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- 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
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SPORTSKE NAUKE I ZDRAVLJE

SPORTS SCIENCE AND HEALTH

SADRŽAJ / CONTENTS

Dragi čitaoci,

U novom decembarskom izdanju našeg Časopisa ponovo imamo rekordan broj radova, Uredništvo je uvrstilo dvadeset radova, autora iz Alžira, Albanije, Indonezije, Turske, Grčke, Srbije, Slovačke, Hrvatske i Bosne i Hercegovine.

U ovom broju ćete pročitati članke koji se odnose na uticaj unutrašnje i spoljašnje motivacije i amotivacije na učešće u fizičkoj aktivnosti, efekti latencije IoT uređaja za mjerenje sportskih aktivnosti, povećanje brzine plivanja na 100m slobodnim stilom kroz trening zamišljanja i rutine prije nastupa, tradicionalne igre i motoričke sposobnosti: njihova interakcija u poboljšanju skoka u dalj kod učenika osnovne škole, efekti 6 nedjelja kompleksnog treninga na brzinu i agilnost indonežanskih sportista borilačke klase Penčak Silat, poboljšanja preciznosti slobodnih udaraca kroz trening zamišljanja i koncentraciju fudbalera, efekti Gamparan treninga na sposobnost dugih udaraca učenica koje učestvuju u vannastavnom fudbalu, veza između fizičkih aktivnosti i uspjeha učenika, afektivna stanja mladih atletičara prije i poslije organizovanih kolektivnih priprema, kako intervalni trening oblikuje fizičke performanse u borilačkim vještinama, najbolja identifikacija talenata na osnovu vještina iznad prosjeka i kreativnosti mladih fudbalera, odnosi između fizičke aktivnosti i simptoma stresa, anksioznosti i depresije, vježbanje i emocionalno blagostanje šta fizička aktivnost donosi našoj sreći, komparativni uticaj metoda komandnog i istraživačkog treninga na vještine sunčanih smečeva u sepaktakrou, utemeljena teorija psiholoških osnova fudbalskog učinka, validnost i pouzdanost medija znakovnog jezika za motoričke vještine gluve djece, odnos između fizičkog stanja i mentalnog stanja fudbalera, sastav tijela i aktivnost kao odrednice kabadi performansi.

Zahvaljujemo svim autorima, recenzentima i članovima uredništva na uloženom trudu i ovom prilikom pozivamo naše dosadašnje saradnike, a posebno nove, mlade koleginice i kolege, da svojim radovima daju doprinos nastojanju da sportske nauke budu sve značajniji faktor dobrog zdravstvenog stanja ljudi. Nadamo se da će i ovaj broj ispuniti očekivanja šire čitalačke populacije. Želimo svima sreću i uspješnu novu 2026. godinu!

UREDNIŠTVO ČASOPISA

Dear readers,

In the new December issue of our Journal, we again have a record number of papers, the Editorial Board included twenty papers by authors from Algeria, Albania, Indonesia, Turkey, Greece, Serbia, Slovakia, Croatia and Bosnia and Herzegovina.

In this issue, you will read articles related to the influence of internal and external motivation and amotivation on participation in physical activity, latency effects of IoT devices for measuring sports activities, increasing swimming speed in 100m freestyle through imagination training and pre-performance routines, traditional games and motor skills: their interaction in improving the long jump in elementary school students, the effects of 6 weeks of complex training on the speed and agility of Indonesian Penchak Silat martial arts athletes, improving the accuracy of freestyle kicks through imagination training and soccer players' concentration, the effects of playing Gamparan training on the long kicking ability of schoolgirls participating in extracurricular soccer, the connection between physical activity and student success, affective states of young athletes before and after organized collective preparations, how interval training shapes physical performance in martial arts, the best identification of talents based on above-average skills and creativity of young soccer players, relationships between physical activity and symptoms of stress, anxiety and depression, exercise and emotional well-being, what is physical activity brings our happiness, comparative influence the method of command and research training on the skills of sun smacking in Sepaktakro, the grounded theory of the psychological basis of football performance, the validity and reliability of sign language media for the motor skills of deaf children, the relationship between the physical state and the mental state of football players, body composition and activity as determinants of kabaddi performance.

We would like to thank all the authors, reviewers and members of the editorial board for their eff orts, and on this occasion we invite our previous collaborators, especially new, young colleagues, to contribute their works to the effort to make sports science an increasingly important factor in people's good health. We hope that this issue will meet the expectations of the wider readership. We wish everyone a happy and successful New Year 2026!

EDITORIAL BOARD OF THE JOURNAL

AFFECTIVE CONDITIONS OF YOUNG ATHLETES BEFORE AND AFTER ORGANIZED TRAINING CAMP

AFEKTIVNA STANJA MLADIH ATLETIČARA PRE I POSLE ORGANIZOVANIH KOLEKTIVNIH PRIPREMA

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Abstract: *The aim of this study was to examine the impact of a seven-day athletic training camp on the emotional state of young athletes. Changes in affective states were assessed using the PANAS instrument at the beginning and end of the training period. The sample included 84 athletes (25 boys and 59 girls), aged 8 to 18 years (M=11.89; SD=2.36), divided into three age groups: younger school age (10 years and younger), older school age (11–15 years), and high school age (16 years and older). All participants were members of the "Partizan" Athletic Club and with at least one year of training experience. Although descriptive indicators suggested slight changes in affective states, the combined analysis of variance (Mixed between-within subjects ANOVA) did not confirm the presence of statistically significant differences either between pre-test and post-test measures or across the age groups. The results, although statistically nonsignificant, indicate emotional stability among the athletes during the camp, likely due to their previous experience with similar programs, good organization, and social support. The findings highlight the importance of continuous monitoring of athletes' emotional states, particularly among younger age groups. For future studies, it is suggested to implement an extended experimental duration, a larger participant group, and to factor in additional psychological variables.*

Keywords: *PANAS, positive affect, negative affect, children*

Sažetak: *Cilj ovog istraživanja je bio da se ispita uticaj sedmodnevnih atletskih priprema na emocionalno stanje mladih sportista. Promene u afektivnim stanjima analizirane su primenom PANAS instrumenta na početku i kraju priprema. Uzorak je činilo 84 atletičara, 25 dečaka i 59 devojčica, uzrasta 8-18 godina (M=11.89; SD=2.36), podeljenih u tri grupe: mlađi školski uzrast (ispitanici od 10 godina i mlađi), stariji školski uzrast (11-15 godine) i srednjoškolski uzrast (16 godina i stariji). Svi ispitanici su članovi atletskog kluba „Partizan" i imaju najmanje godinu dana trenažnog iskustva. Iako su deskriptivni pokazatelji ukazivali na blage promene u afektivnim stanjima atletičara, kombinovana analiza varijanse, (Mixed between-within subjects ANOVA) nije potvrdila postojanje statistički značajnih razlika ni između početnog i završnog merenja, niti između starosnih grupa. Rezultati, iako statistički neznačajni, sugerišu emocionalnu stabilnost sportista tokom priprema, verovatno zahvaljujući prethodnom iskustvu sa sličnim programima, dobroj organizaciji, kao i socijalnoj podršci. Nalaz ističe važnost kontinuiranog praćenja emocionalnog stanja, posebno mlađih uzrasta. Za buduća istraživanja preporučuje se duži eksperimentalni period, veći uzorak i praćenje drugih psiholoških faktora.*

Ključne reči: *PANAS, pozitivni afekt, negativni afekt, deca*

INTRODUCTION

Athletics is a fundamental sport that encompasses basic basic human movements (Ćuk & Rakić, 2019). It is recommended for the healthy and well-balanced development of children and youth. In addition to physical development, participation in sports activities contributes to improved mental health and emotional well-being by enhancing resilience to stress and everyday challenges (Malagodi et al., 2024; Catalino & Fredrickson, 2011). Namely affective states are most commonly measured through two basic dimensions - positive affect (PA) and

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Atletika je bazičan sport, koja obuhvata osnovne oblike kretanja (Ćuk & Rakić, 2019). Preporučuje se za zdrav i uravnotežen razvoj dece i mladih. Pored fizičkog razvoja, učešće u sportskim aktivnostima doprinosi poboljšanju mentalnog zdravlja i emocionalnog blagostanja, povećavajući otpor na stres i svakodnevne izazove (Malagodi, et al., 2024; Catalino & Fredrickson, 2011).

Afektivna stanja se najčešće mere kroz dve osnovne dimenzije – pozitivan (PA) i negativan afekt (NA). Negativan afekt obuhvata neprijatna osećanja poput zlobe,

negative affect (NA). Negative affect includes unpleasant emotions such as hostility, anger, sadness, fear, and worry (Diener et al., 2010). It impacts children's physical, psychological, and social health, lowering self-esteem, reducing the quality of relationships, and increasing anxiety and depression, which in turn narrows attentional focus (Basso et al., 1996). In contrast, positive affect reflects pleasant emotional experiences (Diener, 1984). It encompasses positive emotions and consists of feelings or experiences that are pleasant, satisfying, happy, and fulfilling. Low levels of positive affect are associated with lower life satisfaction (Bishop et al., 2011). Recent studies confirm that even short-term physical activity programs can produce immediate changes in the affective states of children and adolescents by increasing positive and reducing negative affect (Xin et al., 2025).

To assess these dimensions, the PANAS scale (Positive and Negative Affect Schedule) is frequently used due to its high reliability and sensitivity to short-term changes in emotional states (Watson et al., 1988; Crawford & Henry, 2004). This characteristic makes it suitable for evaluating the effects of seven-day training camps and other short-term sports activities (Laborde et al., 2016). Contemporary research indicates that the PANAS scale, in addition to measuring short-term mood changes, can serve as a useful tool for monitoring the effects of brief sports camps among youth (Liu et al., 2025).

An enthusiastic and supportive coach not only satisfies the need for relatedness but also promotes autonomous motivation in students, thereby increasing participation in physical education (White et al., 2021). Training fosters communication, cooperation, and the development of individual social skills beneficial for personal growth. Training camps, as an integral part of the training process, offer opportunities for both physical and psychological development, as well as social interaction. They also contribute to the development of work habits and team spirit. The relationship between the training process - specifically, sports camps - and athletes' emotional states remains underexplored. Therefore, the aim of this study was to examine the effects of a seven-day athletics training camp on athletes' emotional states by analyzing changes in the perception of positive and negative affect at the beginning and end of the camp. It was expected that the results would show an increase in positive affect and a decrease in negative affect, thus confirming the importance of training camp for the physical and psychosocial development of children and adolescents.

besa, tuge, straha i zabrinutosti (Diener, et al., 2010). Utiče na fizičko, psihološko, socijalno zdravlje dece. Snižava samopoštovanje, smanjuje kvalitet odnosa sa drugima i dovodi do anksioznosti i depresije koja sužava pažnju (Basso, et al., 1996). Nasuprot tome, pozitivan afekt odnosi se na prijatna emocionalna iskustva (Diener, 1984). Uključuje pozitivne emocije i sastoji se od pozitivnih, dobrih, prijatnih, srećnih i zadovoljavajućih osećanja ili iskustava. Nizak pozitivan afekt je povezana sa niskim nivoom zadovoljstva životom (Bishop, et al., 2011). Novija istraživanja potvrđuju da i kratkoročni programi fizičke aktivnosti mogu izazvati neposredne promene u afektivnim stanjima dece i adolescenata, povećavajući pozitivan i smanjujući negativan afekt (Xin et al., 2025).

Za procenu ovih dimenzija često se koristi PANAS skala (Positive and Negative Affect Schedule), zbog njene visoke pouzdanosti i osetljivosti na kratkoročne promene u emocionalnim stanjima (Watson, et al., 1988; Crawford & Henry, 2004). Ova karakteristika čini je pogodnom za procenu efekata sedmodnevnih priprema i kratkotrajnih sportskih aktivnosti (Laborde, et al., 2016). Savremeni radovi ukazuju da PANAS skala, osim što meri kratkoročne promene u raspoloženju, može biti koristan alat za praćenje efekata kraćih sportskih kampova kod mladih (Liu et al., 2025).

Entuzijastičan i pozitivan trener ne samo da poboljšava osnovnu potrebu za povezanošću, već utiče i na autonomnu motivaciju učenika i stoga može povećati učešće u fizičkom vaspitanju (White, at el., 2021). Trening podstiče komunikaciju, saradnju, razvijanje individualnih socijalnih veština pogodnih za razvoj ličnosti. Sportske pripreme kao integralni deo trenažnog procesa pružaju mogućnost kako za fizičko tako i za psihološko i socijalno usavršavanje. Takođe, doprinose i jačanju timskog duha, sticanju radnih navika.

Nedovoljno je istražena veza između trenažnog procesa, odnosno sportskih priprema i emocionalnog stanja sportista. Stoga ovaj rad ima za cilj da ispita dejstvo sedmodnevnih atletskih priprema na emocionalno stanje sportista pri čemu je bilo potrebno analizirati promene u doživljaju pozitivnog i negativnog afekta na početku i kraju priprema. Očekivalo se da će rezultati pokazati porast pozitivnih i smanjenje negativnih emocija kod sportista, kao i da će promene u afektivnim stanjima biti različite u zavisnosti od grupe ispitanika, čime se potvrđuje značaj sportskih priprema u fizičkom, kao i psiho-socijalnom razvoju dece i mladih.

Methods

Study Design

Each year, the "Partizan" Athletics Club organizes a seven-day training camp for its members. The camp is held in Trebinje, at the "City of the Sun" resort, which offers optimal conditions for training and accommodation. Participants follow a structured training program that includes morning jogging and two training sessions per day. Trainings are adapted to the athletes' age and abilities. They are designed to be interesting, with different content, because it is primarily about all-round development, improving existing and acquiring new skills and abilities.

Accommodation is provided in a modern hotel complex with facilities such as swimming pools, sports fields, and parks, contributing to children's relaxation after training. In addition to the athletic component, educational and creative activities were organized (e.g., art workshops, educational videos, reading), as well as excursions to local landmarks. Evening programs included themed events, with a costume party being particularly popular.

The study was conducted during the April 2025 camp. Questionnaires were administered on the first (baseline measurement) and last day of the camp (post - intervention measurement). Participants were informed about the purpose of the study and the procedure. Questionnaires were filled out without revealing identities, in a regulated setting, and with coaches present to offer explanations, particularly for younger respondents. Parents were made aware of the study objectives, data gathering, and data handling, and they gave informed consent for their children to take part.

Participants

The sample consisted of 84 athletes (25 boys and 59 girls), members of the "Partizan" Athletics Club from Belgrade, aged 8 to 18 years (M=11.89; SD=2.36). All participants had been actively training in athletics for at least one year. They were divided into three groups: early school age (10 years and younger, N=38), older school age (11–15 years, N=39), and high school age (16 years and older, N=7).

The limited sample size and uneven age-group distribution, especially the small number of high school athletes, constitute a methodological limitation that could reduce the statistical power of the analyses and limit the generalizability of the findings.

Metode

Dizajn studije

Tradicionalno, svake godine atletski klub „Partizan" organizuje za svoje članove sedmodnevne pripreme. Održavaju se u Trebinju u „Gradu Sunca" koji svojim bogatim sadržajem i infrastrukturom pruža optimalne uslove za rad i boravak sportista. Tokom boravka učesnici su izloženi trenažnom programu koji obuhvata jutarnji futing i dva treninga dnevno. Treninzi su prilagođeni uzrastu i sposobnostima atletičara. Osmišljeni su tako da budu zanimljivi, različitog sadržaja jer se pre svega radi o svestranom razvoju, usavršavanju postojećih i sticanju novih veština i sposobnosti.

Smeštaj je organizovan u modernom hotelskom kompleksu koji nudi bogate sadržaje bazene, sportske terene, parkove koji doprinose relaksaciji dece nakon treninga. Pored sportskog dela organizovane su edukativne i kreativne aktivnosti (likovne radionice, čitanje i gledanje edukativnog sadržaja), upoznavanje i obilaženje znamenitosti grada i okoline. Večernji program je podrazumevao različite tematske aktivnosti, među kojima je posebno popularan maskenbal.

Istraživanje je realizovano tokom priprema u aprilu 2025. godine. Upitnici su distribuirani prvog (kako bi se utvrdilo inicijalno emocionalno stanje) i poslednjeg dana priprema (kako bi se utvrdile eventualne promene i dejstvo priprema). Ispitanicima je detaljno objašnjena svrha istraživanja, kao i postupak izvođenja. Popunjavanje upitnika je bilo anonimno, u kontrolisanim uslovima uz prisustvo trenera, koji su bili dostupni za pojašnjenja, posebno kod dece mlađeg školskog uzrasta. Roditelji su obavešteni o cilju, načinu prikupljanja i obradi podataka i dali su saglasnost za učešće svoje dece u istraživanju.

Ispitanici

Uzorak je obuhvatio 84 atletičara (25 dečaka i 59 devojčica), članova atletskog kluba „Partizan" iz Beograda, starosti 8-18 godina (M=11.89; SD=2.36). Ispitanici aktivno treniraju atletiku najmanje godinu dana. Bili su podeljeni u tri grupe: mlađi školski uzrast (10 godina i mlađi, N=38), stariji školski uzrast (11-15 godina, N=39) i srednjoškolci (16 godina i stariji, N=7).

Veličina i neravnomerna raspodela uzorka, posebno manji broj srednjoškolaca, predstavljaju metodološko ograničenje koje može uticati na statističku snagu testova i generalizaciju rezultata.

Instrument

To assess affective states, the PANAS scale (Positive and Negative Affect Schedule; Watson et al., 1988) was used. It measures two dimensions of emotional functioning - positive affect (PA) and negative affect (NA) and consists of 20 items, with 10 items assessing PA (e.g., excited, inspired, interested, strong) and 10 items assessing NA (e.g., distressed, angry, afraid). Each item is rated on a 5 - point Likert scale (1= very slightly or not at all; 5 = extremely), with participants indicating the extent to which they currently feel each emotion. Total PA and NA scores were calculated for each participant prior to statistical analysis. Scores range from 10 (lowest) to 50 (highest), and were used as dependent variables in subsequent analysis.

The PANAS scale has been shown to be reliable, concise, and easy to administer. It is suitable for measuring high-arousal emotional states (Ekkekakis, 2012). PA reflects the degree to which a person feels positively, while NA reflects negative mood (Pfeifer-Seib et al., 2017). In addition to the PANAS, participants provided demographic information, including gender, age, and training experience.

Statistical Analysis

Basic descriptive statistics were calculated for all variables, including mean values (Mean), standard deviations (SD) and the 95% confidence interval (CI).

Prior to interpreting the results, the assumption of homogeneity of variances was tested using Levene's test (Pallant, 2020). The normality of data distribution was examined with the Shapiro–Wilk test, while the reliability of the scale was verified before the main analysis using Cronbach's alpha coefficient (Cronbach α).

To assess the effects of the intervention and differences between groups, a mixed between-within subjects ANOVA was used (Tabachnick & Fidell, 2013). Two factors were included: time (within-subjects variable) and age group (between-subjects variable). A 2 × 3 mixed factorial design was employed to compare the affective states of three age groups (younger school age, older school age, and high school students) at two time points (pre-test and post-test). The actual impact of the independent variables (training camp and group), both jointly (interaction effect) and separately, was evaluated using partial eta squared (η²), according to Cohen's (1988) guidelines. This analysis was applied to mean scores for PA and NA obtained before and after the camp.

All statistical analyses were performed using IBM SPSS Statistics v.24, and all inferences were drawn at

Instrument

Za procenu afektivnog stanja korišćena je PANAS skala (Positive and Negative Affect Schedule; Watson, et al., 1988) koja meri dve dimenzije emocionalnog funkcionisanja pozitivan afekt (PA) i negativn afekt (NA). Sadrži 20 stavki, 10 koje mere pozitivan afekt (npr. oduševljeno, nadahnuto, zainteresovano, jako,...) i 10 koje mere negativan afekt (npr. nesrećno, gnevno, uplašeno,...). Svaka stavka je praćena petostepenom skalom Likertovog tipa (1 - veoma malo ili nimalo, a 5 - izuzetno, jako), a zadatak ispitanika je bio da izrazi svoj stepen trenutnog raspoloženja ili emocionalnog stanja. Pre statističke analize izračunati su ukupni skorovi za pozitivan i negativan afekt za svakog učesnika. Skorovi se kreću od 10 (najniži) do 50 (najviši) i korišćeni su kao zavisne varijable u daljoj statističkoj obradi.

Dokazano je da je ovaj upitnik pouzdan, kratak i jednostavan za primenu; može se koristiti za merenje stanja visokog uzbuđenja (Ekkekakis, 2012). PA odražava stepen u kojem neko doživljava pozitivno, a NA negativno raspoloženje (Pfeifer-Seib, et al., 2017). Pored PANAS skale, ispitanicima su bila postavljena pitanja o polu, uzrastu i sportskom stažu.

Statistička analiza

Za svaku varijablu izračunati su osnovni deskriptivni parametri - aritmetička sredina (Mean), standardna devijacija (SD) i 95% interval poverenja (CI).

Pre tumačenja rezultata, primenom Levinovog testa (*Levene's test*), proverena je pretpostavka o homogenosti varijansi (Pallant, 2020). Normalnost distribucije podataka proverena je pomoću Shapiro–Wilk testa, a pre glavne analize proverena je pouzdanost skale pomoću Kronbahovog alfa koeficijenta (Cronbach α).

Za procenu efekata eksperimentalnog tretmana i proveru razlika između grupa korišćena je kombinovana analiza varijanse koja se u literaturi naziva *Mixed between-within subjects* ANOVA (Tabachnick & Fidell, 2013). Kombinovana su dva faktora (dve nezavisne varijable): vreme (unutargrupni varijabilitet) i specifičnost tri starosne grupe (međugrupni varijabilitet). Primenjen je 2 x 3 kombinovani nacrt za poređenje podataka tri grupe ispitanika (mlađi i stariji školski uzrast, te srednjoškolski) u dve različite vremenske tačke (pre-test i post-test). Stvarni uticaj nezavisnih varijabli (pripreme i grupa), kako zajednički (interakcija faktora) tako i separatni, procenjen je pomoću parcijalnog eta kvadrata (η²), na osnovu kriterijuma koje je predložio Cohen (1988). Ovaj postupak primenjen je na prosečne skalarne vrednosti PA i NA dobijene pre i nakon priprema.

the 0.05 significance level (p < 0.05).

Results

The normality of the data distribution was tested using the Shapiro–Wilk test, and the results showed that the data for all variables (PA and NA) did not significantly deviate from normal distribution (p > 0.05). Reliability coefficients (Cronbach's α) exceeded 0.60, indicating satisfactory reliability of the PANAS scale (PA pre-test = 0.73, PA post-test = 0.79; NA pre-test = 0.79, NA post-test = 0.75).

Descriptive statistics for pre-test and post-test scores on positive and negative affect across all three age groups are presented in Table 1, and illustrated in Figure 1. The results indicate a slight decrease in positive affect in the early school age group (ESA), while there is an increase among the older (OSA) and high school (HSA) age groups. Regarding negative affect, an increase was observed in the early school age group (ESA), whereas a decrease was found in both the older (OSA) and high school (HSA) groups.

Results from the mixed-design ANOVA for positive affect (Table 2) revealed that the interaction between the training intervention and age group was not statistically significant, although the effect size was moderate, with a moderate level of statistical power. The primary impact of the training intervention was not statistically significant. Nevertheless, the primary effect of age group came close to reaching statistical significance, displaying relatively good statistical power, which indicates a possible difference between groups. For negative affect, the interaction between the training intervention and age group, as well as the main effects of both intervention and age group, were not statistically significant. All observed effects were of low magnitude, accompanied by low statistical power, indicating a lack of measurable impact of the intervention.

Kompletna statistička analiza sprovedena je pomoću aplikacionog statističkog programa IBM SPSS v.24. Svi zaključci su izvedeni na nivou značajnosti od 0,05 (p < 0.05).

Rezultati

Normalnost distribucije je proverena primenom Shapiro–Wilk testa i rezultati su pokazali da podaci za sve varijable (PA i NA) nisu značajno odstupali od normalne distribucije (p > 0,05). Koeficijenti pouzdanosti (Cronbach α) su preko 0.60, što ukazuje na dobru pouzdanost PANAS skale (PA pre-test=0.73, PA post-test=0.79; NA pre-test=0.79, NA post-test=0.75).

