivica Nikolić[2], Nina Rasković[3]
[1]Faculty of sport and psychology, Educons University, Novi Sad, Serbia
[2]Faculty of teacher education. Educons University, Novi Sad, Serbia
[3]Nina Raskovic, Sports and Recreational Association "Korak napred sa Ninom i Doris", Novi Sad, Serbia

Correspondence:
Romana Romanov
Faculty of sport and psychology, Educons University, Novi Sad, Serbia, romana.romanov@tims.edu.rs

Abstract: *Lumbar pain is one of the key problems that affects people with reduced physical activity. This study aims at identifying different frequencies of pain in patients with lumbar syndrome and to determine differences in their quality of life. From a total sample of 202 subjects (93 men and 109 women, mean age 47.5 ± 13.85 years), 3 subsamples of respondents were stratified depending on the frequency of back pain: those with occasional back pain, those with frequent episodes of back pain and those whose episodes of back pain occur very often. The data in the study were collected using a measuring instrument, which is intended to be used for self-assessment of the quality of life. The non-parametric statistical method Chi-squared test was used to determine the differences between groups of subjects. Statistically significant differences (p = 0.00) were identified in three analyzed variables: I can declare that my quality of life is, How would you assess your physical fitness and How often do you walk continuously for 60 minutes, whereby the survey results obtained for the variable assessing the quality of life significantly differ in favor of respondents who only occasionally experience pain compared to the other two groups of respondents who reported frequent or very frequent incidences of back pain. Respondents occasionally affected with lower back pain had a better assessment of their lives, their physical fitness was at a higher level and were shown to be more active when it came to continuous walking for 60 minutes.*
Keywords: *lumbar syndrome, frequency of pain, quality of life*

Introduction

Increasing inactivity in people nowadays is a significant risk factor associated with our health, and thus our quality of life. Insufficient movement is one of the causes of many chronic diseases. Chronic lower back pain, i.e. Lumbar Syndrome (LS), is one of the most common painful conditions that affects both women (58%) and men (45%). In addition to the appearance of chronic pain, people suffering from LS, also experience insufficiency of the functionality of the locomotor system, restriction of motion, and movement. As a limiting disease, LS affects the efficiency of an individual's everyday activities but also social and economic aspects of the life of a person suffering from LS.

A lumbar syndrome is a health problem with the most frequent incidence after respiratory infections and is among the leading causes of limitations of activity, and a significant factor in cases of sick leave. A lumbar syndrome is defined as pain or discomfort located below the level of the twelfth rib, and above the gluteal sulcus, with or without the presence of pain in the legs. Pain that occurs continuously for up to six weeks is considered acute, while most authors believe that lower back pain present for at least three or more months may be characterized as chronic pain. The chronic lower back pain as the pain presents for at least seven to twelve weeks, while other authors believe that chronic lower back pain must be understood as the pain that continues for as long as six months or more (Silva et al, 2004; Walker et al, 2004; Almeida et al, 2008). In almost 85% of cases, the etiology of most types of lower back pain is unknown (National Guide for General Practitioners, 2004), while in 50% of cases the pain appears without a clear cause, which indicates its multifactorial nature. Numerous causes of LS, associated with congenital or acquired conditions, can be classified into several groups, biomechanical disorders of the spine, diseases of other organs and organ systems in which the disease affects the lumbar spine (Popović, 2003), as well as with injuries of muscles, ligaments, soft connective tissue, cartilage and blood vessels of the lumbar vertebrae (Božić, 2017).

A lot of studies dealt with the apparent absence of an organic basis for chronic lower back problems and other syndromes of chronic pain. As previously mentioned, as many as 85% of cases of lower back problems do not have a definitive pathoanatomical diagnosis. In that regard, two conclusions have been proposed in the medical literature (McGill, 2007): 1. Many patients with LS show "inorganic signs" that suggest psychological disorders as the cause of

their condition; 2. Poor diagnostic techniques, applied either on the part of inadequately trained physicians or because of the limitations of widely used diagnostic technology, resulted in frequent misdiagnoses.

The characteristic pain that accompanies LS, may occur occasionally or it may regularly reoccur and is identified already in the population of people between 20 and 40 years of age. However, in people over 50 years of age, the symptomatology of lumbar syndrome is much more intense than in the younger population (Romanov & Radak, 2013). Although almost 85% of the world population experiences lower back pain at least once in their life (Nachemson & Jonsson, 2000), this matter was not yet the subject of a serious study (Lopez et al, 2006). Back pain as a limiting factor of both work performance and usual daily activities affects not only the individual but also their family, as well as the wider social community (professional activities, health care, etc.) (Thelin, Holmberg & Thelin, 2008). For example, in the United States, in terms of costs of medical treatment, LS is in third place, behind malignant tumors and heart conditions (Thelin, Holmberg & Thelin, 2008).

Until about ten years ago, it was widely believed that lumbar syndrome was limited to Western countries, highly developed countries with a higher standard of living. However, an increasing number of studies indicate that lower back pain is also a major problem in underdeveloped countries, countries with lower and average standards of living (National Guide for General Practitioners, 2004). Lumbar syndrome as a cause of unfitness for work occurs in more than 25% of the working-age population, and its relapses occur in at least 50% of those who have undergone treatment (Middleton & Fish, 2009; Barkhordari, Halvani & Barkhordari, 2013). The treatment of lumbar syndrome involves a multidisciplinary team of experts (physiatrist, neurologist, neurosurgeon, psychologist, physiotherapist, occupational therapist, social worker), but with exception to therapy with medications, surgical treatment, physical therapy, the movement therapy (exercise) which contributes to the reduction of pain and improvement of health in general, has a principal place in the treatment of LS (Mačak-Hadžiomerović et al, 2009).

Some studies point out that the prevention of lumbar syndrome is associated with targeted and continuous physical exercise (Henewer et al, 2011). Insufficient strength of the back muscles is one of the causes of pain in the lower back, that is, it is also the cause of recurrence of painful episodes (Lee et al, 2012). Segmental stabilization exercises applied (Franca et al, 2012) in the context of targeted exercise, are directed at the global (*erector spinae, external obliques, quadratus lumborum, rectus abdominis*), and the local (*multifidus, transversus abdominis, internal obliques*) lumbar-core stabilizer muscles. Exercising is also significant in the treatment of LS, especially in the treatment of chronic conditions (Hayden et al, 2005; Van Tulder et al, 2006; Chou et al, 2007). Exercising can prevent the recurrence of pain, it can reduce pain, improve the functioning of locomotor apparatus, reduce effects of a possible ongoing condition (Sherman et al, 2005; Mailloux et al, 2006; Van Middelkoop et al, 2011) and thus prevent the appearance of the negative socio-economic context reflected in certain aspects of the quality of life of people with LS. On the other hand, quality of life, as a multidimensional aspect of a person, represents an individual's perception of their position in the context of the value system in which they live with regard to their own goals, expectations, personal standards, and interests. Such a broad concept in the most general sense includes basic determinants such as the physical health of an individual, their psychological state, economic independence, social relations, and attitude towards significant events in their environment. With this in mind, the goal of this study was to distinguish the category of the population prone to a lumbar syndrome as well as to identify several facets of LS that can be related to certain aspects of an individual's quality of life, with their physical fitness and self-assessment of quality of their life.

Patients and Methods

In this empirical non-experimental transversal study, we have identified a number of factors that may influence certain aspects of the quality of life of individuals affected with lumbar syndrome primarily through physical activity and exercise. The sample of respondents in this study consisted of a total of 202 people (M = 93; F = 109) affected with a lumbar syndrome, who at the time the survey was conducted were undergoing physical treatment in the centers for physical medicine and rehabilitation in four cities of the Autonomous Province of Vojvodina, Serbia (Novi Sad, Subotica, Kanjiža and Bačka Palanka). Out of the entire sample of respondents, depending on the frequency of back pain, we have stratified three respondent subsamples: the ones with occasional pain (133 respondents or 55.94%), the ones with frequent pain (48 respondents or 23.76%), and the ones with very frequent episodes of pain (41% or 20.30%). The mean age of the respondents in the study was 47.5 ± 13.85 years old.

Data obtained in this survey were collected using a measuring instrument, a questionnaire specifically designed

for this research. In designing the survey instrument, we have used the items of the questionnaires whose construct was based on the modified version of the WHOQOL-BREF questionnaire (World Health Organization Quality of Life Questionnaire - BREF) (The WHOQOL group, 1998) and the PAL questionnaire (Perception of Active Lifestyle) (Nešić, 2016), which are designed for the quality of life self-assessment. The questionnaire covered four determinants that outline the concept of the quality of life: physical health (8 items), mental health (7 items), social relations (5 items), and the environment (9 items). We used the following variables from the questionnaire the *Perception of Active Lifestyle - Self-assessment of quality of life* (Nešić, 2016):

1. *I experience lower back pain?* (occasionally, frequently, and very often) - was a categorical variable in the study,
2. *I can declare that my quality of life is* (bad, average, good, very good, much better than a majority of people) – health self-assessment,
3. *How would you rate your overall physical fitness?* (bad, on a satisfactory level, good, excellent) and
4. *How often do you walk continuously for 60 minutes?* (every day, two to three times a week, only on weekends, occasionally, never).

For all variables of the survey questionnaire, the frequencies and the percentage values were calculated using the results of the entire sample of respondents. The results of the study were given in percentages and presented in tables. A non-parametric statistical method - the chi-squared test with a level of statistical significance of $p \leq 0.05$, was used to determine differences in the life habits of people affected by the LS. The collected data were processed using the statistical package SPSS.20 (Statistical Package for the Social Sciences, V.20; SPSS Inc., Chicago, Illinois, USA).

Results

Self-assessment of the Quality of Life

The results shown in Table 1 point to the existence of significant statistical differences in an individual's self-assessment of health manifested through the variable "*I can declare that my quality of life is*" ($p = 0.00$) at the value of $\chi^2 = 36.75$. The notable difference goes in favor of respondents who reported that they occasionally experience back pain, because 14.16% of them rated their lives as *much better than of majority of people*, compared to 4.17% of respondents who frequently experience back pain and 4.87% who experience episodes of back pain very often. The highest percentage of respondents who also declared that their quality of life is good had occasional back pain (43.37%), followed by respondents who frequently have back pain (29.27%), and in third place were respondents who experience episodes of back pain very often (18.76%).

The greatest percentage of respondents who rated the quality of their life as *bad* were from the group of respondents with frequent back pain (10.41%) (Table 1).

Table 1. *Differences in values with regard to frequency of back pain and health self-assessments*

	I can declare that my quality of life is					Total
	Bad	Average	Good	Very good	Much better than that of the majority of people	
Occasionally	1 (0.88%)	31 (27.43)	49 (43.37)	16 (14.16)	16 (14.16)	113 (100.0%)
Frequently	5 (10.41%)	31 (64.58%)	9 (18.76%)	1 (2.08%)	2 (4.17%)	48 (100.0%)
Very often	3 (7.32%)	21 (51.22%)	12 (29.27%)	3 (7.32%)	2 (4.87%)	41 (100.0%)
Total	9 (4.46%)	83 (41.09%)	70 (34.65%)	20 (9.90%)	20 (9.90%)	202 (100.0%)

$\chi^2(df=8, 202)=36.75, p=0.00$

χ^2 – chi-squared test value; p – the level of statistical significance of the chi-squared test; df - degrees of deviation

The results of the chi-squared test survey given in Table 2 show significant statistical differences in the survey of the variable for assessing the quality of life "*How would you rate your overall physical fitness*" ($p = 0.00$) at the value of $\chi^2 = 34.73$. A notably higher percentage of respondents with occasional back pain rated their overall physical

fitness as *excellent* (7.96%) compared to respondents who frequently experience back pain (4.17%) and those who experience back pain very often (0%), which may be due to the possibility to exercise and move without pain on the part of those who only occasionally experience back pain, and therefore we may note a significant statistical difference in the results obtained through the survey of this variable. 25.66% of respondents with occasional back pain rated their overall physical fitness as *good*, while respondents who frequently have back pain (8.33%) and those who experience back pain very often (12.2%) had much lower percentages in this category of their fitness assessment.

Table 2. *Differences in values concerning the frequency of back pain, and the "How would you assess your overall physical fitness?" variable*

	How would you rate your overall physical fitness?				Total
	Bad	Satisfactory	Good	Great	
Occasionally	17 (15.04%)	58 (51.34%)	29 (25.66%)	9 7.96%	113 (100.0%)
Frequently	19 (39.58%)	23 (47.92%)	4 (8.33%)	2 (4.17%)	48 (100.0%)
Very often	24 (58.54%)	12 (29.26%)	5 (12.2%)	0 (0.0%)	41 (100.0%)
Total	60 (29.70%)	93 (46.04%)	38 (18.81%)	11 (5.45%)	202 (100.0%)

$\chi^2(df=6, 202)=34.73, p=0.00$

χ^2 –chi-squared test value of; p – the level of statistical significance of the chi-squared test; df - degrees of deviation

Given the evidence in Table 3 significant differences in values in self-assessment of quality of life manifested are manifested in the variable "*How often do you walk continuously 60 minutes?*" ($\chi^2 = 33.86$, p = 0.00). Respondents with occasional back pain walk continuously for 60 minutes every day account for 17.70% of the sample, while 12.19% of them very often experience back pain and only 8.33% of respondents who frequently experience back pain take continuous walks every day. The respondents with occasional back pain (23.89%) were in the majority of those who declared that they take continuous walks two or three times a week. Only 8.85% of the respondents experiencing occasional back pain have reported that they never skip their 60-minute walks.

Table 3. *Differences in values concerning the frequency of back pain, and the "How often do you walk continuously 60 minutes?" variable*

	How often do you walk continuously for 60 minutes?					Total
	Every day	2-3 times a week	Only on weekends	Occasionally	Never	
Occasionally	20 (17.70%)	27 (23.89%)	9 (7.96%)	47 (41.60%)	10 (8.85%)	113 (100.0%)
Frequently	4 (8.33%)	3 (6.25%)	9 (18.75%)	19 (39.58%)	13 (27.09%)	48 (100.0%)
Very often	5 (12.19%)	4 (9.76%)	2 (4.88%)	13 (31.71%)	17 (41.46%)	41 (100.0%)
Total	29 (14.36%)	34 (16.83%)	20 (9.90%)	79 (39.11%)	40 (19.8%)	202 (100.0%)

$\chi^2(df=8, 202)=33.86, p=0.00$

χ^2 – chi-squared test value; p – the level of statistical significance of the chi-squared test; df - degrees of deviation

Discussion

The conducted study aimed at analyzing the differences in quality of life with regard to overall physical fitness, frequency of walking, and self-assessment of quality of life in persons with a different incidence of lumbar pain (back pain). For that purpose, respondents filled out a survey that is a part of the standardized questionnaire the *Percep-*

tion of Active Lifestyle - Self-assessment of quality of life (Nešić, 2016). For the study, we have used questions from the first part of the questionnaire, which deal specifically with the assessment of the quality of life. The t sample consisted of a total of 202 respondents from the Autonomous Province of Vojvodina. Degenerative processes on the spinal column begin around the age of 20, so after the age of 50 the intervertebral disc becomes completely fibrous and surrounded by connective tissue (Von Waldburg & Van Elegem, 2003). The average age of the respondents in this study was 47.5 ± 13.85 years, therefore one of the causes of lumbar pain in the respondents may be attributed to the physiological aging process, because with increasing age the intervertebral disc contains less water, loses strength, elasticity, and thus its function in dampening of pressure decreases as well. This causes the formation of microtraumas, which gradually lead to fissures and cause rupture of *annulus fibrosus*, resulting in intervertebral disc herniation (Von Waldburg & Van Elegem, 2003).

All the respondents in this study have had a history of lumbar pain, which means that they were fully affected by the their condition, firstly by pain, followed by all the accompanying facets of this pathological condition, e.g. limited motion range, that cause extreme discomfort, and collectively affect the quality of everyday life of a person. The survey conducted using the variable "*I can declare that my quality of life is*", which directly reflects the quality of life, resulted in significantly different ($p = 0.00$) statistical scores of the three groups of respondents that have a varying frequency of back pain. The largest number of respondents who have reported that their quality of life is better than of majority of people was from the group that occasionally experiences back pain (14.16%), and only 0.88% of respondents from the same group rated their life as *bad.* Since it was found that a considerable number of patients affected with LS suffer from relapses of their condition that require renewed treatment (Itz, Geurts, van Kleef, Nelemans, 2013), the respondents of this study understood the role of physical activity in reducing the risk factors that lead to a recurrence of lumbar pain episodes. This is most likely the reason why 17.70% of the respondents of the study who occasionally experience back pain exercise in the form of continuous 60-minute walks every day, while 23.89% of them exercises two to three times a week. Additionally, through regular performance of physical activities, the appearance of muscle imbalance which, along with other risk factors, would lead to the appearance of lumbar pain, is reduced to a minimum. The explanation for the above conclusion should be sought through the assessment of the fitness of the musculature and the occurrence and frequency of pain in the other two groups of respondents. The respondents who occasionally experience back pain had the best score (41.60%) even in the survey of the category *Occasional, continuous 60-minute walks,* compared to the respondents who frequently experience back pain (39.58%) and those whose episodes of back pain occur very often (31.71%). Physical activity has a positive effect on reducing the occurrence of lumbar syndrome, while time spent doing sedentary activities, such as watching television and working on a computer for more than 15 hours a week will contribute to the appearance of pain in the lumbar vertebrae (Sjolie, 2004).

By correlating the third variable for the assessment of the quality of life *How would you rate your overall physical fitness?* we have established a statistically significant difference of the results in favor of the respondents with the occasional back pain when compared to the other two groups of respondents. It was determined that most of the respondents in the study rated their physical fitness as *excellent*, and the least of them rated their physical fitness as *bad*. Most of the respondents with very frequent back pain rated their physical fitness as *bad*, and least of them assessed their physical fitness as *excellent*, which is certainly a consequence of the appearance and frequency of pain in this group of respondents and the fact that their condition certainly has a chronic nature and affects the quality of their daily life. Since these respondents experience very long and frequent episodes of lumbar pain, their ability to perform everyday physical activities is reduced, they are not able to move without difficulties or to continuously walk, and thus their level of fitness was assessed by them as *very bad*.

The evidences of this study suggest that respondents with a varying incidence of lumbar pain have a poorer quality of life than those with a less frequent incidence of lumbar pain. The six-month monitoring study indicated that as many as 70.7% of respondents with lumbar pain experienced a decline in their quality of life, and that occurrence of lumbar pain is in direct correlation with the quality of life and physical activity (Nolet, Kristman, Côté, Carroll & Cassidy, 2015). Exercises for activation of the muscles of the torso often applied in the treatment of people who experience back pain, have been proved in numerous studies to be successful in reducing back pain. This study has shown that back pain could be a limiting factor of normal physical activity, fitness, and it can even affect the performance of ordinary daily activities, which supports the findings of the study conducted by Thelin, Holmberg & Thelin, (2008).

The subject of this study was the assessment of the quality of life through a survey of three variables of the above questionnaire. Based on the results obtained in the study, we noticed that there are significant statistical differences in quality of life in favor of respondents who only occasionally feel back pain, compared to respondents who experience back pain frequently or very often. This conclusion is in line with the findings of the study conducted by Bošković et al. (2009). The afore-named authors concluded that the quality of life of patients with lumbar radiculopathy was reduced only in the domain of its physical components and that the quality of life decreases as episodes of lower back pain become more frequent and last longer. Disruptions in overall physical fitness and quality of life were reported in 64% of patients with nonspecific (occasional) lumbar pain, (Veresciagina, Spakauskas, & Ambrozaitis, 2010), which is a slightly higher percentage compared to 55.94% of the respondents from our study. Nevertheless, we may consider that all the respondents affected with back pain (lumbar pain or lumbar syndrome) are experiencing similar problems.

Presuming that exercise (targeted physical activity) is one of the treatments proven to be effective in the treatment of lumbar syndrome (Maher, 2004), we can infer that the respondents with the reported rarest incidence of back pain are also the physically most active ones, as confirmed by the study. The results have confirmed that the respondents who occasionally feel back pain were the physically most active ones, so we can assume that exercise, physical activity, and regular movement resulted not only in the lower incidence of lumbar pain but also in a better quality of life of this group of respondents. The respondents who reported the occasional back pain were exactly the ones who rated their quality of life as *great,* their physical fitness was at the highest level, and were physically most active. Since physical activity has a positive effect on the reduction of incidence of the lumbar syndrome (Sjolie, 2004), consequently the quality of life in the respondents who frequently or very often experience pain in the lumbar region is at the lower level. Perhaps the frequent episodes of lumbar pain in other two groups of respondents occur due to insufficient or inadequate performance of physical activities, while not taking into account the influence of factors that have not been assessed and which were not the subject of this study. While conducting this study, we have found significant statistical differences between the three groups of respondents, and therefore we may take note of the fact that the respondents who reported higher values of the physical component had a lower recurrence of back pain. Numerous studies where the respondents were people affected with lumbar pain proved that physical activity has a positive effect on the quality of life (Teyhen et al, 2008).

Physical activity is any bodily movement produced by skeletal muscles that results in energy consumption (Caspersen, Powell & Christenson, 2008). The term physical effort or physical activity, however, is often used in everyday speech to express many related concepts such as physical labor, physical exercise, sports activities, competitive sports, playing, physical education, physical culture. According to the World Health Organization, physical activity, along with a healthy diet and abstaining from smoking, is a major component in the prevention of chronic diseases (WHO, 2013). Regular physical activity results in numerous benefits to physical, mental, and social health, and therefore it improves the quality of life not only of people affected by lumbar pain or by some other type of back pain, but it also improves the quality of life of healthy people. By reviewing many relevant articles we may find a correlation between normal physical activity during adolescence (Froberg & Andersen, 2005) and adulthood, and long-term positive health effects throughout adult age (Hills, King & Armstrong, 2007; Must & Tybor, 2005).

One group of physical exercises, which are the spinal stabilization exercises, is particularly effective when it comes to the improvement of the quality of life of people affected by lumbar pain. The goal of these exercises is to improve the function of critical muscles of the torso, and at the same time to protect the spine from suffering damage. The majority of traditional approaches to creating exercises for the back emphasizes restoring or improving the range of motion of the spine and muscle strength. This approach, generally, has not been effective enough in reducing the occurrence of back problems and the latest review of expert findings suggests that people with a greater range of motion of the spine are at greater risk of experiencing future health problems, while endurance, rather than strength is associated with reducing of symptoms of back problems (McGill, 2001). We should always have in mind what goal we want to achieve by exercising. In fact, there are no safe or dangerous exercises, but only exercises that are poorly prescribed (McGill, 2009).

One of the causes of lumbar pain is, among other things, muscle imbalance, low level of flexibility of muscles and tendons from the back of the thigh, structural changes in the spine (degenerative changes in the spine), as well as inadequate training (dosage, intensity of training). During our growth, muscles and ligaments cannot properly ac-

company the growth of bones, which leads to muscle imbalance and the appearance of lumbar pain. The functional spinal unit (or motion segment), is the structure of two adjacent vertebrae and the intervertebral disc together with the adjoining structure of ligaments and muscles. Favoring one or more muscle structures while neglecting the others, leads to muscle imbalance and mutual dysfunction. Muscle imbalance occurs when a certain agonist muscle is significantly stronger than its corresponding antagonist muscle, or when one or the other is shortened or elongated beyond their physiological limits. Decreased static endurance of the abdominal and lumbar musculature influences the occurrence of the muscle imbalance in the lower back region, which over time causes the appearance of lumbar syndrome - LS (McGill, 2001).

Conclusion

The main limitation of this study can be referred to the subjectivity in self-assessment for the given categorization of answers. For this reason, the conclusions refer primarily to the perception of the respondents, and not to the directly measured condition. The respondents with occasional lower back pain had a better perception of their life, their fitness was at a higher level, and they have shown greater physical activity when it came to continuous walking for 60 minutes. Therefore, we may conclude that the quality of life could and must be related to the current health condition and frequency of pain in this population of respondents. The respondents who reported only an occasional incidence of back pain during the previous year had a higher quality of life and assessed their life as *better*. Further monitoring and studying of this group of respondents is still deemed necessary because there is a possibility that in some individuals the episodes of acute pain may prolong and turn into a chronic condition, followed by a possible decline in the quality of their life. In a practical sense, the results of this study may indicate that occasional pain in the lower back does not necessarily reduce the quality of life, so prevention and physical activity programs can be adapted to encourage continuous movement and preserve the functional readiness of the subjects.

Taking everything into account, the results of this study in a practical sense may indicate that occasional pain in the lower back does not necessarily reduce the quality of life, and that prevention and physical activity programs can be adapted to encourage continuous movement and preservation of functional fitness.

References:

Andersson, G. B. J. (1999). Epidemiological feature of chronic low-back pain. *The Lancet*, *354*(9178), 581-585.

Barkhordari, A., Halvani, G., & Barkhordari, M. (2013). The prevalence of low back pain among nurses in Yazd, Southeast Iran. *International Journal of Occupational Hygiene*, *5*(1), 19-22.

Bošković, K., Todorović-Tomašević, S., Naumović, N., Grajić, M., Knežević, A. (2009). Quality of life of conservatively treated patients with lumbar radiculopathy. *Military medical review, 66*(10), 807-812.

Božić, A. (2017). Risk factors for the occurrence of lumbar syndrome in nurses – medical technicians. *Doctoral dissertation*. Novi Sad: University of Novi Sad, Faculty of Medicine.

Carey, T. S., Garret, J. M. & Jackman, A. M. (2000). Beyond the Good Prognosis: Examination of an Inception Cohort of Patients with Chronic Low Back Pain. *Spine*, *25*(1), 115–120.

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports, 100*(2), 126–131.

Chou, R. & Huffman, L. H. (2007). Nonpharmacologic therapies for acute and chronic low back pain: a review of the evidence for an American Pain Society/American College of Physicians clinical practice guideline. *Annals of Internal Medicine*, *147*(7), 492-504.

Dionne, C. E., Dunn, K. M. & Croft, P. R. (2006). Does back pain prevalence really decrease with increasing age? A systematic review. *Age and Ageing*, *35*(3), 229–334.

Franca, F. R., Burke, F. N., Caffaro, R. R., Ramos, L. A. & Marques, A. M. (2012). Effects of Muscular Stretching and Segmental Stabilization on Functional Disability and Pain in Patients with Chronic Low Back Pain: A Randomized, Controlled Trial. *Journal of Manipulative and Physiological Therapeutics, 35***(4), 279-285.**

Freburger, J. K., Holmes, G. M., Agans, R. P., Jackman, A. M., Darter, J. D., Wallace, A. S. & Carey, T. S. (2009). The Rising Prevalence of Chronic Low Back Pain. *Archives of Internal Medicine, 169*(3), 251-258.

Froberg, K. & Andersen, L. B. (2005). Mini review: Physical activity and fitness and its relations to cardiovascular diseases risk factors in children. *International Journal of Obesoty; 29(*2), 34-39.

Hayden, J. A., van Tulder, M. W., Malmivaara, A. V. & Koes, B. W. (2005). Meta-analysis: exercise therapy for nonspecific low back pain. *Annals of Internal Medicine, 142*(9), 765-775.

Henewer. H., States, F., Aufdemkampe, G., van Rijin, M., & Vanhees, L. (2011). Physical activity and low back pain: a systematic review of recent literature. *European Spine Journal*, 20(6), 826-845.

Heuch I, Stange Foss I. (2013). Acute low back usually resolves quickly but persistent low back pain often persists. *Journal of Physiotherapy,* 59(2): 127.

Hills, A. P., King, N. A. & Armstrong, T. P. (2007). The contribution of physical activity and sedentary behaviors to the growth and development of children and adolescents: Implication for overwight and obesity. *Sports Medicine,* 37(6), 533-545.

Itz, C. J., Geurts, J. W., van Kleef, M. & Nelemans, P. (2013). Clinical course of non-specific low back pain: a systematic review of prospective cohort studies set in primary care. *European Journal of pain, 17*(1), 5-15.

Jacob, T., Baras, M., Zeev, A. & Epstein, L. (2004). Physical Activities and Low Back Pain: A Community – Based Study. *Medicine and Science in Sports Exercise*, *36*(1), 9-15.

Jandrić, S. & Antić, B. (2006). **Low back pain and degenerative disc disease.** *Medical review*, *59*(9-10), 456-461.

Lee, H J., Lim, W. H., Park, J. W., Kwon, B. S., Ryu, K. H., Lee, J. H., & Park, Y. G. (2012). The relationship between cross sectional area and strength of back muscles in patients with chronic low back pain. *Annals of Rehabilitation Medicine*, *36*(2), 173-181.

Lopez, A., Mathers, C., Ezzati M, Jamison, D. T. & Murray, C. J. L. (2006). *Global burden of disease and risk factors.* Washington (DC): The International Bank for Reconstruction and Development/The World Bank; New York: Oxford University Press

Mačak-Hadžiomerović, A., Čustović-Hadžimuratović, A. i Mujezinović A. (2009). *A guidebook to the prevention and treatment of lumbar pain syndrome.* University of Sarajevo: Institute for Scientific Research and Clinical Center Development.

Maher, C.G. (2004). Effective physical treatment for low back pain. *Orthopedics Clinics in North America, 35*(1),57–64.

Mailloux, J., Finno, M. & Rainville, J. (2006). Long-term exercise adherence in the elderly with chronic low back pain. *American Journal of Physical Medicine & Rehabilitation*, *85*(2), 120-126.

McGill, S. (2001). Low back stability: From formal description to issues for performance and rehabilitation. *Exercise and Sport Science Reviews.* 29 (1), 26–31.

McGill, S. (2007). *Low back disorders: Evidence-based prevention and rehabilitation, 2nd edition*. Human Kinetics, Champaign, Illinois.

McGill, S. (2009). *Ultimate back fitness and performance, 4th edition*. Wabuno Publishers, Backfitpro Inc., 292 Beechlawn Dr., Waterloo, Ontario, Canada.

Meucci, R. D., Fassa, A. G., Paniz, V. M. V., Silva, M. C. & Wegman D. H. (2013). Increase of chronic low back pain prevalence in a medium-sized city of southern Brazil. *BioMed Central Musculoskeletal Disorders*, 14, 155.

Middleton, K., & Fish, D. E. (2009). Lumbar spondylosis: clinical presentation and treatment approaches. *Current Reviews in Musculoskeletal Medicine*, *2*(2), 94–104.

Must, A. & Tybor, D. J. (2005). Physical activity and sedentary behavior: A review of longitudinal studies of weight and adiposity in youth. *International Journal of Obesity, 29*(2), 84-96.

Nachemson, A L. & Jonsson, E.J. (2000). *Neck and Back Pain. The Scientific Evidence of Causes, Diagnoses and Treatment*. Philadelphia: Lippincott, 241-304.

National Guide for General Practitioners (2004). *Lumbar Syndrome.* Belgrade: Faculty of Medicine of the University of Belgrade.

Nešić, M. (2016). Valorization of a questionnaire for the assessment of the quality of life of students. *Teaching and education*, *65*(2), 329-343.

Nolet, P. S., Kristman, V. L., Côté, P., Carroll, L. J. & Cassidy, J. (2015). Is low back pain associated with worse health-related quality of life 6 months later? *European Spine Journal, 24*(3), 458-466.

Picavet, H. S. J. & Schouten, J. S. A. G. (2000). Physical Load in Daily Life and Low Back Problems in the General Population-The MORGEN Study. *Preventive Medicine*, 31, 506–512.

Popović, S. (2003). *Assessment of work ability in the most common conditions affecting the locomotor system*. U: Pavlović, M.Ž., & Vidaković, A. (ur.). Assessment of work ability. Lazarevac: Elvod-print, 496-509.

Romanov, R., & Radak, M. (2013). Yoga exercises for lower back pain. *Sense, 3*, 124-135.

Sherman, K. J., Cherkin, D. C., Erro, J., Miglioretti, D. L. & Deyo, R. A. (2005). Comparing yoga, exercise, and a self-care book for chronic low back pain: a randomized, controlled trial. *Annals of Internal Medicine*, *143*(12), 849-856.

Silva, M. C., Fassa, A. G. & Valle, N. C. (2004). Chronic low back pain in a Southern Brazilian adult population: prevalence and associated factors. *Caderons de Saude Publica*, 20(2), 377–385.

Sjolie, A. N. (2004). Assosiation between activities and low back pain in adolescents. *Scandinavien Journal of Medicine and Science in Sports, 14*(6), 352-359.

Teyhen, D. S., Rieger, J. L., Westrick, R. B., Miller, A. C., Molloy, J. M., Childs, J. D. (2008). Changes in deep abdominal muscle thickness during common trunkstrengthening exercises using ultrasound imaging. *Journal of Orthopaedic Sports and Physiacal Therapy,38*(10), 596-605.

The WHOQOL Group (1998). Development of the World Health Organization WHOQOL-BREF Quality of Life Assessment. *Psychological Medicine*, 28, 551—558.

Thelin, A., Holmberg, S. & Thelin, N. (2008). Functioning in neck and low back pain from a 12-year perspective: a prospective population-based study. *Journal of Rehabiltation Medicine, 40*(7), 555–561.

Van Middelkoop, M., Rubinstein, S. M., Kuijpers, T., Verhagen, A. P., Ostelo, R., Koes, B. W., & van Tulder, M. W. (2011). A systematic review on the effectiveness of physical and rehabilitation interventions for chronic non-specific low back pain. *European Spine Journal, 20*(1), 19–39.

Van Tulder, M. W., Koes, B. & Malmivaara, A. (2006). Outcome of non-invasive treatment modalities on back pain: an evidence-based review. *European Spine Journal*, *15*(1), S64-S81.

Veresciagina, K., Spakauskas, B., & Ambrozaitis, K. V. (2010). Clinical outcomes of patients with lumbar disc herniation, selected for one-level open-discectomy and microdiscectomy. *European Spine Journal, 19*(9), 1450–1458

Von Waldburg, T. & van Elegem, P. (2003). Etiologies of lumbago. *Revue Médicale de Bruxelles, 28*(20), 2331-2337.

Walker, B. F., Muller, R. & Grant, W. D. (2004). Low back pain in Australian adults: prevalence and associated disability. *Journal of Manipulative and Physiological Therapeutics*, *27*(4), 238–244.

Primljen: 20. novembar 2025. / Received: Novembar 20, 2025
Izmjene primljene: 20. decembar 2025. / Changes Received: December 20, 2025
Prihvaćen: 30. mart 2026. / Accepted: March 30, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601129S
UDC: 159.922.7:37.018
Original scientific paper
Originalni naučni rad

Revitalizing Mental Readiness: Mindsport Navigator Application (Minna) to Strive for the Best Performance of Undiksha FC

I Made Satyawan[1], I Nyoman Laba Jayanta[1], Ni Luh Putu Spyanawati[1], Gede Doddy Tisna[1], I Gusti Putu Suharta[1], Ni Putu Dwi Sucita Dartini[1], Prisca Widiati[1], Yovhandra Ockta[2]
[1]Universitas Pendidikan Ganesha, Indonesia
[2]Universitas Teuku Umar, Indonesia

Correspondence:
I Made Satyawan
Universitas Pendidikan Ganesha, Indonesia, made.satyawan@undiksha.ac.id

Abstract: *This study aims to develop the Mindsport Navigator Application (MINNA) as a digital tool to systematically assess and enhance the mental readiness of Undiksha FC athletes. The research was conducted using a development model adapted from Borg and Gall, consisting of ten stages including product design, expert validation, small group trials, large group trials, and final product refinement. The MINNA application integrates three psychological measurement instruments: the Sport Competition Anxiety Test (SCAT), Athlete Burnout Questionnaire (ABQ), and Perceived Stress Scale (PSS). The results from 60 athletes show that anxiety and stress levels fall into the moderate category, while burnout levels indicate no significant signs of emotional exhaustion. Descriptive analysis reveals varying levels of anxiety and stress, but relatively stable burnout conditions. Correlation analysis indicates a significant positive relationship between anxiety and stress, whereas burnout shows no significant relationship with either variable. Overall, the MINNA application effectively provides personalized psychological assessments and coping recommendations, making it a useful tool for continuous mental monitoring and for supporting optimal athletic performance. The application demonstrates strong potential to be integrated into training programs to maintain athletes' psychological well-being and enhance performance outcomes.*
Keywords: *MINNA application; psychological readiness; athlete anxiety; athlete burnout; perceived stress; mental training; sport psychology; mobile application development*

Introduction

When learning resources and media are limited, starting with a lack of innovation and renewal as well as the utilization of media to be applied, this will certainly have an impact on the learning outcomes of students or athletes themselves. In addition, there are many factors that can influence success, including psychological factors, learning outcomes, level of understanding, available facilities, curriculum, and media used by educators and trainers in the learning and training process. One factor that will be emphasized is the development of media in the form of applications to facilitate students or athletes in learning and training. The achievement of students or athletes in the world of sports is closely related to psychological factors.

Achieving success in the world of sports is closely related to psychological factors. In an increasingly competitive sporting world, mental health is a key factor in determining success. Psychological skills training is the systematic learning and practice of psychological skills through self-regulation strategies to help athletes consistently achieve peak performance (Weinberg & Gould, 2018). In particular, techniques such as goal setting, imagery, self-talk, and arousal are considered to improve performance (Morris, 2003). The most commonly implemented psychological skill training is self-talk (Johnson et al., 2004; Maynard et al., 1995) and *goal setting* (Ann Boyce, 1992). Self-talk is when athletes engage in self-instruction to perform specific tasks or regulate emotional stimuli (Hardy et al., 2001). Emotional motivation helps athletes maintain focus and build confidence (Chroni et al., 2007) and in enhancing the positive effects of the competitive level of physiological stimulation. This proves that sports psychology plays an important role in achieving optimal athletic performance. However, both professional and amateur athletes face high pressure and demands from various parties, which can lead to burnout. Burnout was initially popularized as a tripartite concept, which includes exhaustion, rejection, and a decline in personal performance (Maslach & Jackson, 1981; Maslach et al., 2001). Burnout has been defined as a syndrome consisting of three factors: depersonalization, emotional exhaustion, and reduced personal accomplishment (Maslach & Jackson, 1981).

Meanwhile, (C. A. Johnson & Gilbert, 2004) highlight that youth sports budgets often prevent the recruitment of sports psychologists, resulting in coaches taking on roles related to psychological skill training. Meanwhile, mental health and psychological aspects are crucial elements that support overall athlete performance. The literature has identified a positive relationship between psychological empowerment and individual performance outcomes such as performance satisfaction (M. T. Maynard et al., 2012), organizational commitment (Avolio et al., 2004) and task performance (Chamberlin et al., 2018; Huang et al., 2010). Psychological abilities have also been shown to influence creativity (Zhang, 2010), innovative behavior (Spreitzer et al., 1999) and career success (Dust et al., 2018).

Therefore, personalization in psychological training is becoming increasingly important to help students or athletes overcome the psychological challenges they face. Unfortunately, psychological training is still often overlooked. Developing training programs that are tailored to individual needs and follow the principles of periodization is often a challenge for educators, coaches, athletes, and students. This process requires a deep understanding of the psychological needs, psychological conditions, and specific goals of each individual. For this reason, the development of mobile applications to analyze the psychological training needs of athletes has emerged as an effective solution. Previous researchers quickly recognized the potential of mobile applications in health (Mosa et al., 2012) and mental health (Luxton et al., 2011), with a systematic review of related research, namely mobile health applications (mHealth), emerged since 2011 (Luxton et al., 2011). By utilizing mobile technology, this application can offer personalized solutions for each individual athlete, helping them overcome psychological barriers and improve their overall performance. With this application, coaches and athletes can find psychological exercises that suit the athlete's needs, accessible anytime and anywhere. Coaches and athletes can monitor progress and receive appropriate training recommendations to help athletes achieve optimal performance. Thus, the development of a mobile application to analyze athletes' psychological training needs is highly relevant in supporting athletes' mental health and performance. This study will examine the application's functionality as a medium for identifying psychological training programs that suit athletes' conditions, while also serving as a tool for coaches to improve their ability to design psychological training programs.

Research Methods

This research is a development study designed in three stages. The first stage is the design projection and development of features in the MINNA application. The second stage is testing by experts to refine the MINNA application product, while the third stage is refinement and field testing. The approach in this development research adopts the steps developed by Borg and Gall, namely 10 stages of product development research consisting of: (1) Conducting research and gathering information (2) Planning (3) Designing the initial product (4) Validating the product with three experts (5) Revising the product (6) Conducting small group trials (7) Revising the product (based on suggestions and small group trial results) (8) Conducting large group trials (9) Revising the final product, and (10) Finalizing the product.