Deskriptivni podaci pre-testa i post-testa, pozitivnog i negativnog afekta za sve tri grupe prikazani su u Tabeli 1 i ilustrovani Slikom 1. Nalazi pokazuju da je došlo do blagog smanjenja pozitivnog afekta kod mlađeg (MŠU) i povećanja kod starijeg (SŠU) i srednjoškolskog uzrasta (SRU). Što se tiče negativnog afekta, uočeno je povećanje kod mlađeg (MŠU), kao i smanjenje kod starijeg (SŠU) i srednjoškolskog uzrasta (SRU).

Rezultati kombinovane analize varijanse za pozitivan afekat (Tabela 2) pokazuju da interakcija između faktora pripreme i grupa nije statističi značajna, iako je efekat srednje jačine sa umerenom snagom testa. Efekat pripreme takođe nije statistički značajan, dok je efekat faktora grupa sa relativno dobrom snagom testa što ukazuje na mogući efekat razlika između grupa. Za negativan afekat, interakcija između efekta priprema i grupe, kao ni priprema, a ni grupe nisu statistički značajne. Svi efekti su slabog intenziteta, sa niskom snagom testa, što ukazuje na odsustvo uticaja sprovedene intervencije.

Table 1. *Descriptive Statistics for Pre-Test and Post-Test Scores on Positive and Negative Affect*

Tabela 1. *Deskriptivni pokazatelji pre-testa i post-testa za pozitivan i negativan afekt*

	Group / Grupa	N	Pre-test			Post-test		
			Mean	SD	95% CI	Mean	SD	95% CI
PA	ESA / MŠU	38	42.87	4.78	41.30-44.44	42.24	6.52	40.09-44.38
	OSA / SŠU	39	39.33	5.98	37.39-41.27	40.51	4.91	38.92-42.10
	HSA / SRU	7	38.00	8.31	30.32-45.68	41.71	5.41	36.71-46.72
NA	ESA / MŠU	38	12.89	3.14	11.86-13.93	14.03	3.64	12.83-15.22
	OSA / SŠU	39	15.36	5.95	13.47-17.29	15.10	4.30	13.71-16.50
	HSA / SRU	7	15.86	5.87	10.43-21.29	14.57	6.68	8.39-20.75

Table 2. *Mixed Between-Within Subjects ANOVA for Positive and Negative Affect*

Tabela 2. *Kombinovana analiza varijanse za pozitivan i negativan afekt*

Impact	Wilks' Lambda	F	p	η^2	Observed power
PA					
Training camp*group / Pripreme*grupa	0.94	2.35	0.10	0.06	0.46
Training camp / Pripreme	0.96	3.16	0.08	0.04	0.42
Group / Grupa	/	2.87	0.06	0.07	0.55
NA					
Training camp*group / Pripreme*grupa	0.98	0.82	0.44	0.02	0.19
Training camp / Pripreme	1.00	0.03	0.87	0.00	0.05
Group / Grupa	/	2.65	0.08	0.06	0.51
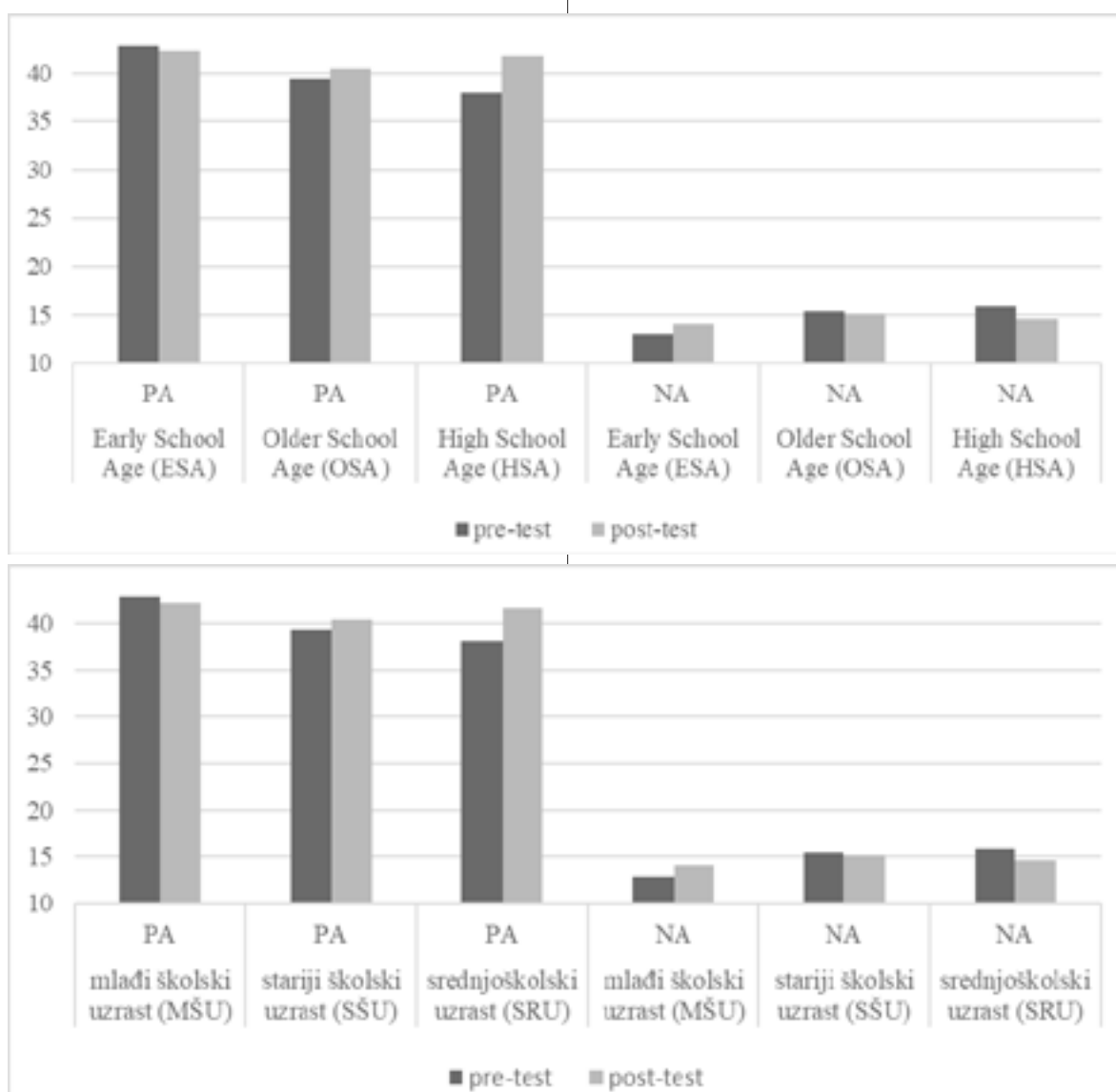
Figure 1. *Mean pre-test and post-test values for positive and negative affect across all three groups*

Slika 1. *Prosečne vrednosti pre-testa i post-testa za pozitivan i negativan afekt za sve tri grupe*

DISCUSSION

The purpose of this study was to investigate how a seven-day athletic training camp affects the emotional states of young athletes by assessing changes in their experiences of positive and negative feelings, measured at the start and finish of the camp using the PANAS tool. It was assumed that the training program, various activities, staying in a stimulating environment would contribute to an increase in positive affect and a decrease in negative affect. Although descriptive statistics indicated some changes in mean values, the results of the mixed-design ANOVA did not reveal statistically significant differences.

Positive affect slightly increased in the older and high school groups, while remaining stable in the younger group, which may suggest that prior sports experience, social support, and well-designed activities contribute to emotional stability. Similar findings were reported by Pasquerella and associates, indicating that short training camps can maintain elevated positive affect up to 24 hours post-activity (Pasquerella et al., 2025).

The obtained partial eta squared values for positive affect suggest the presence of a small to moderate effect size, particularly for the group factor, which may indicate differences in emotional responses depending on age. However, these differences were not statistically significant. The emotional experiences of children and teenagers are not stable or constant as they grow (Li et al., 2022). One study found that in late adolescence, the stability of positive emotions tends to decrease (Reitsema et al., 2022), and that adolescents frequently experience rapid mood shifts and tend to conceal their emotions (Žiropađa & Miočinović, 2012). Results from a six-week high- and moderate-intensity exercise program have demonstrated a significant positive impact on mood improvement (Balchin et al., 2016). Bandura (1977) emphasized long ago that regular physical activity can aid in improving emotional control and enhancing self-confidence, while also reducing negative emotions and increasing self-efficacy (Tikac et al., 2021).

A slight increase in negative affect (NA) was observed among children in the early school-age group. This may be attributed to initial enthusiasm gradually diminishing as the camp progressed - reflecting a decline in positive emotions due to fatigue, stress, social conflicts, or separation from family. The rise in negative affect is likely the result of accumulated physical and psychological strain, as well as insufficient sleep and rest (Clemente et al., 2019; Selmi et al., 2022). Decreased physical performance may also be associated with fatigue accumulation (Coutts & Reaburn, 2008; Selmi et al., 2020). Training camps may induce significant mood disturbances (Selmi et al., 2022).

DISKUSIJA

Cilj ovog istraživanja bio je da se ispita dejstvo sedmodnevnih atletskih priprema na emocionalno stanje sportista pri čemu je bilo potrebno analizirati promene u doživljaju pozitivnih i negativnih afekata na početku i kraju priprema, popunjavanjem PANAS instrumenta. Pretpostavljeno je da će trenažni program, raznovrsne aktivnosti, boravak u stimulativnom okruženju doprineti porastu pozitivnih i smanjenju negativnih afekata. Iako su deskriptivni pokazatelji pokazali izvesne promene u prosečnim vrednostima, rezultati kombinovane analize varijanse nisu pokazali statistički značajne razlike.

Pozitivan afekt je blago porastao kod starijeg i srednjoškolskog uzrasta, dok je kod mlađeg uzrasta bio stabilan, što može ukazivati da prethodno sportsko iskustvo, socijalna podrška i dobro osmišljene aktivnosti doprinose emocionalnoj stabilnosti. Slične rezultate iznose Pasquerella i saradnici, koji su pokazali da kratki trenažni kampovi mogu održati povišen pozitivan afekt i do 24 sata nakon završetka aktivnosti (Pasquerella et al., 2025).

Dobijene vrednosti parcijalnog eta kvadrata za pozitivan afekt sugerišu postojanje efekta male do srednje jačine, naročito u faktoru grupa i može ukazivati na razlike u emocionalnom odgovoru zavisno od uzrasta. Međutim, ove razlike nisu statistički značajne. Emocije dece i adolescenata nisu stabilne ili konstantne tokom razvoja (Li, et al. 2022). Jedna studija je pokazala da je posebno u kasnoj adolescenciji stabilnost pozitivnih emocija smanjena (Reitsema, et al., 2022), kao i da adolescenti naglo menjaju raspoloženja i prikrivaju svoja osećanja (Žiropađa i Miočinović, 2012). Rezultati šestonedeljnog vežbanja visokog i umerenog intenziteta imaju značajan pozitivan uticaj na poboljšanje raspoloženja (Balchin, et al., 2016). Bandura je još davno rekao da redovna fizička aktivnost može pomoći u poboljšanju kontrole emocija i povećanju samopouzdanja (Bandura, 1977), kao i smanjenju negativnih emocija i povećanju samoefikasnosti (Tikac, et al., 2021).

Kod dece mlađeg školskog uzrasta uočeno je blago povećanje NA. Ovo može biti rezultat početnog entuzijazma koji polako slabi kako pripreme odmiču, tj. doživljaj određenog pada u pozitivnim emocijama zbog umora, stresa, društvenih konflikata, razdvojenosti od porodice. Porast negativnog afekta je posledica akumulacije fizičkog i psihološkog napora, nedostatka sna i odmora (Clemente, et al., 2019; Selmi, et al., 2022). Smanjenje fizičkih performansi može biti povezano sa akumulacijom umora (Coutts & Reaburn, 2008; Selmi, et al., 2020). Sportske pripreme mogu dovesti do značajnih poremećaja raspoloženja (Selmi, et al., 2022). Kod dece starijeg

In contrast, a reduction in negative affect was noted among older school and high school students, suggesting better adaptation to environmental changes and more effective emotional regulation. Children and adolescents over the age of 12 gradually develop more advanced emotional regulation strategies (Zimmermann & Iwanski, 2014). These findings are supported by research from Li et al. (2022), which indicates that the impact of physical activity on positive emotions is more pronounced in groups older than 12 years compared to younger age groups.

In the case of negative affect, the results indicated extremely low effect sizes and very low statistical power, confirming the absence of a significant impact of the training camp on negative affect. An effective training program requires a balance between load and recovery, along with individualization and progression (Kasper, 2019). In addition to the lack of statistically significant results, emotional stability observed during the training camp represents a positive finding. The consistency of emotional states across all three age groups may suggest that the camp was well-designed and effectively implemented, allowing for the maintenance of emotional balance in children (Skinner Zimmer-Gembeck, 2007).

This stability may also be the result of social support, team cohesion, a structured daily schedule, and the presence of coaches - all of which contribute to a sense of psychological safety. It is important to note that a low level of statistical power was recorded (*power* < 0.60), which increases the risk of failing to detect actual effects due to insufficient sample size. The small sample, the short intervention period (only seven days), as well as the nature of the instrument used (the PANAS scale measures momentary affective states, which can fluctuate from minute to minute), represent the main limitations of this study.

Conclusion

It was expected that the track and field training camp, featuring an engaging and diverse training program alongside educational, creative, and social activities, would contribute to emotional improvement in the athletes. However, the results suggest that the seven-day camp did not lead to significant changes in the participants' emotional states. Preliminary findings suggest a slight decrease in positive affect and an increase in negative affect among the younger school-age group, whereas the older and high school groups exhibited the opposite trends, with a modest increase in positive affect and a decrease in negative affect. Although the observed changes were in the expected direction, the Mixed between-within subjects ANOVA did not reveal statistically significant

školskog uzrasta i srednjoškolaca dolazi do smanjenja NA, što ukazuje da se bolje prilagođavaju promenama uslova sredine i bolje upravljaju svojim emocijama. Deca i adolescenti stariji od 12 godina postepeno razvijaju efikasniju emocionalnu regulaciju (Zimmermann & Iwanski, 2014). To podržavaju rezultati istraživanja Lija i saradnika (Li, et al., 2022) koji pokazuju da je uticaj fizičke aktivnosti na pozitivne emocije veći u grupi starijoj od 12 godina nego u mlađim grupama.

U slučaju negativnog afekta, rezultati su bili izuzetno niskog intenziteta, uz vrlo nisku snagu testa, što potvrđuje odsustvo značajnog uticaja priprema na negativan afekt. Efikasan trenažni program zahteva balans između opterećenja i oporavka, uz individualizaciju i progresiju (Kasper, 2019). Pored statističke neznačajnosti rezultata, emocionalna stabilnost tokom priprema predstavlja pozitivan nalaz. Stabilnost emocija u sve tri grupe može ukazivati da su pripreme bile dobro osmišljene i realizovane, što je omogućilo održavanje emocionalne ravnoteže kod dece (Skinner & Zimmer-Gembeck, 2007).

Važno je napomenuti da je zabeležena niska vrednost statističke snage (power<0.60), što povećava rizik da se realni rezultati ne prikazuju zbog nedovoljne veličine uzorka. Mala i neravnomerno raspoređena veličina uzorka, posebno kod srednjoškolaca, kratak vremenski period (samo 7 dana delovanja intervencije), kao i priroda instrumenta (PANAS skala meri trenutno stanje i može varirati iz minuta u minut) su glavna ograničenja ove studije. Uticaj pola nije analiziran u ovoj studiji, što predstavlja potencijalnu varijablu koja može uticati na afektivna stanja i trebalo bi je uključiti u budućim istraživanjima.

Zaključak

Očekivalo se da će atletske pripreme uz zanimljiv i raznovrstan trenažni program, edukativne, kreativne i društvene aktivnosti doprineti emocionalnom poboljšanju kod atletičara. Međutim, rezultati pokazuju da sedmodnevni boravak dece nije izazvao velike promene u afektivnom stanju učesnika.

Preliminarni nalazi ukazuju da je kod mlađeg školskog uzrasta došlo do blagog smanjenja pozitivnog i povećanja negativnog afekta, dok su kod starijeg i srednjoškolskog uzrasta zabeleženi suprotni trendovi, blagi porast pozitivnog i smanjenje negativnog afekta. Iako su promene išle u očekivanom smeru, kombinovana analiza varijanse (Mixed between-within subjects ANOVA) nije pokazala statistički značajne razlike ni između početnog i završnog merenja (p>0.05), niti između starosnih grupa.

differences between pre- and post-test measurements (p > 0.05) or between age groups. The reliability of the PANAS scale was satisfactory (Cronbach's α ranging from 0.73 to 0.79), confirming the adequacy of the instrument used. These results suggest a certain degree of emotional stability among participants during the camp, which may be attributed to prior training experience, well-organized activities, and social support. Nevertheless, the small number of participants in the older groups and the short duration of the camp likely contributed to the absence of statistically significant effects.

A practical implication of these findings is the need for continuous monitoring of athletes' emotional states, particularly among younger age groups, as well as the implementation of appropriate psychological support during training, camps, and competitions. Coaches and parents should pay attention to potential signs of emotional stress, such as sudden mood changes, withdrawal, fatigue, or loss of motivation, and provide timely support through conversation, encouragement of rest, and balancing physical load with psychological well-being. Psychological stability and emotional regulation are important factors for long-term athletic development and mental health preservation. For future research, it is recommended to include a larger sample, additional psychological variables (e.g., stress, motivation), and a longer experimental period to gain a better understanding of athletes' emotional states. Additionally, combining qualitative and quantitative methods would provide a more comprehensive insight into athletes' emotional experiences during training camps.

Pouzdanost PANAS skale bila je zadovoljavajuća (Cronbach α od 0.73 do 0.79), što potvrđuje adekvatnost korišćenog instrumenta.

Ovakvi rezultati sugerišu određenu emocionalnu stabilnost učesnika tokom priprema, što se može pripisati prethodnom trenažnom iskustvu, dobroj organizaciji i socijalnoj podršci. Ipak, manji broj ispitanika u starijim grupama i kratak period trajanja priprema verovatno su uticali na odsustvo statistički značajnih efekata.

Praktična implikacija ovih nalaza jeste potreba za kontinuiranim praćenjem emocionalnog stanja sportista, posebno kod mlađih uzrasta, kao i uvođenje adekvatne psihološke podrške tokom treninga, priprema i takmičenja. Treneri i roditelji bi trebalo da obrate pažnju na moguće znakove emocionalnog stresa, kao što su nagle promene raspoloženja, povlačenje, umor ili gubitak motivacije, i da pravovremeno pruže podršku razgovorom, podsticanjem odmora i balansiranjem između fizičkog opterećenja i psihološkog blagostanja. Psihološka stabilnost i emocionalna regulacija predstavljaju važne faktore za dugoročan sportski razvoj i očuvanje mentalnog zdravlja.

Za buduća istraživanja preporučuje se veći uzorak, uključivanje dodatnih psiholoških varijabli (npr. stres, motivacija), kao i duži eksperimentalni period kako bi se bolje razumelo stanje sportista. Takođe, bilo bi korisno kombinovati kvalitativne i kvantitativne metode kako bi se dobio sveobuhvatniji uvid u emocionalna iskustva sportista tokom priprema.

References

Balchin, R., Linde, J., Blackhurst, D., Rauch, H.L., & Schonbachler, G. (2016). Sweating away depression? The impact of intensive exercise on depression. *Journal of Affective Disorders*, 200, 218-221. https://doi.org/10.1016/j.jad.2016.04.030

Bandura, A. (1977). Self-Efficacy: Toward a Unifying Theory of Behavioral Change. *Psychological Review*, 84(2), 191-215. https://doi.org/10.1037/0033-295X.84.2.191

Basso, M.R., Schefft, B.K., Ris, M.D., & Dember, W.N. (1996). Mood and global visual-local processing. *Journal of Neuropsychol Society*, 2(3), 249-255. https://doi.org/10.1017/S1355617700001193

Bishop, J.A., Martin, P., Poon, L., & Johnson, M.A. (2011). Exploring Positive and Negative Affect as Key Indicators of Life Satisfaction among Centenarians: Does Cognitive Performance Matter? *Journal of Aging Research*, 1-10, 953031. https://doi.org/10.4061/2011/953031

Catalino, L.I., & Fredrickson, B.L. (2011). A Tuesday in the life of a flourisher: the role of positive emotional reactivity in optimal mental health. *Emotion,* 11(4), 938-950. https://doi.org/10.1037/a0024889

Clemente, F.M., Martinho, R., Calvete, F., & Mendes, B. (2019). Training load and well-being status variations of elite futsal players across a full season: Comparisons between normal and congested weeks. *Physiology and Behavior*, 201, 123-129. https://doi.org/10.1016/j.physbeh.2019.01.001

Cohen, J.W. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.), pp. 284-287. Lawrence Erlbaum Associates.

Coutts, A.J., & Reaburn, P. (2008). Monitoring changes in rugby league players perceived stress and recovery during intensified training. *Perceptual and Motor Skills,* 106(3), 904-916. https://doi.org/10.2466/pms.106.3.904-916

Crawford, J. R., & Henry, J. D. (2004). The positive and negative affect schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample. *The British Journal of Clinical Psychology, 43*(Pt 3), 245–265. https://doi.org/10.1348/0144665031752934

Ćuk, I., & Rakić, S. (2019). Osnove atletike: teorija i metodika [Basics of athletics: Theory and methodology]. Beograd: Univerzitet Singidunum.[in Serbian]

Diener, E., Wirtz, D., Tov, W., Kim-Prietno, C., Choi, D.W., Oishi, S., & Biswas-Diener, R. (2010). New well-being measures: Short scales to assess flourishing and positive and negative feelings. *Social Indicators Res*earch, 97(2), 143-156. https://doi.org/10.1007/s11205-009-9493-y

Diener, E. (1984). Subjective well-being. *Psychological Bulletin*, 95(3), 542-575. https://doi.org/10.1037/0033-2909.95.3.542

Ekkekakis, P. (2012). Affect, mood, and emotion. In G.Tenenbaum, R. C. Eklund, & A. Kamata (Eds.), *Measurement in Sport and Exercise Psychology* (pp. 321-332). Human Kinetics. https://doi.org/10.5040/9781492596332.ch-028

Kasper, K. (2019). Sports Training Principles. *Current Sports Medicine Reports*, 18(4), 95-96. https://doi.org/10.1249/JSR.0000000000000576

Laborde, S., Dosseville, F., & Allen, M. S. (2016). Emotional intelligence in sport and exercise: A systematic review. *Scandinavian Journal of Medicine & Science in Sports, 26*(8), 862–874. https://doi.org/10.1111/sms.12510

Li, J., Huang, Z., Si, W., & Shao, T. (2022). The Effects of Physical Activity on Positive Emotions in Children and Adolescents: A Systematic Review and Meta-Analysis. *International Journal of Environmental Research Public Health,* 19(21), 14185. https://doi.org/10.3390/ijerph192114185

Liu, Y., Zhang, T., & Wang, H. (2025). Associations between physical activity, academic stress, and sleep quality among adolescents. *BMC Pediatrics, 25*(1), 5803. https://doi.org/10.1186/s12887-025-05803-5

Malagodi, F., Dommett, E.J., Findon, J.L., & Gardner, B. (2024). Physical activity interventions to improve mental health and wellbeing in university students in the UK: A service mapping study. *Mental Health and Physical Act*ivity, 26(18),100563. https://doi.org/10.1016/j.mhpa.2023.100563

Pallant, J. (2020). *SPSS Survival Manual* (7th ed.). Routledge, pp. 177-196. https://doi.org/10.4324/9781003117452

Pasquerella, L., Aychman, M. M., Tasnim, N., Piccirillo, A., Holmes, V., & Basso, C. J. (2025). The benefits of chronic sport participation and acute exercise on mental health and executive functioning in adolescents. *Scientific Reports, 15,* 22392. https://doi.org/10.1038/s41598-025-88427-0

Pfeifer-Seib, E.L., Pugnaghi, G., Beauducel, A., & Leur, A. (2017). One the replication of factor structures of the Positive and Negative Affect Schedule. *Personality and Individual Differences*, 107, 201-207. https://doi.org/10.1016/j.paid.2016.11.053

Reitsema, A.M., Jeronimus, B.F., van Dijk, M., & de Jonge, P. (2022). Emotion Dynamics in Children and Adolescents: A Meta-Analytic and Descriptive Review. *Emotion*, 22(2), 374-396. https://doi.org/10.1037/emo0000970

Selmi, O., Levitt, E.D., Ouregui, I., Aydi, B., Bouassida, A., Weiss, K., & Knechtle, B. (2022). Effect of Intensified Training Camp of Psychometric Status, Mood State, and Hematological Markers in Youth Soccer Players. *Children*,19(12),1996. https://doi.org/10.3390/children9121996

Selmi, O., Ouergui, I., Castellano, J., Levitt, D., & Bouassida, A. (2020). Effect of an intensified training period on well-being indices, recovery and psychological aspects in professional soccer players. *European Review Applied Psychology,* 70(6), 100603. https://doi.org/10.1016/j.erap.2020.100603

Selmi, O., Ouergui, I., Levitt, D.E., Marzouki, H., Knechtle, B., Nikolaidis, P.T., & Bouassida, A. (2022). Training psychometric status, biological markers and neuromuscular fatique in soccer. *Biology of Sport*, 39(2), 319-327. https://doi.org/10.5114/biolsport.2022.104065

Skinner, E.A., & Zimmer-Gembeck, M.J. (2007). The development of coping. *Annual Review of Psychology*, 58, 119-144. https://doi.org/10.1146/annurev.psych.58.110405.085705

Tabachnick, B.G., & Fidell, L.S. (2013). *Using multivariate statistics* (7th ed.), pp. 33-46. Pearson Education.