Results & Discusions

The results of this study are in the form of a web-based application that can be accessed at https://minna.sehato.my.id/ using a smartphone or laptop connected to the internet. The Mindsport Navigator Application (MINNA) serves to revitalize mental readiness in order to achieve the best performance for Undiksha FC. The following are the results of the development of the MINNA application:

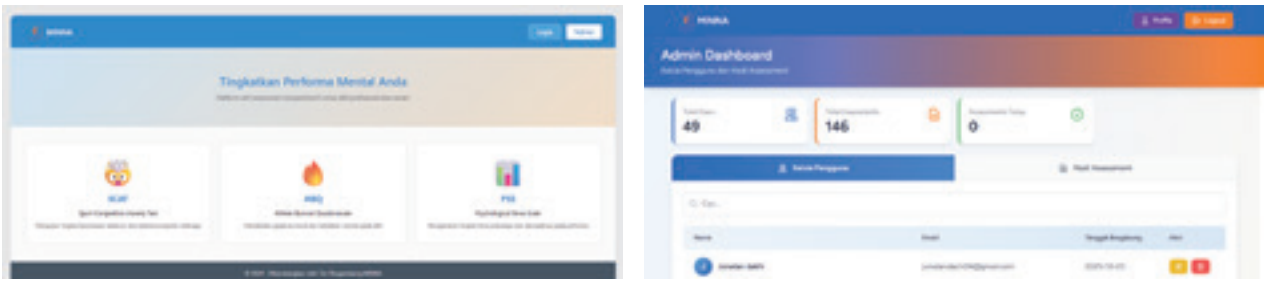


Figure 1. *MINNA Application*

In this study, data was obtained using three types of psychological measurements, namely the Sport Competition Anxiety Test (SCAT), Athlete Burnout Questionnaire (ABQ), and Psychological Stress Scale (PSS). The Sport Competition Anxiety Test (SCAT) instrument was used to measure the level of anxiety athletes experience when facing sports competitions. The aim was to determine whether athletes tended to have low, moderate, or high anxiety levels when competing, thereby providing a basis for coaches or researchers to understand the psychological condition of athletes and design appropriate strategies to improve their performance. The Athlete Burnout Questionnaire (ABQ) instrument serves to measure the level of burnout in athletes. The aim is to determine the extent to which athletes experience emotional exhaustion, a reduced sense of accomplishment, and negative attitudes towards their sport, so that the results can be used by coaches or researchers to identify psychological problems and develop prevention and treatment strategies to maintain optimal athlete performance. The Perceived Stress Scale (PSS) instrument is used to assess the level of stress felt by individuals in the past month. The aim is to determine the extent to which a person feels depressed, unable to control the situation, or able to cope with the problems they are experiencing, so that the results can help researchers and practitioners understand the psychological condition of respondents and design more appropriate stress management strategies.

Based on the results of the SCAT test conducted on 60 athletes using the MINNA application, the average test result was 18.6, which falls into the "Moderate Anxiety" category. A total of 18 athletes were categorized as having low anxiety, 36 athletes had moderate anxiety, and 6 athletes were classified as having high anxiety. Based on the results of the ABQ test conducted on 60 athletes using the MINNA application, the average score was 2.45, indicating "No Indication of Burnout." A total of 54 athletes were in the No Indication of Burnout category, 3 athletes were categorized as Mild Burnout, and 3 athletes were categorized as Severe Burnout. Based on the PSS test results conducted on 60 athletes using the MINNA application, the average score was 18.5, categorized as "Moderate Stress." The distribution showed that 10 athletes experienced low stress, 50 athletes experienced moderate stress, and none were categorized as having high stress.

Table 1. *Descriptive Statistics*

Descriptive Statistics						
	N	Minimum	Maximum	Sum	Mean	Std. Deviation
SCAT	30	10.00	27.00	1116.00	18.6000	4.25000
ABQ	30	1.53	3.67	147.00	2.4500	0.41000
PSS	30	5.00	24.00	1110.00	18.5000	4.05000
Valid N (listwise)	30					

Overall, the descriptive analysis results show that athletes are in varying psychological conditions. The Sport Competition Anxiety Test (SCAT) and Perceived Stress Scale (PSS) are in the moderate category with considerable score variation, indicating differences in anxiety and stress levels among athletes, ranging from low to moderately high. Meanwhile, the Athlete Burnout Questionnaire (ABQ) showed no indication of burnout with low variation, indicating that the athletes' emotional exhaustion was relatively uniform and at a safe level. These findings suggest that, in general, athletes have stable burnout levels, but they still experience moderate levels of anxiety and stress that require attention in their mental training.

Table 2. *Correlations Test*

Correlations				
		SCAT	**ABQ**	**PSS**
SCAT	Pearson Correlation	1	.063	.447*
	Sig. (2-tailed)		.740	.013
	N	30	30	30
ABQ	Pearson Correlation	.063	1	.216
	Sig. (2-tailed)	.740		.251
	N	30	30	30
PSS	Pearson Correlation	.447*	.216	1
	Sig. (2-tailed)	.013	.251	
	N	30	30	30

**. Correlation is significant at the 0.05 level (2-tailed)*

Based on the results of the correlation analysis, it is known that the relationship between sports anxiety (SCAT) and burnout (ABQ) shows a very weak correlation value (r = 0.063) with a significance of 0.740. This indicates that there is no significant relationship between the level of anxiety experienced by athletes and their level of burnout. Meanwhile, the relationship between sports anxiety (SCAT) and stress levels (PSS) shows a moderate positive correlation (r = 0.447) and is statistically significant (p = 0.013). This finding indicates that the higher the competitive anxiety felt by athletes, the higher their stress levels. The relationship between burnout (ABQ) and stress (PSS) showed a weak correlation (r = 0.216) with a significance value of 0.251, so it can be concluded that burnout has no significant relationship with athletes' stress levels. Overall, only anxiety has a significant relationship with stress, while burnout does not show a meaningful relationship with either anxiety or stress.

The development of the Mindsport Navigator Application (MINNA) in this study shows that digital media can be an effective tool for analyzing and mapping athletes' mental readiness more systematically. The results of using the application on 30 Undiksha FC athletes provide a comprehensive picture of three important psychological aspects, namely the Sport Competition Anxiety Test (SCAT), Athlete Burnout Questionnaire (ABQ), and Perceived Stress Scale (PSS). In general, the research findings show that the athletes' anxiety and stress levels are in the moderate category, while their burnout levels tend to be low/non-existent. This indicates that although the athletes do not experience serious emotional exhaustion, they still face considerable mental pressure, especially in the context of competition.

On the Sport Competition Anxiety Test (SCAT) instrument, the average score of 18.40 indicates a predominance of moderate anxiety. The large variation in scores (SD = 4.30) illustrates the significant differences between athletes with low to high anxiety levels. This condition is common in sports teams, given that individuals often have different levels of readiness to face competitive pressure. These findings reinforce the theory of sports psychology which states that anxiety is one of the main factors that affect athletes' readiness to compete and their performance (Weinberg & Gould, 2018). Therefore, the coping feature in the MINNA application plays a crucial role in helping athletes manage anxiety through breathing exercises, visualization, and positive self-talk.

The Athlete Burnout Questionnaire (ABQ) instrument showed an average burnout score of 2.41, which falls into the "No Indication of Burnout" category. The low standard deviation (0.41) indicates that the athletes' burnout levels are relatively uniform and within safe limits. Although two athletes showed mild and severe burnout, this number is not significant overall. These findings suggest that training programs, team support, and the coaching environment have likely been effective in maintaining athletes' emotional stability. Cognitive emotion regulation plays an important mediating role in how stress affects burnout. Athletes who use adaptive strategies tend not to experience increased burnout (Ma et al., 2025). Therefore, the MINNA application can serve as a continuous monitoring tool to detect burnout symptoms earlier.

Meanwhile, the Perceived Stress Scale (PSS) instrument produced an average score of 18.37, which falls into the moderate stress category. The considerable variation in scores (SD = 4.08) indicates differences in stress levels among athletes, ranging from mild to moderate. The moderate stress experienced by most athletes can be caused by various factors, such as academic workload, training demands, competitive pressure, and social dynamics. Through

the coping recommendations feature on the MINNA app, athletes can obtain self-guided guidance on managing stress, such as relaxation techniques, emotional journaling, or time management.

The relationship between the three instruments shows an interesting pattern. Correlation analysis reveals that the Sport Competition Anxiety Test (SCAT) has a significant relationship with the Perceived Stress Scale (PSS) ($r = 0.447$; $p = 0.013$). This shows that athletes with higher anxiety tend to feel greater stress, in line with the view that the two variables are closely related in the psychological dynamics of athletes. However, no significant relationship was found between the Athlete Burnout Questionnaire (ABQ) and anxiety or stress. The absence of this relationship can be interpreted as meaning that burnout among Undiksha FC athletes is not at a level that interferes with other psychological conditions, so it does not contribute significantly to anxiety or stress. Thus, anxiety is the most dominant psychological factor and requires special attention in the mental training of athletes.

Overall, this discussion confirms that the MINNA app has successfully provided a comprehensive overview of athletes' mental health and offered practical guidance through its coping features. The research results show that although burnout is not a significant problem, anxiety and stress still require systematic handling. Therefore, the use of the MINNA application can be continued as a medium for regular mental monitoring and assistance to support the best performance of Undiksha FC athletes. If integrated into physical training and team training programs, this application has the potential to improve mental readiness while preventing more serious psychological problems in the future.

Conclusions

Based on the research that has been conducted, it can be concluded that the Mindsport Navigator Application (MINNA) has been successfully developed as a digital medium to systematically map and revitalize the mental readiness of Undiksha FC athletes. This application is able to provide a comprehensive overview of three important psychological aspects, namely the Sport Competition Anxiety Test (SCAT), Athlete Burnout Questionnaire (ABQ), and Perceived Stress Scale (PSS). In general, the test results show that athletes are in a fairly stable psychological condition, characterized by moderate levels of anxiety and stress, and no indication of burnout. The variation in SCAT and PSS scores is quite large, indicating differences in psychological states among athletes, while the variation in ABQ scores is relatively small, indicating stability in terms of burnout.

The correlation results show that anxiety has a significant and positive relationship with stress, so that the higher the athlete's anxiety, the higher the level of stress experienced. However, burnout does not show a significant relationship with either anxiety or stress. These findings confirm that anxiety is the most dominant psychological factor affecting the mental condition of athletes, while burnout does not emerge as a major problem. Overall, the MINNA app has been proven to help athletes recognize their mental state, while providing adaptive coping recommendations to help manage anxiety, stress, and potential burnout. MINNA can be used as a continuous monitoring tool to improve mental readiness and optimize athlete performance.

References

Ann Boyce, B. (1992). Effects of Assigned Versus Participant-Set Goals on Skill Acquisition and Retention of a Selected Shooting Task. *Botterill*.

Avolio, B. J., Zhu, W., Koh, W., & Bhatia, P. (2004). Transformational leadership and organizational commitment: mediating role of psychological empowerment and moderating role of structural distance. *Journal of Organizational Behavior*, *25*(8), 951–968.

Chamberlin, M., Newton, D. W., & LePine, J. A. (2018). A meta-analysis of empowerment and voice as transmitters of high-performance managerial practices to job performance. *Journal of Organizational Behavior*, *39*(10), 1296–1313. https://doi.org/10.1002/job.2295

Chroni, S., Perkos, S., & Theodorakis, Y. (2007). Function and preferences of motivational and instructional self-talk for adolescent basketball players. *Athletic Insight: The Online Journal of Sport Psychology*, *9*(1), 19–31.

Dust, S. B., Resick, C. J., Margolis, J. A., Mawritz, M. B., & Greenbaum, R. L. (2018). Ethical leadership and employee success: Examining the roles of psychological empowerment and emotional exhaustion. *Leadership Quarterly*, *29*(5), 570–583. https://doi.org/10.1016/j.leaqua.2018.02.002

Hardy, J., Gammage, K., & Hall, C. (2001). A Descriptive Study of Athlete Self-Talk. *The Sport Psychologist*.

Huang, X., Iun, J., Liu, A., & Gong, Y. (2010). Does participative leadership enhance work performance by inducing empowerment or trust? The differential effects on managerial and non managerial subordinates. *Journal of Marriage and Family*, *31*(1), 122–143. https://doi.org/10.1002/job

Johnson, C. A., & Gilbert, J. N. (2004). The Psychological Uniform: Using Mental Skills in Youth Sport. *Strategies*, *18*(2), 5–9. https://doi.org/10.1080/08924562.2004.10591116

Johnson, J. J. M., Hrycaiko, D. W., Johnson, G. V., & Halas, J. M. (2004). Self-Talk and Female Youth Soccer Performance. *Sport Psychologist*,

18(1), 44–59. https://doi.org/10.1123/tsp.18.1.44

Luxton, D. D., McCann, R. A., Bush, N. E., Mishkind, M. C., & Reger, G. M. (2011). MHealth for mental health: Integrating smartphone technology in behavioral healthcare. *Professional Psychology: Research and Practice*, *42*(6), 505–512. https://doi.org/10.1037/a0024485

Ma, Q. S., Chun, B. O., & Yao, S. J. (2025). Associations between life stress and athlete burnout: the chain mediation role of mindfulness and cognitive emotion regulation strategies. *BMC Psychology*, *13*(382), 1–11. https://doi.org/10.1186/s40359-025-02670-8

Maslach, C., & Jackson, S. E. (1981). The measurement of experienced burnout. *Journal of Organizational Behavior*, *2*(2), 99–113. https://doi.org/10.1002/job.4030020205

Maslach, C., Schaufeli, W. B., & Leiter, M. P. (2001). Job burnout. *Annual Review of Psychology*, *52*, 397–422. https://doi.org/10.1146/annurev.psych.52.1.397

Maynard, I. W., Hemmings, B., & Warwick-Evans, L. (1995). The Effects of a Somatic Intervention Strategy on Competitive State Anxiety and Performance in Semiprofessional Soccer Players. *The Sport Psychologist*, *9*(1), 51–64. https://doi.org/10.1123/tsp.9.1.51

Maynard, M. T., Gilson, L. L., & Mathieu, J. E. (2012). Empowerment-Fad or Fab? A Multilevel Review of the Past Two Decades of Research. *Journal of Management*, *38*(4), 1231–1281. https://doi.org/10.1177/0149206312438773

Morris, T. (2003). Foundations Of Exercise Psychology. *International Journal of Sport and Exercise Psychology*, *1*(3), 307–310. https://doi.org/10.1080/1612197x.2003.9671721

Mosa, A. S. M., Yoo, I., & Sheets, L. (2012). A systematic review of healthcare applications for smartphones. *BMC Medical Informatics and Decision Making*, *12*(1). https://doi.org/10.1186/1472-6947-12-67

Spreitzer, G. M., De Janasz, S. C., & Quinn, R. E. (1999). Empowered to lead: The role of psychological empowerment in leadership. *Journal of Organizational Behavior*, *20*(4), 511–526. https://doi.org/10.1002/(SICI)1099-1379(199907)20:4<511::AID-JOB900>3.0.CO;2-L

Weinberg, R. S., & Gould, D. (2018). Foundations of sport and exercise psychology. In *Foundations of sport and exercise psychology 2nd ed*.

Zhang, X. (2010). Linking empowering leadership and employee creativity: The influence of psychological empowerment, intrinsic motivation, and creative process engagement. *Development and Learning in Organizations: An International Journal*, *24*(5), 4–9. https://doi.org/10.1108/dlo.2010.08124ead.007

Primljen: 28. januar 2026. / Received: January 28, 2025
Izmjene primljene: 21. april 2026. / Changes Received: April 21, 2026
Prihvaćen: 30. april 2026. / Accepted: April 30, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601135J
UDC: 796.012.11:159.942
Original scientific paper
Originalni naučni rad

Training Plan Elements as Predictors of Exercise Motivation: A Cross-Sectional Study

Stefan Janković[1], Tatjana Tubić[2]
[1]Faculty of Sports Science, PanEuropean University „Aperion" Banja Luka, The Republic of Srpska, Bosnia and Herzegovina,
[2]Faculty of Sport and Physical Education, University of Novi Sad, Novi Sad, Serbia

Correspondence:
Stefan Janković
Faculty of Sports Science, PanEuropean University „Aperion" Banja Luka, Bosnia and Herzegovina, stefan.z.jankovic@apeiron-edu.eu

Abstract: *Motivation is a key determinant of sustained engagement in physical exercise; however, the influence of training plan elements on specific motivational dimensions remains insufficiently understood. This study aimed to examine the influence of training plan elements on motivation to exercise. A two-month cross-sectional study was conducted on a total sample of 1,087 participants from fitness centres in the Banja Luka region. Two sets of variables were applied: the first set, a self-developed questionnaire, was used to describe training plan elements such as training level, training mode, training structure, prescribed training plan, training type, training breaks, training frequency, and training volume, including the personal variable of gender; and the second set consisted of the EMI-2 questionnaire (Markland & Ingledew, 1997). The EMI-2 scale comprises 14 subscales: Social Recognition, Health Pressures, Competition, Weight Management, Affiliation, Challenge, Appearance, Stress Management, Ill-Health Avoidance, Nimbleness, Enjoyment, Strength and Endurance, Revitalisation, and Positive Health. Multiple regression analysis was performed to examine the predictive influence of training plan elements on the EMI-2 subscales. Overall, training type and training mode emerged as consistent positive predictors, whereas training level and structure functioned as a negative predictor, highlighting the complex and multidirectional relationship between training plan elements and exercise motivation.*

Keywords: *training plan, exercise, motivation, fitness*

Introduction

Fitness and healthy lifestyles are the worldwide trends and have become more popular all over the world (Chekhovska, 2017). Exercise represents a key element of them, while Caspersen, Powell, and Christenson (1985) defined it as a planned and systematic activity that includes repetitive movements aimed at maintaining or improving one or more fitness components. Wackerhage and Schoenfeld (2021) state that a training plan, or exercise prescription, represents the point at which sport and exercise science is translated into practice; that is, a training plan or exercise prescription typically comprises a combination of multiple interacting elements, such as training mode, training level, training structure, training type, training breaks, and/or training load.

Motivation can be defined as the degree of determination, drive,or desire with which an individual approaches or avoids a behavior (Mears & Kilpatrick, 2008). Therefore, exercise motives are considered as essentially intrinsic (e.g., seeking affiliation, personal growth, enjoyment and health) as those viewed to be more nearly related to the satisfaction of basic psychological needs, or extrinsic (e.g., social recognition, appearance) those typically are not truly or universally essential to well-being and personal growth (Weman-Josefsson, Lindwall, & Ivarsson, 2015). Ryan and Deci (2007) state that the self-determination theory (SDT) provides a useful theoretical basis for research of motivation and behaviors that lead to exercise, based on the fact that it is triggered by various reasons, experiences, and/or consequences, as differences between intrinsic (autonomous) motivation (e.g., for enjoyment, interest, and challenge) and extrinsic (controlled) motivation (e.g., gain a social reward or avoid disapproval), which is also constructed from four parts: external regulation (behavior controlled by obtaining external rewards or avoid punishments), introjected regulation (doing an activity to avoid internal pressure and self-esteem-related contingencies), identified regulation (recognition of the value of a behavior), and integrated regulation (engagement in a behavior because it is consistent with the person's core values and beliefs). So, these statements make motivation for exercise an interesting sphere for research, but without the application of an adequate measuring instrument that is imposible. Thus, Markland and Ingledew (1997) developed the Exercise Motivations Inventory–2 (EMI-2) scale.

There is a lack of studies that indicate the application of the EMI-2 questionnaire to the fitness population, as most studies (Cho & Beck, 2016; Ednie & Stribor, 2017; Kulavic, Hultquist, & McLester, 2013) indicate the application of the questionnaire to the university population. Other studies (Vuckovic, Cuk, & Duric, 2023; Vuckovic & Durić, 2024) were conducted with the aim of investigating motivational factors for exercise in relation to the sociodemographic data and status of the participants. Therefore, it is necessary to establish the relationship between the training plan elements and the motivation for exercise.

The aim of this study is to examine the influence of the training plan elements on the motivation to exercise.

Method

Participants

The survey was administered in the fitness centres and fitness groups of the Banjaluka region (cities Banjaluka and Laktaši), on a total sample of 1,087 participants. Of the total sample, 339 (31.2%) were male and 748 (68.8%) were female. The average age of participants was 31.23 ± 10.79 years, and the age range was from 13 to 75 years.

Measures

In researching the impact of training plan elements on exercise motivation, two sets of variables were applied. The first set,self-developed questionnaire was used to collect data on the descriptive characteristics of the respondents and the elements of the training plans they implemented. The open-ended questions referred to personal information such as age, and educational level, while the remaining questions were closed-ended and related to the elements of the training plan followed by the respondents. The closed-ended questions addressed the following variables: gender, training level, training mode according to the number of participants in the training session, training structure according to the parts of the training, prescribed training plan, training type according to the type of exercise that predominates during training, training breaks, training frequency, and training volume.

The EMI-2 (Markland & Ingledew, 1997), was used to assess exercise motivation, while for the purposes of this study, the Serbian version of the EMI-2 questionnaire (Janković & Tubić, 2025) was used. The EMI-2 scale comprises 14 subscales, each consisting of three or four items. The subscales of the EMI-2 questionnaire are Social Recognition, Health Pressures, Competition, Weight Management, Affiliation, Challenge, Appearance, Stress Management, Ill-Health Avoidance, Nimbleness, Enjoyment, Strength and Endurance, Revitalisation, and Positive Health. The scores derived from these subscales constituted the second set of variables in the present study and were measured using a six-point Likert scale ranging from 0 (‘Does not apply to me at all’) to 5 (‘Applies to me very much’). The Serbian version of the EMI-2 demonstrated good internal consistency reliability, with Cronbach’s alpha coefficients for the subscales ranging from 0.606 to 0.850 and an overall internal consistency coefficient of 0.932 (Janković & Tubić, 2025).

Procedure

Data collection was carried out using the survey method, according to the principle of paper-pencil format. In the Banja Luka region, verbal agreement for conducting the survey among clients was obtained from the owners, managers, and/or leaders of gyms, fitness centres, studios, and/or fitness groups, who were instructed to distribute the questionnaires to their clients. Clients were instructed to complete the questionnaires immediately upon arrival, before the start of their training session, and to return the completed questionnaires to the person from whom they had received them. Individuals authorised to distribute the questionnaires were instructed to return all completed questionnaires to the researcher. The study was approved in advance by the Decision of the Bodybuilding and Fitness Association of the Republic of Srpska, Banja Luka (No. 104-01/2024, dated October 14, 2024), and it lasted over a two-month period from October 15 to December 15. All participants voluntarily provided written informed consent prior to participation.

Statistical analyses

Descriptive statistics included frequencies, mean, standard deviation, and range to describe the participants, and rank, mean, standard deviation, skewness, and kurtosis to describe the EMI-2 subscales. Multiple regression analysis was performed to examine the predictive influence of training plan elements on the EMI-2 subscales. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS Statistics 20; IBM, Armonk, NY, USA).

Results

Table 1 indicates the values for the descriptive statistics of the EMI-2 subscales.

Table 1. *Descriptive Statistics of the EMI-2 Subscales*

EMI-2 subscales	Rank	M±SD	Skewness	Kurtosis
Stress Management	7	3.71±1.13	-1.09	0.87
Revitalisation	2	4.42±0.74	-1.85	4.70
Enjoyment	4	4.09±1.01	-1.38	1.72
Challenge	9	3.57±1.24	-0.90	0.25
Social Recognition	14	1.56±1.43	0.64	-0.68
Affiliation	10	3.32±1.24	-0.48	-0.56
Competition	12	2.45±1.36	0.09	-0.92
Health Pressures	13	1.71±1.43	0.52	-0.72
Ill-Health Avoidance	6	3.99±1.04	-1.20	1.26
Positive Health	1	4.54±0.71	-2.12	5.73
Weight Management	11	3.29±1.29	-0.51	-0.62
Appearance	8	3.67±1.18	-0.98	0.54
Strength & Endurance	3	4.20±0.93	-1.50	2.38
Nimbleness	5	4.06±1.08	-1.31	1.45

Note. M- mean; SD- standard deviation

Table 1 shows the results of the EMI-2 subscales. In the range of mean and standard deviation values from the lowest to the highest, the order is as follows: Social Recognition, Health Pressures, Competition, Weight Management, Affiliation, Challenge, Appearance, Stress Management, IllHealth Avoidance, Nimbleness, Enjoyment, Strength & Endurance, Revitalisation, and Positive Health. The distribution is approximately normal except for the Positive Health subscale, which indicates a deviation (negative skewness). Table 2 indicates the results of the multiple regression analysis for the training plan elements and the EMI-2 subscales.

Table 2. *The multiple regression analysis for the training plan elements ande the EMI-2 subscales*

	SM	Re	En	Ch	SR	Aff	Co	HP	I-HA	PH	WM	App	S&E	Ni
	β	β	β	β	β	β	β	β	β	β	β	β	β	β
Gender	.110*	.097*	.063	.034	-.110*	-.015	-.119*	-.057	.067	.138*	.067	.077*	.022	.085*
Training level	-.017	-.051	-.084*	-.155*	-.142*	-.034	-.182*	-.004	.018	.007	-.020	-.079*	-.090*	-.073*
Training mode	.061	.108*	.147*	.002	.008	.244*	.146*	.074	.088*	.041	-.003	-.075	.012	.081
Training structure	.019	-.089*	-.058	-.041	.017	.003	.017	-.064*	-.074*	-.068*	-.071*	-.049	-.042	-.093
Prescribed training plan	-.021	-.061	-.073	.024	.066	.053	.003	.073	.002	-.001	.052	-.021	-.029	.036
Training type	.067*	.065*	.017	.077*	.012	.022	.055	.038	.081*	.094*	.045	-.020	-.026	.134*
Training break	.036	.067*	.014	-.022	.017	.083*	.046	.000	.005	.006	-.091*	-.065*	-.019	-.065*
Training frequency	.023	.110*	.161*	.094*	.102	.088*	.127*	-.109*	-.014	.059	.060	.129*	.177*	.028
Training volume	.017	.015	.122*	.053	-.059	.078*	.021	-.040	-.079*	-.018	-.101*	-.060	.025	-.014

*Note.SM-Stress Management; Re-Revitalisation; En-Enjoyment; Ch-Challenge; SR-Social Recognition; Aff-Affiliation; Co-Competition; HP-Health Pressures; I-HA-Ill-Health Avoidance; PH-Positive Health; WM-Weight Management; App-Appearance; S&E-Strenght& Endurance; Ni-Nimbleness; β- standardized coefficient; *- p≤.05*

The multiple regression analysis presented in the Table 2 indicates how gender and the elements of the training plan, as predictors, influence exercise motivation as measured by the EMI-2 subscales. Statistical significance was established at $p \leq .05$.

The results indicate that the prescribed training plan has no predictive significance for exercise motivation. In contrast, positive predictive significance was observed for gender and training type in relation to Stress Management; for gender, training mode, training type, training breaks, and training frequency in relation to Revitalisation; for training mode, training frequency, and training volume in relation to Enjoyment; for training type and training frequency in relation to Challenge; for training structure, training breaks, training frequency, and training volume in relation to Affiliation; for training mode and training frequency in relation to Competition; for training mode and training type in relation to Ill-Health Avoidance; for gender and training type in relation to Positive Health; for gender and training frequency in relation to Appearance; for training frequency in relation to Strength and Endurance; and for gender and training type in relation to Nimbleness.

Significant negative predictive effects were observed for training structure in relation to Revitalisation; for training level in relation to Enjoyment and Challenge; for gender and training level in relation to Social Recognition and Competition; for training structure and training frequency in relation to Health Pressures; for training structure and training volume in relation to Ill-Health Avoidance; for training structure in relation to Positive Health; for training structure, training breaks, and training volume in relation to Weight Management; for training level and training breaks in relation to Appearance; for training level in relation to Strength and Endurance; and for training level and training breaks in relation to Nimbleness.

Discussion

This study examined the effects of training plan elements on exercise motivation. The findings demonstrate that specific elements of a training plan differentially influence motivation to exercise. The source of the training plan—whether self-designed, obtained online, or provided by a trainer or fitness instructor—did not predict exercise motivation. In contrast, other elements exhibited either positive or negative associations with motivation. Notably, the training model and type of training emerged exclusively as positive predictors, whereas the level of training was identified as a negative predictor of exercise motivation.

Ednie and Stribor (2017) reported that gender was positively associated with exercise motivation, particularly in relation to Stress Management. The present findings are consistent with this observation, as gender demonstrated a positive association with Stress Management. In addition, gender was positively associated with Revitalisation, Weight Management, Strength and Endurance, and Nimbleness, while negative associations were identified for Social Recognition and Competition. Previous research (Cho & Beck, 2016; Boone & Brausch, 2016; Ednie & Stribor, 2017) suggested that Social Recognition and Competition are more pronounced among males; the negative regression coefficients observed in the present analysis indicate that these motives vary according to gender.

Vuckovic, Cuk, and Duric (2023) identified Revitalisation, Positive Health, and Appearance as salient motivators. In the current study, gender was positively associated with Revitalisation and Weight Management, whereas no significant association was observed for Positive Health. Al Salim (2024) reported a positive contribution of Nimbleness irrespective of gender; correspondingly, Nimbleness was positively associated with gender in the present model.

Kilpatrick, Hebert, and Bartholomew (2005) found that Appearance and Nimbleness could be negatively associated with motivation. In the current analysis, Appearance was negatively associated with training break, whereas Nimbleness showed a negative association with training level. Ball, Bice, and Perry (2014) emphasised Social Recognition among athletes; however, in the present results, Social Recognition was negatively associated with gender and training level. Frederick and Ryan (1993) identified Enjoyment as a primary motivator for sport participants; in the current model, Enjoyment was positively associated with training mode and training frequency, but negatively associated with training level.

Tsaur, Lin, and Cheng (2015) conceptualised Challenge as context-dependent. In the present findings, Challenge was positively associated with training type and training frequency, and negatively associated with training level. Finally, although Vuckovic and Duric (2024) reported generally positive predictive effects of motivational factors regardless of training mode, the current multivariate results indicate that several predictors demonstrated both positive and negative regression coefficients across different EMI-2 subscales.

The ACSM Guidelines for Exercise Testing and Prescription describe a standard session as comprising three phases: warm-up, conditioning, and cool-down. Research indicates that many exercisers neglect proper implementation of these phases, often underestimating the value of warm-up and cool-down (Vaidahazan, Hantiu, & Staicu, 2016). Warm-up routines have been shown to reduce injury risk (Nuhu et al., 2021) and alleviate exercise-related discomfort (Oh, 2013), whereas cool-down exercises contribute to improvements in general and specific motor skills (Lee, Yoon, Song, & Oh, 2021). In the present regression analyses, poorly structured sessions were associated with lower motivation in health-related domains, suggesting that inadequate planning can negatively predict these outcomes, even after accounting for other variables. Conversely, well-structured sessions were positively linked to affiliation, implying that organised training may foster social engagement within exercise communities. It is important to note that these findings reflect predictive associations in a cross-sectional design and should not be interpreted as evidence of causality.

Campos et al. (2022) reported that exercisers, regardless of training type, tended to score higher on motivational measures than non-exercisers. Consistent with these findings, the training type in the current study accounted for a significant positive proportion of variance in exercise motivation, indicating its role as a positive predictor within a multivariate context. Albulescu et al. (2022) demonstrated, through meta-analysis, that breaks—irrespective of their type or duration—positively influence performance, reduce fatigue, and increase vigour. In the present analysis, appropriately timed breaks were positively associated with revitalisation and affiliation, whereas poorly planned breaks were negatively related to nimbleness. This suggests that the motivational impact of rest intervals depends on how they are integrated into the broader training structure rather than their mere inclusion.

Motivation has also been strongly linked with exercise frequency, which contributes to the organisation of exercise behaviour (Costa, Oliva, & Cuzzocrea, 2014). Bycura, Feito and Prather (2017) found training frequency to be positively correlated with revitalisation, affiliation, competition, and challenge, while showing only a negligible negative association with health pressures. In the present regression model, health pressures retained a small negative coefficient, suggesting that, when other motivational factors are considered, they negatively predict overall exercise motivation. Duncan et al. (2010) highlighted the role of training volume in supporting integrated regulation. Similarly, in the current study, training volume was positively associated with affiliation and enjoyment, though its predictive contribution decreased when intrinsic motivational dimensions were considered together, indicating some overlap in explanatory power. Finally, Martinez, Gillespie and Bale (2014) noted that individuals with higher body mass indexes often exercise for weight management and illness prevention. In line with this, inadequately programmed training volume in the present study was negatively associated with motivation when specific weight-related objectives were not met, underscoring the importance of tailoring volume to participants' goals to sustain motivation.

The strengths of this study lie in its large sample of the fitness population and the use of a standardised questionnaire tailored to the specific context and speaking area in which the research was conducted. A particular advantage of the study is that the independent variables were defined as elements of the training plan, whereas in other studies these variables are typically limited to participants' socio-demographic characteristics. The primary limitation is the absence of the researcher during questionnaire completion, which may have compromised adherence to the study protocol and methodology.

The practical significance of this study lies in its demonstration of how elements of the training plan influence exercise motivation. The findings can inform the design of training programmes to ensure that they do not negatively affect individuals' motivation to exercise.

Recommendations for future research include ensuring the presence of researchers during questionnaire completion, conducting a longitudinal study across the whole of Republika Srpska, and investigating exercise motivation within the context of a precisely structured training programme.

Conclusion

The findings of this study demonstrate that different elements of the training plan exert varying influences on exercise motivation. While most elements may act as either positive or negative predictors, the training mode and type of training consistently serve as positive predictors, whereas the training level and training structure emerge as a negative predictor. These results highlight the importance of carefully structuring training programmes to optimise motivation among exercisers.

References

Albulescu, P., Macsinga, I., Rusu, A., Sulea, C., Bodnaru, A., &Tulbure, B. T. (2022). "Give me a break!" A systematic review and meta-analysis on the efficacy of micro-breaks for increasing well-being and performance. *PloS one*, *17*(8), e0272460. https://doi.org/10.1371/journal.pone.0272460

American College of Sports Medicine. (2013). *ACSM's guidelines for exercise testing and prescription*. Lippincott williams&wilkins.

Al Salim, Z. (2024). Motivation for physical activity in college students: The influence of gender and type activity. *ASEAN Journal of Psychiatry*, *25*(3).

Ball, J. W., Bice, M. R., & Parry, T. (2014). Adults' motivation for physical activity:Differentiating motives for exercise, sport, and recreation. *Recreational Sports Journal*, *38*(2), 130-142.

Boone, S. D., &Brausch, A. M. (2016). Physical activity, exercise motivations, depression, and nonsuicidal self-injury in youth. *Suicide and Life-Threatening Behavior*, *46*(5), 625-633.

Bycura, D., Feito, Y., & Prather, C. (2017). Motivational factors in CrossFit® training participation. *Health Behavior and Policy Review*, *4*(6), 539-550.

Campos, L. A., Dos Santos, A., Sampaio, M. M. B., Marôco, J., & Campos, J. A. D. B. (2022). Exercise motives among university students - A Brazil-Portugal transnational study. *Frontiers in psychology*, *13*, 1009762. https://doi.org/10.3389/fpsyg.2022.1009762

Caspersen, C.J., Powell, K.E., & Christenson, G.M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Publichealth reports*,100(2),126.

Chekhovska, L. (2017). Fitness industry: state and prospects of development in the countries of the world. *Slobozhanskyi herald of science and sport*, (2 (58)), 19-24.

Cho, D., & Beck, S. (2016) Competitive physical activity participation: effect on motivation of international college students. *Journal of the Oklahoma Association for Health, Physical Education, Recreation, and Dance*, 53(3), 63–70.

Costa, S., Oliva, P., &Cuzzocrea, F. (2014). Motivational aspects and personality correlates of physical exercise behavior. *Facta Universitatis, Series: Physical Education and Sport*, 83-93.

Duncan, L. R., Hall, C. R., Wilson, P. M., & Jenny, O. (2010). Exercise motivation: a cross-sectional analysis examining its relationships with frequency, intensity, and duration of exercise. *International Journal of Behavioral Nutrition and Physical Activity*, *7*, 1-9.

Ednie, A., &Stibor, M. (2017) Influence and interpretation of intrinsic and extrinsic exercise motives. *Journal of Human Sport and Exercise*, 12(2), 414–425.

Frederick, M., & Ryan, M. (1993). Differences in motivation for sport and exercise and their relations with participation and mental health. *Journal of Sport Behavior*, 16, 125–145.

Janković, S., &Tubic, T. (2025). Internal consistency reliability of the Serbian version of the EMI-2 questionnaire in the fitness population. Exercise and Quality of Life, 18(1). https://doi.org/10.31382/20260603

Kilpatrick, M., Hebert, E., & Bartholomew, J. (2005). College students' motivation for physical activity: differentiating men's and women's motives for sport participation and exercise. *J. Am. Coll. Health* 54, 87–94. doi: 10.3200/JACH.54.2. 87-94

Kulavic, K., Hultquist, C. N., &McLester, J. R. (2013) A comparison of motivational factors and barriers to physical activity among traditional versus nontraditional college students. *Journal of American College Health*, **61**(2), 60–66.

Lee, Y. H., Yoon, J. H., Song, K. J., & Oh, J. K. (2021). Effects of cool-down exercise and cold-water immersion therapy on basic fitness and sport-specific skills among Korean college soccer players. *Iranian journal of public health*, *50*(11), 2211.

Markland, D., &Ingledew, D. K. (1997). The measurement of exercise motives: factorial validity and invariance across gender of a revised exercise motivations inventory. *Br. J. Health Psychol.* 2, 361–376. doi: 10.1111/j.2044-8287.1997.tb00549.x

Martinez, C. T., Gillespie, K., & Bale, S. (2014). Exercise motivation: The role of gender, age, and body mass index. *Int J Health Wellness Soc*, *4*, 2014.

Mears, J., & Kilpatrick, M. (2008). Motivation for exercise: Applying theory to make a difference in adoption and adherence. *ACSM's health & fitness journal*, *12*(1), 20-26.

Nuhu A, Jelsma J, Dunleavy K, & Burgess T. (2021) Effect of the FIFA 11+ soccer specific warm up programme on the incidence of injuries: A cluster-randomised controlled trial. *PLoS ONE* 16(5): e0251839.https://doi.org/10.1371/journal. pone.0251839

Oh, D. W. (2013). Effects of warm-up and cool-down exercises for preventing delayed onset muscle soreness on pain and muscle activation. *Physical Therapy Korea*, *20*(1), 28-35.

Ryan, R. M., & Deci, E. L. (2007). Introduction: Active Human Nature. *Intrinsic motivation and selfdetermination in exercise and sport,* 1-20.

Tsaur, S. H., Lin, W. R., & Cheng, T. M. (2015). Toward a structural model of challenge experience in adventure recreation. *Journal of Leisure Research*, *47*(3), 322-336.

Vaidahazan, R. C., Hantiu, I., &Staicu, A. (2016). Weight training in gyms of Cluj-Napoca as leisure physical activity: Warm-up and cool-down phases. *Studia Universitatis Babeș-BolyaiEducatioArtisGymnasticae*, 5-14.

Vuckovic, V., Cuk, I., &Duric, S. (2023). Purchase channels and motivation for exercise in the slovenian population: customer behavior as a guarantee of fitness center sustainability. *Behavioral Sciences*, *13*(6), 447.

Vuckovic, V., &Duric, S. (2024) Motivational variations in fitness: a population study of exercise modalities, gender and relationship status. *Front. Psychol.* 15:1377947. doi:10.3389/fpsyg.2024.1377947

Wackerhage, H., & Schoenfeld, B. J. (2021). Personalized, evidence-informed training plans and exercise prescriptions for performance, fitness and health. *Sports Medicine*, *51*(9), 1805-1813.

Primljen: 28. januar 2026. / Received: Januar 28, 2026
Prihvaćen: 5. maj 2026. / Accepted: May 5, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601141S **UDC:** 796.386:371.382
Original scientific paper ***Originalni naučni rad***

The Effect of the Return Board Tool on Improving Backhand Topspin Skills in Table Tennis Athletes

Teguh Santosa[1], Hari Setiono[1], Fatchul Imron[1], Shodig Hutomono[1], Rivan Sagitha[1] Pratama[2] Susanto[3]
[1]Universitas Tunas Pembangunan, Surakarta, Indonesia
[2]Fakultas Ilmu Keolahragaan dan Kesehatan, Universitas Negeri Semarang, Indonesia
[3]UIN Sayyid Ali Rahmatullah Tulungagung, Indonesia

Correspondence:
Tegus Santosa
Universitas Tunas Pembangunan, Surakarta, Indonesia, Teguhsantosa@lecture.utp.id

Abstract: *One of the challenges in table tennis training, particularly at the youth athlete development level, is the limited time and training media. This study aims to determine the effect of using a return board on improving backhand topspin skills in table tennis athletes. The method used was a quasi-experimental design with a pretest-posttest group design. The research subjects were 12 youth-level table tennis athletes from a club in Solo. The data collection instrument was a backhand topspin skill test validated by experts. Data analysis using the paired sample t-test showed a significant improvement in backhand topspin ability after training with the return board ($p = 0.001 < 0.05$). These findings indicate that the return board can be an effective training tool for improving backhand topspin technique.*

Keywords: *table tennis, backhand topspin, return board, technical skills*

Introduction

Table tennis is one of the sports that requires a combination of fine motor skills, quick reaction time, and high-level game strategy (Pujianto, A., 2015). It relies heavily on speed, accuracy, and agility in ball control. As a skill-based sport, table tennis demands a systematic, consistent, and efficient learning process of basic techniques. In practice, learning fundamental techniques such as forehand, backhand, push, and topspin requires repetition and immediate feedback to optimally develop motor skills. However, various obstacles such as limited coaching time, a high number of participants, and inadequate facilities often hinder the effective learning of basic techniques (Rahmawati & Winarsih, 2022).

One of the essential techniques in this sport is the backhand topspin, which is widely used to control the pace of the game and deliver quick attacks (Kondrič et al., 2013). However, this technique requires consistent repetition and feedback to be mastered effectively. In the context of basic gameplay, the backhand topspin is a crucial element because it is frequently used both in defensive and offensive situations, especially when facing opponents with fast and aggressive playstyles (Kondrič et al., 2013). This technique demands good coordination between arm movement, body positioning, and precise ball contact timing. Therefore, systematic and consistent training is essential for mastering it.

One of the challenges in table tennis training, particularly at the junior athlete development level, is the limited time and training media. Technical training is sometimes suboptimal due to dependence on the availability of coaches or sparring partners. Additionally, many young athletes still do not train effectively (Kullal, M. A. et al., 2024). A significant number of athletes also struggle with mastering playing techniques during training (Mahamuddin, M., 2021). To address this issue, the use of training aids such as the return board has become a practical and efficient alternative solution. This tool allows athletes to return the ball after a stroke, creating a repetitive training cycle that can be performed independently without a partner (Malagoli Lanzoni et al., 2014). Coaches often face difficulties in delivering basic technique materials effectively. The lack of equipment and limited training time result in unequal training opportunities for participants. This leads to uneven and suboptimal development of skills among athletes (Widodo et al., 2022).

Motor learning is highly influenced by training frequency and the quality of feedback. According to motor learning theory, movement corrections occur more quickly when athletes receive immediate information about the outcome of their actions after performing a movement (Schmidt & Lee, 2019). In this regard, the return board functions not only as a device that provides a consistent ball rebound but also as a mirror for athletes to self-evaluate their technique. This is particularly important during the development phase of young athletes, where continuous repeti-

tion is necessary to establish optimal movement patterns. In the context of motor learning, repeated movement with immediate feedback is crucial to reinforcing muscle memory and improving technical precision (Magill & Anderson, 2017; Susanto et al., 2024).

In addition, this tool also supports the principles of self-training and deliberate practice, which involve structured, specific training aimed at improving particular technical aspects of athletic performance (Ericsson, Krampe, & Tesch-Römer, 1993). According to Zhang et al. (2020), the proper use of training aids can accelerate the learning of basic techniques and help reduce the coach's workload. With the return board, athletes can adjust the intensity and frequency of training according to their individual needs, while continuously receiving feedback through the ball's rebound. Therefore, it is important to further explore how the return board can be optimized in technical sports training, especially in supporting direct and continuous movement correction. The return board provides consistent ball rebounds, which can help athletes make immediate corrections to their movements and enhance kinesthetic awareness. Moreover, this tool enables increased training volume in a shorter amount of time, which, according to Schmidt and Lee (2019), will accelerate motor adaptation. The return board also proves helpful for athletes in correcting their technique during training sessions (Syamsudin, N., 2024).

Nevertheless, most previous studies have primarily focused on the effectiveness of the return board in improving forehand or service skills. Scientific research specifically examining the effect of using the return board on mastering the backhand topspin technique remains limited, particularly among adolescent athletes who are in the skill development phase. The use of training aids has become a solution to enhance the effectiveness of learning basic techniques. Physical aids such as the return board have been reported to be effective in improving drive skills in beginner players. For example, research by Hanim & Tomoliyus (2018) stated that the use of the return board had a significant positive impact on mastering the punch drive technique among beginners. One such tool is the return board, which functions by rebounding the ball struck by the player, allowing for individual practice without a partner or coach (Malagoli Lanzoni et al., 2014). In addition, the development of digital and robotic models has advanced, where table tennis robot systems are capable of returning the ball consistently and at high speed, enabling athletes to perform technique repetitions more intensively. Such systems provide real-time motor feedback that accelerates correction and the formation of optimal movement patterns (Triaiditya, B. S. M., & Santoso, D. A., 2021).

Basic techniques such as forehand and backhand strokes form the foundation of good gameplay patterns (Sukoco & Nugroho, 2021). Previous studies have mostly highlighted the use of the return board for forehand training, while studies on its application in developing backhand topspin are still very limited. Therefore, this study aims to analyze the effect of using the return board in improving backhand topspin technique among table tennis athletes. This research is expected to contribute to the development of more innovative and efficient training methods in table tennis coaching.

Method

This study employed a quantitative approach using a quasi-experimental method with a pretest-posttest one-group design. This design was chosen to measure changes in technical skills before and after the intervention training using a return board without a control group. Research Subjects: A total of 12 table tennis athletes aged 13–16 years from PTM Bengawan Table Tennis Club and Mitra Medika in Solo were selected purposively based on relatively homogeneous skill levels. Research Procedure: (1) A pretest of backhand topspin skills was conducted to assess the initial ability. (2) A 4-week training program (3 sessions per week) was implemented using the return board. (3) Each training session lasted 60 minutes and focused on the backhand topspin stroke. (4) A posttest was administered at the end of the fourth week using the same instrument as the pretest. Data Collection Instrument: The backhand topspin skill test assessed accuracy, speed, and consistency (scoring 1–10 for each aspect). Instrument validity was assessed by two nationally certified coaches, and the reliability test yielded a Cronbach's alpha value of $\alpha = 0.87$ (high reliability). Data Analysis: Normality was tested using the Shapiro-Wilk test, and data analysis was conducted using a paired sample t-test at a 0.05 significance level with the aid of SPSS version 25.

Resulth

This study aims to determine the effect of using a return board on improving backhand topspin skills in table tennis athletes. Data collection was carried out through backhand topspin skill tests conducted before and after a four-week training program.

1. Descriptive Statistics

The pretest and posttest results were analyzed descriptively to determine the mean, standard deviation (SD), minimum, and maximum scores of the backhand topspin skill.

Table 1. *Descriptive Statistics of Pretest and Posttest Results for Backhand Topspin Skills*

No	Phase	Minimum	Maximum	Mean	SD
1	Pretest	55	70	62.50	5.20
2	Posttest	68	82	75.83	4.90

The table above shows an increase in the average score of backhand topspin skills from 62.50 in the pretest to 75.83 in the posttest. This indicates an improvement of 13.33 points or approximately 21.3% from the initial score.

2. Normality Test

Before conducting the hypothesis test, a normality test using the Shapiro-Wilk method was carried out to determine the data distribution.

Table 2. *Shapiro-Wilk Normality Test Results*

Phase	Statistic W	Sig. (p)
Pretest	0.958	0.732
Posttest	0.948	0.581

Since the significance value ($p > 0.05$), the data are normally distributed and meet the assumptions for parametric testing.

3. Hypothesis Testing (Paired Sample t-test)

Hypothesis testing was conducted using a paired sample t-test to determine whether there is a significant difference between the pretest and posttest results.

Hypotheses:

H_0 (null): There is no significant difference between the pretest and posttest results.

H_1 (alternative): There is a significant difference between the pretest and posttest results.

Table 3. *Paired Sample t-test Results*

Variable	Mean Difference	t	df	Sig. (2-tailed)
Posttest - Pretest	13.33	8.211	11	0.000

Based on the t-test results above, the significance value was 0.000 ($p < 0.05$), indicating a significant difference between the pretest and posttest results. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted.

4. Practical Effect (Effect Size)

To determine the magnitude of the effect of using the return board on improving backhand topspin skills, the effect size (Cohen's d) was calculated. A Cohen's d value of 2.63 indicates a very large effect size, according to Cohen's (1988) interpretation.

Interpretation of Results

The athletes showed a significant improvement in their backhand topspin stroke technique. Training with the return board helped increase the number of repetitions and strengthened shot consistency. The instant feedback from the ball's rebound accelerated the process of technical correction.

Discussion

The results of the study indicate that the use of the return board significantly improved backhand topspin skills in table tennis athletes. The average skill score increased by 13.33 points after four weeks of training, with a significance value ($p = 0.000$) showing a highly significant difference between the pretest and posttest results. This indicates that training with the return board is effective in enhancing backhand topspin technique. Intensive and structured training can improve both technique and skill (Susanto et al., 2020; Susanto et al., 2024). These findings align with

the principles of motor learning theory, which state that movement repetition accompanied by immediate feedback is key to developing precise motor skills (Magill & Anderson, 2017). In addition, modified training methods have been shown to successfully influence an individual's motor abilities (Susanto et al., 2024). The return board functions as a training tool that allows athletes to receive instant feedback through ball rebound, thereby accelerating the self-correction process. This mechanism facilitates the internalization of movement, which is crucial for improving stroke consistency and accuracy (Schmidt & Lee, 2019).

In addition, the use of the return board encourages more intensive and efficient self-training. Athletes do not need to wait for their turn as in group training and are not dependent on the presence of a coach or training partner. This allows for a high frequency of technical practice within a limited timeframe. According to Malagoli Lanzoni et al. (2014), intensive and repetitive training under uniform conditions (such as predictable board rebounds) can improve timing and footwork two essential aspects for successful backhand topspin performance. Furthermore, circuit-based training also supports performance improvement (Susanto et al., 2021). This skill improvement can also be explained from a cognitive perspective. When training with the return board, athletes are required to continuously monitor the ball's rebound and adjust their movements accordingly. This process enhances concentration, visual perception, and anticipation—key components in motor decision-making (Abernethy et al., 2005). In other words, this type of training not only improves physical aspects but also stimulates the mental components of playing skills.

Furthermore, the effect size value (Cohen's d = 2.63) indicates a very large impact of this intervention. This means that the use of the return board is not only statistically significant but also practically relevant for implementation in regular training programs. This supports the adoption of such training aids in both junior and professional athlete development contexts. However, there are several limitations to this study. The sample size was relatively small (n = 12), and the training duration was limited to only four weeks. Further research with a larger scope and extended duration is recommended to examine the long-term effects of return board usage on other technical skills such as forehand topspin, service, and tactical rally play. The improvement in backhand topspin skills following the use of the return board demonstrates that this tool can provide instant feedback through consistent ball rebounds. This supports motor learning theory, which states that repeated practice with immediate feedback can accelerate the acquisition of movement skills (Magill & Anderson, 2017).

In addition, training with a return board allows athletes to practice independently and increase the volume of technical training without the need for a partner or direct supervision from a coach. This aligns with the findings of Malagoli Lanzoni et al. (2014), who stated that the use of a return board can enhance the efficiency of stroke training in table tennis. Moreover, the return board supports self-directed learning, where athletes can identify technical errors such as body positioning, racket swing, or balance, and immediately correct them in the next attempt. This is in line with the principle of deliberate practice, where training should be specific, repetitive, and accompanied by correction (Ericsson et al., 1993). Therefore, the return board is an effective training aid for developing backhand technique not only for beginner players but also at advanced levels as a means to improve accuracy and consistency. Furthermore, the use of training aids has a positive impact on learning motivation. Practice becomes more engaging and less monotonous, encouraging participants to train independently outside of formal training sessions (Mustofa & Kurniawan, 2020).

Conclussion

Based on the results of this study, it can be concluded that the use of a return board has a significant effect on improving backhand topspin skills in junior table tennis athletes. The increase in the average technical skill score from pretest to posttest indicates that training methods involving the return board are effective in developing accuracy, consistency, and movement control in backhand topspin strokes. These findings support the view that training with immediate feedback, high repetition, and active athlete involvement in self-correction greatly contributes to motor learning, especially in closed-skill sports like table tennis. The return board functions not only as a technical training aid but also as a tool that enhances athlete independence, focus, and training intensity. Furthermore, the high practical effect size (Cohen's d = 2.63) emphasizes that the use of this tool is not only statistically significant but also practically relevant in daily training contexts. Therefore, the return board can be recommended as a primary training aid in technical skill development programs for table tennis, particularly for improving backhand topspin performance. However, the results of this study should also be considered alongside its limitations, such as the small sample size and relatively short intervention duration. Thus, further research using a longitudinal approach and a larger sample is highly recommended

to investigate the long-term effects and the effectiveness of this tool in developing other technical skills in table tennis.

Suggestions

1. Coaches are encouraged to incorporate return board training into individual technical training programs.
2. Future research can explore the impact of using return boards on tactical aspects of the game.
3. Further studies with larger sample sizes and longer training durations are recommended to strengthen these findings.

Reference

Abernethy, B., Thomas, K. T., & Thomas, J. T. (1993). Strategies for improving understanding of motor expertise [or mistakes we have made and things we have learned!!]. In *Advances in psychology* (Vol. 102, pp. 317-356). North-Holland.

Abdulrahaman, MD, Faruk, N., Oloyede, AA, Surajudeen-Bakinde, NT, Olawoyin, LA, Mejabi, OV, Imam-Fulani, YO, Fahm, AO, & Azeez, AL (2020). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon*, 6(11).

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, 100(3), 363–406. https://doi.org/10.1037/0033-295X.100.3.363

Hanim, M., & Tomoliyus, T. (2018). Design of Table Tennis Tool for Drive Stroke Drill Training to Beginner. *In Proceedings of the 1st International Conference on Science and Technology for an Internet of Things*. European Alliance for Innovation (EAI).

Kondrič, M., Furjan-Mandić, G., & Medved, V. (2013). Table tennis–modern techniques and tactics. *Sport Science*, 6(1), 42–47.

Kullal, M. A., Setiawan, D., Pratama, R. A., Junaidi, A., Artanty, A., Lufthansa, L., & Khotimah, K. (2024). Efektivitas Pelatihan Tenis Meja Pada Siswa Kelas VII dan IX SMP Islam Muqorrobin Singosari. *JPM Pambudi: Jurnal Pengabdian Kepada Masyarakat*, 8(01), 8-12.

Magill, R. A., & Anderson, D. I. (2017). *Motor learning and control:* Concepts and applications (11th ed.). McGraw-Hill Education.

Mahamuddin, M. (2021). *UPAYA MENINGKATKAN HASIL BELAJAR TENIS MEJA MELALUI METODE PEMBELAJARAN TERBIMBING DAN DEMONSTRASI PADA SISWA KELAS VII UPT SMP NEGERI 7 SATAP SEKO* (Doctoral dissertation, UNIVERSITAS NUHAMMADIYAH PALOPO).

Malagoli Lanzoni, I., Di Michele, R., Merni, F., & Viggiani, S. (2014). Technical-tactical performance indicators in top-level table tennis matches. *International Journal of Table Tennis Sciences*, 8(1), 29–33.

Mustofa, M., & Kurniawan, D. (2020). Penerapan media bantu dalam meningkatkan motivasi belajar tenis meja siswa SMA. *Jurnal Pendidikan Jasmani dan Olahraga*, 5(1), 45–52. https://doi.org/10.21831/jpjo.v5i1.2020

Pujianto, A. (2015). Profil kondisi fisik dan keterampilan teknik dasar atlet tenis meja usia dini di kota semarang. *Journal of physical education health and sport*, 2(1), 38-42.

Queiroz, A. C. M., Fauville, G., Herrera, F., Leme, M. I. D. S., & Bailenson, J. N. (2022). Do students learn better with immersive virtual reality videos than conventional videos? A comparison of media effects with middle school girls. *Technology, Mind, and Behavior*, *3*(3), 468.

Rahmawati, E., & Winarsih, S. (2022). Analisis kebutuhan media pembelajaran olahraga pada sekolah menengah pertama. *Jurnal Pendidikan Olahraga*, 7(1), 13–20. https://doi.org/10.21009/jpor.071.02

Schmidt, R. A., & Lee, T. D. (2019). *Motor learning and performance: From principles to application* (6th ed.). Human Kinetics.

Sukoco, A., & Nugroho, H. (2021). Dasar-dasar teknik tenis meja untuk pemula. Surabaya: Pustaka Olahraga Nasional.

Susanto, S. (2024). The Effect of Using a Paralon Bow on the Archery Performance of Novice Athletes. Innovative: *Journal Of Social Science Research*, 4(3), 11185-11197.

Susanto, S., & Siswantoyo, S. (2022). Traditional Sport-Based Physical Education Learning Model in Character Improvement and Critical Thinking of Elementary School Students. *Sports science and health*, *24*(2), 165-172.

RAHAYU, D. P., Setyawan, H., & Iswanto, A. (2024). MODIFICATION OF THE GAME ENGKLEK TO IMPROVE THE CHARACTER OF DISCIPLINE AND THINKING IN EARLY CHILDHOOD. *Sports Science & Health/Sportske Nauke i Zdravlje*, *14*(2).

Susanto, S., Setyawan, H., García-Jiménez, J. V., Pavlovic, R., Nowak, A. M., & Susanto, N. (2024). Analysis of One-Hole Game Tools in Developing Fine Motor Skills in Early Childhood. *SPORTS SCIENCE AND HEALTH*, *27*, 135-139.

Susanto, S., Setyawan, H., Susanto, N., García-Jiménez, J. V., Latino, F., Tafuri, F., & Eken, Ö. (2024). The Influence Of Modified One-Hole Game Media In Improving Fine Motor Skills In Early Childhood. *Sports Science and Health*, *14*(5), 151.

Susanto, S., Siswantoyo, S., Prasetyo, Y., & Putranta, H. (2021). The effect of circuit training on physical fitness and archery accuracy in novice athletes. *Physical Activity Review*, 1(9), 100-108.

Susanto, Siswantoyo, Sumaryanto, Adi Wijayanto. (2020). Lung Vital Capacity Levels on disability in Swimming Learning. *Fizjoterapia Polska* 20(5); 122-126.

Syamsudin, N. (2024). *Panduan Teknik Forehand Drive dalam Tenis Meja: Meningkatkan Akurasi dan Konsistensi Pemain Pemula*. Penerbit NEM.

Widodo, H., Santoso, A., & Mulyono, T. (2022). Efektivitas pembelajaran teknik dasar tenis meja dengan pendekatan drill menggunakan media bantu. *Jurnal Ilmu Keolahragaan dan Kesehatan*, 10(3), 165–172. https://doi.org/10.31227/jikk.v10i3.2022

Triaiditya, B. S. M., & Santoso, D. A. (2021, November). Review Aplikasi Teknologi Digital di Olahraga Tenis Meja. In *Prosiding Seminar Nasional IPTEK Olahraga (SENALOG)* (Vol. 4, No. 1, pp. Ilmu-Or).

Zhang, Q., Chen, L., & Wang, H. (2020). Table tennis training optimization using smart feedback devices. *International Journal of Sports Science & Coaching*, 15(1), 123–131. https://doi.org/10.1177/1747954120902527

Primljen: 28. januar 2026. / Received: Januar 28, 2026
Prihvaćen: 25. februar 2026. / Accepted: February 25, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601146N
Original scientific paper

UDC: 796.332:796.012.414
Originalni naučni rad

The Effect of Small-Sided Games as a Contextual Training Method on Shooting Accuracy and Physical Activity Enjoyment in Futsal Extracurricular Participants

Yahya Eko Nopiyanto[1], Ipa Sari Kardi[2], Cahyo Wibowo[3], Muhammad Maulana Fajar[4], Eko Putra Utama.J[5], Herdiansyah Agus[6], Novriansyah[4]

[1]*University of Bengkulu, Department of Physical Education, Bengkulu, Indonesia*
[2]*University of Cenderawasih, Faculty of Sport Science, Jayapura, Indonesia*
[3]*Satya Wacana Christian University, Faculty of Medicine and Health Sciences, Salatiga, Indonesia*
[4]*Universitas Samudra, Department of Physical Education, Aceh, Indonesia*
[5]*Universitas Dehasen, Department of Physical Education, Bengkulu, Indonesia*
[6]*Universitas Pendidikan Indonesia, Department of Physical Education, Bandung, Indonesia*

Correspondence:
Yahya Eko Nopiyanto
University of Bengkulu, Department of Physical Education, Bengkulu, Indonesia, yahyaekonopiyanto@unib.ac.id

Abstract: *Student enthusiasm for futsal continues to increase, but has not been accompanied by a contextual training model to enhance shooting accuracy and enjoyment of physical activity. This study aimed to investigate the impact of small-sided games on shooting accuracy and enjoyment of physical activity in futsal extracurricular participants. A quasi-experimental method with a one-group pretest and posttest design was used to achieve the research objectives. Participants in this study were 20 futsal extracurricular at State Senior High School 10, Bengkulu City, selected using a purposive sampling technique. All participants participated in the intervention for 4 weeks, with a frequency of 4 sessions per week, and a duration of 60 minutes per session. The shooting accuracy test was used to determine shooting accuracy, and the physical activity scale was used to determine players' physical activity during small-sided games. SPSS software version 22 was used to analyze the research data. Paired sample t-tests revealed that small-sided games significantly improved shooting accuracy and enjoyment of physical activity, with Cohen's d indicating contributions of 66.67% and 27.45%, respectively. It can be concluded that this contextual training method is efficacious in improving shooting accuracy and enhancing the enjoyment of physical activity among young futsal players. Small-sided games training is recommended as a practical approach to simultaneously improve shooting accuracy and enhance enjoyment in high school futsal players.*

Keywords: *games, shooting, physical activity, futsal*

Introduction

High school students show a high level of interest in futsal. Students participate in futsal as an extracurricular activity at both school and club levels, catering to students of all ages (Gemael & Sari, 2025). Futsal has dynamic characteristics, making it an appropriate medium for developing students' motor and cognitive skills (Machado et al., 2018). Student success in playing futsal cannot be separated from mastering basic technical skills such as passing, dribbling, controlling, heading, tackling, and shooting (Khurrohman et al., 2021). Of these various techniques, shooting accuracy is dominant in determining the effectiveness of attacks and overall success in the game (Doewes et al., 2022). However, mastering shooting accuracy presents its own challenges for students. Based on observations, many students experience limitations in executing accurate shots due to training environments that are not contextual and attractive to futsal extracurricular participants.

Most school coaches and physical education teachers employ traditional training methods, such as drills, to improve basic game techniques. Drills training can improve basic technical skills, but are less relevant to real-life match conditions (Hidayat et al., 2025). Furthermore, repetitive and unvaried training can lead to training boredom, resulting in decreased motivation. Therefore, training methods that accommodate futsal extracurricular participants to real-world match conditions are needed. To address these issues, many researchers have focused on small-sided games (SSG) as a training method to address technical, tactical and physiological indicators in futsal student in an educational context (Coutinho et al., 2016).

SSG is a training method that involves modifying the number of players, field size, and game rules to facilitate

athletes' self-exploration, as outlined in the provided training materials (Bujalance-Moreno et al., 2019). SSG creates greater opportunities for athletes to move with the ball, provides opportunities for making correct decisions, and offers experience in pressure situations similar to real matches (Coutinho et al., 2024). In addition to improving technique and tactics, the SSG method can also improve an athlete's physiology and psychology (Clemente et al., 2022).

SSG increases the enjoyment of physical activity, enhances athlete enthusiasm, encourages engagement in meaningful physical activity, boosts intrinsic motivation, and fosters a sense of connectedness among players (Clemente, 2025). The psychological aspect focused on in this study is the enjoyment of physical activity. For high school futsal extracurricular participants, the enjoyment of physical activity deserves attention because it plays a crucial role in supporting their involvement and development (Domville et al., 2019). Futsal training delivered in a fun way can increase training motivation, thereby strengthening technical skills and tactical understanding. Furthermore, positive experiences during training encourage teamwork, social interaction, and reduce stress and psychological fatigue. Enjoyment in playing futsal also contributes to long-term participation in physical activity, which has a positive impact on overall fitness and health. Therefore, physical activity enjoyment is a crucial factor supporting the effectiveness of training and the development of student-athletes in both sports and academic competitions.

SSG has been widely implemented as a training method in futsal, but the majority emphasize aerobic aspects, tactical development, and general skills (Amani-Shalamzari et al., 2019; Clemente et al., 2023). Meanwhile, the effect of SSG on shooting accuracy and enjoyment of physical activity in futsal among adolescent players in educational settings remains limited. The selection of SSG as a training method is appropriate because it aligns with contemporary pedagogical models that emphasize student-centered and game-based learning in physical education and youth sports development (Kizi, 2025). Therefore, training methods that balance technical improvement with enjoyment of physical activity are needed to encourage performance and promote lifelong adherence to physical activity (Heisz et al., 2016).

Based on the description above, this study aims to examine the effect of SSG on shooting accuracy and enjoyment of physical activity in futsal extracurricular participants. The results of this study can provide empirical support for the application of contextual and pedagogical training models in improving futsal performance.

Material and Methods

This research employed an experimental method to investigate the effect of SSG on shooting accuracy and satisfaction with physical activity in futsal players. The research design used a one-group pretest-posttest design, with a pretest to assess baseline levels before treatment and a posttest to determine levels after treatment. This allowed for more accurate comparisons because it enabled comparisons between the before and after treatment periods.

Participants

Participants in this study were 20 futsal extracurricular at State Senior High School 10 in Bengkulu City, selected using a purposive sampling technique. Sampling criteria included volunteering, actively participating in training for at least six months, no sports injuries, and obtaining parental/guardian permission. All participants underwent a four-week intervention, with four sessions per week, each lasting 60 minutes. Each session consisted of a warm-up, a 10-minute shooting technique drill, and a 30-minute main training session (SSG), with modified rules to increase enjoyment of physical activity.

Instrument

The shooting accuracy test determines a player's shooting accuracy before and after the SSG. Before the test, players are allowed to attempt it twice. After that, players shoot 10 times. The shooting position is 10 meters from the goal. The goal is divided into nine sections, as shown in Figure 1 below. A score of 1 is awarded for the center target, a score of 2 for the bottom and top middle targets, a score of 3 for the right and left middle targets, a score of 4 for the bottom right and left targets, and a score of 5 for the top right and left targets. If the shot hits the goalpost, the rope, or goes outside the designated target, it does not receive a score. To determine the test ability category, the final score obtained in the test is converted to the corresponding category in Table 1.

Table 1. *Category of Shooting Test*

No	Interval	Category
1	41 - 50	Excellent
2	31 – 40	Good
3	21 - 30	Fair
4	11 - 20	Poor
5	1 - 10	Very Poor

The physical activity scale assessed enjoyment of physical activity during the SSG training program. The questionnaire consisted of four indicators, 15 statements, and five Likert-type response options. Each positive statement with a strongly agree response received a score of 5, and vice versa.

Table 2. *Physical Activity Enjoyment Indicator*

No.	Indicator	Items
1	Excitement and Enjoyment	1. 2. 3. 4
2	Engagement and Challenge	5. 6. 7. 8
3	Motivation	9. 10. 11. 12
4	Discomfort	13. 14. 15

The final score is converted into Table 3 to determine the category of physical activity enjoyment.

Table 3. *Category of physical activity enjoyment*

No.	Score	Category
1	61-75	Very High
2	46-60	High
3	31–45	Moderate
4	16–30	Low
5	15	Very Low

Data Analysis

Data normality and homogeneity were tested using the Shapiro–Wilk test, and data homogeneity was tested using the Levene test. If the data were regular and homogeneous, a paired-sample t-test was used. Cohen's d was used to determine the effectiveness of the treatment.

Result

The data are presented in tables and graphic visualizations to show the differences in shooting accuracy and enjoyment of physical activity categories before and after the intervention.

Table 4. *Descriptive data on shooting accuracy*

Test	Mean	Median	Variance	Std deviation	Minimum	Maximum
Pre	19.83	16.50	17.04	4.12	12	25
Post	33.05	33.00	18.78	4.33	25	41

Table 4 shows a clear improvement in shooting accuracy after SSG training. The mean score increased from 19.83 to 33.05, indicating a significant improvement in shooting accuracy. Data on variance and standard deviation suggest that this improvement occurred consistently, with no substantial differences between participants.

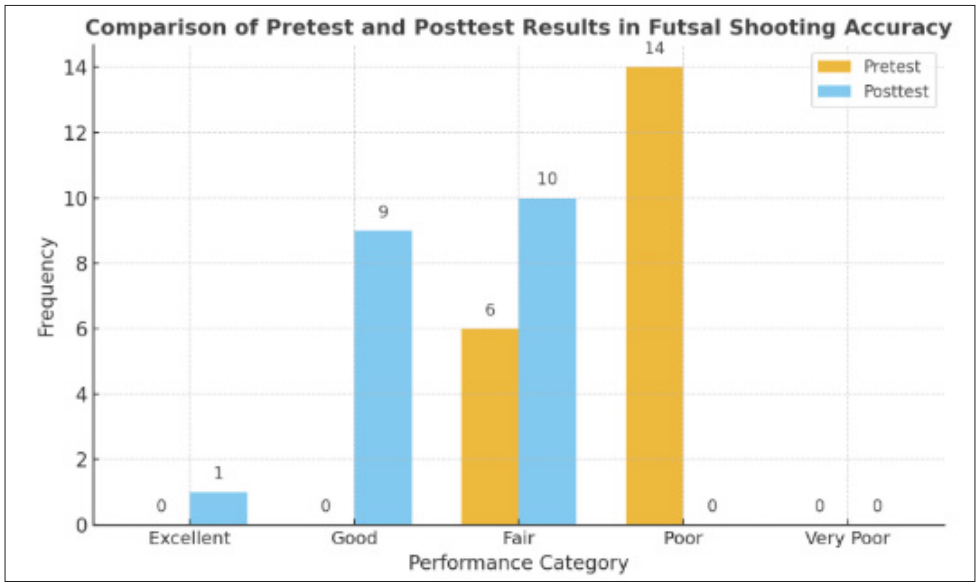


Figure 1. *Pretest and Posttest Shooting Accuracy*

Figure 1 illustrates the improvement in futsal shooting accuracy from the pre-test to the post-test. In the pretest, most participants were in the Poor category. After participating in the SSG, shooting accuracy increased to the Fair, Good, and Excellent categories. These results indicate an overall improvement in shooting ability.

Table 5. *Tests of Normality*

	Shapiro-Wilk		
	statistic	df	Sig.
Pre	.923	20	.113
Post	.962	20	.578

Table 5 shows the results of the Shapiro–Wilk normality test for the pretest and posttest data on futsal shooting accuracy. The significance values (Sig.) for the pretest and posttest data are both > 0.05. Since both data sets were normally distributed, a paired sample t-test statistical analysis could be used to test their differences.

Table 6. *Test of Homogeneity of Variances*

Levene Statistic	df1	df2	Sig.
.703	1	38	.607

Table 6 shows that the Levene's Statistic value is 0.703, which is greater than 0.05, meaning the data have homogeneous variance between the pretest and posttest groups. Therefore, a paired sample t-test statistical analysis could be used to test the differences between the pretest and posttest.

Table 7. *Paired Sample t-test*

t	df	Sig. (2-tailed)
-43.286	19	.000

The results of the Paired Sample t-test showed that Sig. = 0.000 ($p < 0.05$), indicating a highly significant difference between the pretest and posttest scores, which suggests that the training provided was effective in improving the participants' futsal shooting abilities.

Table 8. *Descriptive Data on Physical Activity Enjoyment*

Test	Mean	Median	Variance	Std deviation	Minimum	Maximum
Pre	44.65	43.5	34.45	5.87	35	55
Post	56.9	57.5	35.25	5.9	47	66

Table 8 shows an increase in enjoyment of physical activity after the SSG exercise. The mean score increased from 44.65 to 56.9, indicating a significant rise in Physical Activity Enjoyment. Data on the variance and standard deviation suggest that this increase occurred consistently, without significant differences among participants.

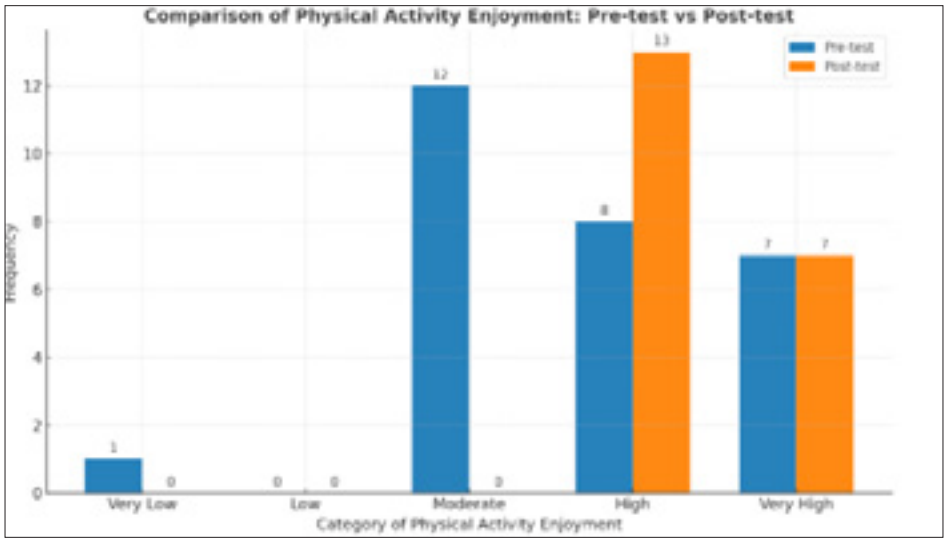


Figure 2. *Pretest and Posttest Physical Activity Enjoyment*

The graph shows an increase in enjoyment levels of physical activity after SSG. Before SSG, most participants were in the moderate and high categories, while after SSG, there was a shift to the high and very high categories. This indicates a significant increase in enjoyment of physical activity after SSG.

Table 9. *Tests of Normality*

	Shapiro-Wilk		
	statistic	df	Sig.
Pre	.954	20	.434
Post	.944	20	.286

The Shapiro-Wilk test results show a significance value of 0.434 for the pretest data and 0.286 for the posttest data. Both values are greater than the 0.05 significance level, thus concluding that the data are normally distributed.

Table 10. *Test of Homogeneity of Variances*

Levene Statistic	df1	df2	Sig.
.17	1	38	.896

Based on the results of the Levene test, a significance value of 0.896 was obtained, which is greater than the significance level of 0.05. Thus, the data have homogeneous variance.

Table 11. *Paired Sample t-test*

t	df	Sig. (2-tailed)
-36.957	19	.000

The results of the Paired Sample t-test showed that Sig. = 0.000 ($p < 0.05$), indicating a highly significant difference between the pretest and posttest scores, which suggests that the training provided was effective in increasing physical activity enjoyment.

Discussion

This study demonstrated that SSG training had a positive impact on the shooting accuracy of futsal extracurricular participants. SSG offers a higher frequency of shooting opportunities compared to conventional training

(Yenes et al., 2025). Shooting training with the SSG model was implemented by modifying the number of players, field size, and game rules to create greater intensity and engagement within a real-life game context (Castillo et al., 2021). Shooting technique drills conducted in SSG make this skill more easily transferable to real-life match conditions. Students develop good technique and the ability to do so under tactical pressure and high game speed. The SSG method enables players to experience realistic yet controlled match situations, thereby practicing shooting accuracy in conditions similar to those of a real match (Coutinho et al., 2024).

The formats 1 vs 1, 2 vs 1, 2 vs 2, 3 vs 2, and 3 vs 3 were applied in this study. This training method allows students to experience realistic yet controlled match situations, thus practicing shooting accuracy in conditions close to a real match. In the 1 vs 1 format, students are directed to shoot under direct pressure from an opponent, so fundamental technical aspects such as body position, shot angle, and ball contact are the primary focus. This training sharpens shooting precision, as any errors in control or execution immediately result in a missed opportunity. As there are fewer students, everyone is more responsible for the attack, and each student has multiple opportunities to shoot. The constant training of high frequency improves eye-foot coordination, reaction speed, and shot direction control.

The 2 vs 1 format makes the situation more saturated with tactical elements. Students get the opportunity to choose the optimal time to start a shot. The right choice reinforces the coordination between the perception of a place in space and the signal for a shot. The 2 vs 2 format allows the students to maintain the accuracy indicator even if the opponent's pressure increases and the areas in which they act are reduced. This fosters a consistent shooting technique under tight playing conditions. SSG places students under pressure in limited time and space, demanding quick decision-making and precise technique execution (Trecroci et al., 2020).

The format of the 3 vs 2 not only develops the formation of a sense of space and time when the goal and positioning of the goalkeeper are quickly assessed, but also enables one to increase the proportion of accurately hit shots. Thus, while playing 3 vs 2, the students note the force, angle, and playtime of their shots to adapt them to the game's circumstances. The activities in 3 vs 2 allow students to focus on the existing numerical advantage and create shot-taking opportunities with more favorable body postures and shot angles. Then, these individuals engage in an intense, high-tempo game of 3 vs 3, and the ability to maintain accurate hits is crucial because they are more game-specific.

The results of this study also demonstrate that SSG has a positive impact on increasing the enjoyment of physical activity among students (Entezari et al., 2023; Ouertatani et al., 2022). The SSG provides ample opportunity for each student to touch the ball, pass, shoot, assist in defense, and attack. The SSG model can meet each student's basic needs for making critical decisions during training, improving technical and tactical skills, and fostering enjoyable social interaction. Furthermore, the SSG model facilitates a balance of competition and collaboration. Students learn to work together while challenging themselves in a realistic game context. This pattern stimulates positive emotions, such as enthusiasm, satisfaction, and excitement (Selmi et al., 2020).

The high intensity of SSG also contributes to the release of endorphins and increased blood flow, resulting in a feeling of refreshment, focus, and post-exercise euphoria (Selmi et al., 2018). These responses in combination cause the body to be refreshed, a better sense of mental concentration, and produce a feeling of post-exercise euphoria. The combination of these three experiences can push the perception of physical and emotional enjoyment. SSG may not only enhance shooting precision, but might have boosted the perception of fun in physical and emotional activity. Given the brevity of this research and the fact that it contains no control group, the findings must be interpreted cautiously to infer causality.

Although this study provides a positive picture, this single educational institution's sample size limits this paper's ability to extrapolate its conclusions to a more varied population. Both shooting accuracy and physical activity enjoyment were also assessed using standard measures and questionnaires, which may have led to assessor bias. These problems with the research do not negate the result. These limitations provide significant opportunities for the use of control groups and technology-based research instruments.

Conclusion

The results of this study indicate that SSG was efficacious in improving shooting accuracy and enjoyment of physical activity in extracurricular futsal participants. The varied game formats allow players to practice their shooting in situations that mimic real matches. The high intensity and interaction during training also increase player engagement. Coaches and physical education teachers should integrate the SSG model into school futsal training programs to enhance both technical and psychological aspects of players. Future research could expand the focus

to include physiological and psychological variables, thereby gaining a more comprehensive understanding of the benefits of SSG in developing the performance and character of young players.