Tikac, G., Unal, A., & Altug, F. (2021). Regular exercise improves the levels of self-efficacy, self-esteem and body awareness of young adults. *The Journal of Sports Medicine and Physical Fitness*, 62 (1), 157-161. https://doi.org/10.23736/S0022-4707.21.12143-7

Watson, D., Clark, L.A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affects: The PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063-1070. https://doi.org/10.1037/0022-3514.54.6.1063

White, R.L., Bennie, A., Vasconcellos, D., Cinelli, R., Hilland, T., Owen, K.B., & Lonsdale, C. (2021). Self-determination theory in physical education: a systematic review of qualitative studies. *Teaching and Teacher Education,* 99(1), 103247. https://doi.org/10.1016/j.tate.2020.103247

Zimmermann, P., & Iwanski, I. (2014). Emotion regulation from early adolescence to emerging and middle adulthood: Age differences, gender diffrences, and emotion-specific developmental variations. *International Journal of Behavioral Development*, 38(238), 182-194. https://doi.org/10.1177/0165025413515405

Žiropađa, Lj., & Miočinović, Lj. (2012). Razvojna psihologija [Developmental psychology]. Beograd: Čigoja štampa. [in Serbian]

Xin, Z., Liu, J., & Zhao, Y. (2025). Sequential adaptation effects of physical activity on negative emotions among adolescents. *Journal of Affective Disorders, 380,* 102270. https://doi.org/10.1016/j.jad.2025.102270

A GROUNDED THEORY OF THE PSYCHOLOGICAL FOUNDATIONS OF SOCCER PERFORMANCE

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Abstract: *This study employed a Grounded Theory approach to synthesize the existing literature on the psychological factors that influence soccer players' performance and career development. A total of 22 review articles were considered suitable for the creation of this theory. Atlas.ti.24 software was used for qualitative analysis. A total of 146 codes were encoded and grouped into six key categories: Psychological Traits and States, Cognitive and Perceptual Skills, Emotional and Stress Management, Social and Environmental Influences, Health, Wellness, and Lifestyle, and Performance and Skill Development. The resulting Grounded Theory explains the complex interplay between these psychological dimensions and their impact on soccer performance. This study emphasizes the importance of holistic athlete development by integrating psychological skills training with physical and technical preparation. This comprehensive framework offers valuable insights for coaches, sports psychologists, and researchers by suggesting targeted interventions to optimize player performance and support long-term career success. This theory underscores the need for individualized approaches to psychological training and the integration of mental health considerations in soccer development programs. While limited by its focus on review articles and the exclusion of primary studies, this research provides a foundation for future empirical investigations and practical applications in soccer psychology. The study concluded that psychological factors are integral to soccer performance, are equal in importance to physical and tactical elements, and should be systematically incorporated into training and development strategies.*

Keywords: *football, psychological factors, sports psychology, athletes' development, review, qualitative research*

INTRODUCTION

The prediction or explanation of performance in soccer is a complex, multifactorial question, influenced by the interaction of technical, tactical, physical, and psychological dimensions (Forsman et al., 2016; Kusuma et al., 2024; Plakias & Karakitsiou, 2024). While traditional models of performance optimization have heavily emphasized physical and technical-tactical factors, recent research increasingly recognizes the foundational role of psychological factors in shaping both immediate performance outcomes and long-term career trajectories (Plakias, 2023). Understanding and integrating psychological processes, ranging from emotional regulation to cognitive flexibility, has emerged as a critical frontier in both sports science and applied practice (Ivarsson et al., 2020; Plakias & Karakitsiou, 2024).

The exploration of psychological determinants in soccer remains a persistent challenge for researchers and practitioners alike. A growing body of evidence suggests that factors such as mental toughness, emotional stability, stress management, and self-confidence are not just peripheral elements but essential components of elite-level performance (Golding et al., 2020; McAuley et al., 2021). Furthermore, psychological stressors, including injury-related trauma, effective athlete recovery, social pressure, fear of failure, and performance anxiety, have been shown to significantly impair athletic outcomes and hinder recovery processes (Haller et al., 2022; Marqués Jiménez et al., 2017; Van Eetvelde et al., 2021).

Within this context, psychological readiness for return-to-play (Van Der Horst et al., 2017), the prevalence of mental health concerns such as depression and burnout (Golding et al., 2020), and the influence of social dynamics within teams (Hills et al., 2018) all contribute to the broader psychological ecology of soccer performance. Moreover, literature underscores the importance of embedding psychological skills training, such as goal setting, imagery,

and self-talk, within the operational frameworks of professional academies and teams (Ivarsson et al., 2020; Raya-Castellano & Uriondo, 2015).

Despite the increasing evidence and applied emphasis, most existing reviews treat psychological factors in isolation, failing to provide a comprehensive, integrative model that reflects the dynamic, interrelated nature of these variables within a competitive soccer environment. For this reason, we chose to conduct a review of existing review articles using the Grounded Theory methodology, based on the model of Onions (2006) and Wolfswinkel et al. (2013) (i.e. using already published studies as data. Regarding the combination of psychology and performance, only Holt and Dunn (2004) adopted Grounded Theory, and using interviews, presented a theory of psychosocial skills and environmental conditions related to how an adolescent can become a professional soccer player. What is absent from the existing literature is a comprehensive Grounded Theory that synthesizes a vast array of psychological factors that affect soccer players' performance and career longevity.

In response to these gaps, the purpose of this study is to construct a data-driven, integrative theory that explains the psychological foundations of soccer performance and career development. This is accomplished through a Grounded Theory analysis of international literature, aiming to explore not only what psychological factors are important but also how they interact and co-construct performance outcomes. The study addresses the following research questions: (a) What are the core psychological dimensions that influence soccer performance and career trajectories? (b) How do these dimensions interrelate to form a holistic framework of psychological readiness and resilience? (c) What implications does this framework have for athlete development, training design, and applied psychological support in soccer? In offering this theory, the study contributes a structured yet flexible model that can guide future research, inform applied practices, and support the holistic development of soccer players within increasingly demanding and psychologically complex environments.

MATERIAL & METHODS

Methodology

We utilized a qualitative research design employing a Grounded Theory approach to conduct the present literature review, wherein the researcher initiated exploration within a specific domain and developed theories based on the collected data (Urquhart, 2022). The Grounded Theory methodology was selected because of its intrinsic ability to provide insights, understanding, and a valuable framework for practical implications (Groom et al., 2011). The execution of this study adhered to a) the recommendations of Strauss and Corbin (1998) for Grounded Theory, and b) the proposition by Onions (2006) and Wolfswinkel et al. (2013) utilizing Grounded Theory as a method for reviewing literature". It is worth noting that the authors have experience constructing Grounded Theory using published scientific articles as data (Karakitsiou et al., 2024; Kasioura et al., 2025; Plakias et al., 2024).

Inclusion-exclusion criteria

Only review articles written in English, for which the authors could access the full text, were included. Articles related to sports other than soccer, articles related to the female sex, or soccer players who had retired from active action were not included.

Search

The search for documents to be used as data was conducted on May 15, 2024, using the Scopus and Web of Science search engines. In the first stage, the BOOLEAN expression "(psychological OR psychology) AND (soccer OR football) AND player AND performance" was used in the titles, abstracts, and keywords of the articles. The initial search yielded 1049 articles on Scopus and 249 on Web of Science. Limiting the findings to only review articles, the numbers from the two databases were 69 and 22, respectively. After removing duplicates, 69 articles remained. Nine articles were excluded because they focused on another sport, three because they were in German, four because they were in Spanish, four because they concerned female individuals, three because they concerned players who had retired, one because it was retracted, six because, although given as reviews by the search engines, they were actually research articles, and 25 because their purpose was different from the subject of our research. Therefore, 14 articles were selected in the first stage. In the second stage, which was carried out gradually, the BOOLEAN expression

(sport OR athlete OR soccer OR soccer) AND (SECTION B) was used. For SECTION B, various expressions were used (psychological factors, mental health, mental toughness, stress, anxiety, mood, etc.). Eight of the articles that met the inclusion criteria were ultimately necessary until theoretical saturation occurred. The search for the articles was conducted by the first and the last author, while in cases where there were disagreements, these were resolved in a meeting in which all the authors participated. Finally, 22 review articles were selected as data to build the theory.

Building the Grounded Theory

The 22 articles were imported into the Atlas.ti.24 software, where an independent comprehensive study of the articles and content analysis were conducted by the first two authors. The two authors separately performed initial coding (open coding) and constructed conditional and consequential matrices. The results from the previous stage were discussed in a joint meeting of all four authors, where the final extraction of key concepts, categories, subcategories, and their connections was made (open coding and axial coding). In the same session, the final conclusions for the theory construction were drawn (selective coding).

RESULTS

The authors, year of publication, and titles of the 22 review articles that were used as data for the extraction of the theory are included in Table 1. The articles were arranged in chronological order from oldest to newest.

Table 1. The articles that were used as data

Authors (Year)	Title
Raglin (2001)	Psychological Factors in Sport Performance
Nippert and Smith (2008)	Psychologic Stress Related to Injury and Impact on Sport Performance
(Slimani et al., 2016)	Do cognitive training strategies improve motor and positive psychological skills development in soccer players? Insights from a systematic review
Gledhill et al. (2017)	Psychosocial factors associated with talent development in soccer: A systematic review
Slimani et al. (2017)	Steroid hormones and psychological responses to soccer matches: Insights from a systematic review and meta-analysis
Rocha and Osório (2018)	Associations between competitive anxiety, athlete characteristics and sport context: evidence from a systematic review and meta-analysis
Heidari et al. (2019)	A practitioner's perspective on psychological issues in soccer
Kalinowski et al. (2019)	Motor and psychological predispositions for playing soccer
Liew et al. (2019)	Mental toughness in sport: Systematic review and future
Golding et al. (2020)	The prevalence of depressive symptoms in high-performance athletes: a systematic review
Ivarsson et al. (2020)	Psychological factors and future performance of soccer players: A systematic review with meta-analysis
Beauchamp et al. (2021)	Achieving Mental Health and Peak Performance in Elite Athletes
Groenewal et al. (2021)	Burnout and Motivation in Sport
Ong and Chua (2021)	Effects of psychological interventions on competitive anxiety in sport: A meta-analysis
Gonzalez-Villora et al. (2022)	The role of mental fatigue in soccer: a systematic review
James et al. (2022)	The use of self-compassion techniques in elite footballers: mistakes as opportunities to learn
van Ierssel et al. (2022)	Which psychosocial factors are associated with return to sport following concussion? A systematic review
Cook and Charest (2023)	Sleep and Performance in Professional Athletes
James et al. (2023)	Treating mental stress in elite footballers using a stigma-free psychological approach: The Power Threat Meaning Framework
Layton et al. (2023)	The measurement, tracking and development practices of English professional soccer academies
Selmi et al. (2023)	Monitoring mood state to improve performance in soccer players: A brief review
Andrade et al. (2024)	Impact of the COVID-19 pandemic on the psychological aspects and mental health of elite soccer athletes: a systematic review

Of the 22 articles, 146 codes were encoded and grouped into six categories: 1) Psychological Traits and States; 2) Cognitive and Perceptual Skills; 3) Emotional and Stress Management; 4) Social and Environmental Influences; 5) Health, Wellness, and Lifestyle; and 6) Performance and Skill Development. The first category was divided into three subcategories (emotional and psychological states, self-rated traits and dispositions, and motivational and resilience factors). All codes, along with the categories and subcategories to which they belong, are listed in Table 2.

Table 2. Codes, along with categories and subcategories

Categories	Codes
1. Psychological Traits and States	**Emotional and Psychological States:** Adaptive perfectionism, Anger, Anxiety, Competitive anxiety, Confidence, Confusion, Depressive symptoms, Emotional exhaustion, Emotional resilience, Emotional stability, Fear of deselection, Fear of failure, Fear, Mental fatigue, Mood disturbances, Perceived stress, Psychological distress, Psychological disturbance, Stress, Tension, Vigor
	Self-Related Traits and Dispositions: Self-acceptance, Self-awareness, Self-compassion, Self-confidence, Self-control, Self-criticism, Self-efficacy, Self-esteem, Self-motivation, Self-regulation, Low levels of neuroticism, Low trait anxiety, High psychic vigor
	Motivational and Resilience Factors: Ability to quickly adapt, Attention, Autonomy, Focus, Grit, Mental toughness, Motivation, Pain tolerance, Perceived competence, Psychological resilience, Psychological strength, Psychological wellbeing
2. Cognitive and Perceptual Skills	Anticipatory skills, Cognitive demands, Cognitive effort, Cognitive load, Cognitive restructuring, Cognitive standpoint, Cognitive strategies, Decision-making skills, Developing self-control, Mental challenges , Mental imagery, Mindfulness, Mindset, Non-verbal intelligence, Perceptual abilities, Perceptual-cognitive functions, Reflective skills
3. Emotional and Stress Management	Coping skills, Coping strategies, Coping with anxiety, Enhancing coping skills, Goal orientation, Goal setting, Imagery, Maintaining focus, Maximization of action, Mindfulness techniques, Positive self-talk, Pre-competition anxiety, Pre-competition stress, Pre-performance routines, Relaxation, Relaxation techniques, Task-oriented coping strategies
4. Social and Environmental Influences	Accessibility to rehabilitation, Coach influence, Competitive environments, Complex social environments, Criticism from fans, Criticism from social media, Demographic Sport ethic/philosophy, Environmental factors, Family dynamics , Financial troubles, Organizational environments, Organizational issues, Parents, Peers, Player-coach-parent triads, Rehabilitation environment, Relatedness, Relationship, Social aspects, Social parameters, Social perception, Social support, Sports medicine team influence, Stakeholders, Team dynamics, Teammate influence, Psychosocial wellbeing
5. Health, Wellness, and Lifestyle	Disordered eating, Healthy sleep habits, Injury concerns, Psychological interventions, Psychological preparation , Psychological readiness, Quality of life, Rehabilitation environment, Sleep disturbances, Stressful situations
6. Performance and Skill Development	Attribution theory, Burnout, Choking under pressure, Commitment therapy, Competence, Competitiveness, Concentration, Control under pressure, Delaying gratification, Development/training of psychological skills, Discipline, Enjoyment, Fostering gratitude, Individual Differences, Intrinsic motivation, Motor activity, Motivation strategies for prevention and treatment, Motivational orientation, Personal issues, Personality traits, Pressure, Psychological barriers, Psychological characteristics, Psychological development, Psychological impacts of the COVID-19, Psychological interventions, Psychological Skill Training (PST) programs, Psychological skills, Reducing perfectionism, Resilience to the rigors of long-term

DICUSSION

Psychological Traits and States

As illuminated by various studies, the complex combination of Emotional and Psychological States, such as adaptive perfectionism, emotional resilience, and stress management; self-rated traits such as self-control, self-efficacy, and self-regulation; and Motivational and Resilience Factors including focus, grit, and psychological well-being,

merge to define the psychological basis of elite athletes (Andrade et al., 2024; Heidari et al., 2019; Slimani et al., 2016).

An athlete's ability to quickly adapt, coupled with high psychological vigor and mental toughness, is considered essential for sporting excellence. Players who can endure through the emotional upheaval of competitive anxiety and depressive symptoms with confidence and concentration are often the ones who achieve the best performances (Kalinowski et al., 2019; Selmi et al., 2023). However, the interplay of mental fatigue, mood disturbances, and perceived stress determines the boundaries between success and burnout (Gledhill et al., 2017; Ivarsson et al., 2020).

The science of sports psychology has evolved to help a better understanding of these psychological domains, acknowledging their role in not only strengthening athletes' intrinsic motivation and attention but also in managing pain tolerance and perceived competence (Cook & Charest, 2023; Slimani et al., 2017). As such, the development of psychological skills is now seen as an indispensable part of an athlete's training process, shaping their response to the rigorous demands of professional sports and decreasing the impact of the fear of failure or deselection (Golding et al., 2020; Layton et al., 2023).

Integrating these psychological aspects into coaching and training practices demands joint effort, aligning with contemporary research that underscores the significance of psychological readiness, emotional stability, and autonomy in optimizing athletic performance (Gonzalez-Villora et al., 2022; James et al., 2022). The constant search for balance in a soccer player's psychological profile suggests a shift towards employing psychological resilience and well-being as key drivers of career longevity and success (Beauchamp et al., 2021; Rocha & Osório, 2018).

In sum, the profound influence of "Psychological Traits and States" on a soccer player's performance trajectory is evident, as it combines with their skill development, reflecting a complex interplay of internal fortitude and external prowess that move them towards achieving their professional zenith (Bédard Thom et al., 2021; Groenewal et al., 2021; Ong & Chua, 2021).

Cognitive and Perceptual Skills

Cognitive and perceptual skills play a critical role in the demanding game of soccer, where split-second decisions can determine the outcome of a match. Players' cognitive load and perceptual abilities are as essential as their physical properties. Anticipatory skills, decision-making abilities, and perceptual-cognitive functions enable players to succeed in the complex and dynamic environment of the field, where rapid information processing and swift responses are required (Heidari et al., 2019; Slimani et al., 2016). Such cognitive demands necessitate robust mental imagery and cognitive strategies that align with the game's unpredictability. Reflective skills, alongside a mindset achieved through cognitive restructuring and mindfulness, reinforce players' capacity to adapt and excel (Andrade et al., 2024).

Moreover, cognitive effort is not just about in-the-moment reactions, but also involves the development of self-control and a disciplined approach to the mental challenges of the sport. Mental fatigue can decrease attention and general performance; hence, there is a need for interventions that enhance mental resilience (Gonzalez-Villora et al., 2022). Soccer players benefit from training that incorporates psychological interventions adapted to cognitive and perceptual demands, thus optimizing their competitive performance and laying the basis for prolonged career success (James et al., 2022). Nonverbal intelligence, another crucial cognitive aspect, equips players with the ability to read the game and their opponents, further influencing their on-field efficacy (Gledhill et al., 2017). Thus, the intersection of cognitive and perceptual skills with athletic performance underscores the importance of an integrated training approach that combines the physical, technical, and cognitive dimensions of player development (Ivarsson et al., 2020; Kalinowski et al., 2019).

Emotional and Stress Management

Emotional regulation and stress management are pivotal for soccer players' performance, as they affect their ability to engage in games with focus and determination. The capacity to employ coping strategies such as goal setting and positive self-talk significantly enhances players' ability to handle pre-competition stress and anxiety, leading to better performance under pressure (Heidari et al., 2019; Rocha & Osório, 2018). Furthermore, incorporating relaxation techniques and imagery can facilitate players to achieve a state of mindfulness, enabling them to maintain focus and maximize their actions in the field (Slimani et al., 2016). A soccer player's skill in managing pre-performance

routines and utilizing task-oriented coping strategies often differentiates those who can consistently perform at their peak from those who are beaten by the pressure (Gledhill et al., 2017).

Effective stress management not only prepares players for the psychological demands of competition, but also supports their long-term well-being and career development. Goal orientation and consistent application of mental toughness strategies ensure that players approach each game with resilience and a mindset equipped to handle the difficulties of professional sports. Additionally, emotional stability contributes to an athlete's success, highlighting the importance of psychological well-being in sustained high-level performance (Raglin, 2001). In essence, the ability to cope with anxiety and manage stress through well-established psychological interventions plays a crucial role in the overall athletic performance, recovery from difficulties, and long-term success of soccer players (Bédard Thom et al., 2021; van Ierssel et al., 2022).

Social and Environmental Influences

The social and environmental contexts within which soccer players operate influence their performance and career trajectory. The complex social environments of clubs, characterized by player-coach-parent triads, can create an environment of stress that must be managed to protect players' performance capabilities (Heidari et al., 2019). Additionally, the role of coaches, as indicated by Ivarsson et al. (2020), extends beyond technical and tactical guidance because their influence can shape an athlete's resilience and adaptation to competitive environments. Furthermore, the dynamics within the team and the support or criticism from fans and social media can shape a player's social perception, impacting their mental health, and consequently, their performance in the field (James et al., 2022).

Moreover, accessibility to a supportive rehabilitation environment, inclusive of a sports medicine team adapted to the athlete's psychosocial well-being, significantly affects recovery outcomes and return-to-sport success (van Ierssel et al., 2022). The support felt by an athlete within their team, combined with social support from family and peers, creates a protective mechanism against competition pressure, fostering a psychological state that is helpful for optimal performance. This relationship between environmental factors and performance underscores the importance of holistic sports medicine approaches that integrate social support structures to address and enhance athletic well-being (Nippert & Smith, 2008; Raglin, 2001). Essentially, the interaction of social parameters, team dynamics, and organizational issues forms a combination of factors that can lead to the maximization of a soccer player's potential and career longevity.

Health, Wellness, and Lifestyle

The concepts of health, wellness, and lifestyle encompass many factors that significantly influence soccer players' performance. The psychological preparation of athletes, which includes the management of stress and establishment of healthy sleep habits, is crucial for maintaining a high level of performance and ensuring psychological readiness for the demands of competition (Cook & Charest, 2023). Injuries are a significant threat not only to physical capabilities, but also to psychological well-being, with concerns such as disordered eating and sleep disturbances that often arise during the rehabilitation process. Thus, the role of a rehabilitation environment is key to supporting an athlete's return to sports (van Ierssel et al., 2022).

Moreover, the quality of life outside the field directly affects on-field performance. Psychological interventions aimed at promoting a balanced lifestyle can help players manage stressful situations, such as criticism from fans or social media, and maintain their focus on games. The implementation of specific psychological strategies, such as goal setting and positive self-talk, can help manage pre-competition anxiety and ensure that athletes are mentally and physically prepared for their performance (Heidari et al., 2019; Ong & Chua, 2021). Overall, health, wellness, and lifestyle are linked to the holistic development of soccer players, which demands a comprehensive approach to optimize performance and career longevity.

Performance and Skill Development

In the search for exceptional soccer performance, more than just physical training is required. This is a result of psychological skills and development. Effective psychological interventions, based on attribution theory and commitment therapy, play a pivotal role in the athlete's journey, enhancing intrinsic motivation and helping overcome psychological barriers that can lead to phenomena such as "choking under pressure" (Heidari et al., 2019). As players

try for competence and success in their sport, commitment to discipline, enjoyment of the process, and the characteristic of not being easily satisfied become integral elements of their psychological profile. The implementation of Psychological Skill Training programs is recommended to improve focus, manage pressure, and foster resilience to the demands of long-term training, which are essential for both emerging talents and seasoned professionals (Beauchamp et al., 2021).

Moreover, individual differences in psychological characteristics, such as motivation strategies for the prevention and treatment of burnout, can influence the development and improvement of motor skills and competitive performance (Gledhill et al., 2017; Groenewal et al., 2021). Personal issues, including the psychological impacts of situations such as the COVID-19 pandemic, have shown the necessity of comprehensive support systems that address not only the physical but also the psychological aspects of recovery and well-being (Andrade et al., 2024). Techniques for reducing perfectionism, fostering gratitude, and nurturing psychological development are part of a holistic approach that aligns an athlete's lifestyle with their professional ambitions, ensuring a balance between mental health and peak performance (James et al., 2022; James et al., 2023).