References

Amani-Shalamzari, S., Khoshghadam, E., Doniaee, A., Parnow, A., Bayati, M., & Clemente, F. M. (2019). Generic vs. small-sided game training in futsal: Effects on aerobic capacity, anaerobic power and agility. *Physiology and Behavior*, *204*(February), 347–354. https://doi.org/10.1016/j.physbeh.2019.03.017

Bujalance-Moreno, P., Latorre-Román, P. Á., & García-Pinillos, F. (2019). A systematic review on small-sided games in football players: Acute and chronic adaptations. *Journal of Sports Sciences*, *37*(8), 921–949. https://doi.org/10.1080/02640414.2018.1535821

Castillo, D., Raya-gonzález, J., Yanci, J., & Clemente, F. M. (2021). Influence of Pitch Size on Short-Term High Intensity Actions and Body Impacts in Soccer Sided Games by. *Journal of Human Kinetics*, *78*(April), 187–196. https://doi.org/10.2478/hukin-2021-0037

Clemente, F. M. (2025). The enjoyment of small-sided games: a narrative review. *Human Movement*, *26*(1), 1–14. https://doi.org/10.5114/hm/197230

Clemente, F. M., Moran, J., Ramirez-Campillo, R., Beato, M., & Afonso, J. (2023). Endurance Performance Adaptations between SSG and HIIT in Soccer Players: A Meta-analysis. *International Journal of Sports Medicine*, *45*(3), 183–210. https://doi.org/10.1055/a-2171-3255

Clemente, F. M., Soylu, Y., Arslan, E., Kilit, B., Garrett, J., van den Hoek, D., Badicu, G., & Silva, A. F. (2022). Can high-intensity interval training and small-sided games be effective for improving physical fitness after detraining? A parallel study design in youth male soccer players. *PeerJ*, *10*. https://doi.org/10.7717/peerj.13514

Coutinho, D., Gonçalves, B., Kelly, A. L., Santos, S., Figueiredo, P., Soares, C., & Travassos, B. (2024). Exploring the impact of ball possession directionality on youth footballers' positioning, technical skills and physical abilities in small-sided games. *International Journal of Sports Science and Coaching*, *19*(6), 2438–2448. https://doi.org/10.1177/17479541241257016

Coutinho, Gonçalves, S., Varanda, B. S., Pereira, A. M., da Eira, A. J., & Correia, N. M. (2016). Manipulating the number of players and targets in team sports. Small-Sided Games during Physical Education classes. *Revista de Psicologia Del Deporte*, *25*(1), 169–177.

Doewes, R. I., Elumalai, G., & Azmi, S. H. (2022). Futsal Shooting Moving Ball Test (FSMT) Assessment as a New Testing Protocol. *International Journal of Human Movement and Sports Sciences*, *10*(6), 1302–1310. https://doi.org/10.13189/saj.2022.100621

Domville, M., Watson, P. M., Richardson, D., & Graves, L. E. F. (2019). Children's perceptions of factors that influence PE enjoyment: a qualitative investigation. *Physical Education and Sport Pedagogy*, *24*(3), 207–219. https://doi.org/10.1080/17408989.2018.1561836

Entezari, M., Shams, A., & Bahram, A. (2023). Effectiveness of Small-Sided Games (SSG) Training on Mental Toughness, Physical Activity Enjoyment and Performance of Soccer Players. *Sport Psychology Studies*, *12*(44), 73–96. https://spsyj.ssrc.ac.ir/article_2578.html?lang=en

Gemael, Q. A., & Sari, Z. N. (2025). Exploring the interest of early teenagers in futsal extracurricular participation. *Jurnal SPORTIF : Jurnal Penelitian Pembelajaran*, *11*(1), 64–80. https://doi.org/10.29407/js_unpgri.v11i1.25108

Heisz, J. J., Tejada, M. G. M., Paolucci, E. M., & Muir, C. (2016). Enjoyment for high-intensity interval exercise increases during the first six weeks of training: Implications for promoting exercise adherence in sedentary adults. *PLoS ONE*, *11*(12), 1–10. https://doi.org/10.1371/journal.pone.0168534

Hidayat, T., Hudain, M. A., Hasan, M. S., Kasmad, M. R., & Jamaluddin, J. (2025). Tactical Approach with Drilling Method on Shooting Ability of Futsal Extracurricular Participants in Elementary Schools. *ETDC: Indonesian Journal of Research and Educational Review*, *4*(3), 920–931. https://doi.org/10.51574/ijrer.v4i3.3410

Khurrohman, M. F., Purwanto, S., Nopembri, S., & Festiawan, R. (2021). The Effectiveness of Small-Sided Game Practice on Improving Basic Futsal Skills. *Jurnal Pendidikan Jasmani Dan Olahraga*, *6*(2), 211–216. https://doi.org/10.17509/jpjo.v6i2.36461

Kizi, O. A. M. (2025). The effectiveness of using game sports in physical education classes for students of higher educational institutions. *European International Journal of Pedagogics*, *5*(3), 25–27. https://doi.org/10.55640/eijp-05-03-07

Machado, A. A., Bezerra, I. S., Ponciano, K., Rica, R. L., Gama, E. F., Figueira, A., Gimenez, R., & Bocalini, D. S. (2018). Futsal as a strategy for the improvement of elementary abilities and for the development of the body image in children. *Motricidade*, *14*(2–3), 11–19. https://doi.org/10.6063/motricidade.12299

Ouertatani, Z., Selmi, O., Marsigliante, S., Aydi, B., Hammami, N., & Muscella, A. (2022). Comparison of the Physical, Physiological, and Psychological Responses of the High-Intensity Interval (HIIT) and Small-Sided Games (SSG) Training Programs in Young Elite Soccer Players. *International Journal of Environmental Research and Public Health*, *19*(21), 1–18. https://doi.org/10.3390/ijerph192113807

Selmi, O., Haddad, M., Majed, L., Khalifa, W. Ben, Hamza, M., & Chamari, K. (2018). Soccer training: high-intensity interval training is mood disturbing while small sided games ensure mood balance okba. *The Journal of Sports Medicine and Physical Fitness*, *58*(7), 1163–1170. https://doi.org/10.23736/S0022-4707.17.07292-9

Selmi, O., Ouergui, I., Levitt, D. E., Nikolaidis, P., Knechtle, B., & Bouassida, A. (2020). Small-Sided Games are More Enjoyable Than High-Intensity Interval Training of Similar Exercise Intensity in Soccer. *Journal of Sports Medicine*, 77–84.

Trecroci, A., Boccolini, G., Duca, M., Formenti, D., & Alberti, G. (2020). Mental fatigue impairs physical activity , technical and decision-making performance during small-sided games. *PLoS ONE*, *15*(9), 1–12. https://doi.org/10.1371/journal.pone.0238461

Yenes, R., Pratama, A. O., Astuti, Y., Orhan, B. E., Kaur, D., Beulah, S., & Valappil, I. N. K. (2025). Small-Side Games (SSG) and Conventional Training: How It Affects the Improvement of Shooting Ability of Young Basketball Athletes? *International Journal of Human Movement and Sports Sciences*, *13*(2), 274–279. https://doi.org/10.13189/saj.2025.130203

Primljen: 20. novembar 2025. / Received: Novembar 20, 2025
Izmjene primljene: 20. decembar 2025. / Changes Received: December 20, 2025
Prihvaćen: 30. mart 2026. / Accepted: March 30, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601153B
UDC: 797.253:796.015.15
Original scientific paper
Originalni naučni rad

Differences in Situational-Motor Abilities of Young Water Polo Players

Razlike u situaciono-motoričkim sposobnostima mladih vaterpolista

Senad Bajrić[1], Edin Mirvić[2], Osmo Bajrić[1], Faris Rašidagić[2], Alma Dizdar[3]

[1]Pan-European University "Apeiron", Banja Luka, Bosnia and Herzegovina
[2]Faculty of Kinesiology, University of Sarajevo, Bosnia and Herzegovina
[3]Olympic Swimming Pool in Sarajevo, Bosnia and Herzegovina

Correspondence:
Senad Bajrić
Pan-European University "Apeiron", Banja Luka, Bosnia and Herzegovina
senad.o.bajric@apeiron-edu.eu

[1] Fakultet sportskih nauka, Panevropski Univerzitet „Apeiron", Banja Luka, Bosna i Hercegovina
[2]Kineziološki fakultet Univerziteta u Sarajevu, Bosna i Hercegovina
[3] Olimpijski bazen u Sarajevu, Bosna i Hercegovina

Korespondencija:
Senad Bajrić
Fakultet sportskih nauka, Panevropski Univerzitet „Apeiron", Banja Luka, Bosna i Hercegovina
senad.o.bajric@apeiron-edu.eu

Abstract: *The research was carried out with the aim of determining the differences in situational-motor abilities between younger (14-16 years) and older juniors (16-18 years) in water polo. The total sample consisted of 174 participants from the following water polo clubs: VK "Borac" from Banja Luka, VK "Mladost", VK "Torpedo" and VK "Invictum" all from Sarajevo, divided into two age categories according to the rules of the BiH Water Polo Federation of Bosnia and Herzegovina. Twelve variables specific to water polo were used to assess situational-motor abilities in the treated sample of subjects. To assess situational-motor abilities in the examined sample, twelve variables specific to water polo performance were applied. For all applied variables, basic central and dispersion parameters were calculated. To determine differences in situational-motor abilities between younger and older junior players, an independent samples T-test was used. The calculated basic and central dispersion parameters show a normal distribution for most variables in both groups of young water polo players. The obtained T-test results show statistically significant differences between the groups in variables that directly determine offensive efficiency and ball handing in favor of older juniors: goals scored (SMGS), goals from play (SMGFP), ball handing 3x5m (BH3x5M) and ball speed (BALLSP) at the level of statistical significance ($p<0.05$). In the remaining variables, no statistically significant differences were found, indicating a similar level of situational-motor abilities in both groups. The results suggest that longer training experience and greater age contribute to higher situational efficiency in water polo performance. Furthermore, the findings highlight the need for targeted training of younger juniors toward the development of speed, coordination, and technique in executing offensive elements, thereby enabling a more effective transition to older categories. The obtained results may assist coaches in implementing more effective selection, diagnostics and planning of individualized training process for young water polo players.*

Sažetak: *Istraživanje je izvršeno s ciljem utvrđivanja razlika u situaciono-motoričkim sposobnostima između mlađih (14–16 godina) i starijih juniora (16–18 godina) u vaterpolu. Ukupan uzorak ispitanika činilo je 174 ispitanika iz sljedećih vaterpolo klubova: VK „Borac" iz Banja Luke, VK „Mladost", VK „Torpedo" i VK „Invictum" svi iz Sarajeva podijeljenih u dvije uzrasne kategorije prema pravilima Vaterpolo saveza BiH. Za procjenu situaciono-motoričkih sposobnosti na tretiranom uzorku ispitanika primijenjeno je dvanaest varijabli specifičnih za vaterpolo igru. Za sve primijenjene varijable situaciono-motoričkih sposobnosti izračunati su osnovni centralni i disperzioni parametri. Za utvrđivanje razlika u situaciono-motoričkim sposobnostima između mlađih i starijih juniora u vaterpolu primijenjena je analiza rezultata T-testa za nezavisne uzorke. Izračunati osnovni i centralni disperzioni parametri pokazuju normalnu distribuciju kod većine varijabli za obje grupe ispitanika-mladih vaterpolista. Dobijeni rezultati T-testa ukazuju na statistički značajne razlike između grupa ispitanika u varijablama koje direktno određuju napadačku efikasnost i manipulaciju loptom u korist starijih juniora: postignuti golovi (SMPOGO), golovi iz igre (SMGOIG), vođenje lopte 3x5m (VL3x5M) i brzina lopte (BRZLOP) na nivou statističke značajnosti ($p<0,05$). U ostalim varijablama nisu registrovane statistički značajne razlike, što ukazuje na sličan nivo ispoljavanja situaciono-motoričkih sposobnosti kod obje grupe ispitanika. Dobijeni rezultati upućuju na zaključak da duže trenažno iskustvo i veća starosna dob doprinose većoj situacionoj efikasnosti u vaterpolo igri. Takođe, rezultati upućuju na potrebu posebnog usmjerenja mlađih juniora ka razvoju brzine, koordinacije i tehnike u realizaciji napadačkih elemenata, čime se omogućava kvalitetniji prelazak u starije kategorije. Dobijeni rezultati mogu poslužiti trenerima u sprovođenju kvalitetnije selekcije, dijagnostici i planiranju individualizovanog trenažnog procesa kod mladih vaterpolista.*

Keywords: *juniors, situational-motor abilities, game efficiency, water polo*

Introduction

Water polo is a complex team sport that requires a high level of physical, technical and situational-motor abilities, with continuous adaptation to the tactical demands of the under real conditions. Modern water polo is a highly demanding sport characterized by high swimming speed, a combination of swimming, and ball handing, explosiveness in executing offensive actions, frequent direct contact between players, and effectiveness in duels under opponent pressure. Particularly important are ball manipulation skills, as well as the precision and speed of executing technical elements, which directly influence game efficiency and the final match outcome (Lozovina & Pavičić, 2004). Water polo is a sport that requires players to possess considerable strength to perform fast, powerful, and accurate shots, successfully block opponents, and maintain physical dominance during matches (Van de Werde, 2005).

The dynamic nature of water polo is reflected in specific swimming techniques, strong musculature, and a highly competitive style of play in all phases of the game (both offense and defense). The modern development of water polo has led to increased strength, stronger shooting power, faster swimming speed, and a higher tempo of play, while defensive tactics have evolved to the level where stopping the attacker at all costs has become a priority. Contemporary water polo has become intense, fast, and dynamic, requiring players to achieve an exceptionally high level of overall preparedness (physical, technical, tactical, and psychological). Consequently, the development of a high-quality water polo player is an extremely demanding and long-term process (Lupo, Tessitore, Minganti, & Capranica, 2010).

The junior age period represents a crucial phase in the development of young water polo players, as significant functional, morphological, and motor adaptations occur during this stage. The difference between younger and older juniors is not only reflected in biological maturation but also in acquired technical-tactical experience, which contributes to better recognition and more successful resolution of complex game situations. In practice, it is often assumed that older juniors achieve a higher level of sports performance; however, it is necessary to scientifically confirm and quantify these differences in specific elements of water polo.

Situational-motor abilities represent a measurable indicator of performance under real competitive conditions. Measuring goals scored, offensive and defensive actions, ball speed, and technical manipulation during swimming with the ball enables an objective assessment of player performance

Ključne reči: *juniori, situaciono-motoričke sposobnosti, efikasnost u igri, vaterpolo*

Uvod

Vaterpolo predstavlja kompleksan timski sport koji zahtijeva visok nivo fizičkih, tehničkih i situaciono-motoričkih sposobnosti, uz kontinuirano prilagođavanje taktičkim zahtjevima igre u realnim uslovima. Savremeni vaterpolo je vrlo zahtjevna sportska igra koju karakteriše velika brzina kretanja u vodi, kombinacija plivanja, manipulacija sa loptom, eksplozivnost u realizaciji napadačkih akcija, veliki broj neposrednih kontakata između igrača i uspješnost u duelima pod pritiskom protivnika. Posebno važnu ulogu imaju sposobnosti manipulacije loptom, preciznost i brzina izvođenja tehničkih elemenata, koje direktno utiču na efikasnost u igri i konačni rezultat utakmice (Lozovina & Pavičić, 2004.). Vaterpolo je igra koja od igrača zahtijeva značajnu snagu da izvede brz, snažan i precizan šut, uspješno blokiranje i odgurne druge igrače tokom utakmice (Van de Werde, 2005.).

Dinamičnost vaterpolo igre izražava se u specifičnim tehnikama plivanja, snažnoj muskulaturi i borbenoj igri u svim fazama igre (u napadu i odbrani). Savremeni razvoj vaterpola uticao je na povećanje snage, jačinu šuta, brzinu plivanja, povećanje tempa igre, a taktika igre u odbrani razvila se do nivoa da se napadač zaustavi po svaku cijenu. Savremeni vaterpolo postao je oštar, brz, dinamičan zbog čega od igrača zahtijeva izrazito visok nivo ukupne pripremljenosti (fizičke, tehničke, taktičke, psihološke), zbog čega je formiranje kvalitetnog vaterpoliste izuzetno težak i dugoročan proces (Lupo, Tessitore, Minganti i Capranica, 2010.).

Period juniorske dobi predstavlja ključnu fazu u razvoju mladih vaterpolista, jer se u tom uzrastu događaju intenzivne funkcionalne, morfološke i motoričke adaptacije. Razlika između mlađih i starijih juniora ne ogleda se samo u biološkom sazrijevanju, već i u stečenom tehničko-taktičkom iskustvu, koje doprinosi kvalitetnijem prepoznavanju i uspješnom rješavanju složenih situacija u igri. U praksi se često pretpostavlja da stariji juniori postižu veći nivo sportske uspješnosti, ali je neophodno naučno potvrditi i kvantifikovati ove razlike u specifičnim elementima vaterpola.

Situaciono-motoričke sposobnosti predstavljaju mjerljiv prikaz uspješnosti u realnim uslovima takmičarske aktivnosti. Mjerenje postignutih pogodaka, napadačkih i odbrambenih akcija, brzine lopte te tehničke manipulacije u plivanju s loptom omogućava objektivnu procjenu uspješnosti vaterpolista tokom igre. Analizom ovih pokazatelja moguće je prepoznati razvojne potrebe

during the game. By analyzing these indicators, it is possible to identify the developmental needs of young water polo players, evaluate the quality of the selection process, and provide guidelines for improving the training process.

Research addressing differences between age categories in water polo is still relatively limited, particularly in Bosnia and Herzegovina. Therefore, there is a need for a scientific approach to evaluating situational-motor abilities in order to obtain relevant information for coaches, selectors, and sports professionals necessary for effective planning and programming of training processes for young water polo players.

Method of Work

Sample of Participants

The sample included a total of 174 participants—young water polo players from clubs in Bosnia and Herzegovina. The total sample was divided into two groups according to age, in line with the rules of the Water Polo Federation of Bosnia and Herzegovina. The first group consisted of 87 younger juniors aged 14 to 16 years, while the second group also consisted of 87 older juniors aged 16 to 18 years.

The study included only those participants who were healthy at the time of testing and actively involved in regular training processes within their clubs. The research was conducted during regular training sessions under appropriate conditions required for testing.

Sample of Variables

A set of 12 variables was applied to assess situational-motor abilities, describing offensive and defensive elements of technical-tactical performance in water polo, as well as ball manipulation speed:

Variables for assessing situational-motor abilities:

1. Goals scored .....(SMGS)
2. Shots on goal .....(SMSHOG)
3. Goals from play ..... (SMGFP)
4. Center (hole set) goals ..... (SMCG)
5. Penalty shots ..... (SMPSH)
6. Goals from penalties ..... (SMGFP)
7. Penalty saves ..... (SMPS)
8. Goals with player advantage ..... (SMGWPA)
9. Shots from fouls ..... (SMSHFF)
10. Goals from fouls ..... (SMGFF)
11. Ball handling 3×5 meters ..... (BH3x5M)
12. Ball speed .....(BALLSP)

Data Processing

For all applied variables assessing situational-motor abilities, basic central and dispersion parameters were calculated, including: Range, Minimum (Min), Maxi-

mladih vaterpolista, kvalitet procesa selekcije i smjernice za unapređenje trenažnog procesa.

Istraživanja koja se bave razlikama između uzrasnih kategorija u vaterpolu još uvijek su relativno ograničena, posebno na prostoru Bosne i Hercegovine. Zbog toga se javlja potreba za naučnim pristupom evaluaciji situaciono-motoričkih sposobnosti kako bi se dobile relevantne informacije za trenere, selektore i sportske stručnjake potrebne za kvalitetno planiranje i programiranje trenažnog rada sa mladim vaterpolistima.

Metod rada

Uzorak ispitanika

U uzorak ispitanika uključeno je ukupno 174 ispitanika-mladih vaterpolista iz klubova Bosne i Hercegovine. Ukupan uzorak ispitanika podijeljen je u dvije grupe u odnosu na uzrasnu dob, a prema pravilima Vaterpolo saveza Bosne i Hercegovine. Prvu grupu ispitanika, njih 87 činili su mlađi juniori uzrasta od 14 do 16 godina, a drugu grupu, takođe njih 87 činili su stariji juniri uzrasta od 16 do 18 godina. Istraživanjem su bili obuhvaćeni samo oni ispitanici koji su u to vrijeme bili potpuno zdravi i koji su bili uključeni u redovan trenažni proces u svojim klubovima. Istraživanje je sprovedeno na redovnom treningu uz odgovarajuće uslove potrebne za testiranje u ovom istraživanju.

Uzorak varijabli

U istraživanju je primijenjen set od **12 varijablui za procjenu situaciono-motoričkih sposobnosti** koje opisuju napadačke i odbrambene elemente tehničko-taktičke uspješnosti u vaterpolu, kao i brzinu manipulacije loptom:

Varijable za procjenu situaciono-motoričkih sposobnosti:

1. Postignuti golovi ..... (SMPOGO)
2. Pokušaji na gol ..... (SMPONG)
3. Golovi iz igre ..... (SMGOIG)
4. Golovi sa sidra .....(SMGOSI)
5. Peterac .....(SMPETE)
6. Gol iz peterca ..... (SMGPET)
7. Odbrana peterca ..... (SMOPET)
8. Gol iz igrača više .....(SMGIVI)
9. Šut iz faula ..... (SMŠUFL)
10. Gol iz faula .....(SMGOFL)
11. Vođenja lopte 3x5 metara ..... (VL3x5M)
12. Brzina lopte .....(BRZLOP)

Obrada podataka

Za sve primijenjene varijable za procjenu situaciono-motoričkih sposobnosti izračunati su osnovni centralni i disperzioni parametri koji su uključivali sljedeće para-

mum (Max), Mean (arithmetic average), Standard Deviation (St. Dev.), and Variance.

The normality of data distribution was tested based on the values of skewness and kurtosis coefficients, along with their standard errors, in order to determine the justification for applying parametric statistical procedures. To identify statistically significant differences in situational-motor abilities between the groups, an independent samples t-test was applied. The level of statistical significance was set at $p < 0.05$.

Effect size was expressed using Eta squared (η^2), which represents the proportion of total variance in the dependent variable explained by a specific independent factor. It is calculated as the ratio of the sum of squares of the effect to the total sum of squares. Its values range from 0 to 1, with higher values indicating a stronger effect. This measure helps in understanding the practical significance of results beyond statistical significance alone.

Statistical data processing was performed using the software package IBM SPSS Statistics 22.

Results

Analysis of Basic Central and Dispersion Parameters of Variables for Assessing Situational-Motor Abilities in Younger Juniors (14–16 years)

Table 1 presents the basic central and dispersion parameters of variables used to assess the situational-motor abilities of younger junior players. The analysis of the obtained results shows that the values of these parameters do not significantly deviate from a normal distribution.

Minor deviations are observed in the variables: center (hole set) goals (SMCG), penalty shots (SMPSH), penalty saves (SMPS), and goals with a player advantage (SMGWPA). The values of the kurtosis coefficient for these variables exceed the normal distribution value of 2.75, indicating a mesokurtic distribution, which reflects a higher concentration of results around the mean.

Despite these minor deviations in the distribution of the obtained results, it can be concluded that the central and dispersion parameters of situational-motor abilities in younger junior water polo players indicate an overall normal distribution of results.

metre: Rangey-Rang, Min-minimalni rezultat mjerenja, Max-maksimalni rezultat mjerenja, Mean- aritmetička sredina, St.Dev.-standardna devijacija, Variance-varijansa. Normalnost distribucije podataka provjerena je na osnovu vrijednosti koeficijenta asimetričnosti (Skewness-a) i koeficijenta izduženosti (Kurtosis-a), kao i njihovih standardnih grešaka, kako bi se utvrdila opravdanost primjene parametrijskih statističkih postupaka. Za utvrđivanje statistički značajnih razlika u situaciono-motoričkim sposobnostima između grupa ispitanika primijenjena je analiza rezultata T-testa za nezavisne uzorke. Nivo statističke značajnosti postavljen je na nivou $p < 0,05$.

Efekat veličine izražen je Eta kvadratom, koja se koristi u statistici, a označava udio ukupne varijance zavisne varijable koji objašnjava određeni nezavisni faktor. Računa se kao odnos sume kvadrata efekta i ukupne sume kvadrata. Raspon vrijednosti kreće se od 0 do 1, pri čemu veće vrijednosti ukazuju na jači učinak. Pomaže u razumijevanju praktične važnosti rezultata izvan same statističke značajnosti.

Statistička obrada podataka sprovedena je u programu IBM SPSS Statistics 22.

Rezultati

Analiza rezultata osnovnih centralnih i disperzionih parametara varijabli za procjenu situaciono-motoričkih sposobnosti mlađih juniora (14-16 godina)

U tabeli 1 prikazani su osnovni centralni i disperzioni parametri varijabli za procjenu situaciono-motoričkih sposobnosti mlađih juniora. Analizom dobijenih rezultata može se vidjeti da dobijene vrijednosti navedenih parametara ne odstupaju značajno od normalne distribucije.

Manja odstupanja primijetna su kod varijabli: golovi iz sidra (SMGOSI), peterac (SMPETE), odbrana peterca (SMOPET) i gol sa igračem više (SMGIVI). Vrijednosti koeficijenta izduženosti (Kurtosis-a) kod navedenih varijabli kreću se iznad normalne vrijednosti distribucije 2,75, što čini distribuciju mezokurtičnom, što ukazuje na povećanu koncentraciju rezultata oko aritmetičke sredine.

Bez obzira na manja odstupanja u raspodjeli dobijenih rezultata, može se konstatovati da dobijeni rezultati centralnih i disperzivnih parametara situaciono-motoričkih sposobnosti kod mlađih juniora u vaterpolu pokazuju da se radi o normalnoj distribuciji rezultata.

Table 1. *Basic central and dispersion parameters of situational-motor abilities in younger juniors (14–16 years)*

Tabela 1. *Osnovni centralni i disperzioni parametri situaciono-motoričkih sposobnosti mlađih juniora (14-16 godina)*

	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
SMGS	87	1.00	.00	1.00	10.00	.1149	.03439	.32080	.103	2.457	.258	4.132	.511
SMSHOG	87	2.00	.00	2.00	117.00	1.3448	.08778	.81879	.670	-.720	.258	-1.126	.511
SMGFP	87	1.00	.00	1.00	10.00	.1149	.03439	.32080	.103	2.457	.258	4.132	.511
SMCG	87	2.00	.00	2.00	8.00	.0920	.04211	.39273	.154	4.376	.258	18.449	.511
SMPSH	87	2.00	.00	2.00	8.00	.0920	.03880	.36191	.131	4.224	.258	18.138	.511
SMGFP	87	2.00	.00	2.00	15.00	.1724	.05942	.55420	.307	2.999	.258	7.285	.511
SMPS	87	2.00	.00	2.00	9.00	.1034	.04336	.40447	.164	4.054	.258	15.882	.511
SMGWPA	87	3.00	.00	3.00	12.00	.1379	.05934	.55348	.306	4.273	.258	18.068	.511
SMSHFF	87	2.00	.00	2.00	13.00	.1494	.05305	.49483	.245	3.268	.258	9.422	.511
SMGFF	87	3.00	.00	3.00	16.00	.1839	.06014	.56091	.315	3.273	.258	10.585	.511
BH3x5M	87	4.52	11.01	15.53	1172.66	13.4789	.14046	1.31016	1.717	-.188	.258	-.524	.511
BALLSP	87	8.00	16.00	24.00	1754.00	20.1609	.29695	2.76974	7.671	-.063	.258	-1.479	.511
Valid N (listwise)	87												

Legend: N – number of participants; Range – range; Min – minimum measurement result; Max – maximum measurement result; Mean – arithmetic mean; St. Dev. – standard deviation; Variance – variance; Skewness – coefficient of asymmetry; Kurtosis – coefficient of kurtosis (peakedness); SMGS – goals scored; SMSHOG – shots on goal; SMGFP – goals from play; SMCG – center (hole set) goals; SMPSH – penalty shots; SMGFP – goals from penalties; SMPS – penalty saves; SMGWPA – goals with player advantage; SMSHFF – shots from fouls; SMGFF – goals from fouls; BH3X5M – ball handling 3 × 5 meters; BALLSP – ball speed.

Legenda: N-broj ispitanika, Rangey-Rang, Min-minimalni rezultat mjerenja, Max-maksimalni rezultat mjerenja, Mean-aritmetička sredina, St.Dev.-standardna devijacija, Variance-varijansa, Skewness-koeficijent asimetričnosti, Kurtosis-koeficijent spljoštenosti, SMPOGO – Postignuti golovi, SMPONG – Pokušaja na gol, SMGOIG – Golovi iz igre, SMGOSI – Golovi sa sidra, SMPETE –Peterac, SMGPET – Gol iz peterca, SMOPET – Odbrana peterca, SMGIVI – Gol iz igrača više, SMŠUFL – Šut iz faula, SMGOFL – Gol iz faula, VL3X5M – Vođenje lopte 3 x 5 metara, BRZLOP – Brzina lopte

Analysis of Basic Central and Dispersion Parameters of Variables for Assessing Situational-Motor Abilities in Older Juniors (16–18 years)

Table 2 presents the basic central and dispersion parameters of variables used to assess the situational-motor abilities of older junior players (16–18 years). The analysis of the obtained results indicates that the values of the central and dispersion parameters show a normal distribution, with no significant deviations observed.

Minor deviations are noted in the variables: shots from fouls (SMSHFF) and goals from fouls (SMGFF).

Based on the obtained results of the central and dispersion parameters for situational-motor abilities in older junior water polo players, it can be concluded that the values of all applied variables are normally distributed. The distribution of the obtained values of the basic central and dispersion parameters of the functional abilities of the participants—older juniors—fits within the standards specific to the situational-motor abilities of water polo players of this age group.

Analiza rezultata osnovnih centralnih i disperzionih parametara varijabli za procjenu situaciono-motoričkih sposobnosti starijih juniora (16-18 godina)

U tabeli 2 prikazani su osnovni centralni i disperzioni parametri varijabli za procjenu situaciono-motoričkih sposobnosti starijih juniora (16-18 godina). Analizom dobijenih rezultata vidljivo je da vrijednosti centralnih i disperzionih parametara varijabli za procjenu situaciono-motoričkih sposobnosti pokazuju normalnu raspodjelu i da u tom kontekstu nema značajnijih odstupanja od normalne raspodjele. Manje odstupanje vidljivo je kod varijabli šut iz faula – SMŠUFL i gol iz faula – SMGOFL.

Na osnovu dobijenih rezultata centralnih i disperzionih parametara varijabli za procjenu situaciono-motoričkih sposobnosti kod starijih juniora u vaterpolu može se zaključiti da su vrijednosti svih primijenjenih varijabli normalno distribuirane. Distribucija dobijenih vrijednosti osnovnih centralnih i disperzionih parametara funkcionalnih sposobnosti ispitanika – starijih juniora uklapaju se u standarde specifične za situaciono-motoričke sposobnosti vaterpolista ovog uzrasta.

Table 2. *Basic central and dispersion parameters of situational-motor abilities in older juniors*

Tabela 2. *Osnovni centralni i disperzioni parametri situaciono-motoričkih sposobnosti starijih juniora*

Descriptive Statistics											
	N	Minimum	Maximum	Sum	Mean		Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error	Statistic	Std. Error
SMGS	87	.00	4.00	67.00	.7701	.11642	1.08586	1.478	.258	1.447	.511
SMSHOG	87	.00	5.00	113.00	1.2989	.13494	1.25860	.952	.258	.647	.511
SMGFP	87	.00	2.00	32.00	.3678	.05921	.55227	1.182	.258	.445	.511
SMCG	87	.00	2.00	16.00	.1839	.05047	.47074	2.618	.258	6.326	.511
SMPSH	87	.00	1.00	16.00	.1839	.04178	.38966	1.661	.258	.775	.511
SMGFP	87	.00	1.00	12.00	.1379	.03718	.34683	2.137	.258	2.627	.511
SMPS	87	.00	1.00	15.00	.1724	.04073	.37993	1.765	.258	1.141	.511
SMGWPA	87	.00	1.00	20.00	.2299	.04537	.42320	1.307	.258	-.300	.511
SMSHFF	87	.00	2.00	12.00	.1379	.04952	.46186	3.404	.258	10.683	.511
SMGFF	87	.00	3.00	17.00	.1954	.06709	.62578	3.332	.258	10.513	.511
BH3x5M	87	10.00	15.90	1035.06	11.8972	.13627	1.27108	1.181	.258	1.645	.511
BALLSP	87	16.00	39.00	2012.00	23.1264	.50202	4.68249	1.268	.258	2.961	.511
Valid N (listwise)	87										

Legend: N – number of participants; Range – range; Min – minimum measurement result; Max – maximum measurement result; Mean – arithmetic mean; St. Dev. – standard deviation; Variance – variance; Skewness – coefficient of asymmetry; Kurtosis – coefficient of kurtosis (peakedness); SMGS – goals scored; SMSHOG – shots on goal; SMGFP – goals from play; SMCG – center (hole set) goals; SMPSH – penalty shots; SMGFP – goals from penalties; SMPS – penalty saves; SMGWPA – goals with player advantage; SMSHFF – shots from fouls; SMGFF – goals from fouls; BH3X5M – ball handling 3 × 5 meters; BALLSP – ball speed.

Legenda: N-broj ispitanika, Rangey-Rang, Min-minimalni rezultat mjerenja, Max-maksimalni rezultat mjerenja, Mean-aritmetička sredina, St.Dev.-standardna devijacija, Variance-varijansa, Skewness-koeficijent asimetričnosti, Kurtosis-koeficijent spljoštenosti, SMPOGO – Postignuti golovi, SMPONG – Pokušaja na gol, SMGOIG – Golovi iz igre, SMGOSI – Golovi sa sidra, SMPETE –Peterac, SMGPET – Gol iz peterca, SMOPET – Odbrana peterca, SMGIVI – Gol iz igrača više, SMŠUFL – Šut iz faula, SMGOFL – Gol iz faula, VL3X5M – Vođenje lopte 3 x 5 metara, BRZLOP – Brzina lopte

Analysis of Differences in Situational-Motor Abilities Between Younger and Older Juniors in Water Polo

Analysis of Differences in Situational-Motor Abilities Using the t-Test

To determine differences in situational-motor abilities between younger and older junior water polo players, an independent samples t-test was applied (Table 3). The results of the t-test indicate positive and statistically significant differences in four out of twelve tests used to assess situational-motor abilities between the two groups of participants.

Statistically significant differences were found in the following tests:

- **Goals scored – SMGS** t(172) = -5.39, p = .000. The average increase in this test was 71.31, with a 95% confidence interval ranging from -0.89 to -0.41. Eta squared was 0.14, indicating a large effect size of this variable on the examined sample.
- **Goals from play – SMGFP** t(172) = -3.69, p = .000. The average increase in this test was 58.37, with a

Analiza razlika u situaciono-motoričkim sposobnostima između mlađih i starijih juniora u vaterpolu

Analiza razlika u situaciono-motoričkim sposobnostima testiranih T-testom

Za utvrđivanje razlika u situaciono-motoričkim sposobnostim između mlađih i starijih juniora u vaterpolu primijenjena je analiza rezultata T-testa za nezavisne uzorke (tabela 3). Rezultati T-testa ukazuju na pozitivne i statistički značajne razlike kod četiri od dvanaest testova za procjenu situaciono-motoričkih testova između dvije grupe ispitanika.

Statistički značajne razlike utvrđene su kod sljedećih testova:

- **Postignuti golovi – SMPOGO** t(172) = -5.39, p = ,000. Prosječno povećanje vrijednosti u ovom testu bilo je 71.31, dok se interval 95-procentne pouzdanosti proteže od -.89 do -.41. Eta kvadrat iznosi 0.14 što čini veliki uticaj varijable na istraženi uzorak ispitanika.
- **Golovi iz igre – SMGOIG t**(172) = -3.69, p = ,000. Prosječno povećanje vrijednosti u ovom testu bilo je

Table 3. *Results of the independent samples t-test for situational-motor abilities*

Tabela 3. *Rezultati T-testa za nezavisne uzorke situaciono-motoričkih sposobnosti*

		Levene's Test for Equality of Variances		t-test for Equality of Means							Eta kvadrat
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
									Lower	Upper	
SMGS	Equal variances assumed	71.315	.000	-5.397	172	**.000**	-.65517	.12139	-.89478	-.41556	0.14
	Equal variances not assumed			-5.397	100.899	**.000**	-.65517	.12139	-.89598	-.41436	
SMSHOG	Equal variances assumed	10.796	.001	.286	172	.776	.04598	.16098	-.27177	.36372	
	Equal variances not assumed			.286	147.736	.776	.04598	.16098	-.27214	.36409	
SMGFP	Equal variances assumed	58.375	.000	-3.693	172	**.000**	-.25287	.06847	-.38803	-.11772	
	Equal variances not assumed			-3.693	138.104	**.000**	-.25287	.06847	-.38827	-.11748	0.07
SMCG	Equal variances assumed	6.872	.010	-1.399	172	.164	-.09195	.06573	-.22169	.03778	
	Equal variances not assumed			-1.399	166.647	.164	-.09195	.06573	-.22172	.03781	
SMPSH	Equal variances assumed	8.929	.003	-1.613	172	.109	-.09195	.05702	-.20449	.02059	
	Equal variances not assumed			-1.613	171.070	.109	-.09195	.05702	-.20450	.02059	
SMGFP	Equal variances assumed	1.820	.179	.492	172	.623	.03448	.07009	-.10387	.17283	
	Equal variances not assumed			.492	144.405	.623	.03448	.07009	-.10406	.17302	
SMPS	Equal variances assumed	3.980	.048	-1.159	172	.248	-.06897	.05949	-.18640	.04847	
	Equal variances not assumed			-1.159	171.331	.248	-.06897	.05949	-.18640	.04847	
SMGWPA	Equal variances assumed	2.818	.095	-1.231	172	.220	-.09195	.07470	-.23940	.05549	
	Equal variances not assumed			-1.231	160.943	.220	-.09195	.07470	-.23947	.05556	
SMSHFF	Equal variances assumed	.118	.731	.158	172	.874	.01149	.07257	-.13175	.15473	
	Equal variances not assumed			.158	171.189	.874	.01149	.07257	-.13175	.15474	
SMGFF	Equal variances assumed	.113	.737	-.128	172	.899	-.01149	.09010	-.18933	.16634	
	Equal variances not assumed			-.128	169.980	.899	-.01149	.09010	-.18935	.16636	
BH3x5M	Equal variances assumed	.001	.976	8.082	172	**.000**	1.58161	.19571	1.19531	1.96790	
	Equal variances not assumed			8.082	171.843	**.000**	1.58161	.19571	1.19531	1.96791	0.27
BALLSP	Equal variances assumed	4.987	.027	-5.084	172	**.000**	-2.96552	.58326	-4.11679	-1.81424	
	Equal variances not assumed			-5.084	139.617	**.000**	-2.96552	.58326	-4.11869	-1.81234	0.13

Legend: t – t-test; df – degrees of freedom; Sig. – level of statistical significance; Mean Difference – difference between arithmetic means; Std. Error Difference – standard error of the mean difference; SMGS – goals scored; SMSHOG – shots on goal; SMGFP – goals from play; SMCG – center (hole set) goals; SMPSH – penalty shots; SMGFP – goals from penalties; SMPS – penalty saves; SMGWPA – goals with player advantage; SMSHFF – shots from fouls; SMGFF – goals from fouls; BH3X5M – ball handling 3 × 5 meters; BALLSP – ball throwing speed

Legenda: t - T test, df - stepeni slobode, Sig.- nivo statističke značajnosti), Mean Difference - razlika aritmetičkih sredina, Std. Error Difference - standardna greška aritmetičkih sredina, SMPOGO – Postignuti golovi, SMPONG – Pokušaji na gol, SMGOIG – Golovi iz igre, SMGOSI – Golovi sa sidra, SMPETE – Peterac, SMGPET – Gol iz peterca, SMOPET – Odbrana peterca, SMGIVI – Gol iz igrača više, SMŠUFL – Šut iz faula, SMGOFL – Gol iz faula, VL3X5M – Vođenje lopte 3 x 5 metara, BRZLOP – Bacanje lopte)

95% confidence interval ranging from -0.38 to -0.11. Eta squared was 0.07, indicating a moderate effect size of this variable on the examined sample.

- **Ball handling 3×5 m – BH3x5M** t(172) = 8.08, p = .000. The average increase in this test was 0.001, with a 95% confidence interval ranging from 1.19 to 1.96. Eta squared was 0.27, indicating a large effect size of this variable on the examined sample.
- **Ball speed – BALLSP** t(172) = -5.08, p = .000. The average increase in this test was 4.98, with a 95% confidence interval ranging from -4.11 to -1.81. Eta squared was 0.13, indicating a moderate effect size of this variable on the examined sample.

In the remaining tests, no statistically significant differences in situational-motor abilities were found between younger and older juniors.

Discussion

The results of this study clearly indicate that there are significant differences in situational-motor abilities between younger and older junior water polo players in Bosnia and Herzegovina. Statistical analysis revealed that the variables Goals scored (SMGS), Goals from play (SMGFP), Ball handling 3×5 m (BH3x5M), and Ball speed (BALLSP) are significantly differentiated between age categories, with older juniors demonstrating superior performance. These findings confirm the expected adaptation of physiological and motor abilities throughout adolescence, including growth, increased strength, coordination, and technical-tactical experience (Uljević, 2013; Idrizović et al., 2013).

The variable Goals scored (SMGS) showed the greatest impact on differences between age groups, implying that older juniors possess more developed technical-tactical abilities and greater efficiency in offensive execution. Similar conclusions were reported in studies by Stipić (2022) and Trivun et al. (2019), where situational efficiency—particularly the number of goals from play and defensive actions—was identified as a key indicator of team success. Differences in the variable Goals from play (SMGFP) further indicate a greater ability of older juniors to synchronize technique and tactics, which is expected given their longer training experience and more developed perceptual-motor control. The variable Ball handling 3×5 m (BH3x5M) demonstrated the highest eta squared value (0.27), suggesting that older juniors have better ball control in confined spaces and during directional changes. This result supports the findings of García-Cervantes et al. (2017), who emphasized the importance of technical precision and ball manipulation for success in water polo, particularly for perimeter players.

58.37, dok se interval 95-procentne pouzdanosti proteže od -.38 do -.11. Eta kvadrat iznosi 0.07 što čini srednji uticaj varijable na istraženi uzorak ispitanika.

- **Vođenje lopte 3x5m – VL3X5M** t(172) = 8.08, p = ,000 gdje je prosječno povećanje vrijednosti u ovom testu bilo .001, dok se interval 95-procentne pouzdanosti proteže od 1.19 do 1.96. Eta kvadrat iznosi 0.27 što čini veliki uticaj varijable na istraženi uzorak ispitanika.
- **Brzina lopte – BRZLOP** t(172) = -5.08, p = ,000. Prosječno povećanje vrijednosti u ovom testu bilo je 4.98, dok se interval 95-procentne pouzdanosti proteže od -4.11 do -1.81. Eta kvadrat iznosi 0.13 što čini srednji uticaj ili srednje razlike varijable na istraženi uzorak ispitanika.

Kod ostalih testova nije utvrđena statistički značajna razlika u situaciono-motoričkim sposobnostima između mlađih i starijih juniora.

Diskusija

Rezultati ovog istraživanja jasno pokazuju da postoje značajne razlike u situaciono-motoričkim sposobnostima mlađih i starijih juniora vaterpolista Bosne i Hercegovine. Statistička analiza pokazala je da su varijable Postignuti golovi (SMPOGO), Golovi iz igre (SMGOIG), Vođenje lopte 3x5 m (VL3X5M) i Brzina lopte (BRZLOP) značajno diferencirane između uzrasnih kategorija, pri čemu stariji juniori pokazuju bolje rezultate. Ovi nalazi potvrđuju očekivanu adaptaciju fizioloških i motoričkih sposobnosti sportista kroz razvojni period adolescencije, koja uključuje rast, povećanje snage, koordinacije i tehničko-taktičkog iskustva (Uljević, 2013; Idrizović i sar. 2013).

Varijabla Postignuti golovi (SMPOGO) pokazala je najveći uticaj na razlike između uzrasta, što implicira da stariji juniori imaju razvijenije tehničko-taktičke sposobnosti i bolju efikasnost u realizaciji napada. Slični zaključci su dobijeni i u studijama Stipića (2022) i Trivuna i sar. (2019), gdje je situaciona efikasnost, posebno broj golova iz igre i odbrane, bila ključni pokazatelj uspješnosti vaterpolo ekipe. Razlike u varijabli Golovi iz igre (SMGOIG) takođe ukazuju na veću sposobnost starijih juniora da sinhronizuju tehniku i taktiku igre, što je očekivano s obzirom na duže trenažno iskustvo i bolju perceptivno-motoričku kontrolu.

Varijabla Vođenje lopte 3x5 m (VL3X5M) pokazala je najviši uticaj eta kvadrata (0,27), što sugeriše da stariji juniori bolje manipulišu (kontrolišu) loptom u malom prostoru i sa promjenom pravca kretanja. Ovaj rezultat podržava nalaze García-Cervantesa i sar. (2017), koji ističu značaj tehničke preciznosti i manipulacije loptom za uspješnost u vaterpolu, posebno kod igrača perimetarskih pozicija.

Brzina lopte (BRZLOP) takođe je pokazala statistički značajne razlike, što ukazuje na unaprijeđenu snagu i tehni-

Ball speed (BALLSP) also showed statistically significant differences, indicating improved throwing strength and technique among older juniors. This ability is crucial in situational-tactical execution and often distinguishes winning from losing teams, as confirmed by Canosa et al. (2020). On the other hand, variables such as Shots on goal (SMSHOG), Center (hole set) goals (SMCG), Penalty shots (SMPSH), Goals from penalties (SMGFP), Penalty saves (SMPS), Goals with player advantage (SMGWPA), Shots from fouls (SMSHFF), and Goals from fouls (SMGFF) did not show statistically significant differences. This may be due to similar training experiences in specific technical segments of the game or the relatively low frequency of such actions during a single match, which makes statistical differentiation more difficult. Similar variability was observed in the study by Uljević (2013), where certain precision and technique-specific tests showed lower reliability in younger age categories. The obtained results confirm the importance of continuous evaluation of situational-motor abilities in the processes of selection and training planning. Coaches can use such data to individualize training loads, emphasize the development of technical elements in younger juniors, and optimize preparation for older categories, with a focus on ball handling efficiency, shot speed, and goal-scoring effectiveness. The study indicates that the development of water polo players during the junior period follows expected adaptations in situational-motor abilities. Differences between younger and older juniors are not universal across all technical-tactical segments; however, key variables demonstrate clear superiority of older juniors, which is consistent with previous research in both domestic and international contexts (Idrizović et al., 2013). Their findings showed that, among all tests, shooting speed demonstrated the highest reliability between participants. Analysis of the overall sample, including national team and club players without division by playing position, revealed multivariate differences in the jump shot test (DSHOOT). In general, national team players were more successful in shooting speed tests compared to club players. When comparing national team and club perimeter players, national team players dominated in shooting speed. Centers did not show differences in any measured tests, while perimeter players achieved significantly better results in shooting, dynamometric strength, and sprint swimming abilities.

Uljević (2013) found that, among all sport-specific tests, the lowest reliability was observed in the accuracy test, where significant differences between items indicated instability in measurement results. High reliability

ku bacanja kod starijih juniora. Ova sposobnost je ključna u situaciono-taktičkoj realizaciji i često čini razliku između pobjedničkih i poraženih timova, što potvrđuju istraživanja Canosa i sar. (2020).

S druge strane, varijable kao što su Pokušaji na gol (SMPOGO), Golovi sa sidra (SMGOSI), Peterac (SMPETE), Gol iz peterca (SMGPET), Odbrana peterca (SMOPET), Gol iz igrača više (SMGOVI), Šut iz faula (SMŠUFL) i Gol iz faula (SMGOFL) nisu pokazale statistički značajne razlike. Ovo može biti rezultat sličnog trenažnog iskustva u pojedinim tehničkim segmentima igre ili niskog broja realizacija u toku jedne utakmice, što otežava statističku diferencijaciju. Slične varijabilnosti su primijećene i u studiji Uljevića (2013), gdje su neki testovi preciznosti i specifičnih tehnika pokazali manju pouzdanost u mlađim uzrasnim kategorijama.

Dobijeni rezultati potvrđuju važnost kontinuirane evaluacije situaciono-motoričkih sposobnosti u procesu selekcije i trenažnog planiranja. Treneri mogu koristiti ovakve podatke za individualizaciju opterećenja, naglašavanje razvoja tehničkih segmenata igre kod mlađih juniora i optimizaciju pripreme za starije kategorije, uz fokus na efikasnost u vođenju lopte, brzinu šuta i realizaciju golova iz igre.

Istraživanje ukazuje da razvoj vaterpolista kroz juniorski period prati očekivane adaptacije u situaciono-motoričkim sposobnostima. Razlike između mlađih i starijih juniora nisu univerzalne za sve tehničko-taktičke segmente, ali ključne varijable pokazale su jasnu superiornost starijih juniora, što je u skladu sa prethodnim istraživanjima u domaćem i međunarodnom kontekstu (Idrizović i sar. 2013.) koji su otkrili da najveću pouzdanost između ispitanika od svih testova je pokazao test brzina šutiranja. Analiza na osnovu ukupnog uzorka ispitanika, između reprezentativaca i klupskih igrača bez podjele prema igračkim pozicijama pokazala je multivarijantne razlike takođe u testu i skok šut (DSHOOT). Generalno su vaterpolisti reprezentativci bili uspješniji u testu brzina šutiranja u odnosu na svoje klupske kolege. Posmatrajući razlike između reprezentativaca i klupskih perimetarskih igrača, igrači nacionalne selekcije su dominirali u brzini šutiranja. Centri nisu ostvarili razlike ni u jednom od mjerenih testova dok su perimetarski igrači imali značajno bolje rezultate u šutiranju, dinamometrijskoj sili i u sprinterskim plivačkim sposobnostima.

Uljević (2013) je dobio da od svih sportsko specifičnih testova najmanja pouzdanost je dobijena u testu preciznosti u kojem su utvrđene značajne razlike između čestica što govori o nestabilnosti rezultata mjerenja. Visok nivo pouzdanosti je bio dobijen kod sva tri testa brzine leta lopte, ali ne i kod testa Šut iz mahanja (2FAKE) u kojem je primijećen trend opadanja brzine leta lopte, te je post hoc analizom

ity was obtained in all three ball speed tests, but not in the "shot after fake" test (2FAKE), where a decreasing trend in ball speed was observed. Post hoc analysis revealed a statistically significant difference between the first and third attempts. Factor analysis identified three factors: the first factor had high projections of jump tests, the second factor included ball speed variables, and the third factor was defined by swimming speed and accuracy tests. García-Cervantes et al. (2017) identified statistically significant differences between male and female water polo players in average maximum ball throwing speed. Significant differences were also observed in the percentage of throws performed from different positions, with both groups most frequently executing throws from lateral positions. No significant differences were found in throwing speed over distance; however, significant differences were identified between throws taken from distances of five meters or less and those taken from distances greater than five meters. There were no significant differences between variables such as small-area play, throwing from different positions, and distance. Additionally, no differences were found between throwing speed from center and lateral positions. Stipić (2022), in a study on situational efficiency of elite water polo players at the Olympic tournament in Tokyo (2021), found statistically significant differences between winning and losing teams in variables such as goals from play, goalkeeper saves, blocks, and exclusions. Winning teams scored more goals from play, while their goalkeepers recorded nearly two more saves on average compared to those of losing teams. Players from winning teams also achieved twice as many blocks. Interestingly, exclusions had a negative impact on situational efficiency, as winning teams recorded more exclusions than losing teams. In female water polo, results differed slightly, with winning teams outperforming losing teams in multiple variables, including goals from play, counterattack shots, counterattack goals, goals with player advantage, goalkeeper saves, opponent shots on goal, blocks, and swimming for the ball. As in male teams, goalkeepers of winning teams had nearly two more saves on average. These results may be attributed to effective player selection and higher individual quality. Trivun et al. (2019), through match analysis in the A1 Regional League, found differences between winning and losing teams in most team efficiency variables. Winning teams performed better in shooting efficiency, goalkeeper performance, shot blocking, utilization of player advantage, and swimming for the ball. No significant differences were found in turnovers, ball recoveries, percentage of shots from five me-

utvrđena statistički značajna razlika između prvog i trećeg pokušaja. Faktorskom analizom su dobijena tri faktora pa je prvi faktor imao visoku projekciju testova iskoka, drugi faktor je imao projekcije brzine leta lopte, dok je treći faktor određen projekcijama brzina plivanja i testom preciznosti.

García-Cervantes i sar. (2017) su došli do statistički značajnih razlika između vaterpolistica i vaterpolista u vrijednostima prosječne maksimalne brzine bacanja lopte. Uočena je također statistički značajna razlika između muških i ženskih igrača u procentu izvedenih bacanja sa različitih pozicija pa su najčešće i jedni i drugi bacanja izvršavali sa bočnih pozicija. Nema statistički značajne razlike u brzini bacanja udalj. Nađene su statistički značajne razlike u brzini bacanja sa udaljenosti od pet metara ili manje i bacanja lopte sa više od pet metara. Nije bilo statistički značajne razlike između varijabli (igra na malom prostoru, bacanje sa različitih pozicija i udaljenost). Nema razlika između brzine bacanja sa pozicija centra i sa strane.

Stipić (2022) se u svojoj naučnoj studiji također bavio razlikama situacione efikasnosti vrhunskih vaterpolista i vaterpolistica sa olimpijskog turnira u Tokiju održanom 2021. godine. Statistička analiza je pokazala da je statistički značajna razlika između pobjedničkih i poraženih ekipa u varijablama situacione efikasnosti bila u sljedećim parametrima: golovi iz igre, odbrane vratara, blokovi i isključenja. Pobjednički timovi su u prosjeku postizali više golova iz igre od poraženih timova. Golmani pobjedničkih timova su imali skoro dvije odbrane više od golmana poraženih timova. Vaterpolisti pobjedničkih timova su ostvarili duplo više blokada od vaterpolista poraženih timova. Varijabla koja je imala negativan uticaj na situacionu efikasnost u vaterpolo igri je broj isključenja u kojoj su pobjednički timovi imali više isključenja za razliku od poraženih što je vrlo neobično i neočekivano. Kod vaterpolistica rezultati su malo drugačiji nego kod muških vaterpolista. Pobjednički timovi od poraženih se razlikuju u više varijabli situacione efikasnosti: golovi iz igre, šutevi iz kontre, golovi iz kontre, golovi s igračem više, odbrane golmana, protivnički šutevi u okvir gola, blokovi i plivanje za loptu. Kao i kod muških kolega i golmanice pobjedničkih ekipa su imale skoro dvije odbrane više od golmanica poraženih ekipa. Razloge za dobijanje ovakvih rezultata koji čine razliku u varijablama golovi iz igre, odbrana golmana i blokovi kao i kod vaterpolista mogu se pripisati odlično odrađenoj selekciji igrača kao i većoj individualnoj kvaliteti pojedinih igrača.

Trivun i sr. (2019) su analizom utakmica utvrdili razlike između pobjedničkih i poraženih ekipa u regularnom dijelu takmičenja A1 Regionalne lige u većini varijabli timske efikasnosti pa su pobjedničke ekipa bile znatno bolje u skoro svim varijablama koje su se odnosile na efikasnost šuta,

ters, or total fouls per match. In a similar study, Canosa et al. (2020) analyzed differences in shooting performance among winning, drawing, and losing teams at the 15th FINA World Championship. Higher shot speeds were recorded at longer distances compared to central areas near the goal. Shooting was most frequently performed from mid-range positions, with approximately 50% efficiency, and from 3 to 6 meters, where efficiency exceeded 75%, with winning teams achieving better results. Winning teams outperformed losing teams in shooting from zone 2 and the 2-meter goal area, as well as in shots from the center forward position and in situations without defensive blocking. Argudo-Iturriaga et al. (2022) identified differences among elite female water polo players ranked 1st to 4th compared to lower-ranked players (5th–8th and 9th–12th) in various shooting situations, including lob shots, rebound shots, short-range unequal situations, counterattacks from the left side, shots with fakes from the center position, direct shots, and jump shots from the water.

Conclusion

The results of the study indicate the existence of statistically significant differences in situational-motor abilities between younger and older junior water polo players in Bosnia and Herzegovina. Older juniors achieved better results in most variables that are crucial for the successful execution of offensive and technical elements in the game, suggesting a progressive development of abilities depending on age, training experience, and the functional maturity of athletes. The identified differences confirm that older juniors possess a higher level of ball manipulation speed, shooting accuracy, efficiency in executing offensive situations, and swimming speed in combination with technical tasks. Younger juniors, on the other hand, are still in a phase of intensive acquisition of technical-tactical knowledge, and their development of situational-motor abilities is ongoing. The obtained data represent a valuable indicator for coaches and sports professionals in Bosnia and Herzegovina, as they enable more effective planning and programming of the training process, with an emphasis on those elements that require additional work and improvement in younger categories. The results may also serve as guidelines for the selection and monitoring of athletes across different age groups.

tj. imale su efikasnijeg golmana, efikasniji učinak u blokadi šuta, bolju iskorišćenost igrača više i efikasnije plivače prilikom plivanja za loptu. Nisu utvrđene statistički značajne razlike u varijablama izgubljene lopte, osvojene lopte, procenat šuta sa 5 metara i ukupan broj prekršaja na utakmici.

U vrlo sličnom istraživanju Canosa i sar. (2020) su se bavili procjenom razlika u izvođenju šutiranja između pobjedničkih, timova koji su remizirali i gubitničkih vaterpolo timova sa 15th FINA svjetskog prvenstva. Pronađene su veće vrijednosti brzine šuta na daljim udaljenostima od cilja nego u središnjim područjima blizu cilja. Izvođenje šutiranja je najčešće bilo sa srednjih pozicija sa visokim procentom učinkovitosti od 50% i sa područja od 3 i 6 metara sa preko 75% učinkovitosti gdje su pobjedničke ekipe postigle bolje rezultate. Pobjedničke ekipe u odnosu na poražene imale su bolje rezultate u šutiranju iz zone 2 i prema gol zoni od 2 metra udaljenosti. Osim toga, pobjednici su ostvarili i bolju efikasnost u udarcima prema gol zoni 1, na polju centarfora, kao i u šutevima bez prednje odbrane bloka.

Argudo-Iturriaga i sar. (2022) su utvrdili razlike između vaterpolistkinja na najvišem takmičarskom nivou koje su rangirane od 1. do 4. mjesta, u odnosu na vaterpolistkinje drugih manjih rangova (srednji rang su igračice od 5. do 8. mjesta, najniži rang su igračice od 9. do 12. mjesta) u više vrsta šutiranja i u situacijama kao što su: lob udarci, povratni udarci, nejednakosti kratkih udaraca u stativu, kontranapadima sa šutiranjem sa lijeve strane, u udarcima sa fintom sa pozicije centra, direktnim udarcima i udarcima sa skokom iz vode.

Lemeš i sar. (2020) su se također bavili razlikama između pobjedničkih i poraženih ekipa na uzorku od sedam ekipa od ukupno 21 utakmica državnog prvenstva Bosne i Hercegovine u vaterpolu za kadete i na osnovu analize dobivenih rezultata uočene su statistički značajne razlike između vaterpolista koji su igrali u pobjedničkim ekipama i vaterpolista koji su igrali u ekipama koje su poražene. Pojedinačnom analizom varijabli može se primijetiti da su od ukupnog broja postignutih golova pobjedničke ekipe postigle procentualno više golova (13,57% ili 89 golova po utakmici) za razliku od poraženih ekipa koje su postigle procentualno 9,06% ili 52 gola po utakmici. Pobjedničke ekipe su imale manji broj pokušaja na gol sa 22,56% dok su poražene ekipe imale veći broj pokušaja sa 25,44%. Najmanja razlika između ekipa koje su pobjeđivale i ekipa koje su gubile su bile u izvođenju penala i kontranapada.

Ademović i sar. (2020) su dobili rezultate koji govore da postoje značajne statističke razlike u analizama različitih dijelova vaterpolo igre između vaterpolo ekipa na turniru u Sisku u odnosu na ekipe na turniru u Sarajevu u kategorijama juniori i kadeti. Ekipe koje su učestvovale na turniru u

Sisku ostvarile su bolje rezultate u postignutim golovima iz kontranapada i većem broju zabilježenih pokušaja šuta na gol što govori da su vaterpolisti brže plivali i bili više aktivni u toku vaterpolo igre. Ekipe koje su učestvovale na turniru u Sarajevu su bile samo bolje u većem uspjehu realizacije penala što govori da su vaterpolo igrači bili dosta grublji i agresivniji u duel igri.

Noronha i sar. (2022) imali su rezultate koji pokazuju da su igrači grupe 2 (13–14 godina) bili brži u plivanju i efikasniji u šutiranju poslije driblinga, dok su vrijednosti direktnog šutiranja bez pomjeranja i procenta šuta poslije driblinga ili pomjeranja su bile slične između sve tri grupe ispitanika (grupa 1 od 12 do 13 godina, grupa 2 od 13 do 14 godina i grupa 3 od 14 do 15 godina).

Panero i sar. (2022) su sproveli eksperimentalne testove na 11 vaterpolistkinja (godina: 22,3 ± 3,5) tako što su uzete tri različite vrste šutiranja a praćena je kinematika gornjih ekstremiteta, snaga i preciznost udarca prilikom izvođenja eksperimentalnih testova kao i njihovo poređenje prije i poslije 45 dana specifičnog trening programa. Od subjekata se zahtijevalo da izvode tri različita šutiranja: penal šut, šut iz dodavanja i finta šut poslije dodavanja. Također je izvršena analiza korelacije između uglova ramena, lakta, kao i brzine bacanja. Kod treće vrste udarca (finta šut poslije dodavanja) povećao se ugao ramena za 7° poslije treninga a maksimalna brzina ($Vmax_{\gamma}$) je bila niža poslije treninga i iznosila je 13,9 m/s a prije treninga je iznosila 14,7 m/s. Video snimak druge vrste šutiranja (šut poslije dodavanja) pokazuje da je rezultat preciznosti bio povećan za dva poena poslije treninga. Do statistički značajnih razlika nije došlo u poređenju uglova lakta i rezultata snage kao što nije bilo ni razlika između regresionih linija prije i poslije trening programa.

Zaključak

rezultati istraživanja su ukazali na postojanje statistički značajnih razlika u situaciono-motoričkim sposobnostima između mlađih i starijih juniora vaterpolista Bosne i Hercegovine. Stariji juniori ostvarili su bolje rezultate u većini varijabli koje su ključne za uspješno izvođenje napadačkih i tehničkih elemenata u igri, što ukazuje na progresivan razvoj sposobnosti u zavisnosti od uzrasta, trenažnog iskustva i funkcionalne zrelosti sportista.

Utvrđene razlike potvrđuju da stariji juniori posjeduju veći nivo brzine manipulacije loptom, preciznosti šuta, uspješnosti realizacije napadačkih situacija i brzine plivanja u kombinaciji sa tehničkim zadacima. Kod mlađih juniora uočeno je da se još uvijek nalaze u fazi intenzivnog usvajanja tehničko-taktičkih znanja, te da je njihov razvoj situaciono-motoričkih sposobnosti u toku.

Dobijeni podaci predstavljaju vrijedan pokazatelj trenerima i sportskim stručnjacima u Bosni i Hercegovini, jer omogućavaju kvalitetnije planiranje i programiranje trenažnog procesa, s naglaskom na one elemente koji kod mlađih kategorija zahtijevaju dodatni rad i unapređenje. Rezultati također mogu poslužiti kao smjernice u selekciji i praćenju sportista u različitim uzrasnim kategorijama.

References

Ademović, K., Mirvić, E., Lemeš, Dž., & Nikšić, E. (2020). Differences of statistical parameters of participants of water polo tournaments in Sisak and Sarajevo. *Turk J Kinesiol* 2020; 6(2): 60–67 Original Research. www.dergipark.gov.tr/turkjkin.

Bajrić, O., Bajrić, S., Mirvić,E., Ademović, K. (2023). *Vaterpolo.* Banja Luka: Panevropski Univerzitet Apeiron. [in Serbian]

Canosa, L., Pérez, M., & González, J. (2020). *Influence of throwing speed on performance in water polo players*. Journal of Sports Science & Medicine, 19(3), 456–463.

García-Cervantes, L., Martínez, R., & López, J. (2017). *Technical and tactical performance indicators in water polo: Analysis of ball handling and shooting speed. International Journal of Performance Analysis in Sport,* 17(4), 563–575.

Idrizović, A., Petrović, V., & Stanić, D. (2013). *Fiziološke karakteristike mladih vaterpolista u funkciji trenažnog procesa. Sport Science Review,* 22(5–6), 115–128. [in Serbian]

Idrizović, K., Uljević, O., Ban, Đ., Spasić, M., & Rausavljević, N. (2013). Sport-Specific and Anthropometric Factors of Quality in Junior Male Water Polo Players. *Collegium Antropologicum,* 37 (4): 1261–1266.

Lemeš, Dž, Mirvić, E., Dizdar, A., & Baždarević-Rašidagić, A. (2020). Differences between winning and defeated teams at the cadet state championship of Bosnia and Herzegovina in water polo. *Sportski logos,* 18(32), 33–37.

Lozovina, V. (2009). *Temelji vaterpola u svjetlu teorije treninga*. Split. [in Croatian]

Noronha, F., Canossa, S., Vilas-Boas, J. P., Afonso, J., Castro, F., & Fernandes, R. J. (2022). Youth Water Polo Performance Determinants: The INEX Study. *International Journal of Environmental Research and Public Health.* 19, 4938.

Panero, E., Agostini, V., & Gastaldi, L. (2022). *Biomechanical Assessment of Throwing Gesture and Performance in Female Water-Polo Players.* Appl. Sci. 2022, 12, 7856. https://doi.org/10.3390/app12157856.

Popo, A., Talović, M., Mekić, M., Bajramović, I., Čolakhodžić, E., & Mirvić, E. (2011). Differences between specific motor skills of water polo players classified by different positions in the game. *Homosporticus.* Sarajevo.

Rukavina, I. (2024). *Antropološke karakteristike i funkcionalne sposobnosti mladih vaterpolista*. /Specijalistički diplomski stručni/. Sveučilište u Zagrebu, Kineziološki fakultet. [in Croatian]

Stipić, D. (2022). *Situaciono-motoričke sposobnosti vaterpolista: analiza napadačkih i odbrambenih elemenata. Journal of Sports Studies,*

14(2), 89–102. [in Croatian]
Trivun, D., Nikolić, N., & Kovačević, S. (2019). *Developmental differences in tactical efficiency of junior water polo players. International Journal of Aquatic Research and Education,* 11(3), 221–235.
Trivun, M., Gardašević, N., & Janjić, B. (2019). Odnos pokazatelja situacione efikasnosti u zavisnosti od ishoda vaterpolo utakmice. *Sport i zdravlje,* XIV 1: 47–53. [in Serbian]
Uljević, O. (2013). *Pouzdanost i validnost sportskih testova kod mladih vaterpolista. Fizikalna kultura,* 67(1–2), 45–60. [in Serbian]
Uljević, O., Latinčić, J., Macan, A., Stipinović, L. (2013). *Neke metrijske karakteristike testa za procijenu aerobnih sposobnosti mlađih vaterpolista-Modificirani Beep Test*. U A. Biberović (ur.), *"Sport i zdravlje",* str. 342-345. Tuzla: Fakultet za tjelesni odgoj i sport. [in Serbian]
Vaterpolo savez Bosne i Hercegovine. (2020). *Pravilnik o takmičenju i uzrasnim kategorijama u vaterpolu*. Banja Luka: VS BiH. [in Serbian]
Van der Wende, K. (2005). *The effects of game-specific task constraints on the outcome of the water polo shot*. In Institute of Sport and Recreation Research. Thesis submitted in partial fulfillment of the degree of Master of Health Science (pp. 1–87). New Zeland: Auckland University of Technology.

Primljen: 25. februar 2026. / Received: February 25, 2025
Prihvaćen: 04. maj 2026. / Accepted: May 04, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601166S
Original scientific paper
UDC: 7
Originalni naučni rad

Relationship Between Morphological Characteristics and Motor Abilities in Children

Povezanost morfoloških karakteristika i motoričkih sposobnosti kod dece

Danijel Stokanović[1], Slobodan Pavlović[2], Ivko Nikolić[3]

[1]Elementary School "Jevrem Obrenović", Sabac, Serbia
[2]University of Kragujevac, Faculty of Education in Užice, Serbia
[3]University of Belgrade, Faculty of Education, Serbia

Correspondence:
Slobodan Pavlović
University of Kragujevac, Faculty of Education in Užice, Serbia
slobodan.b.pavlovic@gmail.com

[1]Osnovna škola „Jevrem Obrenović", Sabac, Srbija
2Univerzitet u Kragujevcu, Pedagoški fakultet Užice, Srbija
[3]Univerzitet u Beogradu, Fakultet za obrazovanje učitelja i vaspitača, Srbija

Korespondencija:
Slobodan Pavlović
Univerzitet u Kragujevcu, Pedagoški fakultet Užice, Užice, Republika Srbija, slobodan.b.pavlovic@gmail.com

Abstract: *Understanding the relationship between motor abilities and anthropometric characteristics in children of younger school age is of considerable importance for the physical education teaching process. Contemporary physical education programmes do not always adequately address the individual needs and abilities of every child. Therefore, the planning and implementation of physical activities should be based on age-specific characteristics, with careful consideration of exercise intensity and workload. The sample consisted of 122 pupils (66 boys and 56 girls), aged 7 years (±0.5 years), from the Elementary School "Janko Veselinović" in Šabac, Serbia. Standardised anthropometric instruments adapted for assessing the morphological characteristics of younger school-aged children were used. Motor abilities were evaluated using the test battery developed by Bala, Stojanović, and Stojanović (2007). The results indicated that children with optimal body height and body weight achieved better performance in motor ability tests. Conversely, excessive body weight negatively affected the execution of tasks requiring coordination, flexibility, strength, and speed. The findings suggest a significant relationship between morphological characteristics and motor abilities in younger school-aged children. It can be concluded that body composition and physical fitness directly influence the development of children's motor abilities.*

Keywords: *morphological characteristics, anthropometry, motor abilities, regression analysis, primary education*

Sažetak: *Razumevanje povezanosti motoričkih sposobnosti i antropometrijskih karakteristika dece mlađeg školskog uzrasta je od velike važnosti za nastavni proces fizičkog vaspitanja. Današnji programi fizičkog vaspitanja ne uspevaju uvek da odgovore na individualne potrebe i mogućnosti svakog deteta, stoga planiranje aktivnosti treba zasnovati na uzrasnim karakteristikama, sa pažljivim doziranjem intenziteta i opterećenja. Uzorak ispitanika obuhvatao je 122 učenika (66 dečaka i 56 devojčica) uzasta 7 godina (± 0,5) godina, iz Osnovne škole „Janko Veselinović" u Šapcu. Za realizaciju istraživanja korišćeni su standardizovani antropometrijski instrumenti prilagođeni za procenu morfoloških karakteristika dece mlađeg školskog uzrasta, dok se za procenu motoričkih sposobnosti primenjivala baterija testova Bala, Stojanović, & Stojanović, 2007. Analizom podataka ustanovljeno je da deca sa optimalnom telesnom težinom i telesnom visinom, pokazuju bolje rezultate u testovima motoričkih sposobnosti. S druge strane, prisustvo viška telesne težine negativno se odražava na izvođenje zadataka koji zahtevaju koordinaciju, gipkost, snagu i brzinu. Na osnovu sprovedenog istraživanja o povezanosti motoričkih sposobnosti i morfoloških karakteristika kod dece mlađeg školskog uzrasta, može se zaključiti da postoji neraskidiva veza. Dobijeni rezultati nas navode na zaključak da telesna građa i fizička spremnost dece imaju direktan uticaj na razvoj njihovih motoričkih sposobnosti.*

Ključne reči: *relacije, antropometrija, motorika, regresija, razredna nastava*

Introduction

Younger school age represents a period of rapid growth and development during which it is essential to take advantage of opportunities for fostering physical growth and acquiring new motor skills (Aivazidis et al., 2019). At this stage, children readily acquire experiences and skills, while missed developmental opportunities may result in long-term consequences (Altınkok, 2017). During

Uvod

Mlađi školski uzrast je period brzog razvoja, kada je ključno iskoristiti priliku za podsticanje rasta i usvajanje novih motoričkih znanja (Aivazidis, Venetsanou, Aggeloussis, Gourgoulis, & Kambas, 2019). U ovom uzrastu deca lako usvajaju iskustva i veštine, a propuštanje tih mogućnosti može ostaviti trajne posledice (Altınkok, 2017). Tokom ovog perioda, pažnja se usmerava

this period, particular attention is directed towards physical development and the enhancement of motor abilities. Understanding the relationship between motor abilities and morphological characteristics is therefore of crucial importance for guiding children through an appropriate pedagogical approach (Gallahue & Donnelly, 2007). Throughout the history of physical education research, the associations, correlations, and relationships between motor abilities and morphological characteristics have frequently been investigated. Findings from these studies provide valuable insights that contribute to improving the quality of physical education instruction, as well as the organisation and planning of teaching activities.

Motor abilities represent the level of development of the organism's motor structures and form the basis for the execution of a wide range of motor responses that can be objectively measured and described (Findak, 1999). They constitute the foundation of all physical activities (Dapp, Gashaj, & Roebers, 2021). Motor abilities are influenced by genetic factors, the environment in which a child grows up, family socioeconomic status, nutrition, and the quality of physical education instruction (Malina, 2010), as well as previous experiences and social interactions (Venetsanou & Kambas, 2017). According to Obradović (2019), motor abilities consist of several fundamental components, including strength, endurance, speed, coordination, flexibility, and balance. Each of these components plays a significant role in both daily activities and sports participation (Stodden, Langendorfer, & Roberton, 2009).

The term morphological characteristics is often used interchangeably with anthropometric characteristics (Hlaselo, 2020). Anthropometry refers to the measurement of the human body as a whole or of its individual segments, providing an objective assessment of an individual's physical development (Utkualp & Ercan, 2015). Anthropometric characteristics, such as body height, body weight, body mass index, chest circumference, and body fat percentage, represent physical dimensions that provide insight into a child's overall growth and developmental status (Silventoinen et al., 2023). Morphological characteristics encompass basic anthropometric dimensions of a latent nature (Bala, 1981), regardless of whether their development is influenced by external factors, such as physical activity, or occurs independently of them (Kurelić et al., 1975). Nevertheless, genetic factors exert a substantial influence, particularly on the skeletal system, where the heritability coefficient is estimated to be approximately 98%. Consequently, external factors such as nutrition and physical activity primarily affect adipose tissue and body weight, whereas their influence on other morphological

na fizički razvoj i unapređenje motoričkih sposobnosti, pri čemu je razumevanje povezanosti motoričkih sposobnosti i morfoloških karakteristika od ključne važnosti za pravilno usmeravanje dece kroz pedagoški pristup (Gallahue, & Donnelly, 2007). Povezanosti, korelacije i relacije, motoričkih sposobnosti i morfoloških karakteristika su kroz istoriju fizičkog vaspitanja bile veoma često predmet istraživanja. Poznati rezultati i dostignuća tih povezanosti nam omogućavaju realno sagledavanje i usmeravanje, kako sa takvim saznanjima doprineti kvalitetu nastave fizičkog vaspitanja, dobroj organizaciji i planiranju.

Motoričke sposobnosti predstavljaju nivo razvijenosti motoričkih struktura organizma i čine osnovu za realizaciju širokog spektra motoričkih reakcija, koje se mogu precizno kvantifikovati i opisati (Findak, 1999). One predstavljaju temelj za izvođenje svake fizičke aktivnosti (Dapp, Gashaj, & Roebers, 2021). Na motorčke sposobnosti utiču genetski faktori, okruženje u kojem dete raste, socioekonomski status porodice, ishrana i kvalitet realizacije nastave fizičkog vaspitanja (Malina, 2010), kao i prethodna iskustva i interakcije sa drugim osobama (Venetsanou, & Kambas, 2017). Prema definiciji Obradović (2019), motoričke sposobnosti čine nekoliko osnovnih komponenti, kao što su snaga, izdržljivost, brzina, koordinacija, fleksibilnost i ravnoteža. Svaka od ovih komponenti ima značajnu ulogu kako u svakodnevnim aktivnostima, tako i u sportskim angažmanima (Stodden, Langendorfer, & Roberton, 2009).

Pojam morfološke karakteristike često se koristi kao ekvivalent za antropometrijske karakteristike (Hlaselo, 2020). Antropometrija je metod merenja čovekovog tela u celini ili njegovih pojedinačnih delova, na osnovu kojih se može dobiti objektivna slika fizičke razvijenosti osobe (Utkualp, & Ercan, 2015). Antropometrijske karakteristike, kao što su telesna visina, telesna težina, indeks telesne mase, obim grudnog koša i procenat telesne masti, predstavljaju fizičke dimenzije koje pružaju uvid u opšte stanje rasta i razvoja deteta (Silventoinen, Maia, Li, Sund, Gouveia, Antunes, ... & Freitas, 2023). Morfološke karakteristike obuhvataju osnovne antropometrijske dimenzije koje su latentne prirode (Bala, 1981), bez obzira na to da li njihov razvoj zavisi od spoljašnjih faktora, poput fizičke aktivnosti, ili nastaje nezavisno od njih (Kurelić, Momirović, Stojanović, Šturm, Radojević, & Viskić-Štalec, 1975). Ipak, genetski faktori imaju značajan uticaj, naročito na skeletni sistem, gde je koeficijent urođenosti čak oko 98%, te stoga spoljašnji faktori, poput ishrane i fizičke aktivnosti, najviše utiču na masno tkivo i telesnu težinu, dok je njihov uticaj na ostale

dimensions is considerably smaller or nearly negligible (Malacko & Radosav, 1985).

Investigating the relationship between motor abilities and anthropometric characteristics in younger school-aged children is essential for understanding the fundamental principles of physical development (Kondrič, Mišigoj-Duraković, & Metikoš, 2017). Djordjević, Pantelić, Kostić, and Uzunović (2015) reported a significant correlation between body height and body weight on one hand and performance in motor tests on the other. Similar findings have been reported by international researchers. For example, Malina, Eisenmann, Cumming, Ribeiro, and Aroso (2004) suggested that morphological characteristics may act as limiting factors for motor performance, particularly in activities requiring high levels of explosive strength or endurance.

Understanding the relationship between motor abilities and anthropometric characteristics has numerous practical implications, especially in the field of physical education (Renshaw, Chow, Davids, & Hammond, 2010). Contemporary physical education programmes do not always adequately meet the individual needs and capabilities of every child (Eather, Morgan, & Lubans, 2013). Therefore, the planning of physical activities should be based on age-specific characteristics and accompanied by careful regulation of exercise intensity and workload (Hennessy et al., 2010). Proper planning and programming of physical activities are of particular importance, as they ensure healthy development and reduce the risk of adverse health outcomes (Afthentopoulou, Kaioglou, & Venetsanou, 2017). Furthermore, such an approach may contribute to the long-term preservation and promotion of health throughout the lifespan (Twisk, 2001). A high-quality physical education programme requires thorough planning and implementation of activities, with an appropriate training load being a key factor in achieving positive outcomes (Altınkök, 2015).

The aim of this study was to determine the relationship between motor abilities and morphological characteristics in children aged 7 to 8 years. Specifically, the study sought to identify the extent to which body dimensions, particularly body height and body weight, influence performance in key motor abilities, with special emphasis on improving assessment procedures and teaching practices within the school environment.

Materials and Methods

Participants

The study was conducted on a sample of 122 younger school-aged children, including 66 boys and 56 girls, aged 7–8 years. All participants were pupils of the

faktore znatno manji ili gotovo zanemarljiv (Malacko, & Radosav, 1985).

Istraživanje povezanosti između motoričkih sposobnosti i antropometrijskih karakteristika kod dece mlađeg školskog uzrasta ključno je za razumevanje osnovnih zakonitosti fizičkog razvoja (Kondrič, Mišigoj-Duraković, & Metikoš, 2017). Djordjevic, Pantelić, Kostić, & Uzunović, (2015) ističu da postoji značajna korelacija između telesne visine i težine s jedne strane, i rezultata u motoričkim testovima s druge strane. Slični nalazi potvrđeni su i u istraživanjima stranih autora, poput (Malina, Eisenmann, Cumming, Ribeiro, & Aroso, 2004) koji ukazuju da morfološke karakteristike mogu biti limitirajući faktor za motoričke sposobnosti, posebno u aktivnostima koje zahtevaju visoki nivo eksplozivne snage ili izdržljivosti.

Razumevanje povezanosti između motoričkih sposobnosti i antropometrijskih karakteristika ima višestruke praktične implikacije, posebno u nastavi fizičkog vaspitanja (Renshaw, Chow, Davids, & Hammond, 2010). Današnji programi fizičkog vaspitanja ne uspevaju uvek da odgovore na individualne potrebe i mogućnosti svakog deteta (Eather, Morgan, & Lubans, 2013), te stoga planiranje aktivnosti treba zasnovati na uzrasnim karakteristikama, sa pažljivim doziranjem intenziteta i opterećenja (Hennessy, Hughes, Goldberg, Hyatt, & Economos, 2010). Planiranje i programiranje aktivnosti, treba biti u skladu sa uzrasnim karakteristikama i od posebnog je značaja, jer se time osigurava pravilan razvoj i smanjuje rizik od negativnih posledica po zdravlje (Afthentopoulou, Kaioglou, & Venetsanou, 2017), a istovremeno time se može dugoročno doprineti očuvanju i unapređenjuzdravlja tokom celog života (Twisk, 2001). Kvalitetan program fizičkog vaspitanja podrazumeva detaljno osmišljavanje i realizaciju aktivnosti, pri čemu je pravilna doza opterećenja ključna za ostvarivanje pozitivnih rezultata (Altınkök, 2015).