GROUNDED THEORY

These six concepts are interconnected through a dynamic network of interdependencies (Figure 1). For example, physical health (5) affects cognitive and perceptual skills (2), which, in turn, influences performance and skill development (6). This sequence is supported by Kalinowski et al. (2019), who discussed the importance of physical and mental preparation in soccer, and Slimani et al. (2016), who emphasized the benefits of cognitive training strategies. Emotional management (3) can improve the handling of social and environmental influences (4), helping the soccer player remain focused and effective on the field, a point that Cook and Charest (2023) also emphasized regarding sleep's role in mental health and performance. In turn, a positive social environment can improve the psychological state (1), enhancing self-confidence and resilience, as Gledhill et al. (2017) showed in the context of psychosocial factors in talent development.

The interconnection of these six concepts can form the basis for a Grounded Theory explaining how psychology affects performance and a soccer player's career. For example, soccer players with excellent cognitive skills (2) can improve their performance (6) through enhancing psychological characteristics (1), such as self-confidence and concentration, while simultaneously managing anxiety (3) in a way that allows them to remain effective under pressure (Andrade et al., 2024). Further, Rocha and Osório (2018) explored how competitive anxiety varies and impacts athletes' performance, emphasizing the importance of interventions tailored to manage such anxiety.

Additionally, the goal of continuous development and improvement (6) presupposes a balanced approach to health and well-being (5), as well as a positive environment that encourages development (4). The studies of Kalinowski et al. (2019) and Cook and Charest (2023) provide insights into how physical fitness, mental preparation, and sleep health are crucial for maintaining performance at the highest level. Awareness of how external and internal influences interact and contribute to performance can help soccer players identify strategies and techniques that lead to improved performance and success. For example, incorporating pre-game routines that include relaxation or concentration techniques can help manage anxiety (3) and enhance performance under pressure, reinforcing the findings of Slimani et al. (2017) on the effects of steroid hormones and psychological responses on soccer players' performance.

By developing a strategy for self-improvement that includes continuous evaluation and improvement of cognitive and perceptual skills (2), soccer players can develop their ability to make quick and effective decisions on the field. Empathy and communication skills, developed through engaging with social and environmental influences (4), can improve team collaboration and social support. The research by Gledhill et al. (2017) underlines the importance of psychosocial factors in talent development and the significant role of social support in fostering psychological characteristics like resilience and commitment.

An approach to health and well-being (5) means that caring for physical health, a balanced diet, adequate sleep, and stress management are fundamental for maintaining performance at the highest possible level. This holistic care contributes to injury prevention and accelerates recovery, allowing greater consistency in performance and skill development (6). Golding et al. (2020) discussed the prevalence of depressive symptoms among high-performance athletes, emphasizing the need for tailored interventions to support mental well-being.

Continuous improvement and skill development require soccer players to be open to new training methods, seek

regular feedback from their coaches, and be willing to experiment with new tactics and strategies during the game. Development is not limited to physical or technical skills but also extends to understanding the significance of psychological readiness and a growth mindset. Ivarsson et al. (2020) highlights the association between psychological factors and future soccer performance, emphasizing the importance of psychological preparation and resilience in athlete development.

This theory of soccer player development, which combines the six basic concepts (psychological characteristics and states, cognitive and perceptual skills, emotional management and anxiety, social and environmental influences, health, well-being, and lifestyle, performance, and skill development), offers a dynamic framework for optimizing performance and professional development in sports. Through the application of this theory, soccer players can recognize and utilize available resources, skills, and opportunities for development to achieve the highest possible performance and advance their professional careers. Continuous self-discovery, self-assessment, and the development of personal goals in combination with strategic training and support from coaches and team, make the realization of these goals possible.

Therefore, this holistic perception of soccer player development underscores the critical balance between physical and mental health, ongoing personal and professional growth, and the resilience needed to overcome challenges. Through understanding and applying the principles contained in the six basic concepts, soccer players can form a stable foundation for achieving success, both on and off the field.
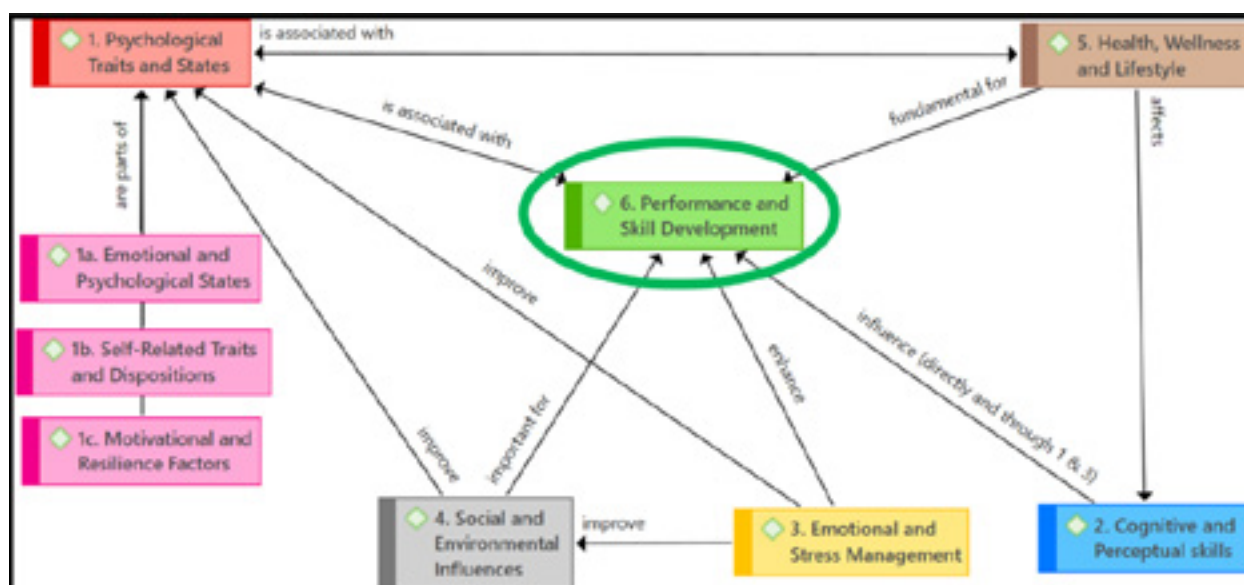
Figure 1. Grounded Theory on the impact of psychological factors on the performance and career of a soccer player

LIMITATIONS

The exclusive use of review articles as primary data sources means that the conclusions drawn depend on the quality and focus of the included reviews. Moreover, in the present research, only articles written in the English language were used that were found in only two searching engines. The exclusion of studies on female athletes and retired soccer players indicates a gap in the representation that future research could aim to fill. Finally, the Grounded Theory approach, while insightful, includes the subjective judgment of the researcher as opposed to the objectivity of quantitative research. Future research is suggested to incorporate a greater variety of sources, including primary research articles, articles written in languages other than English, more search engines as well as interviews with current professional players, which could provide direct insights into the psychological aspects of soccer performance. An expansion of the study to include female athletes and athletes from varying levels of play would offer a broader understanding of the psychological factors at play.

CONCLUSIONS

This study synthesized 22 studies to construct a Grounded Theory elucidating the impact of psychological factors on soccer players' performance and career development. Central to this framework is the recognition of psychology as an integral component of soccer, combined with physical, technical, and tactical elements. The findings highlighted the role of cognitive and perceptual skills in decision-making, the importance of emotional and stress management in resilience, and the influence of social and environmental factors on athletes' mental health and performance. This study's contribution to the international literature lies in its comprehensive integration of psychological factors into a holistic framework. A simple listing of the factors was not done, but the connections between them and the way they interact with the final result of improving the performance of soccer players were detected.

For coaching staff and sports psychologists, the practical applications of this study lie in the development of specific psychological skill training programs that consider individual athlete's needs. Implementing strategies to manage stress, build resilience, and enhance cognitive and perceptual skills should be integrated into routine training sessions. The advancement of psychological knowledge within the soccer context can potentially revolutionize training methodologies, enhance athlete care, and improve performance outcomes. Therefore, the incorporation of psychological factors into training and rehabilitation programs could be decisive in establishing psychology as a basis for athlete development equivalent to physical conditioning and technical-tactical training.

Conflict of interest
The authors declare no conflicts of interest.

REFERENCES

Andrade, A., D'Oliveira, A., Neiva, H. P., Gaertner, G., & da Cruz, W. M. (2024). Impact of the COVID-19 pandemic on the psychological aspects and mental health of elite soccer athletes: a systematic review. *Frontiers in psychology*, *14*, 1295652. https://doi.org/10.3389/fpsyg.2023.1295652

Beauchamp, P., Kamis, D., & Stull, T. (2021). Achieving Mental Health and Peak Performance in Elite Athletes. *The Psychiatric Clinics of North America*, *44*(3), 347-358. https://doi.org/10.1016/j.psc.2021.04.002

Bédard Thom, C., Guay, F., & Trottier, C. (2021). Mental toughness in sport: The goal-expectancy-self-control (Ges) Model. *Journal of applied sport psychology*, *33*(6), 627-643. https://doi.org/10.1080/10413200.2020.1808736

Cook, J. D., & Charest, J. (2023). Sleep and performance in professional athletes. *Current sleep medicine reports*, *9*(1), 56-81. https://doi.org/10.1007/s40675-022-00243-4

Forsman, H., Blomqvist, M., Davids, K., Liukkonen, J., & Konttinen, N. (2016). Identifying technical, physiological, tactical and psychological characteristics that contribute to career progression in soccer. *International Journal of Sports Science & Coaching*, *11*(4), 505-513. https://doi.org/10.1177/1747954116655051

Gledhill, A., Harwood, C., & Forsdyke, D. (2017). Psychosocial factors associated with talent development in football: A systematic review. *Psychology of Sport and Exercise*, *31*, 93-112. https://doi.org/10.1016/j.psychsport.2017.04.002

Golding, L., Gillingham, R. G., & Perera, N. K. P. (2020). The prevalence of depressive symptoms in high-performance athletes: a systematic review. *The Physician and Sportsmedicine*, *48*(3), 247-258. https://doi.org/10.1080/00913847.2020.1713708

Gonzalez-Villora, S., Prieto-Ayuso, A., Cardoso, F., & Teoldo, I. (2022). The role of mental fatigue in soccer: a systematic review. *International Journal of Sports Science & Coaching*, *17*(4), 903-916. https://doi.org/10.1177/17479541211069536

Groenewal, P. H., Putrino, D., & Norman, M. R. (2021). Burnout and motivation in sport. *Psychiatric Clinics*, *44*(3), 359-372. https://doi.org/10.1016/j.psc.2021.04.008

Groom, R., Cushion, C., & Nelson, L. (2011). The delivery of video-based performance analysis by England youth soccer coaches: towards a grounded theory. *Journal of applied sport psychology*, *23*(1), 16-32. https://doi.org/10.1080/10413200.2010.511422

Haller, N., Hübler, E., Stöggl, T., & Simon, P. (2022). Evidence-based recovery in soccer–Low-effort approaches for practitioners. *Journal of Human kinetics*, *82*(1), 75-99. https://doi.org/10.2478/hukin-2022-0082

Heidari, J., Pelka, M., Beckmann, J., & Kellmann, M. (2019). A practitioner's perspective on psychological issues in football. *Science and Medicine in Football*, *3*(2), 169-175. https://doi.org/10.1080/24733938.2018.1526397

Hills, S. P., Barwood, M. J., Radcliffe, J. N., Cooke, C. B., Kilduff, L. P., Cook, C. J., & Russell, M. (2018). Profiling the responses of soccer substitutes: A review of current literature. *Sports medicine*, *48*, 2255-2269. https://doi.org/10.1007/s40279-018-0962-9

Holt, N. L., & Dunn, J. G. (2004). Toward a grounded theory of the psychosocial competencies and environmental conditions associated with soccer success. *Journal of applied sport psychology*, *16*(3), 199-219. https://doi.org/10.1080/10413200490437949

Ivarsson, A., Kilhage-Persson, A., Martindale, R., Priestley, D., Huijgen, B., Ardern, C., & McCall, A. (2020). Psychological factors and future performance of football players: A systematic review with meta-analysis. *Journal of Science and Medicine in Sport*, *23*(4), 415-420. https://doi.org/10.1016/j.jsams.2019.10.021

James, I., Medea, B., Harding, M., Glover, D., & Carraça, B. (2022). The use of self-compassion techniques in elite footballers: mistakes as opportunities to learn. *The Cognitive Behaviour Therapist*, *15*, e43. https://doi.org/10.1017/S1754470X22000411

James, I. A., Morris, S., Johnston, A., & Glover, D. (2023). Treating mental stress in elite footballers using a stigma-free psychological approach: the Power Threat Meaning Framework. *BJPsych Advances*, *29*(6), 373-380. https://doi.org/10.1192/bja.2022.48

Kalinowski, P., Bojkowski, Ł., & Śliwowski, R. (2019). Motor and psychological predispositions for playing football. *Trends in Sport Sciences*,

2(26), 51-54. https://doi.org/10.23829/TSS.2019.26.2-2

Karakitsiou, G., Plakias, S., Christidi, F., & Tsiakiri, A. (2024). Unraveling Childhood Obesity: A Grounded Theory Approach to Psychological, Social, Parental, and Biological Factors. *Children*, *11*(9), 1048. https://doi.org/10.3390/children11091048

Kasioura, C., Plakias, S., Mousena, E., & Foti, P. (2025). A Grounded Theory on Creativity, Collaboration, and Innovation in Preschool Education. *The International Journal of Early Childhood Learning*, *32*(2). https://doi.org/10.18848/2327-7939/CGP/v32i02/23-41

Kusuma, I. D. M. A. W., Kusnanik, N. W., Lumintuarso, R., & Phanpheng, Y. (2024). The Holistic and Partial Approach in Soccer Training: Integrating Physical, Technical, Tactical, and Mental Compo-nents: A Systematic Review. *Retos*, *54*, 328-337. https://doi.org/10.47197/retos.v54.102675

Layton, M., Taylor, J., & Collins, D. (2023). The measurement, tracking and development practices of English professional football academies. *Journal of sports sciences*, *41*(18), 1655-1666. https://doi.org/10.1080/02640414.2023.2289758

Liew, G. C., Kuan, G., Chin, N. S., & Hashim, H. A. (2019). Mental toughness in sport: Systematic review and future. *German Journal of Exercise and Sport Research*, *49*(4), 381-394. https://doi.org/10.1007/s12662-019-00603-3

Marqués Jiménez, D., Calleja González, J., Arratibel Imaz, I., Delextrat, A., & Terrados Cepeda, N. (2017). Fatigue and recovery in soccer: Evidence and challenge. *Open Sports Sciences Journal*, *10*((Suppl 1: M5)), 52-70. https://doi.org/10.2174/1875399X01710010052

McAuley, A. B., Hughes, D. C., Tsaprouni, L. G., Varley, I., Suraci, B., Roos, T. R., Herbert, A. J., & Kelly, A. L. (2021). Genetic association research in football: A systematic review. *European Journal of Sport Science*, *21*(5), 714-752. https://doi.org/10.1080/17461391.2020.1776401

Nippert, A. H., & Smith, A. M. (2008). Psychologic stress related to injury and impact on sport performance. *Physical medicine and rehabilitation clinics of North America*, *19*(2), 399-418. https://doi.org/10.1016/j.pmr.2007.12.003

Ong, N. C., & Chua, J. H. (2021). Effects of psychological interventions on competitive anxiety in sport: A meta-analysis. *Psychology of Sport and Exercise*, *52*, 101836. https://doi.org/10.1016/j.psychsport.2020.101836

Onions, P. E. (2006). Grounded theory applications in reviewing knowledge management literature. Leeds Metropolitan University Innovation North Research Conference,

Plakias, S. (2023). An integrative review of the game model in soccer: definition, misconceptions, and practical significance. *Trends in Sport Sciences*, *30*(3), 85-92. https://doi.org/10.23829/TSS.2023.30.3-1

Plakias, S., & Karakitsiou, G. (2024). Neuropsychophysiological Aspects of Soccer Performance: A Bibliometric Analysis and Narrative Review. *Perceptual and Motor Skills*, *131*(6), 2346–2368. https://doi.org/10.1177/00315125241292969

Plakias, S., Kasioura, C., Pamboris, G. M., Kokkotis, C., Tsatalas, T., Moustakidis, S., Papalexi, M., Giakas, G., & Tsaopoulos, D. (2024). A grounded theory for professional soccer teams' playing styles: Towards a consensus. *International Journal of Sports Science & Coaching*. https://doi.org/10.1177/17479541241300605

Raglin, J. S. (2001). Psychological factors in sport performance: The mental health model revisited. *Sports medicine*, *31*, 875-890. https://doi.org/10.2165/00007256-200131120-00004

Raya-Castellano, E. P., & Uriondo, L. F. (2015). A review of the multidisciplinary approach to develop elite players at professional football academies: Applying science to a professional context. *International Journal of Performance Analysis in Sport*, *15*(1), 1-19. https://doi.org/10.1080/24748668.2015.11868773

Rocha, V. V. S., & Osório, F. d. L. (2018). Associations between competitive anxiety, athlete characteristics and sport context: evidence from a systematic review and meta-analysis. *Archives of Clinical Psychiatry (São Paulo)*, *45*(3), 67-74. https://doi.org/10.1590/0101-60830000000160

Selmi, O., Ouergui, I., Muscella, A., Levitt, D. E., Suzuki, K., & Bouassida, A. (2023). Monitoring mood state to improve performance in soccer players: A brief review. *Frontiers in psychology*, *14*, 1095238. https://doi.org/10.3389/fpsyg.2023.1095238

Slimani, M., Baker, J. S., Cheour, F., Taylor, L., & Bragazzi, N. L. (2017). Steroid hormones and psychological responses to soccer matches: Insights from a systematic review and meta-analysis. *PloS one*, *12*(10), e0186100. https://doi.org/10.1371/journal.pone.0186100

Slimani, M., Bragazzi, N. L., Tod, D., Dellal, A., Hue, O., Cheour, F., Taylor, L., & Chamari, K. (2016). Do cognitive training strategies improve motor and positive psychological skills development in soccer players? Insights from a systematic review. *Journal of sports sciences*, *34*(24), 2338-2349. https://doi.org/10.1080/02640414.2016.1254809

Strauss, A., & Corbin, J. (1998). Basics of qualitative research techniques.

Urquhart, C. (2022). *Grounded theory for qualitative research: A practical guide*. Sage. https://www.torrossa.com/en/resources/an/5409512

Van Der Horst, N., Backx, F., Goedhart, E. A., & Huisstede, B. M. (2017). Return to play after hamstring injuries in football (soccer): a world-wide Delphi procedure regarding definition, medical criteria and decision-making. *British journal of sports medicine*, *51*(22), 1583-1591. https://doi.org/10.1136/bjsports-2016-097206

Van Eetvelde, H., Mendonça, L. D., Ley, C., Seil, R., & Tischer, T. (2021). Machine learning methods in sport injury prediction and prevention: a systematic review. *Journal of experimental orthopaedics*, *8*(27), 1-15. https://doi.org/10.1186/s40634-021-00346-x

van Ierssel, J., Pennock, K. F., Sampson, M., Zemek, R., & Caron, J. G. (2022). Which psychosocial factors are associated with return to sport following concussion? A systematic review. *Journal of sport and health science*, *11*(4), 438-449. https://doi.org/10.1016/j.jshs.2022.01.001

Wolfswinkel, J. F., Furtmueller, E., & Wilderom, C. P. (2013). Using grounded theory as a method for rigorously reviewing literature. *European journal of information systems*, *22*(1), 45-55. https://doi.org/10.1057/ejis.2011.51

BODY COMPOSITION AND AGILITY AS DETERMINANTS OF KABADDI PERFORMANCE: A CROSS-SECTIONAL STUDY

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Abstract: *Kabaddi is a team sport that requires physical strength, agility, endurance, and offensive and defensive skills. Body composition, such as muscle mass, fat-free mass, and fat mass, is believed to influence performance. This study analyzes the relationship between body composition, agility, and the performance of kabaddi athletes, as well as the contribution of each variable to the performance of kabaddi athletes. This correlational study with a cross-sectional approach involved 32 active kabaddi athletes from East Java. Data collection was carried out by measuring waist circumference with a measuring tape, while muscle mass, fat-free mass (FFM), and fat mass were measured using bioelectrical impedance analysis (BIA) with the InBody 270; agility was assessed with the T-agility test, and kabaddi performance was evaluated by experts based on raiding, catching, and teamwork skills. The results showed that muscle mass had the strongest correlation with kabaddi performance (r=0.957, p=0.001), followed by fat-free mass (r=0.937, p=0.001) and waist circumference (r=0.749, p=0.001), while fat mass showed a lower significant correlation (r=0.512, p=0.010). Agility showed a significant negative correlation (r=-0.775, p=0.001), where faster agility test times were associated with better performance. The regression model explained 95.3% of the variability in kabaddi performance. In conclusion, muscle mass, fat-free mass, and agility are the main predictors of kabaddi athlete performance, while fat mass and waist circumference had minimal impact.*

Keyword: Kabaddi, Body composition, Agility, Physical strength, Endurance

INTRODUCTION

Kabaddi is a martial art that lasts 40 minutes, interspersed with a 5-minute break (20-5-20). The game aims to touch as many defenders as possible without running out of breath while charging into the opponent's area to score points (Singh, 2023). Therefore, one can gauge a player's Kabaddi performance by the number of points they score in a 40-minute period. Kabaddi is a team contact sport that requires high endurance, explosive power, strength, agility, response time, spatial awareness, and speed (Anita et al., 2020). Players must move quickly and think quickly, requiring quick reflexes and decision-making abilities even outside the game (Singh, 2023). The combination of movements in this sport, such as jumping, dodging, turning, pushing, and falling, increases the risk of injury for each athlete (Dahiya and Kumar, 2023). Therefore, we can conclude that agility plays a crucial role in kabaddi performance. Consequently, Kabaddi players focus their training regimens on agility (Prakash et al., 2021).

The literature well documents the importance of agility in kabaddi. According to Muthukumar and Kumaresan (2019), the most important motor skill in Kabaddi is agility. Majlesi et al. (2012) state that in order to evade adversary grappling, each player must have a high level of speed, particularly while changing directions, in order to catch their opponents successfully (Mamgain, 2021; Patel Ankur Chaturbhai and Dr. Gagan Vyas, 2023). An athlete's agility directly impacts the fast-paced game of Kabaddi, which involves sprinting, dodging, and quick reflexes (De et al., 1982). An athlete's agility directly influences the need for "both aerobic and anaerobic endurance with a well-built physique," according to another study on Indian national kabaddi players (Dey, Khanna, and Batra, 1993). Yallap and Munireddy (2019) found that training with shuttle runs to increase speed did not significantly affect the performance of kabaddi athletes (Utama et al., 2022).

Kabaddi differs from other sports in that it involves direct physical contact with the opponent, necessitating a

good body composition and agility to avoid or attack the opponent for optimal performance (Kumar, Nara, and Dhull, 2023). Therefore, we anticipate that body composition, including aspects like muscle mass, body fat percentage, and lean body mass, will significantly influence a Kabaddi player's level of success (Kumar Kaushik et al., 2018). It is possible that athletes with varied body compositions would experience a variety of benefits and drawbacks when participating in this activity. In order to improve player growth and overall success, it is essential for players, coaches, and sports scientists to have a solid understanding of the link between body composition and Kabaddi performance (Johnson and Ivarsson, 2017).

Kabaddi is a sport that emphasizes physical strength, agility, endurance, and defensive and attacking abilities, so optimal body parameters are key to athlete success (Aggarwala et al., 2019). High muscle mass and low fat mass contribute to increased strength and agility (Dharmajayanti, Negara, and Artini, 2023), while proportional waist circumference correlates with better movement ability and endurance (Devaraju & Kalidasan, 2012). Fat-free mass, as a primary indicator of muscle strength, plays a major role in intense physical activities such as attacking and defending in kabaddi (Portella et al. 2014; Roy and Sarkar, 2022). However, despite evidence supporting the importance of body composition in other sports such as football and wrestling, specific research examining the direct relationship between these body components and specific performance in kabaddi is limited. Most studies focus more on the general benefits of physical fitness without taking into account the unique physiological and biomechanical needs of kabaddi. Furthermore, the majority of studies have focused on general athlete populations, neglecting contextual factors like player positions (raider or defender) or variations in competition levels. This study intends to bridge this gap by thoroughly examining the impact of waist circumference, muscle mass, fat-free mass, and fat mass on kabaddi performance, thereby offering more precise guidance for kabaddi athlete training and evaluation programs.