Cilj ovog istraživanja je utvrđivanje povezanosti između motoričkih sposobnosti i morfoloških karakteristika kod dece uzrasta od 7 do 8 godina. Ovo uključuje identifikovanje načina na koji telesne dimenzije (visina i težina) utiču na rezultate u ključnim motoričkim sposobnostimasa posebnim naglaskom na mogućnosti unapređenja metoda za procenu i podučavanje u školskom okruženju.

Materijal i metod

Učesnici

Istraživanje je sprovedeno na uzorku od 122 učenika mlađeg školskog uzrasta, od kojih je 66 dečaka i

Elementary School "Janko Veselinović" in Šabac, Serbia. The balanced representation of both sexes within the sample enabled more reliable analyses and comparisons between boys and girls, as well as a better understanding of individual differences in motor abilities and morphological characteristics during this developmental period.

Particular attention was paid to participants' health status during the sampling procedure. Only children who regularly attended physical education classes and who had no chronic diseases, physical injuries, or functional limitations that could affect motor performance were included in the study. Participants' health status was verified through school medical records.

Anthropometric Assessment

Standardised anthropometric instruments adapted for the assessment of morphological characteristics in younger school-aged children were used. All measurements were conducted according to established anthropometric standards and recommendations.

Body height was measured using a portable stadiometer (SECA 213, Germany), with an accuracy of 0.1 cm. Participants stood barefoot in an upright position with their heels together and arms relaxed alongside the body. The head was positioned according to the Frankfurt plane, ensuring that the lower margin of the orbit and the upper margin of the external auditory meatus were aligned horizontally. The movable headpiece was lowered to the highest point of the head, and body height was recorded in centimetres.

Body weight was measured using a digital scale (Tanita BC-730, Japan), with an accuracy of 0.1 kg. Measurements were performed in the morning before any physical activity in order to minimise daily fluctuations in body weight. Participants were barefoot and dressed in light sportswear. Each child stood in the centre of the scale with body weight evenly distributed on both feet. The value was recorded only after the reading had stabilised.

All anthropometric measurements were performed under controlled conditions. Participants were familiarised with the measurement procedures beforehand to reduce any potential discomfort or anxiety. Privacy and confidentiality were ensured throughout the assessment process.

56 devojčica, starosti 7 i 8 godina. Ispitanici su učenici Osnovne škole „Janko Veselinović" u Šapcu. Polna i uzrasna ravnoteža u uzorku omogućava relevantnije analize i poređenja među polovima, kao i uvid u individualne razlike u motoričkim sposobnostima i morfološkim karakteristikama u ovom razvojnom periodu.

Prilikom odabira uzorka, posebna pažnja je posvećena zdravstvenom statusu učenika. U istraživanju su učestvovali ispitanici koji su redovno pohađali nastavu fizičkog vaspitanja, zdravi i koji nemaju hronične bolesti, fizičke povrede ili ograničenja koja bi mogla uticati na njihove motoričke sposobnosti. Zdravstveno stanje ispitanika provereno je na osnovu uvida u školske zdravstvene evidencije.

Antropometrijska procjena

Za realizaciju istraživanja korišćeni su standardizovani antropometrijski instrumenti prilagođeni za procenu morfoloških karakteristika dece mlađeg školskog uzrasta. Svi antropometriski instrumenti su odabrani u skladu sa normama i preporukama za antropometrijska ispitivanja.

Za merenje visine tela ispitanika korišćen je prenosivi visinomer SECA 213, poznat po svojoj preciznosti i lakoći upotrebe. Ovaj visinomer omogućava merenje sa preciznošću od 10 mm, dok njegova konstrukcija podržava merenje visine do 200 cm, što ga čini univerzalnim instrumentom za različite uzraste. Za merenje težine tela ispitanika korišćena je savremena digitalna vaga, model Tanita BC-730, koja pruža visoku tačnost i pouzdanost. Vaga meri težinu sa preciznošću od 100 g, a njen kapacitet dostiže do 150 kg, što je čini pogodnom za rad sa decom svih uzrasta.

Morfološke karakteristike ispitanika, konkretno telesna visina i telesna težina, merene su u kontrolisanim uslovima u svrhu prikupljanja osnovnih podataka o telesnoj građi ispitanika. Ispitanici su prethodno upoznati sa postupcima merenja, a poseban akcenat stavljen je na smirivanje eventualne nelagode ili uzbuđenja. Svako merenje zabeleženo je pojedinačno, uz obezbeđenje diskrecije i poštovanje privatnosti deteta.

Telesna visina ispitanika merena je prenosivim visinomerom. Ispitanici su bili bosi i stajali su uspravno, sa petama spojenim i rukama uz telo. Glava je postavljena tako da donji rub očne duplje i gornji rub ušne školjke budu u horizontalnoj ravni (Frankfurtova linija). Pokretna letvica visinomera spuštana je do najviše tačke glave, uz blagi pritisak kako bi se eliminisao efekat frizure. Rezultat merenja evidentiran je u centimetrima, sa preciznošću od 0,1 cm.

Telesna težina ispitanika merena je digitalnom vagom. Merenje je obavljeno ujutru pre fizičkih aktivnosti, kako bi se eliminisale dnevne varijacije u težini.Ispitanici su bili bosi i nosili laganu sportsku odeću.Svaki ispitanik je stajao

Assessment of Motor Abilities

Motor abilities were assessed using the test battery developed by Bala, Stojanović, and Stojanović (2007), which is widely applied in the evaluation of motor performance among younger school-aged children.

The following tests were administered:

1. Backward Polygon Test – assessment of body coordination and movement pattern reorganisation.
2. Three-Ball Slalom Test – assessment of whole-body coordination.
3. Hand Tapping Test – assessment of movement frequency.
4. Seated Straddle Forward Bend Test – assessment of flexibility.
5. Standing Long Jump Test – assessment of lower-limb explosive strength.
6. 20-Metre Sprint from a Standing Start – assessment of running speed.
7. 60-Second Sit-Up Test – assessment of repetitive trunk strength.
8. Bent-Arm Hang Test – assessment of static strength of the upper limbs and shoulder girdle.

Research Procedure

Prior to data collection, parents or legal guardians received detailed information regarding the purpose, procedures, and duration of the study and provided written informed consent for their children's participation.

The research was conducted in September 2025 during regular school activities. Testing sessions were organised during morning hours when participants were expected to be physically and mentally prepared for performance assessments. The study was carried out in the school gymnasium under standardised environmental conditions. The facility was spacious, adequately ventilated, and maintained at an average temperature of approximately 21°C.

Participants were introduced to the purpose and procedures of the study using age-appropriate language. Testing was conducted individually to ensure maximum attention to each participant. Anthropometric measurements were completed prior to motor testing in order to eliminate the potential influence of fatigue on body measurements.

Before motor testing, all participants completed a standardised 10-minute warm-up consisting of dynamic exercises designed to reduce the risk of injury and prepare the musculoskeletal system for physical activity. Throughout the entire testing process, special attention was given to participant safety and well-being. Children were allowed to take breaks whenever necessary and were informed of their right to withdraw from the study at any time without consequences.

na sredini vage, sa jednakim osloncem na obe noge, dok se očitavanje vrednosti vršilo tek nakon stabilizacije rezultata na ekranu.Rezultat merenja zabeležen je u kilogramima, sa preciznošću od 0,1 kg.

Procjena motoričkih sposobnosti

Za procenu motoričkih sposobnosti kod dece mlađeg školskog uzrasta primenjivala se sledeća baterija testova (Bala, Stojanović, & Stojanović, 2007):

1. Test Poligon natraške - koordinacija tela i reorganizacija stereotipa kretanja.
2. Test Slalom sa tri lopte - koordinacija celog tela.
3. Test Taping rukom - frekvencija pokreta.
4. Test Pretklon raznožno u sedu - gipkost
5. Test Skok udalj iz mesta - ekspolzivna snaga nogu.
6. Test Trčanje 20 m iz visokog starta - procjena brzine trčanja.
7. Test Podizanja trupa za 60 sekundi - repetitivna snaga trupa.
8. Test Izdržaj u zgibu - Statička snaga ruku i ramenog pojasa.

Istraživanje

Pre početka istraživanja, roditelji/staratelji dece su bili detaljno informisani o ciljevima, planu i trajanju istraživanja i dali pismenu saglasnost za učešće svoje dece. Nakon dobijanja saglasnosti, sprovedena su antropometrijska merenja i procena motoričkih sposobnosti.

Istraživanje je sprovedeno početkom septembra 2025. godine, u skladu sa redovnim školskim aktivnostima, kako bi ispitanici bili uobičajeno fizički i mentalno pripremljeni za testiranje. Aktivnosti su se odvijale u jutarnjim časovima, kada su učenici najspremniji za fizičke izazove, čime je minimiziran uticaj umora ili drugih nepovoljnih faktora. Istraživanje je realizovano u fiskulturnoj sali Osnovne škole "Janko Veselinović". Sala je bila prostrana, provetrena i održavana na optimalnoj temperaturi od oko 21 °C, kako bi se ispitanicima obezbedili što prijatniji uslovi za testiranje. spitanici su detaljno upoznati sa ciljem i procedurama istraživanja kroz njima prilagođen jezik, kako bi se obezbedilo njihovo razumevanje i saradnja. Testiranja su sprovedena individualno što je omogućilo fokusiranu pažnju na svakog učesnika. Sekvenca merenja bila je strukturisana na način da se prvo obave antropometrijska merenja, a zatim motorički testovi, kako bi se izbegao uticaj fizičkog zamora na rezultate. Sve aktivnosti bile su prethodno pripremljene zagrevanjem od 10 minuta, koje je uključivalo dinamičke vežbe za smanjenje rizika od povreda. Tokom celokupnog procesa poseban akcenat je stavljen na dobrobit

Statistical Analysis

Data processing involved several stages. Descriptive statistical parameters were calculated for all variables. The normality of data distribution was examined prior to inferential analyses. Multiple regression analysis was subsequently performed to determine the extent to which morphological characteristics (body height and body weight) predicted performance in motor ability tests.

Results

The analysis of the results obtained for boys, presented in Table 1, indicates satisfactory discriminative power of the measured variables, reflected in the consistent relationship between the standard deviation and the arithmetic mean. An exception was observed for the variables assessing static strength of the upper limbs and shoulder girdle (*Bent-Arm Hang Test*) and trunk strength (*60-Second Sit-Up Test*), which did not demonstrate the expected level of discriminative power. Specifically, for these variables, the distribution of results did not meet the criterion according to which three standard deviations can be accommodated within the range of the arithmetic mean.

Table 1. *Descriptive Statistics of Motor Abilities and Anthropometric Characteristics in Boys and Girls*

Variables / Varijable	*Sex* / Pol	*M* / AS	*SD*	*KS coefficeent*	*Asymp. Sig.*
Body Height (cm) / Telesna visina (cm)	*Boys* / Dečaci	125.54	3.24	1.04	0.22
	Girls / Devojčice	126.48	4.25	0.88	0.41
Body Weight (kg) / Telesna težina (kg)	*Boys* / Dečaci	24.83	4.50	1.23	0.09
	Girls / Devojčice	25.16	5.47	0.90	0.38
Backward polygon (s) / Poligon natraške (s)	*Boys* / Dečaci	33.22	6.19	0.97	0.29
	Girls / Devojčice	36.12	6.49	0.70	0.70
Three Ball Slalom (s) / Slalom sa tri lopte (s)	*Boys* / Dečaci	86.94	8.18	0.68	0.73
	Girls / Devojčice	91.48	10.85	0.79	0.55
Hand Tapping (n) / Taping rukom (n)	*Boys* / Dečaci	18.37	4.08	0.87	0.42
	Girls / Devojčice	19.69	3.23	0.71	0.52
Seated Straddle Forward Bend (cm) / Sed u pretklonu raznožno (cm)	*Boys* / Dečaci	64.28	11.93	0.79	0.55
	Girls / Devojčice	76.94	10.54	0.99	0.27
Standing Long Jump (cm) / Skok u dalj iz mesta (cm)	*Boys* / Dečaci	99	16.62	0.87	0.42
	Girls / Devojčice	101.05	14.90	0.78	0.56
20m Sprint (s) / Trčanje 20m (s)	*Boys* / Dečaci	8.27	0.83	0.61	0.84
	Girls / Devojčice	8.27	1.01	1.01	0.25
Bent Arm Hang (s) / Izdržaj u zgibu (s)	*Boys* / Dečaci	8.62	2.99	0.87	0.42
	Girls / Devojčice	6.56	1.24	0.95	0.31
60 Second Sit Up Test (n) / Podizanje trupa (n)	*Boys* / Dečaci	8.82	3.26	1.14	0.14
	Girls / Devojčice	14.94	3.48	0.96	0.30

Note. M = arithmetic mean; SD = standard deviation; KS = Kolmogorov–Smirnov coefficient; p = significance level of the Kolmogorov–Smirnov test.

In girls, the results indicate a high level of discriminative power across all analysed variables. This is evi-

učesnika, sa obezbeđenim pravom na pauzu i mogućnošću odustajanja u bilo kom trenutku bez posledica.

Statistička analiza

Metode obrade podataka obuhvatale su višeetapni proces, koji je uključivao: Izračunavanje osnovnih deskriptivnih pokazatelja; Testiranje normalnosti distribucije; Sprovođenje regresione analize radi ispitivanja uticaja morfoloških karakteristika na motoričke sposobnosti.

Rezultati

Analizom rezultata kod dečaka prikazanih u Tabeli 1. može se zaključiti da podaci poseduju zadovoljavajuću diskriminativnost, što se ogleda u konzistentnim vrednostima standardne devijacije u odnosu na aritmetičku sredinu. Izuzetak predstavljaju varijable koje se odnose na statičke snage ruku i ramenog pojasa, *Izdržaj uzgibu* i procenu snage trupa, *Podizanje trupa*, gde je uočeno da pomenute varijable ne zadovoljavaju očekivanu diskriminativnost. Naime, kod njih nije moguće tri vrednosti standardne devijacije svrstati u jedinu vrednost aritmetičke sredine.

Tabela 1. *Deskriptivni pokazatelji motoričkih sposobnosti i antropometrijskih karakteristika kod dečaka i devojčica*

Legenda: AS – aritmetička sredina vrednosti; SD – standardna devijacija; Kolmogorov-Smirnov Z (vrednost KS koeficijenta, predstavlja test statistiku koja meri veličinu odstupanja distribucije od normalne) – Asymp. Sig. (2-tailed) (vrednost značajnosti dvosmernog testiranja za Z, ova vrednost pokazuje nivo značajnosti testa).

denced by the consistent relationship between the standard deviation and the arithmetic mean, with the standard deviation not exceeding one-third of the arithmetic mean for any of the measured variables.

Analysis of the distribution asymmetry coefficients in boys revealed that most variables exhibited a relatively symmetrical distribution of results, with a few exceptions. Specifically, the variables Body Weight and 60-Second Sit-Up Test demonstrated a noticeable positive skewness, indicating a tendency towards lower scores with a smaller number of higher values.

Similarly, the results obtained for girls showed that the majority of variables were characterised by a symmetrical distribution of scores, suggesting an adequate representation of the measured characteristics within the sample.

Based on the presented descriptive statistical indicators, it can be concluded that the selected set of variables meets the assumptions required for further statistical analyses and may therefore be used in subsequent inferential procedures without methodological limitations.

Kod devojčica se može zaključiti da podaci poseduju visoku diskriminativnost, što se ogleda u konzistentnim vrednostima standardne devijacije u odnosu na aritmetičku sredinu. Konkretno, kod svih analiziranih varijabli standardna devijacija ne premašuje trećinu aritmetičke sredine.

Analizom koeficijenta asimetrije distribucije kod dečaka je uočeno da većina varijabli pokazuje simetričnu raspodelu rezultata, uz nekoliko izuzetaka. Dakle, varijable *Telesna težina* i *Podizanje trupa* pokazale su značajnu pozitivnu asimetriju. Kod devojčica je uočeno da većina varijabli pokazuje simetričnu raspodelu rezultata.

Na osnovu iznetih rezultata za osnovne dekriptivne pokazatelje zaključuje se da se izabrani set varijabli može nesmetano koristiti u daljim statističkim analizama.

Table 2. *Regression Analysis of the Backward Polygon Test in Boys and Girls*

Tabela 2. *Regresiona analiza poligona natraške za dečake i devojčice*

	***Boys and Girls* / Dečaci i devojčice**			
***Variables* / Varijable**				
	r	***p***	***Beta***	***pbeta***
Body Height / Telesna visina	0.175	0.120	-0.165	0.120
Body Weight / Telesna težina	0.639	0.000	0.717	0.000
R	0.656;			
R^2	0.430			
Adjusted R^2 / Prilagođen R^2	0.413			
P	0,000			

Note. r = Pearson correlation coefficient; p = significance level of Pearson's correlation coefficient; Beta = standardized regression coefficient; pBeta = significance level of the regression coefficient; R = multiple correlation coefficient; R^2 = coefficient of determination; Adjusted R^2 = coefficient of determination adjusted for sample size; p = significance level of the multiple correlation coefficient.

Legenda: r – Pirsonov koeficijent korelacije; p – nivo statističke značajnosti za r; Beta –regresioni koeficijent; pbeta – nivo značajnosti regresionog koeficijenta; R – koeficijent multiple korelacije; R^2–koeficijent determinacije; Prilagođen R^2– koeficijent determinacije koji je prilagođen za male uzorke; P –značajnost koeficijenta multiple korelacije.

The results of the regression analysis presented in Table 2 show the relationship between the predictor variables (Body Height and Body Weight) and the criterion variable (Backward Polygon Test).

Analysis of Pearson's correlation coefficients revealed that Body Weight was strongly and positively associated with performance in the Backward Polygon Test ($r = 0.639$, $p < .001$), whereas Body Height showed a weak and statistically non-significant correlation ($r = 0.175$, $p = .120$). These findings suggest that body weight is more closely related to

U tabeli 2. prikazani su rezultati regresione analize, gde je analizirana povezanost između prediktorskih varijabli (*Telesna visina* i *Telesna težina*) i kriterijumske varijable (*Poligon natraške*). Analizom Pirsonovog koeficijenta korelacije (r) primećuje se da *Telesna težina* ima jaku, pozitivnu, statistički značajnu povezanost sa uspešnošću testa *Poligon natraške*($r = 0.639$, $p < 0.001$), dok *Telesna visina* ima slabu, pozitivnu, statistički neznačajnu povezanost ($r = 0.175$, $p = 0.120$). Ovakav rezultatukazuje da ispitanici sa optimalnom telesnom te-

performance in tasks requiring coordination and movement reorganisation than body height.

The regression coefficients further confirmed these relationships. Body Weight demonstrated a statistically significant positive predictive effect on the test result (Beta = 0.717, p < .001), while Body Height showed a negative but statistically non-significant effect (Beta = –0.165, p = .120). Consequently, body height cannot be considered a reliable predictor of performance in the Backward Polygon Test.

The overall relationship between the predictor variables and the criterion variable, expressed by the multiple correlation coefficient (R = 0.656), indicates a relatively strong association. Furthermore, the coefficient of determination (R^2 = 0.430) showed that Body Height and Body Weight together explained 43.0% of the variance in Backward Polygon Test performance. The adjusted coefficient of determination (Adjusted R^2 = 0.413) additionally confirmed the stability and adequacy of the regression model.

Based on these findings, it can be concluded that body weight plays a significant role in performance on the Backward Polygon Test, whereas body height does not represent a significant predictor in the examined sample of younger school-aged children.

Table 3. *Regression Analysis of the Three-Ball Slalom Test in Boys and Girls*

žinom ostvaruju bolje rezultate na testu. Daljom analizom regresionog koeficijenata (Beta) potvrđuje se da *Telesna težina* pozitivno utiče na rezultat u testu (Beta = 0.717, pbeta < 0.001), dok *Telesna visina*pokazuje negativan, statistički neznačajan uticaj (Beta = -0.165, pbeta = 0.120), štopotvrđuje da visina ispitanika ne može biti pouzdan prediktor uspešnosti na ovom testu. Ukupna povezanost prediktora (*Telesna visina* i *Telesna težina*) sa rezultatom na testu izražena kroz koeficijent multiple korelacije (R = 0.656) ukazuje na jaku povezanost prediktorskih varijabli sa kriterijumskom varijablom. Koeficijent determinacije (R^2 = 0.430) pokazuje da *Telesna visina* i *Telesna težina* zajedno objašnjavaju 43 % varijacija u rezultatima testa *Poligon natraške*, dok prilagođeni koeficijent determinacije (prilagođeni R^2 = 0.413) potvrđuje da je modelpouzdan.

Na osnovurezultata može se zaključiti daoptimalna-*Telesna težina* igra ključnu ulogu u izvođenju testa *Poligon natraške*, dok *Telesna visina* nije značajan faktor.

Tabela 3. *Regresiona analiza slaloma sa tri lopte za dečake i devojčice*

	***Boys and Girls* / Dečaci i devojčice**			
***Variables* / Varijable**				
	r	***p***	***Beta***	***pbeta***
Body Height / Telesna visina	0.048	0.011	-0.284	0.011
Body Weight / Telesna težina	0.566	0.000	0.701	0.000
R	0.619			
R^2	0.383			
Adjusted R^2 / Prilagođen R^2	0.365			
P	0,000			

Note. r = Pearson correlation coefficient; p = significance level of Pearson's correlation coefficient; Beta = standardized regression coefficient; pBeta = significance level of the regression coefficient; R = multiple correlation coefficient; R^2 = coefficient of determination; Adjusted R^2 = coefficient of determination adjusted for sample size; p = significance level of the multiple correlation coefficient.

The results of the regression analysis presented in Table 3 show the relationship between the predictor variables (Body Height and Body Weight) and the criterion variable (Three-Ball Slalom Test).

Analysis of Pearson's correlation coefficients indicates that Body Weight was strongly and positively associated with performance in the Three-Ball Slalom Test (r = 0.566, p < .001), whereas Body Height showed a very weak positive association with the criterion variable (r = 0.048, p = .011). These findings suggest that body weight

U tabeli 3. prikazani su rezultati regresione analize, gde je analizirana povezanost između prediktorskih varijabli (*Telesna visina* i *Telesna težina*) i kriterijumske varijable (*Slalom sa tri lopte*). Analizom Pirsonovog koeficijenta korelacije (r) primećuje se da *Telesna težina* ima jaku, pozitivnu, statistički značajnu povezanost sa uspešnošću testa *Slalom sa tri lopte* (r = 0.566, p < 0.001), dok *Telesna visina* ima slabu, pozitivnu, statistički neznačajnu povezanost(r = 0.048, p = 0.011). Ovakav rezultat ukazuje daispitanici sa optimalnom telesnom

is more closely related to performance in coordination-based motor tasks than body height.

The regression coefficients further confirmed these relationships. Body Weight was identified as a statistically significant positive predictor of performance in the Three-Ball Slalom Test (Beta = 0.701, p < .001), while Body Height demonstrated a statistically significant negative predictive effect (Beta = –0.284, p = .011). This indicates that higher body height is associated with slightly poorer performance in this motor task compared to lower stature, although its contribution is relatively small.

The overall model showed a relatively strong relationship between predictor and criterion variables, as indicated by the multiple correlation coefficient (R = 0.619). The coefficient of determination (R^2 = 0.383) revealed that Body Height and Body Weight together explained 38.3% of the variance in Three-Ball Slalom Test performance. The adjusted coefficient of determination (Adjusted R^2 = 0.365) further confirmed the stability and adequacy of the regression model.

Based on these results, it can be concluded that body weight plays a dominant role in explaining performance in the Three-Ball Slalom Test, while body height represents a less influential factor in the examined sample of younger school-aged children.

težinom ostvaruju bolje rezultate na testu. Daljom analizom regresionog koeficijenata (Beta) potvrđuje se da *Telesna težina*pozitivno utiče na rezultat u testu (Beta = 0.701, pbeta< 0.001), dok *Telesna visina*pokazuje negativan, statistički neznačajan uticaj (Beta = -0.284, pbeta = 0.011), što potvrđujeda viši ispitanici nešto slabije prolaze test u poređenju sa nižim ispitanicima. Ukupna povezanost prediktora (*Telesna visina* i *Telesna težina*) sa rezultatom na testu izražena kroz koeficijent multiple korelacije (R = 0.619) ukazuje na jaku povezanost prediktorskih varijabli sa kriterijumskom varijablom. Koeficijent determinacije (R^2 = 0.383) pokazuje da *Telesna visina* i *Telesna težina* zajedno objašnjavaju 38.3% varijacija u rezultatima testa *Slalom sa tri lopte*, dokprilagođeni koeficijent determinacije(prilagođeni R^2 = 0.365) potvrđuje da je model pouzdan.

Na osnovu rezultata može se zaključiti da optimalna *Telesna težina* ima dominantan pozitivan uticaj na izvođenje testa *Slalom sa tri lopte*, dok *Telesna visina*nije značajan faktor.

Table 4. *Regression Analysis of the Hand Tapping Test in Boys and Girls*

Tabela 4. *Regresiona analiza tapinga rukom za dečake i devojčice*

	***Boys and Girls* / Dečaci i devojčice**			
***Variables* / Varijable**				
	r	***p***	***Beta***	***pbeta***
Body Height / Telesna visina	0.201	0.000	0.465	0.000
Body Weight / Telesna težina	-0.336	0.000	-0.557	0.000
R	0.530			
R^2	0.281			
Adjusted R^2 / Prilagođen R^2	0.259			
P	0,000			

Note. r = Pearson correlation coefficient; p = significance level of Pearson's correlation coefficient; Beta = standardized regression coefficient; pBeta = significance level of the regression coefficient; R = multiple correlation coefficient; R^2 = coefficient of determination; Adjusted R^2 = coefficient of determination adjusted for sample size; p = significance level of the multiple correlation coefficient.

The results of the regression analysis presented in Table 4 show the relationship between the predictor variables (Body Height and Body Weight) and performance in the Hand Tapping Test.

Analysis of Pearson's correlation coefficients indicates that Body Height had a moderate, positive, and statistically significant association with performance in the Hand Tapping Test (r = 0.201, p < .001), whereas

U tabeli 4. prikazani su rezultati regresione analize, gde je analizirana povezanost između prediktorskih varijabli (*Telesna visina* i *Telesna težina*) i kriterijumske varijable (*Taping rukom*).

Analizom Pirsonovog koeficijenta korelacije (r) primećuje se da varijabla *Telesna visina*ima umerenu, pozitivnu, statistički značajnu povezanost sa uspešnošću testa *Taping rukom* (r = 0.201, p < 0.001), dok *Telesna težina*

Body Weight showed a moderate, negative, and statistically significant association with the criterion variable (r = -0.336, p < .001). These results suggest that taller and lighter participants tend to achieve better performance in movement frequency tasks.

The regression analysis further confirmed these findings. Body Height was identified as a statistically significant positive predictor of performance in the Hand Tapping Test (Beta = 0.465, p < .001), while Body Weight demonstrated a statistically significant negative predictive effect (Beta = -0.557, p < .001). This indicates that higher body height contributes to better performance, whereas increased body mass negatively affects the ability to perform rapid and repetitive hand movements.

The overall model indicated a moderate relationship between predictor and criterion variables, as shown by the multiple correlation coefficient (R = 0.530). The coefficient of determination (R^2 = 0.281) revealed that Body Height and Body Weight together explained 28.1% of the variance in Hand Tapping Test performance, while the adjusted coefficient of determination (Adjusted R^2 = 0.259) confirmed the stability of the regression model.

Based on these results, it can be concluded that body weight represents a limiting factor for the execution of fast and precise hand movements, whereas body height appears to be associated with slightly better performance in the Hand Tapping Test among younger school-aged children.

Table 5. *Regression Analysis of the Seated Straddle Forward Bend Test in Boys and Girls*

	***Boys and Girls* / Dečaci i devojčice**			
***Variables* / Varijable**				
	r	***p***	***Beta***	***pbeta***
Body Height / Telesna visina	0.319	0.001	0.448	0.001
Body Weight / Telesna težina	-0.060	0.036	-0.272	0.036
R	0.399			
R^2	0.159			
Adjusted R^2 / Prilagođen R^2	0.134			
P	0,003			

The results of the regression analysis presented in Table 5 show the relationship between the predictor variables (Body Height and Body Weight) and performance in the Seated Straddle Forward Bend Test.

Analysis of Pearson's correlation coefficients indicates that Body Height had a moderate, positive, and statistically significant association with performance in the Seated Straddle Forward Bend Test (r = 0.319, p = .001), whereas Body Weight showed a weak, negative, and sta-

ima umereno, negativnu, statistički značajnu povezanost (r = -0.336, p < 0.001).Ovakav rezultat ukazuje da lakši i viši ispitanici ostvaruju bolje rezultate na testu. Daljom analizom regresionog koeficijenata (Beta) potvrđuje se da *Telesna visina* pozitivno utiče na rezultat u testu (Beta = 0.465, pbeta< 0.001), dok *Telesna težina* pokazuje negativan,statistički značajan uticaj (Beta = -0.557, pbeta< 0.001), što potvrđujeda viši ispitanici imaju prednost u brzini izvođenja testa. Ukupna povezanost prediktora (*Telesna visina* i *Telesna težina*) sa rezultatom na testu izražena kroz koeficijent multiple korelacije (R = 0.530) ukazuje na jaku povezanost prediktorskih varijabli sa kriterijumskom varijablom. Koeficijent determinacije (R^2 = 0.281) pokazuje da *Telesna visina* i *Telesna težina* zajedno objašnjavaju 28.1% varijacija u rezultatima testa-*Taping rukom*, dok prilagođeni koeficijent determinacije (prilagođeni R^2 = 0.259) potvrđuje da je model pouzdan.

Na osnovurezultata može se zaključiti *Telesnatežina* ima otežane uslove za brze i precizne pokrete rukom, dok *Telesna visina* pokazuju nešto bolje rezultate na testu *Taping rukom*.

Tabela 5. *Regresiona analiza pretklona raznožno u seduza dečake i devojčice*

U tabeli 5. prikazani su rezultati regresione analize, gde je analizirana povezanost između prediktorskih varijabli (*Telesna visina* i *Telesna težina*) i kriterijumske varijable (*Pretklon raznožno u sedu*).Analizom Pirsonovog koeficijenta korelacije (r) primećuje se da *Telesna visina*ima umerenu, pozitivnu, statistički značajnu povezanost sa uspešnošću testa*Pretklon raznožno u sedu*(r = 0.319, p = 0.001), dok *Telesna težina*ima slabu, negativnu, statistički neznačajnupovezanost(r = -0.060, p = 0.036).

tistically significant association with the criterion variable (r = -0.060, p = .036). These results suggest that taller participants achieve better results in this flexibility test.

The regression analysis further confirmed these findings. Body Height demonstrated a statistically significant positive effect on test performance (Beta = 0.448, p = .001), while Body Weight showed a negative, statistically non-significant effect (Beta = -0.272, p = .036), indicating that higher body mass may limit flexibility in this test.

The overall relationship between predictors and the criterion variable, expressed through the multiple correlation coefficient (R = 0.399), indicates a relatively weak association. The coefficient of determination (R^2 = 0.159) shows that Body Height and Body Weight together explain 15.9% of the variance in Seated Straddle Forward Bend Test performance, while the adjusted coefficient of determination (Adjusted R^2 = 0.134) confirms the modest explanatory power of the model.

Based on the results, it can be concluded that body height has an advantage in the Seated Straddle Forward Bend Test, whereas higher body weight may represent a limiting factor for flexibility performance.

Table 6. *Regression Analysis of the Standing Long Jump Test in Boys and Girls*

Tabela 6. *Regresiona analiza skoka udalj iz mesta za dečake i devojčice*

	***Boys and Girls* / Dečaci i devojčice**			
***Variables* / Varijable**				
	r	***p***	***Beta***	***pbeta***
Body Height / Telesna visina	0.327	0.000	0.534	0.000
Body Weight / Telesna težina	-0.183	0.001	-0.437	0.001
R	0.505			
R^2	0.255			
Adjusted R^2 / Prilagođen R^2	0.233			
P	0,000			

The results of the regression analysis presented in Table 6 show the relationship between the predictor variables (Body Height and Body Weight) and performance in the Standing Long Jump Test. Analysis of Pearson's correlation coefficients indicates that Body Height had a moderate, positive, and statistically significant association with performance in the Standing Long Jump Test (r = 0.327, p < .001), whereas Body Weight showed a weak, negative, and statistically significant association with the criterion variable (r = -0.183, p = .001). These findings suggest that taller participants tend to achieve better performance, while higher body weight may negatively affect performance in this test.

The regression analysis further confirmed these relationships. Body Height demonstrated a statistically significant positive effect on test performance (Beta = 0.534, pbeta = 0.001), while Body Weight showed a negative, statistically significant effect (Beta = -0.437, pbeta = 0.001), indicating that higher body mass may limit flexibility in this test.

The overall relationship between predictors and the criterion variable, expressed through the multiple correlation coefficient (R = 0.505), indicates a relatively strong association. The coefficient of determination (R^2 = 0.255) shows that Body Height and Body Weight together explain 25.5% of the variance in Standing Long Jump Test performance, while the adjusted coefficient of determination (Adjusted R^2 = 0.233) confirms the modest explanatory power of the model.

Based on the results, it can be concluded that body height has an advantage in the Standing Long Jump Test, whereas higher body weight may represent a limiting factor for explosive performance.

U tabeli 6. prikazani su rezultati regresione analize, gde je analizirana povezanost između prediktorskih varijabli (*Telesna visina* i *Telesna težina*) i kriterijumske varijable (*Skok udalj iz mesta*). Analizom Pirsonovog koeficijenta korelacije (r) primećuje se da *Telesna visina* ima umerenu, pozitivnu, statistički značajnu povezanost sa uspešnošću testa *Skok udalj iz mesta* (r = 0.327, p < 0.001), dok *Telesna težina* ima slabu, negativnu, statistički značajnu povezanost (r = -0.183, p = 0.001). Ovakav rezultat ukazuje da viši ispitanici imaju tendenciju da postižu bolje rezultate, dok veća telesna tezina može otežavati test. Daljom analizom regresionog koeficijenata (Beta) potvrđuje se da *Telesna visina* pozitivno utiče na rezultat u testu (Beta = 0.534, pbeta<0.001), dok*Telesna težina* pokazuje negativan, statistički značajan uticaj

Ovakav rezultat ukazuje da viši ispitanici ostvaruju bolje rezultate na testu.Daljom analizomregresionog koeficijenata (Beta) potvrđuje se da*Telesna visina*pozitivno utiče na rezultat u testu (Beta = 0.448, pbeta = 0.001), dok *Telesna težina* pokazuje negativan, statistički neznačajan uticaj (Beta = -0.272, pbeta = 0.036), što potvrđuje da većatežina može ograničiti fleksibilnost u ovom testu. Ukupna povezanost prediktora (*Telesna visina* i *Telesna težina*) sa rezultatom na testu izražena kroz koeficijent multiple korelacije (R = 0.399) ukazuje na jaku povezanostprediktorskih varijabli sa kriterijumskom varijablom. Koeficijent determinacije (R^2 = 0.159) pokazuje da *Telesna visina* i *Telesna težina*zajedno objašnjavaju 15.9% varijacija u rezultatimatesta *Pretklon raznožno u sedu*, dok prilagođeni koeficijent determinacije(prilagođeni R^2 = 0.134)potvrđuje da je model pouzdan.

Na osnovurezultata može se zaključiti da *Telesna visina* ima prednost utestu *Pretklon raznožno u sedu*, dok veća*Telesna težina*može predstavljati ograničavajući faktor.

cant positive effect on Standing Long Jump performance (Beta = 0.534, p < .001), while Body Weight showed a statistically significant negative effect (Beta = -0.437, p = .001), indicating that morphological characteristics play an important role in success in this motor task.

The overall relationship between predictor and criterion variables, expressed by the multiple correlation coefficient (R = 0.505), indicates a relatively strong association. The coefficient of determination (R^2 = 0.255) shows that Body Height and Body Weight together explain 25.5% of the variance in Standing Long Jump performance, while the adjusted coefficient of determination (Adjusted R^2 = 0.233) confirms the adequacy of the regression model.

Based on these results, it can be concluded that body height has a positive influence on Standing Long Jump performance, while body weight acts as a limiting factor in this test.

Table 7. *Regression Analysis of the 20-Metre Sprint from a Standing Start in Boys and Girls*

	***Boys and Girls* / Dečaci i devojčice**			
***Variables* / Varijable**				
	r	***p***	***Beta***	***pbeta***
Body Height / Telesna visina	-0.018	0.014	-0.298	0.014
Body Weight / Telesna težina	0.450	0.000	0.591	0.000
R	0.521			
R^2	0.271			
Adjusted R^2 / Prilagođen R^2	0.250			
P	0,000			

The results of the regression analysis presented in Table 7 show the relationship between the predictor variables (Body Height and Body Weight) and performance in the 20-Metre Sprint from a Standing Start.

Analysis of Pearson's correlation coefficients indicates that Body Weight had a moderate, positive, and statistically significant association with performance in the 20-Metre Sprint (r = 0.450, p < .001), whereas Body Height showed a very weak, negative association with the criterion variable (r = -0.018, p = .014). These results suggest that lighter participants tend to achieve better sprint performance, while body height has a negligible but negative relationship with sprint outcomes.

The regression analysis further confirmed these findings. Body Weight demonstrated a statistically significant positive effect on sprint performance (Beta = 0.591, p < .001), while Body Height showed a negative and statistically significant effect (Beta = -0.298, p = .014), indicating that lower stature may be associated with slightly better sprint performance in this sample.

(Beta = -0.437, pbeta = 0.001), što potvrđuje da su telesne karakteristike ključne za uspešnost u ovom testu.

Ukupna povezanost prediktora (*Telesna visina* i *Telesna težina*) sa rezultatom na testu izražena kroz koeficijent multiple korelacije (R = 0.505) ukazuje na jaku povezanost prediktorskih varijabli sa kriterijumskom varijablom. Koeficijent determinacije (R^2 = 0.255) pokazuje da *Telesna visina* i *Telesna težina* zajedno objašnjavaju 25.5% varijacija u rezultatima testa *Skok udalj iz mesta*, dok prilagođeni koeficijent determinacije (prilagođeni R^2 = 0.233) potvrđuje da je model pouzdan.

Na osnovu rezultata može se zaključiti da *Telesna visina* imaznačajan pozitivan uticaj u testu *Skok udalj iz mesta*, dok *Telesna težina* deluje ograničavajuće.

Tabela 7. *Regresiona analizatrčanja 20 m iz visokog startaza dečake i devojčice*

U tabeli 7. prikazani su rezultati regresione analize, gde je analizirana povezanost između prediktorskih varijabli (*Telesna visina* i *Telesna težina*) i kriterijumske varijable (*Trčanje 20 m iz visokog starta*). Analizom Pirsonovog koeficijenta korelacije (r) primećuje se da *Telesna težina* ima umerenu, pozitivnu, statistički značajnu povezanost sa uspešnošću testa *Trčanje 20 m iz visokog starta*(r = 0.450, p < 0.001), dok *Telesna visina* ima slabu, negativnu, statistički neznačajnu povezanost (r = -0.018, p = 0.014). Ovakav rezultat ukazuje da niži ispitanici imaju tendenciju da postižu bolje rezultate.

Daljom analizom regresionog koeficijenata (Beta) potvrđuje se da *Telesna težina* pozitivno utiče na rezultat u testu (Beta = 0.591, pbeta < 0.001), dok *Telesna visna* pokazuje negativan, statistički neznačajan uticaj (Beta = -0.298, pbeta = 0.014), što potvrđuje da veća visina ispitanika nešto slabije prolaze test u poređenju sa nižim ispitanicima. Ukupna povezanost prediktora (*Telesna visina* i *Telesna težina*) sa rezultatom na testu izražena kroz koeficijent multiple korelacije (R = 0.521) ukazuje

The overall relationship between predictor and criterion variables, expressed by the multiple correlation coefficient (R = 0.521), indicates a relatively strong association. The coefficient of determination (R^2 = 0.271) shows that Body Height and Body Weight together explain 27.1% of the variance in 20-Metre Sprint performance, while the adjusted coefficient of determination (Adjusted R^2 = 0.250) confirms the adequacy of the regression model.

Based on these results, it can be concluded that body weight has a moderate positive influence on 20-Metre Sprint performance, while body height may act as a limiting factor in this motor test.