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METHOD

Study design and participants

This type of research is a correlational study that uses a cross-sectional approach to identify the relationship between body composition, agility, and performance of Kabaddi athletes. All 34 East Java kabaddi athletes, who were still actively competing in official national tournaments and had no history of serious injuries or medical conditions that affected performance, comprised the population. The determination of the number of samples was calculated using the Slovin formula with a margin of error of 5%, and a value of 31.336 was obtained and rounded up to 32 (Adhikari, 2021). All participants were male and ranged in age from 19 to 24 years (M = 21.28 ± 1.75). None had a history of significant injuries or illnesses that could impact their performance. Participants must actively compete in recognized tournaments and follow consistent training routines to qualify. As is common in regional Kabaddi training environments, all had experience in both offensive and defensive roles. However, specific positions like raider (attacker) or defender were not distinguished during data collection. Future research should consider grouping players by their role to better understand position-specific physical and performance demands.

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Data collection

Data collection was carried out by measuring waist circumference with a measuring tape. In contrast, muscle mass, fat-free mass (FFM), and fat mass were measured using bioelectrical impedance analysis (BIA) with the In-Body 270 brand made by InBody Co., Ltd., South Korea (Duren et al., 2008). The T agility test was used in this study to measure agility (Subramani, Perumal, and Velu, 2019; Labib Siena Ar Rasyid *et al.*, 2023). Researchers sought the help of kabaddi experts to conduct a kabaddi performance assessment. Kabaddi experts evaluate the Kabaddi players' playing performance by assigning points based on three factors, including their raiding ability. The evaluation also accounted for the following factors: We evaluated the athletes' catching ability and teamwork skills. Kabaddi experts rate each criterion on a scale of 1–10, with 10 representing the best performance (Singh, 2023).

Data analysis

Descriptive statistics used the mean, standard deviation, minimum, and maximum values of the research variables to describe the characteristics of the data. These variables included body composition (waist circumference, muscle mass, fat-free mass, and fat mass), agility, and Kabaddi performance. Furthermore, Pearson correlation analysis was used to identify the relationship between the independent variables, namely body composition and agility, with the dependent variable, Kabaddi performance. Then, multiple linear regression analysis was conducted to test the contribution of each independent variable to Kabaddi performance simultaneously. The results of linear regression were evaluated through the coefficient of determination (R-squared) value to determine how much the independent variables could explain the variance in the dependent variable. The ANOVA test was used to test the significance of the overall regression model by examining the F value and significance level (p-value). Finally, regression coefficient analysis was conducted to determine the specific contribution of each independent variable to Kabaddi performance. Variables with a p-value of less than 0.05 were considered to have a significant effect, with the direction and strength of the effect expressed through the regression coefficient value (β) and standard error. This approach provides a comprehensive understanding of the relationship between body composition, agility, and the performance of Kabaddi athletes.

RESULTS

Table 1-3 will present the mean data, standard deviation, and minimum and maximum values of the variables in this study.

Table 1. Descriptive Statistics of Anthropometric Parameters

Variable	Mean±SD	Min	Max
Age (years)	21.28±1.75	19	24
Body weight (kg)	67.95±7.68	58	87
Body height (cm)	170±0.07	158	186

The 32 male Kabaddi athletes ranged in age from 19 to 24, with an average age of 21.28 ± 1.75 years. The average height was 170 cm, ranging from 158 to 186 cm, and the average weight was 67.95 ± 7.68 kg. These numbers show that young adult athletes in the competitive age range for high-performance Kabaddi comprised most of the sample.

Table 2. Descriptive Statistics of Body Composition Data

Variable	Mean±SD	Min	Max
Waist Circumference (cm)	0.83±0.06	0.72	0.93
Muscle Mass (kg)	21.77±2.32	16.4	26.3
Fat-Free Mass (kg)	45.28±3.49	40.2	53.7
Fat Mas (kg)	17.31±1.38	15.2	19.7

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Table 2 shows the waist circumference, which ranged from 0.72 to 0.93 meters with a mean of 0.83 ± 0.06 meters. Muscle mass varied from 16.4 kg to 26.3 kg, averaging 21.77 ± 2.32 kg. Fat-free mass (FFM) had a mean of 45.28 ± 3.49 kg, indicating a consistent level of lean tissue among participants. Fat mass averaged 17.31 ± 1.38 kg and had a smaller range, suggesting that the athletes' fat tissue varied relatively little.

Table 3. *Descriptive Statistics of Agility and Kabaddi Performance Data*

Variable	Mean±SD	Min	Max
Waist Circumference (cm)	0.83±0.06	0.72	0.93
Muscle Mass (kg)	21.77±2.32	16.4	26.3
Fat-Free Mass (kg)	45.28±3.49	40.2	53.7
Fat Mas (kg)	17.31±1.38	15.2	19.7
Agility (s)	10.39±0.82	9.21	12.32
Kabaddi performance (raiding skills, catching skills, teamwork skills)	21.78±2.38	18	26

Table 3 presents the descriptive data on performance and agility. The fastest and slowest T-agility test times were 9.21 and 12.32 seconds, respectively, with an average of 10.39 ± 0.82 seconds. This range suggests there is room for performance improvement through targeted training, as it shows a moderate variation in agility levels among participants. Expert evaluators assessed the players' raiding, catching, and teamwork skills to determine their kabaddi performance, which resulted in a mean score of 21.78 ± 2.38, with scores ranging from 18 to 26. These scores indicate moderate-to-high proficiency across key kabaddi performance areas, reflecting relatively high consistency within the sample.

Table 4. *Pearson correlation of body composition and agility with kabaddi performance*

Variabel	Subvariabel	p (sig.)	R	R	R Square	Adjusted R Square	Std. Error of the Estimate
Body Composition	Waist Circumference	0.001*	0.749	0.976	0.953	0.944	0.56053
	Muscle Mass	0.001*	0.957				
	Fat-Free Mass	0.001*	0.937				
	Fat Mas	0.010*	0.512				
Agility		0.001*	-0.775				

significant at p<0.05

Table 4 uses Pearson correlation analysis to describe the correlation between body components, agility, and Kabaddi performance. Muscle mass showed the strongest correlation with Kabaddi performance (r=0.957, p=0.001), followed by fat-free mass (r=0.937, p=0.001) and waist circumference (r=0.749, p=0.001). Fat mass had a lower but significant correlation (r=0.512, p=0.010). In contrast, agility showed a significant negative correlation (r=-0.775, p=0.001), indicating that the faster the agility time, the better the Kabaddi performance of the players. Overall, the model's R-value of 0.953 suggests that combining these variables can explain 95.3% of the variance in Kabaddi performance.

Table 5. *Anova test result*

Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.
Kabaddi performance	167.300	5	33.460	106.494	0.000[b]

b. Predictors: (Constant), waist circumference, muscle mass, fat-free mass, fat mas, agility

The ANOVA test in Table 5 supports the overall significance of the model, with an F value of 106.494 and p = 0.000. These results indicate that the combination of the variables waist circumference, muscle mass, fat-free mass, fat mass, and agility contributes significantly to Kabaddi players' performance. This analysis confirms that body factors and agility are the main determinants of athlete success in this sport.

Table 6. Coefficients of Kabaddi Performance

Model	B	Std. Error	β	t	Sig.
(Constant)	4.701	3.628		1.296	0.206
Waist Circumference	1.822	2.341	0.050	0.778	0.443
Muscle Mass	0.571	0.121	0.544	4.723	0.000
Fat-Free Mass	0.191	0.079	0.281	2.408	0.023
Fat Mas	-0.005	0.104	-0.003	-0.045	0.964
Agility	-0.501	0.204	-0.173	-2.463	0.021

Dependent Variable: Kabaddi Performance

The coefficient analysis in Table 6 explains the individual contribution of each variable to Kabaddi performance. Increasing muscle mass directly improves kabaddi performance (B=0.571, p=0.000). Fat-free mass also has a significant positive contribution (B=0.191, p=0.023). In contrast, fat mass (B=-0.005, p=0.964) and waist circumference (B=1.822, p=0.443) have no significant effect on performance. The study reveals a significant negative contribution from agility (B=-0.501, p=0.021), suggesting a correlation between improved performance and excellent agility times. This study shows that muscle mass, fat-free mass, and agility are the main predictors of Kabaddi athlete performance, with muscle mass being the most influential variable.

DISCUSSION

This study shows that muscle mass is a significant factor in Kabaddi players' performance. The relevance of substantial muscle mass (β = 0.544, p < 0.001) can be explained by the fact that this sport needs quick reactions for moves like jumping, pushing, and catching (Pramanick et al., 2022). Higher muscle mass allows athletes to produce greater power quickly, as noted by Kumar et al. (2023). In the context of Kabaddi, explosive power becomes especially important during the attacking phase, where players must quickly counter physical pressure from defenders (Sathshivam et al., 2023). Power, which is a combination of muscular strength and speed, allows athletes to produce force in a short period of time (Rusdiawan et al., 2024; Wismanadi et al., 2020).

In terms of raiding, strong power provides significant advantages (Dharod et al., 2020). Athletes possess the ability to swiftly engage with opponents and swiftly retreat to the safe zone prior to capture. In addition, explosive strength allows athletes to penetrate defenses and escape defenders' grips. This ability relies heavily on the core muscles, arms, and legs, which play a role in supporting rapid and dynamic movements (Singh, 2016). In terms of defense, power also plays an important role, especially when doing takedowns or stopping the opponent's movement (Pramanick et al., 2022). Athletes with explosive strength can provide enough force to stop the raider effectively, even when in a difficult position. High power also supports the ability to maintain body stability and utilize momentum, enabling athletes to maintain a solid defensive position (Ahmed, Saraswat, and Esht, 2022). Training that focuses on increasing muscle hypertrophy through methods such as resistance training and plyometrics is a highly recommended strategy to support this performance (Fatouros et al. 2000; Grgic, Schoenfeld, and Mikulic, 2021; Gunasekar and Balamurugan, 2021).

The significant correlation between fat-free mass (FFM) and Kabaddi performance (r = 0.937, p = 0.001) supports the argument that this component is not only relevant for power production but also metabolic efficiency. FFM reflects aerobic and anaerobic work capacity, which is essential for maintaining high intensity during 40 minutes of play. Additionally, increasing FFM may reduce the risk of premature fatigue, which is an important factor in long-duration competitions (Johnson and Ivarsson, 2017). Research has shown that protein-rich diets and creatine supplementation effectively increase FFM, and athlete development programs may prioritize these strategies (Hecht et al., 2023; Wax et al., 2021).

The study found a lower positive relationship (r = 0.512, p = 0.010) for fat mass, while waist circumference did not show a significant effect. This is consistent with previous studies, which stated that a high proportion of body fat can reduce movement efficiency due to excessive load (Damayanti & Adriani, 2021; Mohajan and Mohajan, 2023). Waist circumference as a proxy for abdominal fat distribution may be less relevant in determining direct Kabaddi performance. Therefore, coaches need to ensure that athlete training programs focus on increasing muscle mass and reducing body fat to improve the optimal muscle-fat ratio (Kurinami et al., 2021; Nishikori and Fujita, 2024).

Agility showed a significant negative correlation (r = -0.775, p = 0.001), indicating that the faster the time achieved in the T-agility agility test, the better the Kabaddi performance. In the game, the ability to move quickly

and precisely in a narrow space is crucial for avoiding defenders and catching opponents. Tamilselvan Scholar *et al.*, (2022) conveyed in their study that SAQ training, which focuses on improving agility, can also enhance the quality of kabaddi players. Agility training combining quick reactions and sudden direction changes is highly recommended. For instance, training methods such as ladder drills, zig-zag patterns, and SAQ training can enhance neuromuscular responses and quick reflexes, thereby supporting situational needs in the game of Kabaddi (Chandrakumar & Ramesh, 2015; Kurinami et al., 2021; Ravi and Divya, 2024; Tamilselvan Scholar et al., 2022). Compared to studies on other sports with similar characteristics, such as wrestling or rugby, the role of agility in Kabaddi is unique. For example, muscle mass has a more dominant influence in rugby than agility due to the greater need for physical contact (Dahiya & Kumar, 2023). This difference can be explored in understanding how each physical element has different significance based on the dynamics of a particular sport.

The results of this study highlight that not all components of body composition contribute significantly to performance. For example, fat mass and waist circumference showed minimal impact, possibly due to the complex interaction between body fat distribution and the specific demands of Kabaddi. Further in-depth research could identify whether there is an optimal threshold for a particular fat mass to support strength and endurance without compromising agility.

CONCLUSION

Agility and body composition significantly influence kabaddi performance, especially muscle mass and fat-free mass. Muscle mass supports explosive power, fat-free mass increases metabolic efficiency and work capacity, while agility allows for quick and precise movements in defense and attack. In contrast, fat mass and waist circumference have a lower or insignificant impact on performance. These findings emphasize the significance of enhancing muscle mass through resistance and plyometric training and enhancing agility through ladder drills. A protein-rich nutritional program and creatine supplementation also support fat-free mass increases. To optimize data-driven kabaddi training programs and support maximum performance at the international level, further research is necessary to understand the influence of player position and competition level.

REFERENCES

Adhikari, G. P. (2021). Calculating the Sample Size in Quantitative Studies. *Scholars' Journal*, *December*, 14–29. https://doi.org/10.3126/scholars.v4i1.42458

Aggarwala, J., Dhingra, M., Bhatia, V., Hasan, U., & Chatterjee, S. (2019). Analysis of Physical and Physiological Requirements of Indian Male Junior Kabaddi Players in Relation to their Playing Positions. *Turkish Journal of Sports Medicine*, *54*(4), 215–224. https://doi.org/10.5152/tjsm.2019.135

Anita, M., Jyoti Professor, D., Author, C., & Jyoti, D. (2020). Agility a real need for Kabaddi player. *International Journal of Physical Education, Sports and Health*, *7*(3), 423–424. www.kheljournal.com

Chandrakumar, N., & Ramesh, C. (2015). Effect of ladder drill and SAQ training on speed and agility among sports club badminton players. *Internat Ional Journal*, *1*(12), 527–529.

Dahiya, S., & Kumar, D. D. (2023). A literature review study on kabaddi injuries. *International Journal of Physical Education, Sports and Health*, *10*(3), 226–228. https://doi.org/10.22271/KHELJOURNAL.2023.V10.I3D.2949

Damayanti, C., & Adriani, M. (2021). Correlation Between Percentage of Body Fat With Speed and Cardiorespiratory Endurance Among Futsal Athletes in Surabaya. *Media Gizi Indonesia*, *16*(1), 53. https://doi.org/10.20473/mgi.v16i1.53-61

De, A. K., Dasgupta, P. K., Panda, B. K., & Bhattacharya, A. K. (1982). Physical efficiency tests on Indian male "Kabaddi" inter-university players. *British Journal of Sports Medicine*, *16*(1), 33–36. https://doi.org/10.1136/BJSM.16.1.33

Devaraju, K., & Kalidasan, R. (2012). Prediction of kabaddi playing ability from selected anthropometrical and physical variables among college level players. *Asian Journal of Information Technology*, *11*(4), 131–134. https://doi.org/10.3923/ajit.2012.131.134

Dey, S. K., Khanna, G. L., & Batra, M. (1993). Morphological and physiological studies on Indian national kabaddi players. *British Journal of Sports Medicine*, *27*(4), 237–242. https://doi.org/10.1136/BJSM.27.4.237

Dharmajayanti, I. A. L., Negara, A. A. G. A. P., & Artini, I. G. A. (2023). The correlation between the body mass index, speed, and agility among athletes: a literature review. *Kinesiology and Physiotherapy Comprehensive*, *2*(3), 81–86. https://doi.org/10.62004/kpc.v2i3.32

Duren, D. L., Sherwood, R. J., Czerwinski, S. A., Lee, M., Choh, A. C., Siervogel, R. M., & Chumlea, W. C. (2008). Body composition methods: Comparisons and interpretation. *Journal of Diabetes Science and Technology*, *2*(6), 1139–1146. https://doi.org/10.1177/193229680800200623

Fatouros, I. G., Jamurtas, A. Z., Leontsini, D., Taxildaris, K., Aggelousis, N., Kostopoulos, N., & Buckenmeyer, P. (2000). Evaluation of Plyometric Exercise Training, Weight Training, and Their Combination on Vertical Jumping Performance and Leg Strength. *Journal of Strength and Conditioning Research*, *14*(4), 470–476. https://doi.org/10.1519/00124278-200011000-00016

Grgic, J., Schoenfeld, B. J., & Mikulic, P. (2021). Effects of plyometric vs. resistance training on skeletal muscle hypertrophy: A review. *Journal of Sport and Health Science*, *10*(5), 530–536. https://doi.org/10.1016/j.jshs.2020.06.010

Gunasekar, T., & Balamurugan, S. (2021). Effects of Plyometric Training on Selected Motor Components in Semi-Professional Kabaddi Players – A Randomised Control Study. *Indian Journal of Physiotherapy & Occupational Therapy - An International Journal*, *15*(3), 184–192.

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https://doi.org/10.37506/ijpot.v15i3.16181

Haegele, J. A., Wilson, W. J., Zhu, X., Bueche, J. J., Brady, E., & Li, C. (2021). Barriers and facilitators to inclusion in integrated physical education: Adapted physical educators' perspectives. *European Physical Education Review*, *27*(2), 297–311. https://doi.org/10.1177/1356336X20944429

Hecht, C., Bank, N., Cook, B., & Mistovich, R. J. (2023). Nutritional Recommendations for the Young Athlete. *Journal of the Pediatric Orthopaedic Society of North America*, *5*(1), 599. https://doi.org/10.55275/jposna-2023-599

Johnson, U., & Ivarsson, A. (2017). Psychosocial factors and sport injuries: prediction, prevention and future research directions. *Current Opinion in Psychology*, *16*, 89–92. https://doi.org/10.1016/J.COPSYC.2017.04.023

Kumar, D., Nara, K., & Dhull, S. (2023). The advantage and disadvantage of body composition on athletic success: A kabaddi player perspective. *International Journal of Yogic, Human Movement and Sports Sciences*, *8*(2), 151–153. https://doi.org/10.22271/yogic.2023.v8.i2c.1448

Kumar Kaushik, D., Kumari, H., & Hooda, H. (2018). A comparative study of sports achievement motivation of national level circle style kabaddi players. *International Journal of Physiology*, *3*(1), 1621–1624. www.journalofsports.com

Kurinami, N., Sugiyama, S., Yoshida, A., Hieshima, K., Miyamoto, F., Kajiwara, K., Jinnouch, K., Jinnouchi, T., Nomura, M., & Jinnouchi, H. (2021). Body Muscle-to-Fat Ratio, Rather Than Fat-to-Muscle Ratio, Significantly Correlates With Measured Insulin Resistance in Patients With Type 2 Diabetes Mellitus. *Journal of Clinical Medicine Research*, *13*(7), 387–391. https://doi.org/10.14740/jocmr4401

Labib Siena Ar Rasyid, M., Wiriawan, O., Siantoro, G., Ardy Kusuma, D., & Rusdiawan, A. (2023). Combination of plyometric and ladder drill: Its impact on improving speed, agility, and leg muscle power in badminton. *Jurnal SPORTIF : Jurnal Penelitian Pembelajaran*, *9*(2), 290–309. https://doi.org/10.29407/js_unpgri.v9i2.20468

Mamgain, R. (2021). Comparison of agility between Kho-Kho and Kabaddi. *International Journal of Physical Education, Sports and Health*, *8*(3), 172–173.

Mohajan, D., & Mohajan, H. K. (2023). A Study on Body Fat Percentage for Physical Fitness and Prevention of Obesity: A Two Compartment Model. *Journal of Innovations in Medical Research*, *2*(4), 1–10. https://doi.org/10.56397/jimr/2023.04.01

Muthukumar, K. M., & Kumaresan, G. (2019). A comparative study on agility and abdominal muscular endurance among various universities male kabaddi players in Tamilnadu. *International Journal of Physiology, Nutrition and Physical Education*, *4*(2), 199–201.

Nishikori, S., & Fujita, S. (2024). Association of fat-to-muscle mass ratio with physical activity and dietary protein, carbohydrate, sodium, and fiber intake in a cross-sectional study. *Scientific Reports*, *14*(1), 1–9. https://doi.org/10.1038/s41598-024-61289-8

Patel Ankur Chaturbhai, & Dr. Gagan Vyas. (2023). Effect of Hurdle Running Training on Explosive Power of Kabaddi Players. *Journal of Survey in Fisheries Sciences*, *10*(1), 1402–1403. https://doi.org/10.53555/sfs.v10i2.2677

Portella, D. L., Cossio-Bolaños, M. A., Hespanhol, J. E., & De Arruda, M. (2014). Fat-free mass and bone mineral content positively affect peak torque production in Brazilian soccer players. *Isokinetics and Exercise Science*, *22*(4), 273–278. https://doi.org/10.3233/IES-140548

Prakash, K. V. S., Sadvika, P. D., & Chakravarthi, C. A. (2021). Effectiveness of Ladder Training Versus Plyometric Training Program on Agility in Kabaddi Players. *International Journal of Health Sciences and Research*, *11*(11), 320–334. https://doi.org/10.52403/ijhsr.20211138

Pramanick, S., Chowdhuri, P., Dutta, R., & Rahaman, A. (2022). the Strength and Power of Kabaddi and Athletics Players. *International Journal of Research -GRANTHAALAYAH*, *10*(3), 50–56. https://doi.org/10.29121/granthaalayah.v10.i3.2022.4532

Ravi, P., & Divya, K. (2024). The science of ladder drills and plyometrics: Enhancing neuromuscular efficiency in athletes. *Edelweiss Applied Science and Technology*, *8*(4), 553–561. https://doi.org/10.55214/25768484.v8i4.1149

Roy, M. C., & Sarkar, S. (2022). Comparison of Body Composition Among the Selected Groups of Female Kabaddi Players. *International Journal of Kinanthropometry*, *2*(2), 58–64. https://doi.org/10.34256/ijk2226

Rusdiawan, A., Kusuma, D. A., Firmansyah, A., Wismanadi, H., Cemal, Ö., Wicahyani, S., & Lani, A. (2024). A combination of swissball hamstring curl and stiff-leg deadlift training on agility, hamstring asymmetry, and leg power in badminton athletes with hamstring asymmetry conditions. *Retos*, *59*, 666-673. https://doi.org/DOI:10.47197/retos.v59.107995

Sathshivam, D., Adhikari, R., Ghosh, S., & Pullinger, S. A. (2023). Countermovement Jump Performance in Elite Senior Male Kabaddi Players: A Cross-Sectional Study. *Journal of Advances in Sports and Physical Education*, *6*(09), 153–158. https://doi.org/10.36348/jaspe.2023.v06i09.003

Singh, K. (2023). An Association of speed, agility and flexibility with the performance of Kabaddi Players. *The Academia*, *01*(1), 21–25. https://admission.kcpgclko.in/WebDoc/PDF/Extra/20220106.pdf

Subramani, A., Perumal, S., & Velu, K. (2019). Effect of Plyometric Training and Weight Training on Leg Explosive Power Among College Men Students. *Journal of Information and Computational Science*, *0*(4), 9–10.

Tamilselvan Scholar, S., Hassan, M., Author, C., & Tamilselvan, S. (2022). Impact of SAQ versus skill based training adaptations on agility performance of male kabaddi players. *International Journal of Physiology, Nutrition and Physical Education*, *7*(1), 225–228. www.journalofsports.com

Utama, M. B. R., Sugiharto, S., Hidayah, T., Mukarromah, S. B., & Sutoro, S. (2022). Circuit training using elastic band: Can it improve the direction-changing agility of Kabaddi athletes? *Sport TK*, *11*, 1–14. https://doi.org/10.6018/sportk.522601

Wax, B., Kerksick, C. M., Jagim, A. R., Mayo, J. J., Lyons, B. C., & Kreider, R. B. (2021). Wax, B.; Kerksick, C.; Jagim, A.; Mayo, J.; Lyons, B.; Kreider, R. Creatine for Exercise and Sports Performance, with Recovery Considerations for Healthy Populations. Nutrients 2021, 13, 1915. https://doi.org/10.3390/nu13061915. *Nutrients*, *13*(6), 3–5.

Wismanadi, H., Kafrawi, F. R., Pramono, M., Firmansyah, A., & Rusdiawan, A. (2020). Rasio Interval Training Dalam Latihan Shadow Bulutangkis Terhadap Power dan Kecepatan. *Journal Sport Area*, *5*(2), 186–198. https://doi.org/10.25299/sportarea.2020.vol5(2).5019

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COMPARATIVE IMPACT OF COMMAND AND EXPLORATORY TRAINING METHODS ON SUNBACK SPIKE SKILLS IN SEPAKTAKRAW: A CASE STUDY OF PPLP WEST SUMATERA ATHLETES

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COMPARATIVE IMPACT OF COMMAND AND EXPLORATORY TRAINING METHODS ON SUNBACK SPIKE SKILLS IN SEPAKTAKRAW: A CASE STUDY OF PPLP WEST SUMATERA ATHLETES

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Abstract: *This study investigates the comparative impact of command and exploratory training methods on the effectiveness of sunback spike skills in sepaktakraw athletes at the PPLP West Sumatra. Using an experimental design, 30 male athletes were selected and homogeneously grouped based on a pre-test of their sunback spike skills. The athletes were divided into two groups using matched subject ordinal pairing, where Group 1 (K1) received command-based training, and Group 2 (K2) received exploratory-based training. Both methods were found to improve the athletes' sunback spike performance significantly. Statistical analysis revealed that the command training method had a more substantial effect, with a t-value of 7.56, compared to the exploratory method's t-value of 5.03, both exceeding the critical value (1.76). Additionally, command training demonstrated superior efficacy in enhancing sunback spike ability, as indicated by a t-value of 8.92, which surpassed the threshold value (1.734). The findings recommend that coaches integrate both methods into training programs, emphasizing the command approach for optimal skill development. Future research should address limitations such as sample size to validate these findings further and expand their applicability.*
Keywords: *Sepaktakraw, Sunback Spike, Command Training, Exploratory Training, Athlete Development*

INTRODUCTION

Exercise improves a person's spirit, physical ability, and fitness (Afrizal et al., 2024; Pagliaro et al., 2024; Paillard, 2023). In the era of globalization, sports have become a vital social interaction platform, including the sport of sepaktakraw, which has social value and can encourage community involvement as one of the traditional cultural identities. A study shows that participation in sports such as sepaktakraw improves physical health, psychological well-being, and social relationshipsb(Crevenna, 2020; Tokarski et al., 2023). In addition, the accessibility and popularity of the sport of sepaktakraw highlight its significance as a means of social integration, transcending economic barriers, and promoting inclusivity (Guspita & Febrina Harahap, 2022; Opstoel et al., 2020).

Sepaktakraw is a popular sport in ASEAN countries, including Malaysia, Thailand and Indonesia (Hassan et al., 2023). In Indonesia, particularly in West Sumatra, the sport is also known as Sepak Rago, a traditional game part of the rich Malay culture. Sepak Rago is similar to modern Sepaktakraw but is more straightforward and relaxed, focusing on togetherness and entertainment. Nonetheless, Sepaktakraw has now evolved into an achievement sport that competes nationally and internationally (Muazu Musa et al., 2020). Sepaktakraw has experienced tremendous progress in West Sumatra, as evidenced by athletes' success in various competitions, especially for young athletes. Long-term coaching strategies are very effective in improving athlete performance, thus acquiring significant regional, national and international achievements (Granacher et al., 2016; Lloyd et al., 2015; Myers et al., 2017; Suchomel et al., 2016).

The development of the ability of Sepaktakraw athletes as an achievement sport depends on several important factors, including physical condition (strength, endurance, flexibility), technique (smash, serve, pass), match tactics, and mental (confidence, focus, and emotional control) (Issurin, 2017; Kovács & Szakál, 2024; Sarkar et al., 2014). These factors are the basis for creating athletes who excel physically and have strong mental and social readiness. Sepaktakraw athletes must master basic techniques such as serving, spike (smash), and heading, as well as special skills such as feints and blocking.

Smash or spike is a vital technique that requires acrobatic skills, strategic placement, and consistent execution (Bais et al., 2023). There are three main types of spike techniques: roll spike (RS), sunback spike (SS), and half-roll

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spike (HRS). Sunback spike is a vital attack technique in sepaktakraw that involves a hard kick using the foot from the back of the body to place the ball in an area complex for the opponent to reach. The success of this technique depends on timing, team coordination, and player strength, agility, and flexibility, which require high skill and reasonable body control to execute effectively in competition.

Sunback spike is a challenging technique that involves acrobatic movements in sepaktakraw. Teams that master this technique tend to have higher win rates and emphasise the importance of strategy in competitive play. Failure in its execution can provide opportunities for the opponent to score points, which can change the momentum of the game (Afonso et al., 2021; Oliveira et al., 2020). However, the complexity of this movement requires extensive practice and skill development, which can be an obstacle for less experienced players.

PPLP West Sumatra players' explosiveness has not produced maximum results, as reported by the team coach. In addition to failing to execute substantial and precise sunback spikes, players often make mistakes in attempts to perform sunback spikes. This is due to several factors that affect sunback spike ability, including coordination, strength, speed, flexibility, explosivity, training programs, and training methods that do not run as they should. In addition, research (Etxebarria & Mujika, 2019) highlighted that the lack of an appropriate training program can exacerbate this problem, resulting in suboptimal results in a competitive environment.

Various training styles have been implemented, such as the reciprocal method, which encourages interaction and feedback between coaches and athletes, and the coach-centered command training method, where players follow and imitate the coach's instructions (Ginciene et al., 2023). In this method, the coach gives clear and specific directions on what to do and the athlete is expected to follow the orders, as well as exploratory methods that provide space for athletes to explore and find solutions to challenges in training. The exploratory training method is an approach that focuses more on engaging athletes in the learning process through self-discovery and problem-solving (Chalmers et al., 2014; Moullin et al., 2019). In this method, the coach provides a specific challenge or situation and lets the athlete figure out the solution or the best way to deal with it rather than giving direct instructions.

In this study, researchers focused on problems related to sunback spike ability in sepaktakraw athletes at the West Sumatra Student Sports Education and Training Center (PPLP) to support the development of athletes' skills and improve their achievements. In coaching this sport, it is necessary to emphasize scientifically and ensure that training methodologies are based on evidence-based practices. They can contribute by using command training methods and exploratory methods in the training process to see which is better for achieving training goals.

Materials and Methods

Research Participants

The method used in this study is experimental and focuses on the command training method (X1) and the exploration training method (X2) as independent variables. The ability to sunback spike (Y) is a dependent variable. The sample for this study comprised 30 homogeneous male athletes. The training was conducted over 6 weeks with 16 sessions, beginning with an initial test to assess lending smash ability.

Research Variable

The sample underwent a pretest of sunback spike ability before treatment, and the test results were sorted from highest to lowest score. Subsequently, the sample was divided into two groups (K1 and K2) using the matching subject ordinal pairing method (Chang & Little, 2018; Subiza-pérez et al., 2018). After forming the two groups, Group 1 was assigned to the command training method. In contrast, Group 2 was assigned to the exploratory training method to determine the effect on sunback spike ability.

Table 1. Research design

Pre-Test	Treatment (Exercise)	Post-Test
T_1	Command Method	T_2
	Exploration Method	

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Table 2. *Commando Training Programme*

	Aerobics
Number of Meetings	16 Sessions
Duration of each meeting	60-90 Minutes
Training Intensity	60-80%
Recovery	1-2 minutes

Table 3. *Exploratory Exercise Programme*

	Aerobics
Number of Meetings	16 Meetings
Duration of each meeting	60-90 Minutes
Training Intensity	60-80%
Recovery	1-2 minutes

Research Methods

The instrument used to measure the sunback spike in this study is the test of the results of the sunback spike, which has a validity of 0.99 and a reliability of 0.78. The purpose of the test is to measure smash skills. The data analysis focused on testing whether the training method (command vs exploration) significantly influenced the athlete's smash ability, considering the normality test as the initial step of the analysis. This study conducted a normality test using Liliefors test statistics with a significance level (α) set at 0.05 using SPPS software. This threshold is the basis for determining whether the data is usually distributed.

RESULTS

Following data collection, the writers processed and evaluated the information before displaying the findings in a table.

Table 2. *Normality Test*

Data	n	L_o	L_{tabel}	Description
Command Practice Method (Pre test)	15	0.1832	0.22	Normal
Exploratory Exercise Method (Pre test)	15	0.1881	0.22	Normal
Command Practice Method (Post test)	15	0.1667	0.22	Normal
Practice method Exploration (Post test)	15	0.1224	0.22	Normal

The result of the pre-test data of the command training method group was 0.1832, which was smaller than the value (L table) of 0.22 at the significance level of $\alpha = 0.05$. The results of the pre-test data of the exploratory exercise method group were 0.1881, also smaller than the value (L table) of 0.22 at the significance level of $\alpha = 0.05$.

The result of the post-test data of the command training method group was 0.1667, smaller than the value (L table) of 0.22 at the significance level of $\alpha = 0.05$. The results of the post-test data of the exploratory exercise method group were 0.1224, smaller than the value (L table) of 0.22 at the significance level of $\alpha = 0.05$. From the above result data, it can be concluded that the data is usually distributed.

The t-test results with a significance level of 0.05 above were used to test the effect in the same group. In the group with the command training method consisting of 15 samples, the maximum score was 12, and the minimum score was 5, with an average of 8.47 and a standard deviation (SD) of 2.20. Meanwhile, in the post-test, they got a maximum score of 16 and a minimum score of 12, with an average of 14.00 and a standard deviation of 1.41 for Kedeng's smash ability. The results of the hypothesis test are presented in Table 5.

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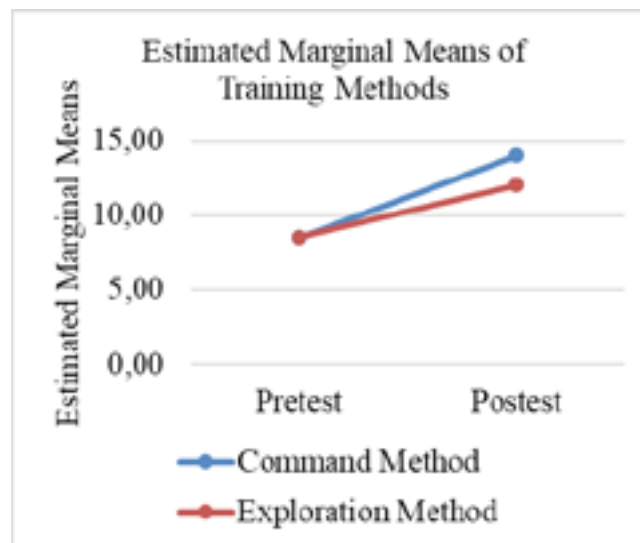
Figure 1. *The Data normality test for each group (cell) was analyzed using Kolmogorov-Smirnov with SPSS*

Table 3. Command Training Method

	Mean	SD	t-count	α	t-tabel	Test results
Pre Test	8.53	2.10	7.56	0.05	1.76	Significant
Post Test	14.00	1.41				

From the table, it can be seen that the t-count is $(7.56) \geq$ t-table (1.76), which means that the research hypothesis is accepted. Therefore, it can be concluded that the command training approach significantly influences Kedeng's smash ability. The average score of the sunback spike ability increased from 8.47 at the time of the pre-test to 14.00 at the time of the post-test, indicating a significant improvement in skill.

The results of the pre-test of smash ability in the exploration exercise method group with a sample of 15 people showed that the maximum score was 12, the minimum was 6, the average was 8.53, and the standard deviation (SD) was 1.92. Meanwhile, the post-test results showed that the sunback spike ability ranged from a score of 9 to 15, with an average of 12.00 and a standard deviation (SD) of 1.69. Table 6 presents the findings from the hypothesis test.

Table 4. Exploratory Exercise Method

	Mean	SD	t-count	a	t-tabel	Test results
Pre Test	8.53	1.92	5.03	0.05	1.76	Significant
Post Test	12.00	1.69				

From the table, it can be seen that the t-count value $(5.03) \geq$ t-table (1.76) shows that the research hypothesis is acceptable. It can be concluded that the exploration training method influences Kedeng's smash ability. The average score of the sunback spike ability increased from 8.53 in the pre-test to 12.00 in the post-test, indicating a significant improvement in the ability.

With a sample of 15 athletes, the final test results (post-test) for the command training method group had a maximum score of 16, a minimum score of 12, an average of 14.00, and a standard deviation (SD) of 1.41 in the ability to sunback spike. Meanwhile, the results of the exploratory training method group's final test (post-test) showed a maximum score of 15, a minimum score of 9, an average of 12.00, and a standard deviation (SD) of 1.69 in the ability to sunback spike. The results of the hypothesis testing of this study can be seen in Table 7.

Table 5. Hypothesis Testing of Effectiveness Between Command Training Method and Exploratory Training Method

	Mean	SD	t-count	a	t-tabel	Test results
Command	5.47	2.79	2.00	0.05	1.77	Significant
Exploration	3.47	2.66				

From the table, it can be seen that t-count (2.00) ≥ t-table (1.77). This indicates that the research hypothesis is acceptable. Therefore, it can be concluded that the command training approach has a more significant impact on the sunback spike ability than the exploration training approach.

DISCUSSION

The problem that often occurs is that the training technique does not change or is not in harmony with the information provided, making it difficult to achieve the training goals and making it difficult for athletes to understand the training concept (Bahtra et al., 2020; Deal et al., 2018; Jia et al., 2021; Kannan et al., 2021). Studies on training plans and methods to improve players' skills have been carried out by experts in the field of sepaktakraw (Tewari et al., 2023; Wang et al., 2024). The command training method is characterized by a top-down approach, where the coach maintains complete control over the training process, directing athletes to follow specific instructions with limited autonomy (Rababa & Mahyar, 2023). This method can result in efficient skill acquisition, but it can limit the athlete's ability to think critically and adapt to dynamic situations.

In contrast, exploratory techniques foster a more autonomous learning environment, encouraging athletes to engage in problem-solving activities and collaborate with their peers. This approach promotes critical thinking and encourages a sense of belonging to the learning process as athletes share findings and insights (Marsuki, 2023). Research shows that although command exercises are more effective for developing basic skills, exploratory techniques are more beneficial for developing adaptability and decision-making skills in competitive scenarios (Hirwana et al., 2023).

The smash skills of athletes from the command training method group at the Student Sports Education and Training Center (PPLP) sepaktakraw West Sumatra increased from an average score of 8.47 in the initial test (pre-test) to 14.00 in the final test (post-test). This supports the research hypothesis that the command training approach significantly impacts the smash ability of athletes in the Sports Education and Training Center Pelajar (PPLP) West Sumatra. Command techniques are effective for mastering simple tasks that do not require quick decision-making, as they provide clear and structured guidance for athletes. However, this approach has limitations, especially in developing the various movements necessary to execute complex playing skills.

Command techniques facilitate rapid skill acquisition. They often limit learners to a narrow set of movements and are defined by task structure, potentially inhibiting their ability to adapt to varied situations in the future. In addition, the study also shows that dependence on coaches can lead to a lack of creativity and flexibility in applying skills. Therefore, while command techniques benefit early learning, it is important to incorporate methods that encourage adaptability and broader skill mastery for the long-term development of play skills.

The results of the post-test from the exploratory training method group showed that the average score of athletes' ability to perform sunback spike at the Student Sports Education and Training Center (PPLP) of Sepaktakraw West Sumatra increased from 8.53 in the preliminary test (pretest) to 12.00 in the final test (post-test). This indicates that the research hypothesis that the exploratory training approach significantly positively impacts the ability of PPLP West Sumatra sepaktakraw athletes to perform sunback spike is acceptable. This increase is likely due to athletes adopting strategies from an exploratory training approach, where they take the initiative and find solutions independently.

Exploration exercises aim to explore athletes' ideas, arguments, and methods through open-ended questions and directions, facilitating their understanding of concepts and problem-solving (Newell & Rovegno, 2021). All training decisions are made by the athletes themselves, who provide feedback in the post-session meeting. The coach's goal is to give the athlete enough time to carry out the movement tasks and play skills as instructed so that they can make decisions based on their understanding of the training results (Bennie & O'Connor, 2012; MacLellan et al., 2018; Selimi et al., 2023; Trninić et al., 2009). These strategies have advantages and disadvantages, which theoretically depend on the context. With this method, the coach acts as a guide and facilitator for the athlete, while the athlete acts as an active explorer.

A solution will emerge when the problem reaches a saturation point due to this activity, providing helpful information regarding the next steps needed to resolve the issue. This process shows how athletes improve their character values as they face challenges. The average score of 14.00 in the command training method and 12.00 in the exploration training method, as well as the results of the hypothesis calculation that showed the t-count value (2.021) $\geq$ t-table (1.771), indicate that the hypothesis is accepted. Thus, the command training method group outperformed the exploratory training method group in the final test results (post-test). The athletes were judged based on their ability to do sunback spike at the Student Sports Education and Training Center (PPLP) sepaktakraw West Sumatra. Therefore, the research hypothesis that the command training approach is superior to the exploratory training approach is correct and significantly influences West Sumatra students' smash ability of sepaktakraw athletes (PPLP).

Overall, the command training approach yielded a higher value than the exploratory training strategy, as evidenced by the hypothesis test results. Compared with the exploration training method, the command training method performs better. The statistical analysis results confirm this. The average difference between the exploratory training method, which is 12.00, and the command training method, which is 14.00, indicates that the command training method has a more significant exercise effect than the exploratory training method.

The study results identified that the command training method outperformed the exploration training method. In the command training method, the trainer determines all the training content. Athletes only imitate and follow the coach's orders and instructions. Every aspect, from planning to execution, depends on the direction of the coach (Cushion et al., 2012; Isoard-Gautheur et al., 2016; Jackson et al., 2009; Jowett, 2017; Smith et al., 2023). This means that the athletes imitate the coach's actions and only listen to the explanations. Therefore, the coach's role includes making all decisions from beginning to end each exercise. The role of athletes is to implement, obey, and obey these instructions. The trainer demonstrates each movement, making decisions about location, posture, start time, cadence, shape, stop time, duration, and intervals (Cranmer et al., 2017; Davis & Jowett, 2014; Erickson et al., 2011; Fouraki et al., 2020; Jones & Turner, 2006). Using the command training method is a strategy to improve sunback spike ability. It is highly recommended that athletes develop their smash skills through this type of training to become as proficient as possible.

Conclusion

Based on the research results, both the exploration exercise approach and the command training method are equally beneficial when used with players. However, the command exercise approach outperforms the exploratory exercise method regarding sunback surge capability.

Based on the study's findings, the recommendation is that coaches should use command and exploration training methods to improve sunback spike ability because both methods have proven to be effective. Given that the command training method improves the smash ability, coaches and players should prioritize using this method in training sessions. Researchers interested in further exploring this topic should consider addressing research limitations, such as sample size limitations, to improve the findings' applicability.

Etichal Consideration

The study was authorized by the Universitas Negeri Padang Research Ethics Committee, which oversees research ethics. Several changes were proposed and implemented by the committee. Following these amendments, the researcher made the necessary adjustments to obtain ethical approval. Ethical approval was granted on December 11, 2024, after the required changes and revisions were made.

Reference

Afonso, J., Ramirez-campillo, R., Lima, R. F., Laporta, L., Paulo, A., Castro, H. D. O., Conti, G. De, Costa, T., & Garc, A. (2021). SS symmetry Unilateral versus Bilateral Landing after Spike Jumps in Male and Female Volleyball : A Systematic Review. *Symmetry*, *13*(April), 1–20. https://doi.org/10.37766/inplasy2021.4.0104.Keywords

Afrizal, S., Purnomo, E., Marheni, E., Jermaina, N., Cahyani, F. I., Saputra, D., Ikhlas, A., & Helmi, R. F. (2024). Integration of Life Skills in Football Training Programs in the Context of Positive Youth Development. *International Journal of Disabilities Sports and Health Sciences*, *7*(1), 29–36. https://doi.org/10.33438/ijdshs.1368983

Bahtra, R., Asmawi, M., Widastuti, & Dlis, F. (2020). Improved VO 2Max : The Effectiveness of Basic Soccer Training at a Young Age. *International Journal of Human Movement and Sports Sciences*, *8*(3), 97–102. https://doi.org/10.13189/saj.2020.080304

Bais, S., Padli, Arwandi, J., Iyakrus, Martha, A., Rudyanto, & Arifan, I. (2023). The contribution of flexibility and eye-to-foot coordination to

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the basic skills of sepak takraw. *Journal of Physical Education and Sport*, *23*(12), 3341–3348. https://doi.org/10.7752/jpes.2023.12382

Bennie, A., & O'Connor, D. (2012). Coach-athlete Relationships: A Qualitative Study of Professional Sport Teams in Australia. *International Journal of Sport and Health Science*, *10*(0), 58–64. https://doi.org/10.5432/ijshs.201208

Chalmers, S., Esterman, A., Eston, R., Bowering, K. J., & Norton, K. (2014). Short-Term Heat Acclimation Training Improves Physical Performance : A Systematic Review , and Exploration of Physiological Adaptations and Application for Team Sports. *Sports Medicine*, *44*, 971–988. https://doi.org/10.1007/s40279-014-0178-6

Chang, R., & Little, T. D. (2018). Innovations for Evaluation Research : Multiform Protocols , Visual Analog Scaling , and the Retrospective Pretest – Posttest Design. *Evaluation & the Health Professions*, 1–24. https://doi.org/10.1177/0163278718759396

Cranmer, G. A., Brann, M., & Weber, K. (2017). Quantifying Coach Confirmation: The Development and Preliminary Validation of the Coach Confirmation Instrument. *Communication and Sport*, *5*(6), 751–769. https://doi.org/10.1177/2167479516660037

Crevenna, R. (2020). Health-enhancing physical activity, exercise and sports—a never-ending success story. *Wiener Klinische Wochenschrift*, *132*(5–6), 113–114. https://doi.org/10.1007/s00508-020-01640-x

Cushion, C., Ford, P. R., & Williams, A. M. (2012). Coach behaviours and practice structures in youth soccer: Implications for talent development. *Journal of Sports Sciences*, *30*(15), 1631–1641. https://doi.org/10.1080/02640414.2012.721930

Davis, L., & Jowett, S. (2014). Coach-athlete attachment and the quality of the coach-athlete relationship: implications for athlete's well-being. *Journal of Sports Sciences*, *32*(15), 1454–1464. https://doi.org/10.1080/02640414.2014.898183

Deal, C. J., Pankow, K., Chu, T. A., Pynn, S. R., Smyth, C. L., & Holt, N. L. (2018). A mixed methods analysis of disciplinary incidents in men's soccer. *Sport Management Review*, *21*(1), 72–85. https://doi.org/10.1016/j.smr.2017.04.002

Erickson, K., Côté, J., Hollenstein, T., & Deakin, J. (2011). Examining coach-athlete interactions using state space grids: An observational analysis in competitive youth sport. *Psychology of Sport and Exercise*, *12*(6), 645–654. https://doi.org/10.1016/j.psychsport.2011.06.006

Etxebarria, N., & Mujika, I. (2019). Training and Competition Readiness in Triathlon. *Sports*, *7*(5), 1–15.