Table 8. *Regression Analysis of the Bent-Arm Hang Test in Boys and Girls*

	***Boys and Girls* / Dečaci i devojčice**			
***Variables* / Varijable**				
	r	***p***	***Beta***	***pbeta***
Body Height / Telesna visina	-0.065	0.162	0.175	0.162
Body Weight / Telesna težina	-0.423	0.000	-0.506	0.000
R	0.450			
R^2	0.203			
Adjusted R^2 / Prilagođen R^2	0.179			
P	0,001			

The results of the regression analysis presented in Table 8 show the relationship between the predictor variables (Body Height and Body Weight) and performance in the Bent-Arm Hang Test.

Analysis of Pearson's correlation coefficients indicates that Body Weight had a moderate, negative, and statistically significant association with performance in the Bent-Arm Hang Test (r = -0.423, p < .001), whereas Body Height showed a weak, negative, and statistically non-significant association with the criterion variable (r = -0.065, p = .162). These findings suggest that lighter participants tend to achieve better performance in this test of static strength of the upper limbs and shoulder girdle.

The regression analysis further confirmed these relationships. Body Weight demonstrated a statistically significant negative effect on performance in the Bent-Arm Hang Test (Beta = -0.506, p < .001), indicating that higher body mass is associated with lower performance. Body Height showed a positive but statistically non-significant effect (Beta = 0.175, p = .162), suggesting no meaningful influence on test performance.

The overall relationship between predictor and criterion variables, expressed by the multiple correlation coefficient (R = 0.450), indicates a moderate association. The

Na jaku povezanost prediktorskih varijabli sa kriterijumskom varijablom. Koeficijent determinacije (R^2 = 0.271) pokazuje da *Telesna visina* i *Telesna težina* zajedno objašnjavaju 27.1% varijacija u rezultatima testa*Trčanje 20 m iz visokog starta*, dok prilagođeni koeficijent determinacije (prilagođeni R^2 = 0.250) potvrđuje da je model pouzdan.

Na osnovu rezultata može se zaključiti da optimalna*Telesna težina* ima umeren pozitivan uticaj u testu *Trčanje 20 m iz visokog starta*, dok *Telesna visina* može predstavljati ograničavajući faktor.

Tabela 8. *Regresiona analiza izdržaja u zgibu za dečake i devojčice*

U tabeli 8. prikazani su rezultati regresione analize, gde je analizirana povezanost između prediktorskih varijabli (*Telesna visina* i *Telesna težina*) i kriterijumske varijable (*Izdržaj u zgibu*). Analizom Pirsonovog koeficijenta korelacije (r) primećuje se da *Telesna težina* ima umerenu, negativnu, statistički značajnu povezanost sa uspešnošću testa *Izdržaj u zgibu*(r = -0.423, p < 0.001), dok *Telesna visina* ima slabu, negativnu, statistički neznačajnu povezanost (r = -0.065, p = 0.162). Ovakav rezultat ukazuje da niži i laksi ispitanici imaju uspešnost u testu. Daljom analizom regresionog koeficijenata (Beta) potvrđuje se da *Telesna težina* ima negativan, statistički značajan uticaj u testu (Beta = 0.506, pbeta < 0.001), dok *Telesna visna* pokazuje pozitivan, statistički neznačajan uticaj (Beta = 0.175, pbeta = 0.162), što potvrđuje da ispitanici sa većom telesnom težinom imaju slabiju uspešnost u testu. Ukupna povezanost prediktora (*Telesna visina* i *Telesna težina*) sa rezultatom na testu izražena kroz koeficijent multiple korelacije (R = 0.450) ukazuje na jaku povezanost prediktorskih varijabli sa kriterijumskom varijablom. Koeficijent determinacije (R^2 = 0.203) pokazuje da *Telesna visina* i *Telesna težina* zajedno objašnjavaju 20.3% varijacija u rezultatima testa *Izdržaj u zgibu*, dok prilagođeni koeficijent

coefficient of determination ($R^2 = 0.203$) shows that Body Height and Body Weight together explain 20.3% of the variance in Bent-Arm Hang performance, while the adjusted coefficient of determination (Adjusted $R^2 = 0.179$) confirms the modest explanatory power of the model.

Based on these results, it can be concluded that higher body weight represents a limiting factor in the Bent-Arm Hang Test, while body height does not have a significant influence on performance in this motor task.

Table 9. *Regression Analysis of the 60-Second Sit-Up Test in Boys and Girls*

	***Boys and Girls* / Dečaci i devojčice**			
***Variables* / Varijable**				
	r	***p***	***Beta***	***pbeta***
Body Height / Telesna visina	0.137	0.017	0.318	0.017
Body Weight / Telesna težina	-0.232	0.004	-0.382	0.004
R	0.363			
R^2	0.132			
Adjusted R^2 / Prilagođen R^2	0.106			
P	0,009			

The results of the regression analysis presented in Table 9 show the relationship between the predictor variables (Body Height and Body Weight) and performance in the 60-Second Sit-Up Test.

Analysis of Pearson's correlation coefficients indicates that Body Height had a weak, positive, and statistically significant association with performance in the 60-Second Sit-Up Test ($r = 0.137$, $p = .017$), whereas Body Weight showed a weak negative association with the criterion variable ($r = -0.232$, $p = .004$). These findings suggest that participants with higher body weight tend to achieve lower performance in this test.

The regression analysis further confirmed these relationships. Body Height demonstrated a positive but statistically non-significant effect on test performance (Beta = 0.318, p = .017), while Body Weight showed a negative effect with a higher level of statistical significance (Beta = -0.382, p = .004), indicating that increased body mass hinders performance in abdominal endurance tasks.

The overall relationship between predictor and criterion variables, expressed by the multiple correlation coefficient ($R = 0.363$), indicates a moderate association. The coefficient of determination ($R^2 = 0.132$) shows that Body Height and Body Weight together explain 13.2% of the variance in 60-Second Sit-Up Test performance, while the adjusted coefficient of determination (Adjusted $R^2 = 0.106$) confirms the relatively low explanatory power of the model.

Based on these results, it can be concluded that higher body weight represents a limiting factor in the determinacije (prilagođeni $R^2 = 0.179$) potvrđuje da je model pouzdan.

Na osnovu rezultata može se zaključiti da veća *Telesna težina* ima otežane uslove za test *Izdržaj u zgibu*, dok veća *Telesna visina* nema značajan uticaj na performanse u ovom testu.

Tabela 9. *Regresiona analiza podizanja trupa za 60 sekundizadečake i devojčice*

U tabeli 9. prikazani su rezultati regresione analize, gde je analizirana povezanost između prediktorskih varijabli (*Telesna visina* i *Telesna težina*) i kriterijumske varijable (*Podizanje trupa za 60 sekundi*).Analizom Pirsonovog koeficijenta korelacije (r) primećuje se da *Telesna visina* ima slabu, pozitivnu, statistički neznačajnu povezanost sa uspešnošću testa *Podizanje trupa u trajanju od 60 sekundi*($r = 0.137$, $p = 0.017$), dok *Telesna težina* ima slabu, negativnu povezanost, sa nižim stepenom značajnosti ($r = -0.232$, $p = 0.004$).Ovakav rezultat ukazuje da ispitanici sa većom telesnom težinom postižu slabije rezultate.Daljom analizom regresionog koeficijenata (Beta) potvrđuje se da *Telesna visina*pozitivno, statistički neznačajno utiče na rezultat u testu (Beta = 0.318, pbeta = 0.017), dok *Telesna težina* pokazuje negativan uticaj, sa nižim stepenom značajnosti (Beta = -0.382, p = 0.004), što potvrđuje da veća telesna težina otežava izvođenje testa.Ukupna povezanost prediktora (*Telesna visina* i *Telesna težina*) sa rezultatom na testu izražena kroz koeficijent multiple korelacije ($R = 0.363$) ukazuje na umerenu povezanost prediktorskih varijabli sa kriterijumskom varijablom. Koeficijent determinacije ($R^2 = 0.132$) pokazuje da *Telesna visina* i *Telesna težina* zajedno objašnjavaju 13.2% varijacija u rezultatima testa*Podizanje trupa za 60 sekundi*, dok prilagođeni koeficijent determinacije (prilagođeni $R^2 = 0.106$) potvrđuje da je model pouzdan.

Na osnovu rezultata može se zaključiti da*Telesnatežina* ima otežane uslove za izvođenje testa*Podizanje tru-*

60-Second Sit-Up Test, while body height shows a slight positive influence on performance in this motor task.

Discussion

The study examined the relationship between morphological characteristics, including body height and body weight as basic parameters, and motor abilities in children of younger school age, assessed through eight different tests. The obtained results indicate a significant relationship between body height, body weight, and performance in motor ability tests, which is largely consistent with the findings of other studies (Herrmann et al., 2019; Podstawski & Borysławski, 2012).

The sample included children aged 7 years (±0.5 years), a period in which growth has not yet reached its most intensive phase. Therefore, the measurements of body height showed that the children were of relatively average and homogeneous stature. The results further indicated that girls had, on average, higher body weight than boys, which is expected at this age. This is consistent with the findings of Costa et al. (2017), who investigated long-term changes in morphological characteristics among Portuguese children and reported that girls at this age are physically larger. Similar trends were observed in the study by Hudda et al. (2018), where higher prevalence of overweight was recorded among South Asian girls compared to boys. Data from the United States also indicate a continuous increase in childhood overweight, which is concerning, as overweight has increased by more than 10% compared to three decades ago (Ogden et al., 2002).

Regression analysis provided insight into the relationship between predictor variables and criterion variables, i.e., the extent to which morphological characteristics influence motor performance. Based on the obtained results, it can be concluded that participants with an optimal relationship between body height and body weight achieved better results in all categories of motor tests. This is consistent with the findings of Antunes et al. (2015), who emphasize the importance of balanced body composition for optimal motor performance.

At younger school age, most children do not have issues with excessive body weight, which facilitates coordination of whole-body movements. Accordingly, the results confirm a significant relationship between coordination abilities and optimal body weight. Optimal body weight has a significant influence on performance in the Backward Obstacle Course (Poligon natraške) and Slalom with Three Balls, while body height is not a significant factor, which is consistent with the findings

pa za 60 sekundi, dok veća *Telesna visina* donosi blagu prednost u testu.

Diskusija

U istraživanju ispitana je povezanost morfoloških karakteristika, koje uključuju telesnu visinu i telesnu težini kao osnovne parametre i motoričkih sposobnosti kod dece mlađeg školskog uzrasta, koje su merene kroz osam različitih testova. Dobijeni rezultati ukazuju na značajnu povezanost između telesne visine, telesne težine i rezultata na testovima motoričkih sposobnosti, što je uglavom u skladu sa rezultatima drugih istraživanja (Herrmann et al. 2019; Podstawski, & Borysławski 2012).

Uzorak ispitanika obuhvatao je decu uzasta 7 godina (± 0,5) godina, kod kojih proces rasta nije još dostigao najintenzivniju fazu, pa su rezultati merenja visine tela pokazali da su deca prosečne i ujednačene visine. Posmatrajući rezultate istraživanja uočeno je da devojčice imaju u proseku veću telesnu težinu od dečaka, što je očekivano za ovaj uzrast. Ovo je u skladu sa rezultatima istraživanja Costa et al. (2017), koji su ispitivali dugoročne promene morfoloških karakteristika kod portugalske dece i konstatovali da su devojčice u ovom uzrastu fizički krupnije od dečaka. Sličan trend je primećen i u studiji Hudda et al. (2018) gde je kod devojčica iz Južne Azije registrovana veća prekomerna telesne težina u odnosu na dečake. Podaci istraživanja iz Sjedinjenih Američkih Država ukazuju da je prekomerna telesna težina kod dece u stalnom porastu i da je zabrinjavajući podatak jer je prekomerna telesna težina porasla za vise od 10 % u odnosu na period od pre 30 godina (Ogden et al.2002).

Regresiona analiza omogućila je sagledavanje odnosa između prediktorskih varijabli i kriterijumske varijable, odnosnoprocenila je u kojoj meri prediktorske varijable mogu imati značajan uticaj na ispoljavanje kriterijumske varijable. Na osnovu dobijenih rezultata regresione analize može se zaključiti da će ispitanici sa optimalnim odnosom telesne visine i težine ostvariti bolje rezultate u svim kategorijama motoričkih testova. Ovo je u skladu s nalazima Antunes et al. 2015, koji ukazuju na značaj uravnotežene telesne kompozicije za optimalne performanse u motoričkim aktivnostima.

U mlađem školskom uzrastu većina ispitanika nema problem sa prekomernom telesnom težinom, što im olakšava održavanje koordinacije celog tela. Shodno tome, rezultati istraživanja potvrđuju postojanje značajne povezanosti između koordinacije i optimalne telesne težine. Optimalna telesna težina ima značajan uticaj na uspešnost izvođenja testova, *Poligon natraške* i *Slalom sa tri lopte*, dok telesna visina nije značajan faktor što je u skladu sa nalazima Morano et al. 2011, pa nivo koordinacije nije determinisan telesom

of Morano et al. (2011) and Čillík & Willwéber (2018), who reported that coordination is not determined by body height.

It is evident that boys achieved slightly better results in coordination tests, while girls showed significantly better performance in flexibility tests. These findings are fully consistent with Abdelkarim et al. (2017), who reported that girls exhibit greater flexibility throughout childhood. The obtained results show that body height has an advantage in the Seated Forward Split Flexibility Test (Pretklon raznožno u sedu), while excessive body weight may act as a limiting factor. In other words, higher body weight negatively affects flexibility tasks, which is in agreement with Vameghi et al. (2013). Accordingly, taller participants achieved better results in flexibility tests.

Based on regression analysis, it was determined that participants who achieved better results in the 60-Second Sit-Up Test also performed better in the seated flexibility test and had lower body weight. Body weight had a limiting effect on sit-up performance, while greater body height showed a slight advantage, which is supported by Podstawski & Borysławski (2012).

Regarding the Tapping Test, higher body weight was associated with more difficult conditions for movement frequency, while taller participants achieved better results. The findings also indicate no statistically significant gender differences in this test. The test primarily depends on coordination and reaction speed rather than body height or body weight, which is also supported by Stodden et al. (2014).

Body composition has a strong influence on performance in motor tests, especially in strength and speed tasks (Costa et al., 2017; Čillík & Willwéber, 2018). A particularly pronounced negative correlation was observed between higher body weight and performance in the Standing Long Jump. Body height showed a positive influence on performance in this test, while body weight acted as a limiting factor. Participants needed to integrate multiple motor actions to achieve optimal performance. No significant gender differences were observed in explosive strength of the lower limbs, while participants with lower body weight achieved better results, i.e., longer jumps.

The results of the 20-meter sprint test indicated better performance in participants with lower body dimensions, i.e., lower body height and body weight. Boys showed better performance in explosive strength tests, which is consistent with Field & Temple (2017), who reported greater explosiveness and speed in boys at this age.

visinom (Čillík, & Willwéber, 2018). Nema sumnje, da su dečaci u neznatnoj meri ostvarili nešto bolje rezultate u koordinaciji, dok su devojčice znatno bolje rezultate ostvarile u testu za procenu gipkosti. Ovakvi rezultati u potpunosti se poklapaju sa zaključcima Abdelkarimet al. (2017),koji su istakli da devojčice tokom celog perioda detinjstva imaju izraženiju gipkost u odnosu na dečake. Dobijeni rezultati pokazuju da telesna visina ima prednost u testu *Pretklon raznožno u sedu,* dok prekomerna telesna težina može predstavljati ograničavajući faktor, tačnije prekomerna telesna težina negativno utiče na zadatke koji zahtevaju gipkost što se poklapa sa rezultatima istraživanja Vameghi et al. 2013. Usled toga, viši ispitanici ostvaruju bolje rezultate u testu za procenu gipkosti. Na osnovu dobijenih rezultata regresione analize, utvđeno je da su ispitanicu koji su postigli bolje rezultate na testu *Podizanje trupa za 60 sekundi* ostvarili I ispitanici koji su imali uspešnije rezultate na testu *Pretklon raznožno u sedu* i koji imaju manju telesnu težinu. Telesna težina imala je otežane uslove za izvođenje testa *Podizanje trupaza 60 sekundi*, dok veća telesna visina donosi blagu prednost u testu, što potvrđuju Podstawski, & Borysławski (2012). Kada je reč o rezultatima u testu *Taping rukom* zaključuje se da veća telesna težina ima otežane uslove za frekvenciju pokreta, dok ispitanici koji imaju veću telesnu visinu ostvaruju bolje rezultate na testu. Takođe, rezultati istraživanja ovog testa ukazuju i na odsustvo statistički značajnih razlika između ispitanika različitog pola.Ovaj test zahteva precizniju koordinaciju i kontrolu pokreta rukom i više zavisi od koordinacije i brzine reakcije nego od telesne visine i telesne težine. Slične rezultate u istraživanju navodi Stodden et al. (2014). Nema sumnje, da istraživanja naglašavaju da telesna konstitucija ima snažan uticaj na uspeh u motoričkim testovima, naročito u zadacima snage i brzine (Costa et al. 2017; Čillík, & Willwéber, 2018) U istraživanju je posebno izražena negativna korelacija između veće telesne težine i rezultata na testu *Skok udalj iz mesta*. Na osnovu rezultata istraživanja zaključeno je da telesna visina ima značajan pozitivan uticaj u testu *Skok udalj iz mesta,* dok telesna težina deluje ograničavajuće. Naime, ispitanici treba da usklade više motoričkih radnji u jedinstvenu celinu, kako bi postigli bolje rezultate. Istraživanjem je potvrđeno da su dečaci imali slične rezultate kao devojčice u testu za procenu eksplozivne snage nogu. Ispitanici sa manjom telesnom težinom postigli su bolje rezultate u skoku, odnosno skočili su dalje.Zaključno, mogu reći da su rezultati istraživanja u velikoj meri, u skladu sa Altinkök (2016). Rezulalti u testu *Trčanje 20 m iz visokog starta* su bolji kod ispitanika sa manjim telesnim dimenzijama, odnosno nižom telesnom visinom i telesnom težinom. Dečaci su pokazali bolje rezultate u testu eksplozivne snage nogu, što potvrđuje i istraživanje

Optimal body weight had a slight positive effect on the 20-meter sprint, while body height acted as a limiting factor. Thus, shorter participants tended to achieve better results, suggesting that taller participants performed slightly worse compared to shorter peers.

In the Bent-Arm Hang Test, results showed a clear advantage for boys. These findings are consistent with Sheikh et al. (2011), who reported greater upper-body strength in boys, particularly in tests requiring static strength of the arms and shoulder girdle. Body weight showed a negative effect on performance, which aligns with Vameghi et al. (2013). Therefore, higher body weight represents a limiting factor, while body height does not significantly influence performance in this test.

In conclusion, the results of this study are largely consistent with previous research indicating a relationship between morphological characteristics and motor abilities in children of younger school age (Herrmann et al., 2019; Podstawski & Borysławski, 2012; Sedlak et al., 2015; Čillík & Willwéber, 2018; Karim et al., 2015; Vameghi et al., 2013). These authors emphasize that younger school age is a critical period for the development of motor abilities and represents a foundation for further physical development and long-term health.

It is evident that stability and directionality of development during this period play a crucial role in achieving higher-quality motor abilities, further confirming the importance of timely promotion of physical activity in children.

Conclusion

Based on the conducted research on the relationship between motor abilities and morphological characteristics in children of younger school age, it can be concluded that there is a strong and inseparable relationship between these variables. The obtained results indicate that children's body structure and physical fitness have a direct impact on the development of their motor abilities. Data analysis showed that children with optimal body weight and body height achieved better results in motor ability tests. In contrast, the presence of excess body weight negatively affected performance in tasks requiring coordination, flexibility, strength, and speed.

Based on the analysis of the results, the research hypothesis regarding the existence of a significant and strong relationship between motor abilities and morphological characteristics in children of younger school age was confirmed. It can be concluded with confidence that children with more optimal morphological characteristics, such as appropriate body weight and body height,

Field, & Temple (2017), koje je pokazalo da dečaci u ovom uzrastu pokazuju veću eksplozivnost i brzinu. Optimalna telesna težina imala je blagi pozitivan uticaj na testu *Trčanje 20 m izvisokog starta*, dok telesna visina može predstavljati ograničavajući faktor, dakle niži ispitanici imaju tendenciju da postižu bolje rezultate,što potvrđuje da veća visina ispitanika nešto slabije prolazi test u poređenju sa nižim ispitanicima. U testu *Izdržaj u zgibu*rezultati su pokazali jasnu prednost dečaka. Ovakvi rezultati se podudaraju sa nalazima Sheikh et al. (2011), koji su utvrdili da dečaci imaju izraženiju snagu gornjeg dela tela, što se naročito manifestuje u testovima koji zahtevaju statičku snagu ruku i ramenog pojasa. Telesna težina je pokazala negativan uticaj na uspešnost izvođenja zadatka, što je u skladu sa literaturom Vameghi et al. (2013). Na osnovu rezultata se zaključuje da veća telesna težina ima otežane uslove za test *Izdržaj u zgibu,* dok veća telesna visina nema značajan uticaj na performanse u ovom testu.

Zaključno, može se reći da su rezultati istraživanja u velikoj meri, u skladu saprethodnim istraživanjima koja ukazuju na povezanost određenih morfoloških karakteristika i motoričkih sposobnosti kod dece mlađeg školskog uzrasta (Herrmann et al. 2019; Podstawski, & Borysławski 2012; Sedlak et al. 2015; Čillík, & Willwéber 2018; Karim et al. 2015;Vameghi et al. 2013). Ovi autori naglašavaju da je period mlađeg školskog uzrasta izuzetno važan za intenzivan razvoj motoričkih sposobnosti, te da predstavlja temelj za dalji fizički razvoj i očuvanje opšteg zdravstvenog stanja. Nema sumnje, da stabilnost i usmerenost razvoja u ovom uzrastu igraju ključnu ulogu u postizanju kvalitetnijih motoričkih sposobnosti, čime se dodatno potvrđuje značajpravovremenog podsticanja fizičke aktivnosti kod dece.

Zaključak

Na osnovu sprovedenog istraživanja o povezanosti motoričkih sposobnosti i morfoloških karakteristika kod dece mlađeg školskog uzrasta, može se zaključiti da postoji neraskidiva veza. Dobijeni rezultati nas navode na zaključak da telesna građa i fizička spremnost dece imaju direktan uticaj na razvoj njihovih motoričkih sposobnosti. Analizom podataka ustanovljeno je da deca sa optimalnom telesnom težinom i telesnom visinom, pokazuju bolje rezultate u testovima motoričkih sposobnosti. S druge strane, prisustvo viška telesne težine negativno se odražava na izvođenje zadataka koji zahtevaju koordinaciju, gipkost, snagu i brzinu.

Na osnovu sprovedene analize rezultata, potvrđena je postavljena hipoteza o postojanju značajne i neraskidive povezanosti između motoričkih sposobnosti i morfoloških karakteristika kod dece mlađeg školskog uzrasta.

achieve better performance in motor tests. Properly guided and appropriately dosed physical activity can contribute to the development of motor abilities, as well as the prevention of potential deviations in physical development. Accordingly, the research hypothesis predicting a significant interdependence between the examined variables is accepted.

The study also showed that children engaged in organized sports activities demonstrate better motor abilities and more favorable morphological characteristics. This indicates the effectiveness of current physical education programs in schools, as well as the need for their further improvement and adaptation to individual needs of children.

Sa sigurnošću može se zaključiti da deca sa optimalnijim morfološkim osobinama, kao što su optimalna telesna težina i optimalna telesna visina, ostvaruju bolje rezultate na motoričkim testovima. Pravilno usmerena i prilagođena fizička aktivnost može doprineti razvoju motoričkih sposobnosti, ali i prevenciji potencijalnih odstupanja u telesnom razvoju. Saglasno dobijenim rezultatima, prihvata se istraživačka hipoteza koja je predviđala postojanje značajne međuzavisnosti između ispitivanih varijabli.

Istraživanje je pokazalo da deca koja su uključena u organizovane sportske aktivnosti, pokazuju bolje motoričke sposobnosti i optimalnije morfološke karakteristike. Ovo ukazuje na efikasnost postojećih programa fizičkog vaspitanja u školama, ali i na potrebu za njihovim daljim unapređenjem i prilagođavanjem individualnim potrebama dece.

REFERENCES

Abdelkarim, O., Ammar, A., Chtourou, H., Wagner, M., Knisel, E., Hökelmann, A., & Bös, K. (2017). Relationship between motor and cognitive learning abilities among primary school-aged children. *Alexandria Journal of Medicine, 53*(4), 325–331.

Afthentopoulou, A. E., Kaioglou, V., & Venetsanou, F. (2017). Overweight and obesity prevalence in young children living in Athens. *Public Health Open Journal, 2*(1), 26–32.

Aivazidis, D., Venetsanou, F., Aggeloussis, N., Gourgoulis, V., & Kambas, A. (2019). Enhancing motor competence and physical activity in kindergarten. *Journal of Physical Activity & Health, 16*(3).

Altınkök, M. (2015). Examining the effects of "activity education with coordination" on the development of balance and arm power in 6-year-old primary school children. *International Online Journal of Educational Sciences, 7*(4).

Altinkök, M. (2016). The effects of coordination and movement education on preschool children's basic motor skills improvement. *Universal Journal of Educational Research, 4*(5), 1050–1058.

Altınkök, M. (2017). The effect of coordinated teaching method practices on some motor skills of 6-year-old children. *Eurasian Journal of Educational Research, 17*(68), 49–61.

Antunes, A. M., Maia, J. A., Stasinopoulos, M. D., Gouveia, É. R., Thomis, M. A., Lefevre, J. A., & Freitas, D. L. (2015). Gross motor coordination and weight status of Portuguese children aged 6–14 years. *American Journal of Human Biology, 27*(5), 681–689.

Bala, G. (1981). *Struktura i razvoj morfoloških i motoričkih dimenzija dece SAP Vojvodine*. Novi Sad: Fakultet fizičke kulture, Institut fizičke kulture. [in Serbian]

Bala, G., Stojanović, M. V., & Stojanović, M. (2007). *Merenje i definisanje motoričkih sposobnosti dece*. Novi Sad: Fakultet sporta i fizičkog vaspitanja. [in Serbian]

Barati, H., Tajrishi, M., & Sajedi, F. (2012). The effect of social skills training on socialization skills in children with Down syndrome. *Iranian Rehabilitation Journal, 10*(2), 35–38.

Barnett, L. M., Van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2008). Does childhood motor skill proficiency predict adolescent fitness? *Medicine & Science in Sports & Exercise, 40*(12), 2137–2144.

Bellows, L. L., Davies, P. L., Courtney, J. B., Gavin, W. J., Johnson, S. L., & Boles, R. E. (2017). Motor skill development in low-income, at-risk preschoolers: A community-based longitudinal intervention study. *Journal of Science and Medicine in Sport, 20*(11), 997–1002.

Costa, A. M., Costa, M. J., Reis, A. A., Ferreira, S., Martins, J., & Pereira, A. (2017). Secular trends in anthropometrics and physical fitness of young Portuguese school-aged children. *Acta Medica Portuguesa, 30*, 108–114.

Čillík, I., & Willwéber, T. (2018). Influence of an exercise programme on level of coordination in children aged 6 to 7.

Dapp, L. C., Gashaj, V., & Roebers, C. M. (2021). Physical activity and motor skills in children: A differentiated approach. *Psychology of Sport and Exercise, 54*, 101916.

Djordjević, M. M., Pantelić, S., Kostić, R., & Uzunović, S. (2015). The correlation between anthropometric characteristics and motor abilities in seven-year-old girls. *Facta Universitatis, Series: Physical Education and Sport*, 251–260.

Đermanović, M., Miletić, I., & Pavlović, Z. (2015). Analysis of macronutrient intake and body mass index in preschool children in the western region of the Republic of Srpska. *Srpski arhiv za celokupno lekarstvo, 143*(11–12), 695–700.

Eather, N., Morgan, P. J., & Lubans, D. R. (2013). Improving the fitness and physical activity levels of primary school children: Results of the Fit-4-Fun group randomized controlled trial. *Preventive Medicine, 56*(1), 12–19.

Field, S. C., & Temple, V. A. (2017). The relationship between fundamental motor skill proficiency and participation in organized

sports and active recreation in middle childhood. *Sports, 5*(2), 43.
Findak, V. (1999). *Metodika tjelesne i zdravstvene kulture*. Zagreb: Školska knjiga. [in Croatian]
Gallahue, D. L., & Donnelly, F. C. (2007). *Developmental physical education for all children*. Human Kinetics.
Hlaselo, D. (2020). *The relationship between morphological and physiological characteristics with performance of senior male cross-country runners in Gauteng Province*. University of Johannesburg.
Hennessy, E., Hughes, S. O., Goldberg, J. P., Hyatt, R. R., & Economos, C. D. (2010). Parent-child interactions and objectively measured child physical activity: A cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity, 7*, 1–14.
Herrmann, C., Heim, C., & Seelig, H. (2019). Construct and correlates of basic motor competencies in primary school-aged children. *Journal of Sport and Health Science, 8*(1), 63–70.
Hudda, M. T., Nightingale, C. M., Donin, A. S., Owen, C. G., Rudnicka, A. R., Wells, J. C., & Whincup, P. H. (2018). Patterns of childhood body mass index, overweight and obesity in South Asian and black participants. *International Journal of Obesity, 42*(4), 662–670.
Karim, O. A., Ammar, A., Chtourou, H., Wagner, M., Schlenker, L., Parish, A., & Bös, K. (2015). A comparative study of physical fitness among Egyptian and German children aged 6 to 10 years.
Kondrič, M., Mišigoj-Duraković, M., & Metikoš, D. (2017). A contribution to understanding relations between morphological and motor characteristics in 7- and 9-year-old boys.
Kurelić, N., Momirović, K., Stojanović, M., Šturm, J., Radojević, Đ., & Viskić-Štalec, N. (1975). *Struktura i razvoj morfoloških i motoričkih dimenzija omladine*. Institut za naučna istraživanja Fakulteta za fizičko vaspitanje. [in Serbian]
Malacko, J., & Radosav, R. (1985). *Uticaj programiranog vežbanja na psihosomatski status dece*. Novi Sad: Institut fizičke kulture. [in Serbian]
Malina, R. M., Eisenmann, J. C., Cumming, S. P., Ribeiro, B., & Aroso, J. (2004). Maturity-associated variation in the growth and functional capacities of youth football players. *European Journal of Applied Physiology, 91*, 555–562.
Malina, R. M. (2010). Physical activity and health of youth. *Ovidius University Annals, Series Physical Education and Sport, 10*(2).
Morano, M., Colella, D., & Caroli, M. (2011). Gross motor skill performance in overweight and non-overweight preschool children. *International Journal of Pediatric Obesity, 6*(Suppl 2), 42–46.
Obradović, J. (2008). *Osnove antropomotorike*. Novi Sad: Fakultet sporta i fizičkog vaspitanja.
Ogden, C. L., Flegal, K. M., Carroll, M. D., & Johnson, C. L. (2002). Prevalence and trends in overweight among US children and adolescents. *JAMA, 288*(14), 1728–1732.
Podstawski, R., & Borysławski, K. (2012). Relationships between selected anthropometric features and motor abilities of children aged 7–9. *Clinical Kinesiology, 66*(4), 82–90.
Renshaw, I., Chow, J. Y., Davids, K., & Hammond, J. (2010). A constraints-led perspective to skill acquisition and game play. *Physical Education and Sport Pedagogy, 15*(2), 117–137.
Sedlak, P., Pařízková, J., Daniš, R., Dvořáková, H., & Vignerová, J. (2015). Secular changes of adiposity and motor development in Czech preschool children. *BioMed Research International, 2015*.
Sheikh, M., Safania, A. M., & Afshari, J. (2011). Effect of selected motor skills on motor development of children aged 5 and 6 years. *Procedia - Social and Behavioral Sciences, 15*, 1723–1725.
Silventoinen, K., Maia, J., Li, W., Sund, R., Gouveia, É. R., Antunes, A., & Freitas, D. (2023). Genetic regulation of body size and morphology in children: A twin study. *International Journal of Obesity, 47*(3), 181–189.
Stodden, D., Langendorfer, S., & Roberton, M. A. (2009). The association between motor skill competence and physical fitness in young adults. *Research Quarterly for Exercise and Sport, 80*(2), 223–229.
Twisk, J. W. (2001). Physical activity guidelines for children and adolescents: A critical review. *Sports Medicine, 31*, 617–627.
Utkualp, N., & Ercan, I. (2015). Anthropometric measurements usage in medical sciences. *BioMed Research International, 2015*.
Vameghi, R., Shams, A., & Shamsipour Dehkordi, P. (2013). The effect of age, sex and obesity on fundamental motor skills among 4- to 6-year-old children. *Pakistan Journal of Medical Sciences, 29*(2).
Venetsanou, F., & Kambas, A. (2017). Can motor proficiency in preschool age affect physical activity in adolescence? *Pediatric Exercise Science, 29*(2), 254–259.

Primljen: 25. februar 2026. / Received: February 25, 2025
Prihvaćen: 15. maj 2026. / Accepted: May 15, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

https://doi.org/10.7251/SSH2601185J
Paper review
UDC: 615.21.015:796.01/.09
Pregledni rad

Sensory and motor neurones and spinal reflexes: a narrative review

Stefan Janković[1], Aleksandra Dominović-Kovačević[2,3], Oliver Krička[1], Sanja Gnjato[3]
[1]Faculty of Sports Science, PanEuropean University „Aperion" Banja Luka, Bosnia and Herzegovina,
[2]Clinic of Neurology, University Clinical Centre of the Republic of Srpska, Banja Luka, Bosnia and Herzegovina,
[3]Faculty of Medicine, University of Banja Luka, Banja Luka, Bosnia and Herzegovina

Correspondence:
Stefan Janković
Faculty of Sports Science, PanEuropean University „Aperion" Banja Luka, Bosnia and Herzegovina, stefan.z.jankovic@apeiron-edu.eu

Abstract: *Neurones are specialised, polarised cells that transmit electrical and chemical signals, underpinning both simple reflexes and complex motor behaviours. Sensory (afferent) neurones relay peripheral information to the central nervous system (CNS), while motor (efferent) neurones convey commands to skeletal muscles. Interneurones within the spinal cord integrate these signals, enabling coordinated motor output. The spinal cord's dorsal, ventral, and lateral horns support sensory processing, motor execution, and the integration of ascending and descending pathways. Spinal reflexes are rapid, stereotyped responses mediated by organised neural circuits. Monosynaptic reflexes, such as the myotatic (stretch) reflex, involve direct sensory–motor communication, regulated by γ-motoneurones and reciprocal inhibition to maintain muscle length and tone. Polysynaptic reflexes, including the flexor withdrawal reflex, engage interneurones to coordinate synergistic and antagonistic muscle activity, adapting to limb posture, stimulus location, and contextual factors. The inverse myotatic reflex, mediated by Golgi tendon organs, safeguards muscles and ligaments by modulating force during contraction. These reflexes employ reciprocal, non-reciprocal, presynaptic, and recurrent inhibitory mechanisms, collectively ensuring precise, adaptable, and stable motor control. A detailed understanding of sensory and motor neurone organisation and spinal reflex dynamics is essential for elucidating human movement, informing clinical assessment, and guiding neuromuscular rehabilitation.*

Keywords: *sensory neurons, motor neurons, spinal reflexes*

Introduction

Neurones are highly polarised specialised cells (Seong, Yuan, & Arikkath, 2015) that act as the primary communicators which transmit electrical and chemical signals across complex neural circuits, enabling everything from simple reflexes to advanced problem-solving (Rasband, 2016). So, according to the functions, neurones can be classified into three categories: sensory or afferent neurones, motor or efferent neurones, and interneurones (Chan et al., 2025).

The human spinal cord is a highly organised, complex part of the central nervous system (the CNS) whose function is to ensure the conduction of neural signals from the peripheral nervous system to the brain and from the brain to the peripheral nervous system, which are relayed and controlled by the spinal interneurones (De Leener, Taso, Cohen-Adad, & Callot, 2016). Therefore, the spinal cord is divided into posterior (dorsal), anterior (ventral) and lateral (middle) horns and is surrounded by ascending and descending tracts (the white matter), which is divided by the grey matter into posterior, lateral and anterior columns (Cho, 2015). So, the dorsal segment (the dorsal horns) mediates exteroceptive sensory processing, the ventral segment (the ventral horns) is crucial for motor execution and the generation of rhythmic motor behaviour, while the middle segment is thought to play a major role in the integration of ascending and descending information for fine-tuning motor output (Ossewald & Pfaff, 2019).

The reflex arc is the anatomical nervous pathway (Jaiswal & Morankar, 2017) which is responsible for the passage of nervous impulses from the receptors to the CNS by the afferent tracts and for the transport of electric impulses to target organs (muscles) by the efferent tracts (Nuzhna, Iakovenko, Gryshchenko, Cherno, Khmyzova, & Yastremskiy, 2018). So, the reflex is defined as an involuntary, qualitatively unchanging reaction of the nervous system to a specific stimulus, and it has five basic components: different receptors, the sensory or afferent neurones, receptors of the CNS, the motor or efferent neurones, and the effectors (e.g., organs and muscles) (Costa, da Veiga Argus, Pisetta, & Evangelista, 2020). Therefore, reflexes play multiple roles, such as for posture, for locomotion, and for maintaining homeostasis in the organism (Costa et al., 2020), and they have a protective role for the body from irreparable damage (Jaiswal & Morankar, 2017).

This review summarises the current knowledge about the sensory and motor neurones and the spinal reflexes based on the literature review with the aim to describe them as well as mechanisms of their action.

Method

This manuscript presents a narrative review and does not report any original data. The literature included in this review was identified through searches of PubMed, which served as the primary database, and Google Scholar, which was used as a supplementary database. The search strategy employed the following terms and Boolean operators: ("sensory neurone" OR "afferent neurone") AND ("motor neurone" OR "efferent neurone") AND ("reflexes" OR "spinal reflexes"). In addition, reference lists of the selected articles were manually screened to identify further relevant publications.

The inclusion criteria comprised full-text articles published in English within the last ten years that focused on key components of the CNS as the primary subject of investigation. Exclusion criteria included conference abstracts and articles without full-text availability, publications not written in English, articles published more than ten years prior to the search, and studies that did not address the specified key components of the CNS.

Sensory neurones

Sensory neurones possess only afferent fibres, and they carry the information obtained from the interior of the body and the external environment to the CNS (Varga & Mravec, 2015). Sensory neurones are primary afferents originating from the neural crest that convey information from the periphery to the central nervous system (Crawford & Caterina, 2020). Their axons enter the spinal cord via the dorsal roots, where sensory input is organised by modality and relayed to second-order neurones in the dorsal horn, and the cell bodies of these neurones are located in the dorsal root ganglia and display a pseudounipolar morphology that supports efficient signal transmission (Middleton, Perez-Sanchez, & Dawes, 2021). Somatosensory afferent fibres mediate modalities such as nociception, touch, and proprioception and together form the somatosensory system, which transmits sensory information from peripheral receptors to central targets (Crawford & Caterina, 2020).

Muscle spindle

Muscle spindles are the primary proprioceptive sensory organs that continuously inform the CNS about muscle length and movement (Kröger, 2018). Most human skeletal muscles contain numerous muscle spindle organs (Dimitrou, 2022), which play a key sensory role in the physiology of these muscles (Sun, Fede, Zhao, Del Felice, Pirri, & Steco, 2024). Accordingly, the muscle spindle is described as a mechano-sensory organ that detects and mediates both static and dynamic information about skeletal muscle fibre length and stretch, transmitting this sensory information to the CNS, where it contributes to the generation of appropriate motor responses (Barrett, Quick, Mudera, & Player, 2020). The muscle spindle is an encapsulated sensory organ located in parallel with extrafusal muscle fibres (Wilkinson, 2022) within the belly of skeletal muscles and is innervated by one primary (group Ia) and several secondary (group II) proprioceptive sensory neurones. These neurones respond to stretch of the intrafusal fibres, such that voluntary or passive changes in limb position (i.e., muscle length) lead to increased or decreased firing rates (Oliver, Florez-Paz, Badea, Mentis, Menon, & de Nooij, 2021). There are three types of intrafusal fibres within the muscle spindle: large nuclear bag 1 fibres, larger nuclear bag 2 fibres, and smaller nuclear chain fibres (Sun et al., 2024).