Fouraki, V., Stavrou, N. A. M., Apostolidis, N., & Psychountaki, M. (2020). Coach and athlete leadership behaviors: Examining their role in athlete's satisfaction. *Journal of Physical Education and Sport*, *20*(6), 3212–3220. https://doi.org/10.7752/jpes.2020.s6435

Ginciene, G., Amato, C., Oliveira, E. R. De, Oliveira, I., Osbel, E. D., & Leonardi, T. J. (2023). Understanding the pedagogical practice in futsal teaching and learning process based on the TGfU approach. *International Journal of Sports Science & Coaching 2023, 18*(1), 91–100. https://doi.org/10.1177/17479541211070790

Granacher, U., Lesinski, M., Büsch, D., Muehlbauer, T., & Prieske, O. (2016). Effects of Resistance Training in Youth Athletes on Muscular Fitness and Athletic Performance : A Conceptual Model for Long-Term Athlete Development. *Frontiers in Physiology*, *7*(May). https://doi.org/10.3389/fphys.2016.00164

Guspita, E., & Febrina Harahap, E. (2022). The Effect of Regional Finance in Improving the Quality of Human Resources in West Sumatra. *KnE Social Sciences*, *2022*(33), 160–168. https://doi.org/10.18502/kss.v7i6.10619

Hassan, N. M. H. M., Johari, N. H., Omar, M. N., Hassan, M. H. A., & Ahmad, Z. (2023). Head injury evaluation strategy for Sepak Takraw ball heading: a systematic review. *IET Conference Proceedings*, *2022*(22), 484–492. https://doi.org/10.1049/icp.2022.2667

Hirwana, P., Alnedral, Komaini, A., Padli, Zarya, F., Sabillah, M. I., & Munir, A. (2023). The Effect of Command Training Methods, Exploration and Motivation Training Methods on the Smash Ability Results of Junior Sepak Takraw Athletes. *International Journal of Multidisciplinary Research And Analysis*, *6*(2), 518–530. https://doi.org/10.47191/ijmra/v6-i2-08

Isoard-Gautheur, S., Trouilloud, D., Gustafsson, H., & Guillet-Descas, E. (2016). Associations between the perceived quality of the coach-athlete relationship and athlete burnout: An examination of the mediating role of achievement goals. *Psychology of Sport and Exercise*, *22*, 210–217. https://doi.org/10.1016/j.psychsport.2015.08.003

Issurin, V. B. (2017). Evidence-Based Prerequisites and Precursors of Athletic Talent : A Review. *Sports Medicine*, *47*(10), 1993–2010. https://doi.org/10.1007/s40279-017-0740-0

Jackson, B., Knapp, P., & Beauchamp, M. R. (2009). The coach-athlete relationship: A tripartite efficacy perspective. *Sport Psychologist*, *23*(2), 203–232. https://doi.org/10.1123/tsp.23.2.203

Jia, Z., Abdullah, B. Bin, Omar Dev, R. D., & Samsudin, S. Bin. (2021). Influence of football basic technical training on youth soccer players in Shanxi province, China. *Cypriot Journal of Educational Sciences*, *16*(2), 777–788. https://doi.org/10.18844/CJES.V16I2.5658

Jones, R. L., & Turner, P. (2006). Teaching coaches to coach holistically: can Problem-Based Learning (PBL) help? *Physical Education & Sport Pedagogy*, *11*(2), 181–202. https://doi.org/10.1080/17408980600708429

Jowett, S. (2017). Coaching effectiveness: the coach–athlete relationship at its heart. *Current Opinion in Psychology*, *16*, 154–158. https://doi.org/10.1016/j.copsyc.2017.05.006

Kannan, L., Vora, J., Varas-Diaz, G., Bhatt, T., & Hughes, S. (2021). Does exercise-based conventional training improve reactive balance control among people with chronic stroke? *Brain Sciences*, *11*(1), 1–15. https://doi.org/10.3390/brainsci11010002

Kovács, K. E., & Szakál, Z. (2024). Factors influencing sport persistence still represent a knowledge gap – the experience of a systematic review. *BMC Psychology*, *12*(1), 1–14.

Lloyd, R. S., Oliver, J. L., Faigenbaum, A. D., Howard, R., Croix, M. B. A. D. S., Williams, C. A., Best, T. M., Alvar, B. A., Micheli, L. J., Thomas, D. P., Hatfield, D. L., Cronin, J. B., & Myer, G. D. (2015). LONG-TERM ATHLETIC DEVELOPMENT,PART 2: BARRIERS TO SUCCESS AND POTENTIAL SOLUTIONS. *Journal OfStrength and Conditioning Research*, *29*(5), 1451–1464.

MacLellan, J., Callary, B., & Young, B. W. (2018). Same coach, different approach? How masters and youth athletes perceive learning opportunities in training. *International Journal of Sports Science and Coaching*, *13*(2), 167–178. https://doi.org/10.1177/1747954117727202

Marsuki. (2023). Experimental Study of Command and Reciprocal Teaching Styles on Improving Upper Service Learning Outcomes in Volleyball Games for Physical Education, Health and Recreation Students, Cenderawasih University.pdf. *Formosa Journal of Science and Technology (FJST)*, *2*(4), 1031–1040.

Moullin, J. C., Dickson, K. S., Stadnick, N. A., Rabin, B., & Aarons, G. A. (2019). Systematic review of the Exploration , Preparation , Implementation , Sustainment (EPIS) framework. *Implementation Science*, *14*, 1–16.

Muazu Musa, R., P.P. Abdul Majeed, A., Kosni, N. A., & Abdullah, M. R. (2020). *Machine Learning in Team Sports*. Springer Singapore.

https://doi.org/10.1007/978-981-15-3219-1

Myers, A. M., Beam, N. W., & Fakhoury, J. D. (2017). Resistance training for children and adolescents. *Translational Pediatrics*, *6*(I), 137–143. https://doi.org/10.21037/tp.2017.04.01

Newell, K. M., & Rovegno, I. (2021). Teaching Children ' s Motor Skills for Team Games Through Guided Discovery : How Constraints Enhance Learning. *Frontiers In Psychology*, *12*, 1–18. https://doi.org/10.3389/fpsyg.2021.724848

Oliveira, L. dos S., Moura, T. B. M. A., Rodacki, A. L. F., Tilp, M., & Okazaki, V. H. A. (2020). A systematic review of volleyball spike kinematics : Implications for practice and research. *International Journal of Sports Science & Coaching*, *0*(0), 1–17. https://doi.org/10.1177/1747954119899881

Opstoel, K., Chapelle, L., Prins, F. J., De Meester, A., Haerens, L., van Tartwijk, J., & De Martelaer, K. (2020). Personal and social development in physical education and sports: A review study. *European Physical Education Review*, *26*(4), 797–813. https://doi.org/10.1177/1356336X19882054

Pagliaro, A., Alioto, A., Rossi, C., Baldassano, S., & Proia, P. (2024). Performance enhancing strategies in sailing sports: beyond training and nutrition. *Human Movement*, *25*(1), 15–25. https://doi.org/10.5114/hm.2024.136051

Paillard, T. (2023). The optimal method for improving postural balance in healthy young and older people: specific training for postural tasks encountered in personal physical practice. *Frontiers in Physiology*, *14*(June), 1–8. https://doi.org/10.3389/fphys.2023.1188496

Rababa, J., & Mahyar, F. (2023). The Effect of Using the Command Method and Cooperative Learning on Learning the Learning Swimming Backstroke Skills Female Students of the Faculty of Sports Sciences at Mutah University. *Educational and Psychological Sciences Series*, *2*(3), 301–328. https://doi.org/10.59759/educational.v2i3.285

Sarkar, M., Fletcher, D., Sarkar, M., & Fletcher, D. (2014). Psychological resilience in sport performers : a review of stressors and protective factors protective factors. *Journal of Sports Sciences*, *32*(15), 1419–1434. https://doi.org/10.1080/02640414.2014.901551

Selimi, E., Lascu, A., Serpiello, F., & Woods, C. T. (2023). Exploring football coaches' views on coach education, role, and practice design: An Australian perspective. *PLoS ONE*, *18*(5 May), 1–19. https://doi.org/10.1371/journal.pone.0285871

Smith, K., Burns, C., O'Neill, C., Duggan, J. D., Winkelman, N., Wilkie, M., & Coughlan, E. K. (2023). How to coach: A review of theoretical approaches for the development of a novel coach education framework. *International Journal of Sports Science and Coaching*, *18*(2), 594–608. https://doi.org/10.1177/17479541221136222

Subiza-pérez, M., Vozmediano, L., Juan, C. S., Subiza-pérez, M., & Vozmediano, L. (2018). Pretest-posttest field studies on psychological restoration : a descriptive review and reflections for the future descriptive review and re fl ections for the future. *Landscape Research*, *00*(00), 1–13. https://doi.org/10.1080/01426397.2018.1493443

Suchomel, T. J., Nimphius, S., & Stone, M. H. (2016). The Importance of Muscular Strength in Athletic Performance. *Sports Medicine*, *46*(10), 1419–1449. https://doi.org/10.1007/s40279-016-0486-0

Tewari, N., Saji, S., Goel, S., & Srivastav, S. (2023). Prevalence of sports-related traumatic orofacial and dental injuries in Asian countries: a systematic review and meta-analysis. *The JourNal of SporTS MediciNe aNd PhySical FiTNeSS*, *63*(9), 982–994. https://doi.org/10.23736/S0022-4707.23.14915-2

Tokarski, W., Tosounidis, A., & Zarotis, G. F. (2023). Need for Health and Prevention through Fitness Sports. *European Journal of Sport Sciences*, *2*(4), 34–42. https://doi.org/10.24018/ejsport.2023.2.4.91

Trninić, M., Papić, V., & Trninić, V. (2009). Influence of coach 's leadership behaviour and process of training on performance and competition efficacty in elite sport. *Acta Kinesiologica*, *3*(1), 18–25.

Wang, A. T., Yang, L., Xu, Q., Dou, J., & Clemente, F. M. (2024). Effects of recreational team sports on the metabolic health, body composition and physical fitness parameters of overweight and obese populations : A systematic review. *Biol Sport*, *41*(3), 243–266. https://doi.org/10.17605/OSF.IO/ACK4T.244

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Improved Free Kick Accuracy: Through Imagery Training And Concentration Of Soccer Players

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Improved Free Kick Accuracy: Through Imagery Training And Concentration Of Soccer Players

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Abstract: *This study aims to 1) analyze the difference in the effect between internal imagery training and external imagery on the accuracy of free kicks of soccer players in terms of concentration, 2) analyze the difference in the effect between athletes who have high and low concentration on improving free kick accuracy, 3) analyze the interaction between internal imagery training and external imagery on free kick accuracy in terms of concentration. This type of research is an experiment with a 2 x 2 factorial design. The instrument used to measure concentration is the Grid Concentration Test, while free kick accuracy uses the free kick accuracy test. The data analysis technique used was two-way Anova. The results showed that: 1) There is a difference between internal imagery and external imagery training (p = 0.045 <0.05), then the internal imagery training method is better than external imagery on the accuracy of free kicks of soccer players. 2) There is a difference between players with high concentration and low concentration (p = 0.018 < 0.05), and players with high concentration are better than players with low concentration on the accuracy of free kicks of soccer players. 3) There is an interaction between internal and external imaging with high and low concentration (p = 0.000 < 0.05). The group of players who have high concentration is more appropriate if trained with internal imagery. In contrast, the players in the low concentration group were better if trained with external imagery.*
Keywords: *Imagery, Concentration, Accuracy, Free Kick*

Introduction

Success in football matches is influenced by physical, technical, strategic, and mental factors. Football players must be continuously trained to achieve the highest achievements (Butler et al., 2021; Jonker et al., 2019). One aspect that supports soccer athletes' success is optimal mental toughness. The mental aspect is very important in the sport of football because mental toughness plays a crucial role in the success of a soccer athlete, especially considering the competitive dynamics and pressures in this sport (Murray et al., 2021). Accuracy techniques in free kicks in football are important because they can immediately score goals without passing (Wunderlich et al., 2021). Success utilizing high-accuracy free kicks can quickly change a match's outcome and create a tactical advantage. Critical situations near the penalty box often provide golden opportunities, and the ability to execute precision techniques can be decisive. Players who master this technique, such as Beckham or Ronaldo, are often the main weapons for the team. In addition to the immediate impact, success in a free kick can also have a huge psychological effect on one's team and opponents. Therefore, investment to maximize the technique of free kick accuracy is considered crucial in achieving victory in football matches (Browne et al., 2019; van Biemen et al., 2022).

Concentration focuses on something exclusive and undisturbed by irrelevant internal and external stimuli. Li et al. (2022) and Zhao & Dong (2022) state that internal stimuli are sensory and thought disorders such as fatigue, anxiety, and so on. External stimuli are distractions from the outside, such as cheers from the audience, boos from the audience, referee decision errors, and others. In global sports, concentration means the ability of athletes to focus on the competition for better performance. In the world of sports, concentration is the ability of athletes to focus on the competition for better performance, as stated by Oguntuase & Sun (2022); Chamorro et al. (2020) state that concentration is needed to achieve optimal performance, not only in shooting, archery, golf, tennis, and swimming but almost in all sports, including football. Based on the statement above, every sport requires good concentration for sports skills. Concentration skills implicitly lead to a specific task or action and are an indicator of proficiency in the achievement of the purpose of using held before and after treatment (Child & Shaw, 2020; Tienza-Valverde et al., 2023). Results of previous research (Fawver et al., 2020; Siekańska et al., 2021) show that the portion of training

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between technical and mental training is still not balanced. Trainers who emphasize training more on the physical aspect and technique only but on the mental aspect are not given good training. As revealed (Dohme et al., 2019; Robin et al., 2019), mentally trained players will certainly be more skilled in overcoming emotional and mental dilemmas that come to them because the atmosphere and requirements of players when competing on the field can change at any time.

Based on observations in the field in July 2023 and information submitted by the Indonesian football coach, the level of accuracy of athletes' free kicks still needs to be higher. This is evidenced by the accuracy of the instrument of shooting the ball into the goal target in getting an average free kick result of 1; this value, when viewed in normative data, is the accuracy of the free kick included in the category of less. Even though the need for mental abilities plays a crucial role in achieving football achievements, football athletes with a good mentality can improve game performance on the field. One visualization exercise to improve the accuracy of a soccer player's free kick is mental imagery. Imagery practice is derived from experiences gained from seeing, feeling, and listening, but holistically, the experience occurs in the brain. Make it more obvious and related to the expression. Franklin (2022) and Pearson (2019) state that imagery happens to the brain. When doing imagery exercises, players must be able to concentrate so that the training goals are achieved optimally.

Mental imagery training is a form of exercise that can enhance the player's technique. Similar to what was expressed (Clark et al., 2022; Lin et al., 2021), mental imagery training is a technique instructors and sports psychologists often use to help improve athlete performance. The existing imagery perspective is based on the player's ability to imagine himself and others when performing a technique. In other words, in mental imagery exercises used according to one's original ability, the player presents a shadow of a free-kick technique in mind visualization. Imagery mental training in football can be done by presenting a shadow of himself doing a movement technique in his brain. For example, when using a free kick technique in football, the players can imagine themselves doing a free kick movement using their minds. As a result, the ball enters the goal net past the goalkeeper (Alkhawaldeh, 2023; Aziz & Bylbyl, 2019). This can prove the imagery exercise itself because, when doing a free kick with imagery, a player must imagine himself (visualization) in his mind (Schaper et al., 2020).

A soccer player doing a free kick can use it to see the post, goal net, and goalkeeper position and build human fort versus hearing and feeling. As a result, the ball goes into the opponent's goal. This goes hand in hand with using (Edensor et al., 2023; Gervis & Goldman, 2020), which confirms a simulation in the brain that can reinforce or describe free-kick movements. So far, fellow scouts only look at the player's technical and skill factors but never mental and psychological factors such as concentration, visualization and imagery skills, and attitude control. Therefore, the talent guide team or coach also needs to start looking at the mental factors of young players. Free kicks are crucial in a soccer match, especially if the team has a precise and lethal free-kick executioner. This situation means an opportunity to create a goal that can be utilized as much as possible, something that might happen so that the team will win the game. Based on the problems that have been described, this study aims to analyze the difference in the influence between internal imagery and external imagery training on the accuracy of free kicks of soccer players in terms of concentration.

Materials and Methods

Research Design

This research method was a quantitative approach. It was an experiment using a 2 x 2 factorial design. The design considers the possibility of moderator variables affecting the outcome's treatment (independent variable) (dependent variable). This experimental study used two groups that received different treatments, namely the provision of training.

Research Procedure

Data collection techniques in this study were tests and measurements. Before pretest and post-test measurements, the sample was measured in concentration to determine high and low concentrations. Trpkovici et al. (2023) measured concentration in this study using the Grid Concentration test with a validity value of 0.89 and a reliability value of 0.80. The instrument used to measure the accuracy of free kicks is a free kick test with a validity value of

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0.89 and a reliability of 0.80. Treatment was carried out in six meetings, and three meetings were held in one week. This is based on the theory of Slimani et al. (2016) that image training aims to improve athletes' psychological ability, which is carried out in as many as six meetings and ends by taking a final test or post-test to measure the accuracy of free kicks using soccer to recognize the comparison of kick accuracy scores to recognize the comparison of free throw accuracy scores after treatment/treatment.

Research Participants

The population in this study was all young Indonesian soccer players, totaling 38 athletes, and the sample in this study amounted to 20 people. Purposive sampling was used in this study. The criteria in determining this sample include (1) specific 13-year-old Indonesian youth soccer players, (2) athletes who actively attend football schools, (3) players who are not sick, (4) willing to follow the imagery training process, (5) Able to follow all training model programs that have been prepared. The sample grouping was taken from players with a high concentration of 27% and players with a low concentration of 27% from the data that had been ranked. Based on this, a sample of 10 players with high and 10 with low concentrations was obtained, so the total sample was 20. This research has received approval from all samples who have filled out a statement of ability to become a research sample and have met the research code of ethics requirements.

Data Analysis

The data analysis method used in this study used the Two Anova test with the help of the SPSS 24 application at the significance level = 0.05. Next, the average treatment companion was compared using the Tukey test (Ferreira, 2020). Before using the Two Anova test, it is necessary to try prerequisite tests, including (1) normality test and (2) variant homogeneity test and hypothesis test.

RESULTS

In this chapter, the results of the research and discussion will be discussed sequentially, including (1) research data, (2) analysis prerequisite tests, and (3) hypothesis tests. The hypothesis test will be presented sequentially, including (a) the disparity in the effect of internal imagery training methods and external imagery training methods on the accuracy of Free Kick in soccer athletes; (b) the difference in the effect of high concentration and low concentration on the accuracy of the free kick in soccer athletes (c) the interaction between the two training methods and concentration on the accuracy of the free kick of soccer players. The complete will be presented as follows:
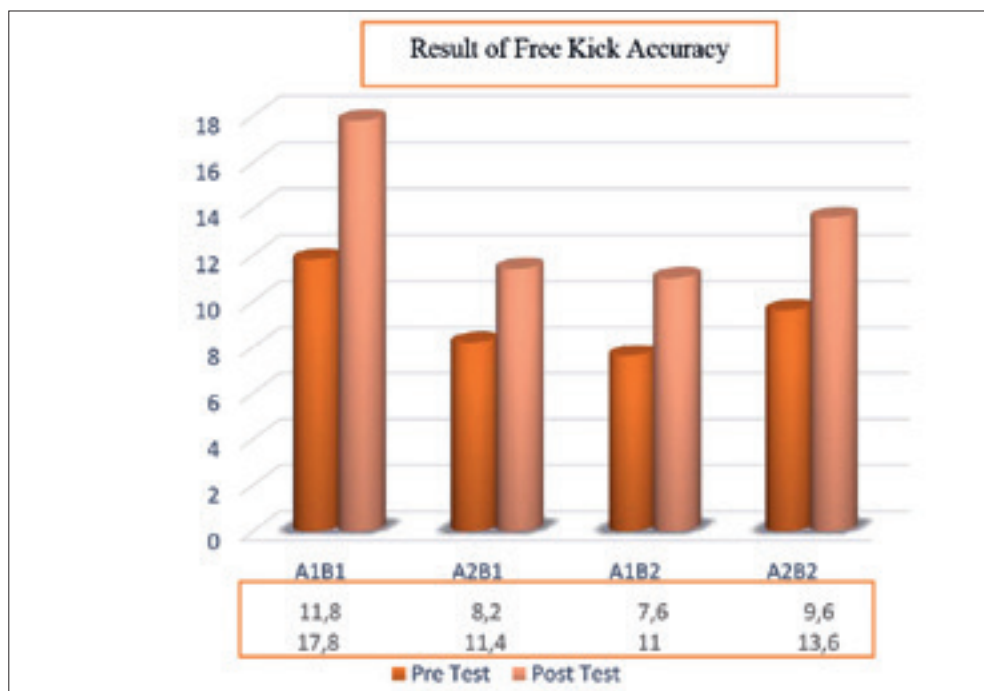
Figure 1. *Free Kick pretest and post-test histogram accuracy results*

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Information:

A1B1: A highly concentrated group of players trained with internal imagery training methods

A2B1: A highly concentrated group of players trained with external imagery training methods

A1B2: The low-concentration group of players was trained with internal imagery training methods

A2B2: The low-concentration group of players was trained with external imagery training methods

Based on the bar chart image above, it shows that the accuracy of the free kick A1B1 group averaged pretest by 11.8 and faced an increase in post-test at 17.8, A2B1 group had an average pretest of 8.2 and faced an increase during the post-test of 11.4, group A1B2 averaged pretest of 7.6 and faced an increase in post-test by 11, The A2B2 group averaged a pretest of 9.6 and faced an increase in post-test of 13.6.

1. Prerequisite Test Results
a. Normality Test

The results of the data normality test conducted in each analysis group were carried out with the SPSS software program version 24.0 for Windows with a significance level of 5% or 0.05. More results are in the appendix. The summary of the data in Table 1 is as follows:

Table 1. Normality Test

Group	P	Significance	Information
Pretest A1BI	0.747		Usual
Post-test A1B1	0.086		Usual
Pretest A2B1	0.421		Usual
Post-test A2B1	0.814		Usual
Pretest A1B2	0.814	0.05	Usual
Posttest A1B2	0.967		Usual
PretestA2B2	0.492		Usual
Posttest A2B2	0.086		Usual

Based on statistical analysis, the normality test carried out on all pretest and post-test data on the accuracy of the free kick is obtained from the normality test data of the significance value of $p > 0.05$, which means that the data is normally distributed.

b. Homogeneity Test

The homogeneity test is carried out to test the equation of several samples, namely homogeneous or not. The homogeneity test tests the variance similarity between the pretest and post-test. The homogeneity test results are in Table 2 as follows:

Table 2. Homogeneity Test

F	df1	df2	Sig.
4.784	3	16	0.014

Based on statistical analysis of homogeneity tests carried out using the Levene Test, the calculation results obtained a significance value of $0.014 \geq 0.05$. This means that a data group has a homogeneous variance. Thus, populations have variance or homogeny in common.

c. Hypothesis Testing

Hypothesis testing in this study can be done based on the data analysis results and two-way ANOVA analysis interpretation. The sequence of the results of hypothesis testing is adjusted to the hypothesis formulated as follows.

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1. This is a hypothesis about the difference in the effect of internal imagery and external imagery training methods on the accuracy of the free kick.

The first hypothesis states, "There is a significant difference in the effect between internal imagery training methods and external imagery training methods on the accuracy of free kicks in football players." The obtained data are in Table 3.

Table 3. Test Results between Internal and External Imagery Training Methods on Increasing Free Kick

Source	Type III sum of squares	Df	Mean square	F	Sig
Method Exercise	18.050	1	18.050	4.719	0.045

From the results of the Two Anova Table 3 test above, it can be seen that the significance value of p is 0.045. Ho is rejected since the significance value of p is 0.045 < 0.05. Thus, there is a significant difference in the influence of the internal and external imagery training methods on the accuracy of the free kick in soccer players. Based on the analysis results, the internal imagery training method is higher (good) with a post-test average of 16.00 compared to the external imagery exercise method with a post-test average of 14.00. This means that the research hypothesis that states a significant difference in the effect of internal and external imagery training methods on the accuracy of free kicks in soccer players has been proven.

2. The difference in the effect of high concentration and low concentration on the accuracy of the free kick.

The second hypothesis reads, «There is a significant difference in the effect of high and low-concentration players on the accuracy of free kicks in football players. The calculation results are presented in Table 4 as follows.

Table 4.Test Results Difference in high and low concentration on free kick accuracy

Source	Type III sum of squares	Df	Mean square	F	Sig
Concentration	26.450	1	26.450	6.915	0.018

From the results of the ANOVA test in Table 4 above, it can be seen that the significance value of p is 0.018. Ho is rejected since the significance value of p is 0.018 > 0.05. Based on this, there is a significant difference in the influence of players with high and low concentrations on the accuracy of free kicks in football players. Based on the analysis results, players with high concentration are higher (good) with an average post-test value of 20.00 compared to players with low concentration with an average post-test value of 14.00. This means that the research hypothesis has been proven that there is a significant difference in the effect of players with high and low concentrations on the accuracy of free kicks in football players.