In humans, the sensory innervation of the muscle spindle arises from both group Ia and group II afferent fibres, sometimes referred to as type Ia or type II fibres, respectively (Kröger & Watkins, 2021). Type Ia afferent nerve terminals form annulospiral endings (primary endings), innervating all intrafusal fibres and showing peak responsiveness to variations in muscle fibre length and stretch magnitude. By contrast, type II afferent neurones (secondary endings) innervate nuclear bag 2 fibres and chain fibres and exhibit maximal activity in response to muscle-stretch magnitude (Sun et al., 2024). Under passive conditions, type Ia fibres exhibit both strong dynamic and fairly good static muscle-length sensitivity, whereas type II fibres primarily demonstrate static length sensitivity with lower dynamic sensitivity. These response patterns align with the general view that type Ia firing encodes both static muscle length and stretch velocity, while type II firing encodes static muscle length (Dimitriou, 2022). Overall, the muscle spindle functions as a stretch sensor that measures both the magnitude and speed of muscle length changes, as intrafusal fibres extend in parallel with the associated muscle fibres, generating action potentials in afferent sensory neurones according to the degree and rate of stretch (Côté, Murray, & Knikou, 2018).

Golgi tendon organ

Golgi tendon organs are mechanoreceptive structures located at the myotendinous junctions of skeletal muscles (Oliver, Florez-Paz, Badea, Mentis, Menon, & de Nooij, 2020). They are innervated by large-diameter Ib proprioceptive sensory neurones, with group Ib afferent terminals interweaving among the collagen fibres that connect extrafusal muscle fibres to tendons or aponeuroses (Imai & Yoshida, 2018; de Nooij, 2022). Golgi tendon organ afferents are highly sensitive to extrafusal muscle contraction, which tensions the collagen fibres and increases afferent firing, allowing detection of changes in muscle tension (Lyle & Nichols, 2019; Imai & Yoshida, 2018). These organs are most effectively stimulated by active contractile force and can detect forces as small as those generated by single muscle fibres (Nichols, 2018). Ib afferents exhibit similar activation thresholds and conduction velocities to group Ia afferents but respond to different stimuli: they are dynamically sensitive to rapid changes in contractile force while showing minimal activation during muscle stretch (Oliver et al., 2020). Golgi tendon organs provide force feedback that, in combination with muscle spindle-mediated length signals, regulates locomotor step cycles and contributes to postural balance and stability (Nichols, 2018; Imai & Yoshida, 2017).

Receptors

The skin contains a complex network of sensory nerve fibres located in both the epidermis and dermis, which transmit sensations such as pain, burning, and itching to specific areas of the brain (Ashrafi, Baguneid, & Bayat, 2015). Mechanoreceptors in the epidermis include Merkel discs with free nerve endings, whereas those in the dermis comprise Ruffini, Meissner, and Pacinian corpuscles with free nerve endings (Ashrafi, Baguneid, & Bayat, 2015). These receptors are classified according to their adaptation speed, with some responding rapidly and briefly (rapidly adapting) and others maintaining firing during sustained stimuli (slowly adapting) (Bear, Connors, & Paradiso, 2020).

Fast-adapting type II (FAII) Aβ afferent fibres correspond to Pacinian and Meissner corpuscles and are highly sensitive to dynamic skin interactions, such as skin slip, motion, and vibrations, including those occurring between the skin and an object. Slowly adapting type I (SAI) mechanoreceptors include Merkel discs and Ruffini endings. Merkel cell–neurite complexes are concentrated in areas requiring fine tactile resolution and are essential for detecting texture and object shape. Ruffini endings, in contrast, are particularly suited for sensing cutaneous stretch and joint movement (Kardashina, 2025).

Motor neurones

Motor function in humans arises from the neuromechanical interplay within the integrated neuromusculoskeletal system and is achieved through neural control of muscle contractions that generate interaction forces across the skeletal system (Sartori, Yavuz, & Farina, 2017). Motor neurones are efferent neurones responsible for transmitting motor commands to skeletal muscles. Those located entirely within the CNS are classified as upper motor neurones, whereas lower motor neurones have cell bodies within the CNS—either in the brainstem or spinal cord—but project axons through peripheral nerves to innervate skeletal muscle fibres (Cheng, Mah, & Seluakumaran, 2021). Motor neurones may also be classified according to their muscle targets. Alpha motor neurones innervate force-generating extrafusal muscle fibres, beta motor neurones innervate both intrafusal and extrafusal fibres, and gamma motor neurones innervate the intrafusal fibres of the muscle spindle (Wilkinson, 2021). Functionally, motor neurones regulate the magnitude of muscle force production (Sartori, Yavuz, & Farina, 2017) and generate mechanical forces essential for physical interaction with the environment (Hug, Avrillon, Ibanez, & Farina, 2023). Moreover, they are fundamental to all skeletal and smooth muscle contractions in the body, contributing to the control of physiological processes such as blood pressure regulation and sweat secretion through their role in activating muscle fibres (Blum et al., 2021).

Gamma motoneurones

Gamma motoneurones are small fusimotor neurones that constitute approximately 30% of all motoneurones in the ventral horn of the spinal cord and induce contraction of sarcomeres in the polar regions, thereby generating tension in the central region of intrafusal muscle fibres (Kröger & Watkins, 2021). Static gamma motoneurones innervate bag 2 and/or chain intrafusal fibres, whereas dynamic gamma motoneurones innervate bag 1 fibres (Wilkinson, 2021). Static gamma motoneurones are thought to encode centrally planned joint angle information and reinforce the intended joint position through regulation of muscle spindle sensitivity. In contrast, dynamic gamma motoneurones

are associated with the encoding of joint acceleration within the planned movement trajectory (Li et al., 2015). Together, these neurones modulate intrafusal fibre tension, sensitivity, and length, enabling muscle spindles to maintain consistent sensitivity during dynamic muscle activity and to prevent excessive muscle stretch that may impose undue stress on muscles, tendons, and joints (Colón, Guo, Akanda, Cai, & Hickman, 2017). Consequently, gamma motoneurones play a crucial role in motor control, locomotion, and balance (Matthews, 2015).

Alpha motoneurones

Alpha motoneurones constitute the final effector component of the lower motor system (de Carvalho & Swash, 2016). They are located within the cranial and spinal motor nuclei (Lemon, 2021) and transform synaptic motor commands into precisely patterned discharges that generate muscle force (Beauchamp, Pearcey, Khurram, Negro, Dewald, & Heckman, 2025). These neurones are specialised to support the extensive repertoire of human motor behaviours (Johnson, Thompson, Tysseling, Powers, & Heckman, 2017), including the regulation of mechanical actuation, muscle tension, and relaxation via extrafusal muscle fibres, as well as the control of muscle contraction dynamics (Colón, Guo, Akanda, Cai, & Hickman, 2017).

The axons of alpha motoneurones, referred to as anterior horn cells in the spinal cord, project through peripheral nerves to innervate skeletal muscle fibres. All muscle fibres innervated by a single alpha motoneurone form a motor unit and exhibit similar mechanical, histochemical, and physiological properties, resulting in comparable contraction and relaxation velocities, fatigability, and force-generating capacity. Within the spinal cord, alpha motoneurones innervating distal limb muscles are positioned laterally in the cervical and lumbar enlargements, whereas those supplying proximal and axial muscles are located progressively more medially. Alpha motoneurones within cranial nerve nuclei innervating cranial musculature are distributed across the medulla, pons, and midbrain (de Carvalho & Swash, 2016).

Alpha-gamma co-activation

Alpha–gamma co-activation is the concurrent activation of alpha and gamma motoneurones by the central nervous system to sustain muscle spindle firing (Cheng, Mah, & Seluakumaran, 2021). This mechanism, consistently observed during movement and postural control, ensures spindle tension during extrafusal muscle contraction (Li et al., 2015; Dimitrou, 2022). Gamma motoneurones maintain the non-contractile central region of intrafusal fibres taut, preserving afferent sensitivity and enabling rapid responses to minimal changes in muscle length (Cheng, Mah, & Seluakumaran, 2021). Co-activation is particularly critical for fine motor control, such as in hand movements, and is evident during isometric or slow, constrained actions (Dimitrou, 2022; Cheng, Mah, & Seluakumaran, 2021).

Spinal reflexes

Spinal reflexes are involuntary and highly stereotyped motor responses mediated by well-defined neural pathways. The simplest reflex arc comprises a sensory receptor that detects the stimulus, an afferent neurone transmitting the signal to the spinal cord, and an efferent motor neurone conveying the response to the effector, typically a skeletal muscle fibre (Cheng, Mah, & Seluakumaran, 2021). In monosynaptic reflexes, direct synaptic communication occurs between the afferent and motor neurones, with a single synapse located within the spinal cord (Cheng et al., 2021). These reflexes generally involve a single muscle group within an agonist–antagonist pair and are commonly accompanied by inhibition of the antagonist muscle to ensure efficient movement execution (Latash, 2018).

More complex reflex actions are mediated by polysynaptic pathways, in which interneurones constitute a critical functional component. Interneurones exhibit considerable functional versatility, as they may act as first-order or last-order neurones across different spinal reflexes, participate in multiple neural networks, and contribute to a wide range of motor behaviours (Côté, Murray, & Knikou, 2018). Within antagonist muscle systems, reflex regulation is achieved through reciprocal and presynaptic inhibition, whereas synergistic muscle systems rely on non-reciprocal (Ib) inhibition and recurrent inhibition mediated by Renshaw cells (Gladchenko et al., 2022).

Reciprocal inhibition between agonist and antagonist muscles represents a fundamental mechanism of spinal motor control. This process is mediated by Ia inhibitory interneurones and ensures the precise temporal coordination of flexor and extensor muscle activity during movement (Jankowska, 2022; Chelnokov & Gorodnichev, 2021). Presynaptic inhibition further modulates spinal reflex activity by limiting excessive afferent input to central neural circuits (Gladchenko et al., 2022). Muscle afferent volleys can depress monosynaptic reflexes by reducing excit-

atory postsynaptic potentials or motoneuronal excitability, thereby preventing excessive reflex activation (Côté et al., 2018). This mechanism plays an essential role in regulating skeletal muscle tone, facilitating voluntary movement and postural control (Gladchenko et al., 2022).

Non-reciprocal inhibition, also referred to as autogenic inhibition, involves the suppression of motoneuronal activity without a reciprocal inhibitory effect on the initiating neurones (Ramia et al., 2020). This process is primarily mediated by Ib afferent fibres originating from Golgi tendon organs, which respond to excessive muscle tension by inhibiting α-motoneurones, thereby reducing efferent output and promoting muscle elongation (Mostafa & Elshafey, 2018; Takahashi et al., 2023). Recurrent postsynaptic inhibition, mediated by Renshaw cells, provides a negative feedback mechanism that limits α-motoneurone firing frequency and constrains excessive muscular force production (Chelnokov et al., 2022). Collectively, these inhibitory spinal mechanisms ensure the stability, precision, and adaptability of human motor control.

Myotatic (stretch) reflex

The myotatic (stretch) reflex is an automatic response in which a muscle contracts following passive stretching, thereby regulating muscle length within physiological limits. Muscle elongation activates intrafusal fibres within the muscle spindle, increasing the firing rate of spindle afferents and enhancing α-motoneurone activity, which induces contraction of the extrafusal muscle fibres and resists further stretch. The sensitivity of this reflex is modulated by γ-motoneurones through adjustment of spindle fibre tension. Concurrently, reciprocal inhibition suppresses activity in the antagonistic muscles, allowing coordinated regulation of muscle length and the maintenance of stable muscle tone (Bhattacharyya, 2017).

In the myotatic reflex, the muscle spindle functions as an intramuscular receptor that detects changes in muscle length. Mechanical stimulation, such as tendon tapping, stretches the spindle and generates afferent action potentials that enter the spinal cord via the dorsal horn, thereby eliciting the reflex response. Accurate induction and assessment of the myotatic reflex require appropriate instruments, correct technique, and reliable evaluation procedures. The National Institute of Neurological Disorders and Stroke (NINDS) has adopted the NINDS myotatic reflex scale as the standard clinical tool for assessing muscle stretch reflexes, with its reliability validated by Litvan et al. (1996). The scale grades reflex responses from 0 (absent) to 4 (exaggerated, including clonus), with intermediate values reflecting increasing reflex amplitude within the normal range (Lin-Wei et al., 2021). Alternatively, reflexes may be described qualitatively using symbolic notation, ranging from absent (–) to very brisk (+++) (Lees & Hurwitz, 2019).

Myotatic reflex assessment is routinely performed in both the upper and lower limbs. In the upper limbs, the biceps, brachioradialis (supinator), and triceps reflexes are most commonly examined, while in the lower limbs the patellar and Achilles reflexes are standardly tested. Detailed and standardised protocols for the evaluation of these reflexes have been described by Lees and Hurwitz (2019) and Lin-Wei et al. (2021).

Goldi tendon (inverse myotatic) reflex

The inverse myotatic reflex originates from Golgi tendon organs, which detect increased muscle tension via Ib afferent fibres and activate spinal interneurones that inhibit Ia afferents. Concurrently, γ-motoneurones innervate intrafusal fibres, maintaining muscle spindle sensitivity during contraction (Naumović, 2018). By regulating motor unit activity in response to stimulus frequency, this reflex helps control muscle force (Adidharma et al., 2022; Köse, Akşit, Açıkgöz, & Ceyhan, 2023). Functioning as an adaptive protective mechanism, the inverse myotatic reflex prevents muscle or ligament injury from joint hyperextension, while increased reflex amplitude reflects synchronized depolarisation of muscle fibres (Pechlivanidou et al., 2024).

Flexor (withdrawal) reflex

The flexor withdrawal reflex is an involuntary limb response that moves the body away from a painful stimulus (Thorell et al., 2023). It is widely used to assess the functional integrity of nociceptive spinal pathways (Dafkin, Green, Oliver, McKinon, & Kerr, 2018), enabling rapid retraction of the affected area from actual or potential harm (Jure et al., 2019). Mediated by polysynaptic spinal circuits, this reflex is influenced by factors such as limb posture, site of stimulation, gait phase, psychological state, and pain threshold (Jure et al., 2019). Functionally, it involves coordinated activation of synergistic muscles to flex the stimulated limb, inhibition of antagonists, and compensatory

movements in the contralateral limb to maintain balance, recruiting multiple muscle groups and joint actions depending on the stimulus location (Henrich, Frahm, & Andersen, 2021).

Summary

Spinal reflexes are rapid motor responses initiated when a stimulus reaches the spinal cord via sensory (afferent) neurones. The information is processed within the spinal centres, and a response is transmitted through motor (efferent) neurones to effectors, resulting in muscle contraction and/or modulation of muscle tension.

Reference

Adidharma, W., Khouri, A. N., Lee, J. C., Vanderboll, K., Kung, T. A., Cederna, P. S., & Kemp, S. W. (2022). Sensory nerve regeneration and reinnervation in muscle following peripheral nerve injury. *Muscle & Nerve*, *66*(4), 384-396.

Ashrafi, M., Baguneid, M., & Bayat, A. (2015). *Cutaneous sensory innervation: structure, function, and clinical significance. Journal of Plastic, Reconstructive & Aesthetic Surgery, 68*(6), 803–813. https://doi.org/10.1016/j.bjps.2015.02.014

Barrett, P., Quick, T. J., Mudera, V., & Player, D. J. (2020). Generating intrafusal skeletal muscle fibres *in vitro*: Current state of the art and future challenges. *Journal of tissue engineering*, *11*, 2041731420985205. https://doi.org/10.1177/2041731420985205

Bear, M., Connors, B., & Paradiso, M. A. (2020). *Neuroscience: Exploring the brain, enhanced edition: Exploring the brain*. Jones & Bartlett Learning.

Beauchamp, J. A., Pearcey, G. E. P., Khurram, O. U., Negro, F., Dewald, J. P. A., & Heckman, C. J. (2025). Intrinsic properties of spinal motoneurons degrade ankle torque control in humans. *The Journal of physiology*, *603*(8), 2443–2463. https://doi.org/10.1113/JP287446

Bhattacharyya, K. B. (2017). The stretch reflex and the contributions of C David Marsden. *Annals of Indian Academy of Neurology*, *20*(1), 1-4.

Blum, J. A., Klemm, S., Shadrach, J. L., Guttenplan, K. A., Nakayama, L., Kathiria, A., Hoang, P. T., Gautier, O., Kaltschmidt, J. A., Greenleaf, W. J., & Gitler, A. D. (2021). Single-cell transcriptomic analysis of the adult mouse spinal cord reveals molecular diversity of autonomic and skeletal motor neurons. *Nature neuroscience*, *24*(4), 572–583. https://doi.org/10.1038/s41593-020-00795-0

Chan, M. K., Jumat, M. I., Landa, F., Saili, N. S., Jambo, S. A., Florentius, D., ... & Lakey, J. R. (2025). Exploring the Complexity of the Human Brain: Cell Types, Numbers, and Lobar Functions. *Am J Biomed Sci & Res*, *26*(4).

Chelnokov AA, Gorodnichev RM. (2021) Patterns of Spinal Inhibition Formation in Humans. *Moscow: INFRA-M Academic Publishing* LLC192 p. Russian. https://doi.org/10.12737/1039428.

Chelnokov, A. A., Roshchina, L. V., Gladchenko, D. A., Pivovarova, E. A., Piskunov, I. V., & Gorodnichev, R. M. (2022). The effect of transcutaneous electrical spinal cord stimulation on the functional activity of spinal inhibition in the system of synergistic muscles of the lower leg in humans. *Human Physiology*, *48*(2), 121-133.

Cheng, H. M., Mah, K. K., & Seluakumaran, K. (2021). Motor System. In *Defining Physiology: Principles, Themes, Concepts. Volume 2: Neurophysiology and Gastrointestinal Systems* (pp. 107-112). Cham: Springer International Publishing.

Cho, T. A. (2015). Spinal cord functional anatomy. CONTINUUM: lifelong learning in neurology, 21(1), 13-35. https://doi.org/10.1212/01.CON.0000461082.25876.4a

Colón, A., Guo, X., Akanda, N., Cai, Y., & Hickman, J. J. (2017). Functional analysis of human intrafusal fiber innervation by human γ-motoneurons. *Scientific reports*, *7*(1), 17202. https://doi.org/10.1038/s41598-017-17382-2

Costa, A. F. B. A., da Veiga Argus, A. P., Pisetta, F. P., & Evangelista, A. G. (2020). Basic background in reflex physiology. *Journal of Molecular Pathophysiology*, *9*(1), 1-8.

Côté, M. P., Murray, L. M., & Knikou, M. (2018). Spinal Control of Locomotion: Individual Neurons, Their Circuits and Functions. *Frontiers in physiology*, *9*, 784. https://doi.org/10.3389/fphys.2018.00784

Crawford, L. K., & Caterina, M. J. (2020). Functional Anatomy of the Sensory Nervous System: Updates From the Neuroscience Bench. *Toxicologic pathology*, *48*(1), 174–189. https://doi.org/10.1177/0192623319869011

Dafkin, C., Green, A., Olivier, B., Mckinon, W., & Kerr, S. (2018). Circadian variation of flexor withdrawal and crossed extensor reflexes in patients with restless legs syndrome. *Journal of sleep research*, *27*(5), e12645. https://doi.org/10.1111/jsr.12645

de Carvalho, M., & Swash, M. (2016). Lower motor neuron dysfunction in ALS. *Clinical neurophysiology: official journal of the International Federation of Clinical Neurophysiology*, *127*(7), 2670–2681. https://doi.org/10.1016/j.clinph.2016.03.024

De Leener, B., Taso, M., Cohen-Adad, J., & Callot, V. (2016). Segmentation of the human spinal cord. *Magma (New York, N.Y.)*, *29*(2), 125–153. https://doi.org/10.1007/s10334-015-0507-2

de Nooij J. C. (2022). MS and GTO proprioceptor subtypes in the molecular genetic era: Opportunities for new advances and perspectives. *Current opinion in neurobiology*, *76*, 102597. https://doi.org/10.1016/j.conb.2022.102597

Dimitriou M. (2022). Human muscle spindles are wired to function as controllable signal-processing devices. *eLife*, *11*, e78091. https://doi.org/10.7554/eLife.78091

Gladchenko, D. A., Roshchina, L. V., Bogdanov, S. M., & Chelnokov, A. A. (2022). Effect of transcutaneous electrical spinal cord stimulation on the functional activity of reciprocal and presynaptic inhibition in healthy subjects. *Russian Open Medical Journal*, *11*(3), 302.

Henrich, M. C., Frahm, K. S., & Andersen, O. K. (2021). Tempo-spatial integration of nociceptive stimuli assessed via the nociceptive withdrawal reflex in healthy humans. *Journal of neurophysiology*, *126*(2), 373–382. https://doi.org/10.1152/jn.00155.2021

Hug, F., Avrillon, S., Ibáñez, J., & Farina, D. (2023). Common synaptic input, synergies and size principle: Control of spinal motor neurons for movement generation. *The Journal of physiology*, *601*(1), 11–20. https://doi.org/10.1113/JP283698

Imai, F., & Yoshida, Y. (2018). Molecular mechanisms underlying monosynaptic sensory-motor circuit development in the spinal cord. *Developmental dynamics: an official publication of the American Association of Anatomists*, *247*(4), 581–587. https://doi.org/10.1002/dvdy.24611

Jaiswal, M., & Morankar, R. (2017). Understanding primitive reflexes and their role in growth and development: A review. *International Healthcare Research Journal*, *1*(8), 243-247.

Jankowska E. (2022). Basic principles of processing of afferent information by spinal interneurons. *Journal of neurophysiology*, *128*(3), 689–695.

https://doi.org/10.1152/jn.00344.2022
Johnson, M. D., Thompson, C. K., Tysseling, V. M., Powers, R. K., & Heckman, C. J. (2017). The potential for understanding the synaptic organization of human motor commands via the firing patterns of motoneurons. *Journal of neurophysiology*, *118*(1), 520–531. https://doi.org/10.1152/jn.00018.2017
Jure, F. A., Arguissain, F. G., Biurrun Manresa, J. A., & Andersen, O. K. (2019). Conditioned pain modulation affects the withdrawal reflex pattern to nociceptive stimulation in humans. *Neuroscience*, *408*, 259–271. https://doi.org/10.1016/j.neuroscience.2019.04.016
Kardashina, T. (2025). Review of mechanoreceptors and the neural processing of touch sensations.
Köse, D. E., Akşit, T., Açıkgöz, O., & Ceyhan, G. (2023). Time course of changes in straddle jump and vertical jump performance after acute static stretching in artistic gymnasts. *Science of Gymnastics Journal*, *15*(1), 75-85.
Kröger S. (2018). Proprioception 2.0: novel functions for muscle spindles. *Current opinion in neurology*, *31*(5), 592–598. https://doi.org/10.1097/WCO.0000000000000590
Kröger, S., & Watkins, B. (2021). Muscle spindle function in healthy and diseased muscle. *Skeletal muscle*, *11*(1), 3. https://doi.org/10.1186/s13395-020-00258-x
Latash M. L. (2018). Muscle coactivation: definitions, mechanisms, and functions. *Journal of neurophysiology*, *120*(1), 88–104. https://doi.org/10.1152/jn.00084.2018
Lees, A. J., & Hurwitz, B. (2019). Testing the reflexes. *Bmj*, *366*.
Lemon R. N. (2021). The Cortical "Upper Motoneuron" in Health and Disease. *Brain sciences*, *11*(5), 619. https://doi.org/10.3390/brainsci11050619
Li, S., Zhuang, C., Hao, M., He, X., Marquez, J. C., Niu, C. M., & Lan, N. (2015). Coordinated alpha and gamma control of muscles and spindles in movement and posture. *Frontiers in computational neuroscience*, *9*, 122. https://doi.org/10.3389/fncom.2015.00122
Lin-Wei, O., Xian, L. L. S., Shen, V. T. W., Chuan, C. Y., Halim, S. A., Ghani, A. R. I., Idris, Z., & Abdullah, J. M. (2021). Deep Tendon Reflex: The Tools and Techniques. What Surgical Neurology Residents Should Know. *The Malaysian journal of medical sciences:MJMS*, *28*(2), 48–62. https://doi.org/10.21315/mjms2021.28.2.5
Lyle, M. A., & Nichols, T. R. (2019). Evaluating intermuscular Golgi tendon organ feedback with twitch contractions. *The Journal of physiology*, *597*(17), 4627–4642. https://doi.org/10.1113/JP277363
Matthews P. B. (2015). Where Anatomy led, Physiology followed: a survey of our developing understanding of the muscle spindle, what it does and how it works. *Journal of anatomy*, *227*(2), 104–114. https://doi.org/10.1111/joa.12345
Middleton, S. J., Perez-Sanchez, J., & Dawes, J. M. (2022). The structure of sensory afferent compartments in health and disease. *Journal of anatomy*, *241*(5), 1186–1210. https://doi.org/10.1111/joa.13544
Mostafa, M. S. E., & Elshafey, M. A. (2018). Autogenic inhibition versus reciprocal inhibition techniques on spastic children
Naumović, N. (2018). Spasticity-a result of central nervous system injury. *Medicinski pregled*, *71*(1-2), 5-8.
Nichols T. R. (2018). Distributed force feedback in the spinal cord and the regulation of limb mechanics. *Journal of neurophysiology*, *119*(3), 1186–1200. https://doi.org/10.1152/jn.00216.2017
Nuzhna, O., Iakovenko, N., Gryshchenko, G., Cherno, V., Khmyzova, O., & Yastremskiy, V. (2018). Human Anatomy Study Guide. The Reflex Arc. The Neural Pathways (Afferent and Efferent Tracts).
Oliver, K. M., Florez-Paz, D. M., Badea, T. C., Mentis, G. Z., Menon, V., & de Nooij, J. C. (2020). Molecular development of muscle spindle and Golgi tendon organ sensory afferents revealed by single proprioceptor transcriptome analysis. *BioRxiv*, 2020-04.
Oliver, K. M., Florez-Paz, D. M., Badea, T. C., Mentis, G. Z., Menon, V., & de Nooij, J. C. (2021). Molecular correlates of muscle spindle and Golgi tendon organ afferents. *Nature communications*, *12*(1), 1451. https://doi.org/10.1038/s41467-021-21880-3
Osseward, P. J., 2nd, & Pfaff, S. L. (2019). Cell type and circuit modules in the spinal cord. *Current opinion in neurobiology*, *56*, 175–184. https://doi.org/10.1016/j.conb.2019.03.003
Pechlivanidou, E., Livanou, M. E., Papadopetraki, A., Zambelis, T., & Philippou, A. (2024). Performance characteristics and lower limb muscle reflex properties in female volleyball athletes and non-athletes. *Sport Sciences for Health*, *20*(4), 1317-1323.
Ramia, N. E., Mangavel, C., Gaiani, C., Muller-Gueudin, A., Taha, S., Revol-Junelles, A. M., & Borges, F. (2020). Nested structure of intraspecific competition network in Carnobacterium maltaromaticum. *Scientific Reports*, *10*(1), 7335.
Rasband M. N. (2016). Glial Contributions to Neural Function and Disease. *Molecular & cellular proteomics: MCP*, *15*(2), 355–361. https://doi.org/10.1074/mcp.R115.053744
Sartori, M., Yavuz, U. Ş., & Farina, D. (2017). In Vivo Neuromechanics: Decoding Causal Motor Neuron Behavior with Resulting Musculoskeletal Function. *Scientific reports*, *7*(1), 13465. https://doi.org/10.1038/s41598-017-13766-6
Seong, E., Yuan, L., & Arikkath, J. (2015). Cadherins and catenins in dendrite and synapse morphogenesis. *Cell adhesion & migration*, *9*(3),202–213.
Sun, Y., Fede, C., Zhao, X., Del Felice, A., Pirri, C., & Stecco, C. (2024). Quantity and Distribution of Muscle Spindles in Animal and Human Muscles. *International journal of molecular sciences*, *25*(13), 7320. https://doi.org/10.3390/ijms25137320
Takahashi, R., Wang, Y., Wang, J., Jiang, Y., & Hosoda, K. (2023). Implementation of basic reflex functions on musculoskeletal robots driven by pneumatic artificial muscles. *IEEE Robotics and Automation Letters*, *8*(4), 1920-1926.
Thorell, O., Ydrefors, J., Svantesson, M., Gerdle, B., Olausson, H., Mahns, D. A., & Nagi, S. S. (2023). Investigations into an overlooked early component of painful nociceptive withdrawal reflex responses in humans. *Frontiers in pain research (Lausanne, Switzerland)*, *3*, 1112614. https://doi.org/10.3389/fpain.2022.1112614
Varga, I., & Mravec, B. (2015). Nerve fiber types. In *Nerves and nerve injuries* (pp. 107-113). Academic Press.
Wilkinson K. A. (2022). Molecular determinants of mechanosensation in the muscle spindle. *Current opinion in neurobiology*, *74*, 102542. https://doi.org/10.1016/j.conb.2022.102542

Primljen: 28. januar 2026. / Received: Januar 28, 2026
Prihvaćen: 25. april 2026. / Accepted: April 25, 2026

This work is licensed under a **Creative Commons Attribution-NonCommercial 4.0 International License**.

Instruction for authors submitting papers

TITLE OF PAPER (TWO LINES AT THE MOST)

First and last name of the first author[1], First and last name of the second author[2]

[1]Name of the Organization, [2]Name of the Organization

Abstract: Every paper must contain the abstract. You should bring basic idea with final results of research to abstract. Paper should be written according the guideline bellow. Abstract may contain up to 250 words.

Keywords: Maximum of five, key words or phrases, separated by commas.

The paper must contain clear introduction, problem statement, method of resolving the problem, results, conclusion, and references. It shoud not contain more than 8 pages of A4 format (21 x 29.7 cm) including figures, tables, references. Paper margins must be: top and bottom 2.5 cm, inside 2.5 cm and outside 2 cm. Pages are not ought to be numbered.

The paper title (use 12 point Times New Roman type of text; the title must be highlighted with Bold option) should be positioned in the middle of the first page, shifted two spaces, font size 10pt, below top margin. After the title, one should leave one space, font size10 pt. The paper must be sent to the Scientific Board in electronic form (DOC) via *Paper Submission Form*, or as an email attachment to *siz@apeiron-edu.eu*.

There should be a caption above the table, which says, for example „Table 1. Intercorrelation matrix". Below the figure, there should be the figure number and legend, for example "Figure 3: Work with preschoolers".

The Editorial Board accepts manuscripts written in English (American English or British English) and optionally in Slavic language.

Manuscripts may be rejected if written in poor English or Slavic language. The author is fully responsible for the style (formal, unbiased in any sense), language, and content of the paper. Yet, the Editorial Board has the right to comment on the form and language of the paper before it is accepted for publication. A good, standard command of grammar is expected in written English. Please, avoid non-standard abbreviations.

REFERENCE

It is necessary to cite all sources used for your paper. APA citation style is recommended.

Authors must write the Contact of the corresponding author with his/her full name, academic title, institution, address, e-mail address and phone number (optionally).

REVIEW PROCESS

Submissions to the journal will initially be evaluated by the Editorial Board using several criteria: the appropriateness of the topic and content for the journal; the editing (preparation of the manuscript) and format; and "general" merit. If these criteria are met, the submission will undergo a double-blind review process by at least two acknowledged and independent reviewers, with the review process taking up to 8 weeks.

Only the papers that receive positive reviews will be accepted. One of the crucial reasons for the review is to provide quotations and references of relevant literature. The Editorial Board has the right to comment on the form of the paper before it is accepted for publication. The Editorial Board is not obliged to publish papers in chronological sequence of their receipt or in the sequence in which they have been accepted for publication. No substantial part of the submission should have been published elsewhere. The adducing of the results in extracts, summaries, abstracts, dissertations and Master's theses, reviews and conference papers (up to three pages, containing abstracts, graphical presentations and references) are not considered as publishing. If the manuscript contains the results that have already been published, the author(s) must get the consent of the first publisher and quote the source clearly.

Uputstvo za autore

NASLOV RADA (NAJVIŠE DVA REDA)

Ime i prezime prvog autora[1], Ime i prezime drugog autora[2]

[1]Naziv organizacije, [2]Naziv organizacije

Sažetak: Svaki rad mora sadržati sažetak. Sažetak treba da sadrži osnovnu ideju sa konačnim rezultatima istraživanja. Rad treba pisati u skladu sa uputstvom u nastavku. Sažetak može sadržati do 250 riječi.

Ključne riječi: Najviše pet ključnih riječi ili fraza odvojenih zarezom.

Rad mora sadržati jasan uvod, naveden problem, način riješavanja problema, rezultate, zaključak i literaturu. Rad ne treba da sadrži više od 8 stranica formata A4 (21 x 29.7 cm), uključujući slike, tabele i literaturu. Margine moraju biti: gornja i donja 2,5 cm, unutrašnja 2,5 cm i spoljašnja 2 cm. Stranice ne treba da budu numerisane.

Naslov rada (koristite font Times New Roman 12; naslov mora biti označen opcijom Bold) treba da bude postavljen na sredini prve stranice, pomjeren za dva razmaka, veličina fonta 10 pt, ispod gornje margine. Nakon naslova treba ostaviti jedan razmak, veličina fonta 10 pt. Rad mora biti poslat Naučnom odboru u elektronskom obliku (PDF ili DOC) putem obrasca za podnošenje radova, ili kao prilog e-mail-u na siz@apeiron-edu.eu.

Trebalo bi da postoji natpis iznad tabele, koji navodi, na primjer, „Tabela 1. Interkorelaciona matrica“. Ispod slike treba da bude broj i legenda, na primjer “Slika 3: Rad sa predškolskim djecom”.

Uredništvo prihvata rukopise napisane na engleskom (američki ili britanski engleski) i opciono na nekom od slovenskih jezika.

Rukopisi mogu biti odbijeni ako su napisani na lošem engleskom ili slovenskom jeziku. Autor je u potpunosti odgovoran za stil (formalan, nepristrasan u bilo kom smislu), jezik i sadržaj rada. Ipak, Urednički odbor ima pravo da komentariše formu i jezik rada prije nego što bude prihvaćen za objavljivanje. Očekuje se dobra, standardna upotreba gramatike u pisanom engleskom jeziku. Izbjegavajte nestandardne skraćenice.

LITERATURA

Potrebno je navesti sve izvore koji se koriste za vaš rad. Preporučuje se APA stil citiranja. Autori moraju da navedu kontakt podatke autora sa njegovim/njenim punim imenom, akademskim nazivom, institucijom, adresom, e-mail adresom i brojem telefona (opciono).

PROCEDURA RECENZIJE

Radovi poslati časopisu će najprije biti ocijenjeni od strane Uredništva imajući u vidu nekoliko kriterijuma: prikladnost teme i sadržaja časopisa; uređivanje (priprema rukopisa) i format; i “opšta” valjanost. Ako su ovi kriteriji ispunjeni, rad će biti poslat na dvostruku anonimnu recenziju od strane najmanje dva priznata i nezavisna recenzenta, a proces recenzije može trajati do 8 sedmica.

Samo radovi koji dobiju pozitivne recenzije će biti prihvaćeni. Jedan od presudnih razloga recenzije je navođenje citata i referenci relevantne literature. Urednički odbor ima pravo da komentariše formu rada prije nego što on bude prihvaćen za objavljivanje. Redakcija nije obavezna da objavljuje radove po hronološkom redosledu njihovog prijema ili po redoslijedu po kom su prihvaćeni za objavljivanje. Nijedan značajan dio rada ne treba da bude objavljen negdje drugdje. Prikazivanje rezultata u izvodima, sažecima, kratkim pregledima, disertacijama i magistarskim tezama, recenzijama i radovima sa konferencija (do tri stranice, koje sadrže sažetke, grafičke prezentacije i literaturu) ne smatra se objavljivanjem. Ako rukopis sadrži rezultate koji su već objavljeni, autor(i) moraju dobiti pristanak prvog izdavača i jasno citirati izvor.

Ethics

Publication ethics, disclosure policy and malpractice statement

Publication and authorship

- All submitted articles are subject to strict peer-review process by at least two reviewers that are experts in the area of the particular paper.
- The factors that are taken into account in review are relevance, soundness, significance, originality, readability and language.
- The paper acceptance is constrained by such legal requirements as shall then be in force regarding libel, copyright infringement and plagiarism.
- For published articles, information on relevant potential conflicts of interest will be made available to the public.

Authors' responsibilities

- Authors must certify that their manuscripts are their original work.
- Authors must certify that the manuscript has not previously been published elsewhere.
- In case a submitted manuscript is a result of a research project, or its previous version has been presented at a conference in the form of an oral presentation (under the same or similar title), detailed information about the project, the conference, etc. shall be provided navesti gde se navode. A paper that has already been published in another journal cannot be reprinted in this journal.
- Authors must certify that the manuscript is not currently being considered for publication elsewhere.
- Authors must identify all sources used in the creation of their manuscript.
- It is the responsibility of each author to ensure that papers submitted in this journal are written with ethical standards in mind.

Reviewers' responsibilities

- Reviews should be conducted objectively, with no personal criticism of the author.
- Reviewers are required to provide written, competent and unbiased feedback in a timely manner on the scholarly merits and the scientific value of the manuscript.
- Reviewers should keep all information regarding articles confidential and treat them as privileged information.
- Reviewers must not have conflict of interest with respect to the research, the authors and/or the funding sources for the research. If such conflicts exist, the reviewers must report them to the Editor without delay.
- Any selected referee who feels unqualified to review the research reported in a manuscript or knows that its prompt review will be impossible should notify the Editor without delay.

Editors' responsibilities

- Editors have complete responsibility and authority to reject/accept an article.
- Editors are responsible for the contents and overall quality of the publication.
- Editors should always consider the needs of the authors and the readers when attempting to improve the publication.
- Editors should preserve the anonymity of reviewers.
- Editors should act if they suspect misconduct, whether a paper is published or unpublished, and make all attempts to persist in obtaining a resolution to the problem.
- Editors should not reject articles based on suspicions.

ETIKA

Etika objavljivanja, pravila objavljivanja i zloupotreba podataka

Objavljivanje i autorska prava

- Svi pristigli članci podliježu strogoj recenziji od strane barem dva recenzenta koji su stručnjaci iz oblasti naučnog rada.
- Faktori koji se uzimaju u obzir prilikom recenzije su relevantnost, ispravnost, značaj, originalnost, čitljivost i jezik.
- Prihvatanje rukopisa je ograničeno takvim zakonskim uslovima koje će se primijeniti u slučaju klevete, zloupotrebe autorskih prava i plagijata.
- Kod objavljenih članka, informacije o relevantnim potencijalnim sukobima interesa biće dostupne javnosti.

Odgovornosti autora

- Autori moraju da potvrde da je njihov rukopis njihovo autorsko djelo.
- Autori moraju da potvrde da njihov rukopis nije prethodno objavljen na nekom drugom mjestu.
- U slučaju da je poslati rukopis rezultat naučnoistraživačkog projekta ili da je, u prethodnoj verziji, bio izložen na skupu u vidu usmenog saopštenja (pod istim ili sličnim naslovom), detaljniji podaci o projektu, konferenciji i slično, navode se u navesti gdje se navode. Rad koji je već objavljen u nekom časopisu ne može biti preštampan u ovom časopisu.
- Autori moraju da potvrde da se njihov rukopis trenutno ne razmatra za objavljivanje negdje drugdje.
- Autori su dužni da navedu sve izvore koje su koristili u pisanju njihovog rukopisa.
- Autori su dužni da se pridržavaju etičkih standarda koji se odnose na naučnoistraživački rad.

Obaveze recenzenta

- Recenzija mora biti objektivna. Komentari koji se tiču ličnosti autora smatraju se neprimjerenim. Sud recenzenata mora biti jasan i potkrepljen argumentima.
- Recenzenti bi trebalo svoje stavove da iskažu jasno, sa pratećim argumentima.
- Recenzenti bi trebalo da čuvaju u povjerenju sve informacije u vezi članka i smatraju ih privilegovanim informacijama.
- Recenzent ne smije da bude u sukobu interesa sa autorima ili financijerom istraživanja. Ukoliko postoji sukob interesa, recenzent je dužan da o tome momentalno obavijesti urednika.
- Recenzent koji sebe smatra nekompetentnim za temu ili oblast kojom se rukopis bavi dužan je da o tome obavijesti urednika.

Obaveze urednika

- Urednici imaju punu odgovornost i ovlaštenje da odbiju/prihvate članak.
- Urednici su odgovorni za sadržaj i ukupni kvalitet publikacije.
- Urednici bi uvijek trebalo da razmotre potrebe autora i čitaoca pri pokušaju da se poboljša publikacija.
- Urednici bi trebalo da sačuvaju anonimnost pregledanog članka.
- Urednici bi trebali da osiguraju da je sav materijal koji objavljuju u skladu sa međunarodno prihvaljivim etičkim smjernicama.
- Urednici bi trebalo da djeluju ukoliko posumnjaju na zloupotrebu, bez obzira da li je rad objavljen ili ne, i preduzmu mjere kako bi uspjeli da riješe problem.
- Urednici ne bi trebalo da odbace članak na osnovu sumnje.

ISSN 2232-8211