3. Interaction between imagery practice methods and concentration on the accuracy of the free kick

The third hypothesis reads, "There is a significant interaction between imagery training methods (internal imagery and external imagery training methods) and concentration (high and low) on the accuracy of free kicks in football players. The results of the calculation are in Table 5 as follows.

Table 5. Anova Test results in the interaction between imagery training methods (internal and external) with concentration (high and low)

Source	Type III sum of squares	Df	Mean square	F	Sig
Exercise methods and Concentration	101.250	1	101.250	26.471	0.000

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From the results of the ANOVA test in Table 5 above, it can be seen that there is a significance value of p of 0.000. Therefore, the significance value of p is $0.000 < 0.05$, meaning Ho is rejected. Based on this, the hypothesis that states a significant interaction between imagery training methods (internal and external imagery training methods) and concentration (high and low) on the accuracy of free kicks in soccer players has been proven.

After being tested, there is an interaction between imagery training methods (internal imagery and external imagery training methods) and concentration (high and low) on the accuracy of free kicks in football players. Therefore, further tests should be conducted using the Tukey test. Further test results can be seen in Table 6 below:

Table 6. *Summary of Post-Hock Test Results*

Group	Interaction	Std, Error	Sig,
A1B1	A1B2	1.25985	.002
	A2B1	1.25985	.001
	A2B2	1.25985	.071
A1B2	A1B1	1.25985	.002
	A1B2	1.25985	.978
	A2B2	1.25985	.490
A2B1	A1B1	1.25985	.001
	A1B2	1.25985	.978
	A2B2	1.25985	.278
A2B2	A1B1	1.25985	.071
	A2B1	1.25985	.490
	A1B2	1.25985	.278

Indicates that the pairs of partners who have significantly different interactions or partners are: (1) A1B1-A1B2, (2) A1B1- A2B1, (3) A1B1-A2B2, (4) A2B1-A1B1, (5) A2B1-A2B2, (6) A1B2-A1B1, (7) A1B2-A2B2, (8) A2B2A1B1, (9) A2B2-A2B1, and (10) A2B2-A1B2.

DISCUSSION

The review of the results of this study shares further understanding, overriding the results of the analysis of the information that has been submitted. Sourced from hypothesis testing creates three groups of analytical discussions: 1) There is a significant difference in influence between the main factors of the study; 2) The difference in influence between football players who have high concentration and low concentration on the accuracy of free kicks of football players; 3) There is a meaningful interaction between the main factors in the form of 2 aspects of interaction. A review of the results of the analysis can be further described as follows:

The difference in the effect of internal imagery and external imagery training methods on free kicks is accuracy

From testing the first hypothesis, it is known that the internal imagery mental training method and the external imagery method have significant differences in enhancing the accuracy of the free kick. This study found that the mental imagery training method positively impacted the accuracy of the free kick. It is reinforced by the results of the study by Shafie et al. (2023), which state that there is a significant difference in imagery method training on gymnastics skills. This is in line with the theory of Martin et al. (2022), which states that imagery training can enhance the performance of athletes or players.

In this study, it is known that the internal imagery mental training method has a better impact on increasing the accuracy of the free kick. It goes hand in hand with the opinions of Dekkers et al. (2022), which state that internal imagery mental exercises are more beneficial than external imagery mental exercises. According to Blair et al. (2018), internal mental imagery exercises higher on shaping psychological responses. This psychological response can form higher endorphin hormones, resulting in a calmer and more comfortable impact on athletes or players in carrying out their duties. According to some theories above, internal imagery mental exercises have many advantages over

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external imagery exercises. The internal imagery method exercise has an advantage, which is higher in increasing the player's psychological response; besides that, the internal imagery mental exercise is simpler and maximizes the player's movement experience (Ramadhan et al., 2024). With several advantages, internal imagery mental training is more influential in enhancing player performance.

The effect of high concentration and low concentration on free kick accuracy

The analysis results show that players use high concentration ability more (good) than players with low concentration ability on the accuracy of free kicks in soccer players. Concentration on this has a crucial role in influencing a technique performed or the result of the origin of a sports match (Farina & Cei, 2019). Attention and concentration are often interpreted the same, even though they have different definitions. Halkiopoulos et al. (2022) state that concentration is the process of personal awareness of an issue (stimulus) received to decide an action (response). Concentration is a person's ability to focus on a selected stimulus (one object) in an exclusive moment. According to Pappalardo et al. (2019), concentration means that a player must display performance on the field. The main component of concentration is the ability to focus attention on something exclusive and not be distracted by internal or irrelevant external stimuli. This is by research conducted by Lirio-Piñar et al. (2023), which states a significant difference between the concentration level and the accuracy of shooting petanque sports.

Interaction between Training Method (Internal imagery and External Imagery) and Concentration (High and Low)

Imagery ability is the ability to conceptualize motor performance (Fortes et al., 2019; Kim et al., 2017). Imagery states are more effective. Suppose the individual has higher imagery ability. Individuals with high concentration skills provide higher motor performance improvements than those with low concentration skills using imagery exercises Navarro et al., (2018). Based on what will happen as a result of this study, there is a significant disparity between training methods (internal imagery and external imagery training methods) and concentration (high and low) on the accuracy of free kicks in soccer players. The form of the relationship appears that the primary factors of the study in the form of 2 factors show a significant interaction. As a result of this study, internal and external methods have significant differences. Soccer players with high and low concentrations will get better results than players trained with external imagery training methods.

Based on the theory of its implementation, internal imagery training will increase the concentration of players. As a result, it will be more effective if applied to players with high concentration. Players with high concentration will be more effective using the internal imagery training method because it will be simpler to focus on the target aimed at when doing a free kick. The statement's origin can be concluded that the high and low concentration of the player determines the effectiveness applied to increase the accuracy of the free kick. Thus, the exercise must be adapted to the player's ability to achieve the optimal result.

CONCLUSION

Based on the results of the research and the results of data analysis that has been carried out, the following conclusions were obtained: 1) There is a significant difference in influence between the internal image training method and the external image training method on the accuracy of free kicks in soccer players. The internal image training method is better than the external image training on free throw accuracy in basketball players. 2) There is a significant difference in the effect of high and low concentrations on the accuracy of free kicks in soccer players. Players with high concentration are better than those with low concentration on free throw accuracy in soccer players. 3) There is a significant interaction between satellite imagery training methods (internal imagery and external imagery) and concentration (high and low) on free throw accuracy in soccer players.

Conflict of Interest
The authors declare no conflict of interest.

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Sports Science and Health 15(2):184-192

References

Alkhawaldeh, I. M. (2023). The Effect of Mental Fatigue on the Accuracy of the Direct Free Kick in Terms of Some Kinematic Variables for Football Players. *Asian Journal of Sports Medicine*, *14*(2).

Aziz, D., & Bylbyl, S. (2019). The free kick kinematics of elite football players. *Education*, *4*(2), 18–27.

Blair, S., Duthie, G., Robertson, S., Hopkins, W., & Ball, K. (2018). Concurrent validation of an inertial measurement system to quantify kicking biomechanics in four football codes. *Journal of Biomechanics*, *73*, 24–32. https://doi.org/10.1016/j.jbiomech.2018.03.031

Browne, P. R., Sweeting, A. J., Davids, K., & Robertson, S. (2019). Prevalence of interactions and influence of performance constraints on kick outcomes across Australian Football tiers: Implications for representative practice designs. *Human Movement Science*, *66*, 621–630. https://doi.org/10.1016/j.humov.2019.06.013

Butler, D., Butler, R., & Eakins, J. (2021). Expert performance and crowd wisdom: Evidence from English Premier League predictions. *European Journal of Operational Research*, *288*(1), 170–182. https://doi.org/10.1016/j.ejor.2020.05.034

Chamorro, J. L., Moreno, R., García-Calvo, T., & Torregrossa, M. (2020). The influence of basic psychological needs and passion in promoting elite young football players' development. *Frontiers in Psychology*, *11*, 570584. https://doi.org/10.3389/fpsyg.2020.570584

Child, S. F. J., & Shaw, S. D. (2020). A purpose-led approach towards the development of competency frameworks. *Journal of Further and Higher Education*, *44*(8), 1143–1156. https://doi.org/10.1080/0309877X.2019.1669773

Clark, J. D., Mallett, C. J., & Coulter, T. J. (2022). Personal strivings of mentally tough Australian Rules footballers. *Psychology of Sport and Exercise*, *58*, 102090. https://doi.org/10.1016/j.psychsport.2021.102090

Dekkers, T., O'Sullivan, K., Collins, K., McVeigh, J. G., Roe, M., Murphy, J. C., & Blake, C. (2022). The epidemiology of back injuries in elite Gaelic football athletes: An 8-year prospective study. *Physical Therapy in Sport*, *57*, 105–111. https://doi.org/10.1016/j.ptsp.2022.07.009

Dohme, L., Bloom, G. A., Piggott, D., & Backhouse, S. (2019). Development , Implementation , and Evaluation of anAthlete-Informed Mental Skills Training Program for EliteYouth Tennis Players. *Journal of Applied Sport Psychology*, *32*(5), 429–449. https://doi.org/10.1080/10413200.2019.1573204

Edensor, T., Millington, S., & Steadman, C. (2023). Making the football stadium homely: Manchester City's relocation from Maine road to the Etihad. *Emotion, Space and Society*, *49*, 100971. https://doi.org/10.1016/j.emospa.2023.100971

Farina, M., & Cei, A. (2019). Concentration and self-talk in football. In *Football Psychology* (pp. 241–254). Routledge.

Fawver, B., Beatty, G. F., Roman, J. T., & Kurtz, K. (2020). The status of youth coach training in the United States: Existing programs and room for improvement. *International Sport Coaching Journal*, *7*(2), 239–251. https://doi.org/10.1123/iscj.2019-0017

Ferreira, D. F. (2020). *Alternative to Tukey test*. *2018*.

Fortes, L. de S., Almeida, S. S., Nascimento Junior, J. R. A. do, Vieira, L. F., Lima-Júnior, D., & Ferreira, M. E. C. (2019). Effect of motor imagery training on tennis service performance in young tennis athletes. *Revista de Psicología Del Deporte*, *28*(1), 157–168.

Franklin, E. (2022). *Dynamic alignment through imagery*. Human Kinetics.

Gervis, M., & Goldman, A. (2020). The Flourishing Footballers programme: Using psycho-education to develop resilience through ACT. *Journal of Contextual Behavioral Science*, *18*, 146–151. https://doi.org/10.1016/j.jcbs.2020.09.004

Halkiopoulos, C., Antonopoulou, H., Gkintoni, E., & Aroutzidis, A. (2022). Neuromarketing as an indicator of cognitive consumer behavior in decision-making process of tourism destination—An overview. *Transcending Borders in Tourism Through Innovation and Cultural Heritage: 8th International Conference, IACuDiT, Hydra, Greece, 2021*, 679–697.

Jonker, L., Huijgen, B. C. H., Heuvingh, B., Elferink-Gemser, M. T., & Visscher, C. (2019). How youth football players learn to succeed. In *Football Psychology* (pp. 297–312). Routledge.

Kim, T., Frank, C., & Schack, T. (2017). *A Systematic Investigation of the Effect of Action Observation Training and Motor Imagery Training on the Development of Mental Representation Structure and Skill Performance*. *11*(October), 1–13. https://doi.org/10.3389/fnhum.2017.00499

Li, Z., Zhang, Q., Zhang, G., Song, G., & Fan, F. (2022). Insight of environmental quality of a semi-enclosed large-scale stadium during football matches: A case study in Harbin, China. *Building and Environment*, *217*, 109103. https://doi.org/10.1016/j.buildenv.2022.109103

Lin, H.-H., Lin, T.-Y., Ling, Y., & Lo, C.-C. (2021). Influence of imagery training on adjusting the pressure of fin swimmers, improving sports performance and stabilizing psychological quality. *International Journal of Environmental Research and Public Health*, *18*(22), 11767. https://doi.org/10.3390/ijerph182211767

Lirio-Piñar, J. A., Orozco-Barrera, S., Delgado, A. V, & Ahualli, S. (2023). Concentration polarization around polyelectrolyte-coated electrodes. Model and observations. *Journal of Molecular Liquids*, *395*, 123757. https://doi.org/10.1016/j.molliq.2023.123757

Martin, J. G., Giulianotti, R., Bandura, C., Morrow, S., Hunt, K., Bancroft, A., & Purves, R. I. (2022). Stakeholder views of current laws surrounding alcohol at UK football matches: Is it a case of using a "sledgehammer to crack a nut"? *International Journal of Drug Policy*, *107*, 103789. https://doi.org/10.1016/j.drugpo.2022.103789

Murray, R. M., Dugdale, J. H., Habeeb, C. M., & Arthur, C. A. (2021). Transformational parenting and coaching on mental toughness and physical performance in adolescent soccer players: The moderating effect of athlete age. *European Journal of Sport Science*, *21*(4), 580–589. https://doi.org/10.1080/17461391.2020.1765027

Navarro, M., van der Kamp, J., Schor, P., & Savelsbergh, G. J. P. (2018). Implicit learning increases shot accuracy of football players when making strategic decisions during penalty kicking. *Human Movement Science*, *61*, 72–80. https://doi.org/10.1016/j.humov.2018.07.004

Oguntuase, S. B., & Sun, Y. (2022). Effects of mindfulness training on resilience, self-confidence and emotion regulation of elite football players: The mediating role of locus of control. *Asian Journal of Sport and Exercise Psychology*, *2*(3), 198–205. https://doi.org/10.1016/j.ajsep.2022.08.003

Pappalardo, L., Cintia, P., Ferragina, P., Massucco, E., Pedreschi, D., & Giannotti, F. (2019). PlayeRank: data-driven performance evaluation and player ranking in soccer via a machine learning approach. *ACM Transactions on Intelligent Systems and Technology (TIST)*, *10*(5), 1–27. https://doi.org/10.1145/3343172

Pearson, J. (2019). The human imagination: the cognitive neuroscience of visual mental imagery. *Nature Reviews Neuroscience*, *20*(10),

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624–634.

Ramadhan, M. N., Sukarmin, Y., Arovah, N. I., Indah, N., & Anwar, A. (2024). *The Effect Of Imagery Training On The Accuracy Of Free Throws In Basketball Players In Terms Of Concentration El efecto del entrenamiento de imágenes en la precisión de los tiros libres en jugadores de baloncesto en términos de concentración. 2041*, 603–609. https://doi.org/10.47197/retos.v51.100554

Robin, N., Toussaint, L., Charles-Charlery, C., & Coudevylle, G. R. (2019). Free throw performance in non-expert basketball players: The effect of dynamic motor imagery combined with action observation. *Learning and Motivation*, *68*, 101595. https://doi.org/10.1016/j.lmot.2019.101595

Schaper, S., Kaaden, L. van der, Boode, V. de, & Savelsbergh, G. (2020). Visual gaze behaviour during free-kicks in football. *International Journal of Sports Science & Coaching*, *15*(5–6), 653–661.

Shafie, M. F., Lai, W. S., & Mohammed, N. (2023). Consumer satisfaction and demand for commercial football fields in Malaysia: A case study in Hulu Langat Selangor. *Social Sciences & Humanities Open*, *8*(1), 100634. https://doi.org/10.1016/j.ssaho.2023.100634

Siekańska, M., Bondár, R. Z., di Fronso, S., Blecharz, J., & Bertollo, M. (2021). Integrating technology in psychological skills training for performance optimization in elite athletes: A systematic review. *Psychology of Sport and Exercise*, *57*, 102008. https://doi.org/10.1016/j.psychsport.2021.102008 Dapatkan hak dan konten

Slimani, M., Tod, D., Chaabene, H., Miarka, B., & Chamari, K. (2016). Effects of mental imagery on muscular strength in healthy and patient participants: A systematic review. *Journal of Sports Science and Medicine*, *15*(3), 434–450.

Tienza-Valverde, A., Hernández-Beltrán, V., Espada, M. C., Bravo-Sánchez, A., Santos, F. J., & Gamonales, J. M. (2023). Analysis of individual performance indicators of football goalkeeper. *Apunts Sports Medicine*, *58*(219), 100420. https://doi.org/10.1016/j.apunsm.2023.100420

Trpkovici, M., Pálvölgyi, Á., & Makai, A. (2023). *Athlete anxiety questionnaire : the development and validation of a new questionnaire for assessing the anxiety , concentration and self-confidence of athletes. December*, 1–9. https://doi.org/10.3389/fpsyg.2023.1306188

van Biemen, T., van Zanten, T. F., Savelsbergh, G. J. P., & Mann, D. L. (2022). "What needs to be seen": An exploration into the visual anticipation behaviour of different skill-level football referees while observing long passes on-field. *Human Movement Science*, *85*, 102980. https://doi.org/10.1016/j.humov.2022.102980

Wunderlich, F., Seck, A., & Memmert, D. (2021). The influence of randomness on goals in football decreases over time. An empirical analysis of randomness involved in goal scoring in the English Premier League. *Journal of Sports Sciences*, *39*(20), 2322–2337. https://doi.org/10.1080/02640414.2021.1930685

Zhao, P., & Dong, G. (2022). Analysis of the optimal shooting angle in football matches based on network data mining. *Optik*, *270*, 169925. https://doi.org/10.1016/j.ijleo.2022.169925

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Increasing 100-Meter Freestyle Swimming Speed: Through Imagery Training And Pre-Performance Routines Viewed From Concentration

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Abstract: *This study aims to determine: (1) the difference in the effect of imagery training and pre-performance routines on increasing 100-meter freestyle swimming speed. (2) The difference in the effect between high and low concentrations on increasing the 100-meter freestyle swimming speed. (3) The interaction between imagery training and pre-performance routines in terms of concentration on increasing 100-meter freestyle swimming speed. This research method is quantitative with an experimental method using a factorial design 2 x 2. The results showed that: (1) There is a difference in the effect of imagery training and pre-performance routines on increasing 100-meter freestyle swimming speed with a sig value of 0.002 <0.05, athletes who are given mental imagery training are better than pre-performance routines with an average difference in post test of 1.77 seconds (2) There is a difference in the effect between high and low concentration on increasing the ability of 100-meter freestyle swimming speed, proven by the F value of 5.447 and a significance value of p 0.006 <0.05, Swimming athletes who have high concentration are better than those who have low concentration, with an average posttest difference of 0.59. (3) There is an interaction between imagery training and pre-performance routines in terms of concentration aspects (high and low) on increasing 100-meter freestyle swimming speed, with an F value of 39.87 and a significance value of p 0.000 <0.05. The conclusion is that the imagery training model is a more effective method for athletes who have high concentration, and the pre-performance routines training model is more effective for athletes who have low concentration.*

Keywords: *imagery; pre-performance routines; concentration; swimming*

Introduction

Swimming is one of the aquatic sports that has a significant contribution to the development and development of sports achievements at the national or international level. In obtaining optimal performance, swimming sports require systematic efforts to achieve maximum results in various competition numbers, whether free style, breast style, back style, or butterfly style, at various distances (Ivanenko et al., 2020). Of the various events, the free style is the most common event in formal swimming competitions, both at national and international levels, including the Olympic Games and FINA World Championships (Beganović, 2019). The free style has a complete range of distances from 50m, 100m, 200m, 400m, 800m (girls), to 1500m (boys). Not only that, the free style is also used in relay events such as 4×100m and 4×200m. This makes the free style the style with the most medal donations in one championship (Makar et al., 2022).

Swimming freestyle occupies a strategic and fundamental position in the world of performance swimming. Not only is the number of competition numbers dominant, but free style reflects the efficiency of the method, physical capacity, and is a universal benchmark of achievement. Therefore, in the coaching and development of athletes, the ability of free style is often the priority before athletes are shown other styles that are more environmental or specialized. As one of the Olympic sports, swimming not only requires good method skills, but also the integration of various components of physical conditions such as strength, endurance, flexibility, speed, and coordination of movements (Lahart & Metsios, 2018; Ockta & Sabillah, 2025). Psychological factors such as concentration, mental preparedness, and stress management also play a crucial role in determining athlete performance (Ben-Zaken et al., 2022). At medium to long distances, swimming speed is greatly influenced by the athlete's mental skills to withstand fatigue, muscle soreness, and willingness to give up. Athletes with great mentality are more able to maintain speed

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in the final session of the race and increase the pace when the opponent begins to slow down (Overbury et al., 2023). This suggests that mental aspects have a direct contribution to swimming speed.

Mental training is very important for speed of swimming athletes because it can help athletes to build confidence, correct mental methods, and prepare for maximum response to the pressure of competition. Saint-Martin et al., (2020) asserted that visualization of the right method increases the efficiency of movement and compresses neuromuscular responses, thus indirectly increasing the speed of performance. Mental aspects such as concentration, anxiety management, mental toughness, visualization, and emotion regulation contribute significantly to swimming speed. Not only that, but concentration is a fundamental component of sports performance. Athletes with high levels of concentration are able to selectively focus their attention on relevant data and ignore distractions (Zhan & Xue, 2022).

The interaction between psychological training methods and concentration levels can have different effects on athlete performance outcomes, making it meaningful to evaluate their efficacy in a more structured context. Concentration is a crucial psychological component in sport, affecting athletes' ability to stay focused on task-relevant cues while ignoring distractions from the immediate area (Samełko et al., 2018). Athletes with great concentration tend to be able to show a more normal and precise method of performance, especially under great pressure. In short events such as the 50m and 100m freestyle, the response time to the start signal and the precision of the method when the swimmer enters the water largely ensure the final result. Athletes who have great concentration and control over distractions tend to have faster and more effective start times (Olanescu-Vaida-Voevod et al., 2022). Moreover, a split-second lapse in focus can have a huge impact on total travel time. In training and coaching athletes, the sport psychology approach should not be ignored and must be integrated with the method and exercise program so that swimming speed can reach peak performance.

But based on the results of field observations in April 2025 with Yogyakarta swimming coaches, it was found that the speed skills of free-style swimming athletes were still low and not optimal. This matter is evidenced by the information obtained during the early test found that the average score of swimmer speed was recorded at 180 seconds; the matter is listed in the type of lack. This matter is due to the training procedures that are running only focus on training methods and bodies, so that mental training is neglected. Meanwhile, the mental aspect in this matter also means paying attention to. If this matter continues to be left until it will affect the increase in the performance of swimming athletes.

One method that is thought to be able as a solution to improve the speed skills of free-style swimming athletes is by sharing imagery exercises and pre-performance routines (PPR). In this context, psychological methods such as imagery and pre-performance routines (PPR) have been widely researched to improve athlete performance. Imagery is a mental method that involves creating sensory images in the mind to represent certain experiences or movements. Previous research has shown that imagery can improve athletes' methods, confidence, and mental readiness (Duarte-Mendes et al., 2019). On the other hand, pre-performance routines are a series of systematic actions that are attempted in the time before competition to condition mental focus and reduce anxiety (Richard et al., 2021; Rupprecht et al., 2024). The implementation of pre-performance routines has invariably been associated with improved performance in various sports, although research in the context of swimming is limited.

Although some research has confirmed that imagery and pre-performance routines can individually improve sports performance, research that directly equates the two in the context of aquatic sports such as swimming is still very scarce (Orbach & Blumenstein, 2022). Not only that, but not many studies have explored how the effectiveness of both procedures can be affected by people's concentration levels. Most research first considers only the direct effects without considering the interactions between psychological variables, while in the context of real performance, such interactions are very likely to occur and ensure the outcome of mental training (Hufton et al., 2024).

Recent research shows that imagery and pre-performance routines can improve swimming performance. For example, one study found that imagery can improve swimmers' 1000-yard training times (Yadolahzadeh, 2021). Not only that, another study showed that PPR can improve swimming performance by producing psychological stability and focus (Yao et al., 2020). However, there is limited research that directly equates these two methods in the context of swimming. Not only that, but recent research has shown that concentration levels can moderate the influence of psychological methods on performance. One study found that good concentration allows athletes to stay focused on their movements, strategies, and competition conditions without being distracted by external or internal aspects (Oli-

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ver et al., 2021). The interaction between psychological training methods and concentration levels can have different effects on athlete performance outcomes, making it meaningful to evaluate their efficacy in a more structured context.

This study aimed to identify whether the implementation of imagery or pre-performance routines can significantly improve free-style swimming skills, and to what extent these effects are influenced by athletes' concentration levels. The results of this research are expected to contribute empirically to the development of fact-based psychological interventions in competitive sport and serve as a reference for coaches and sport psychologists in designing mental training programs that are structured and based on athlete characteristics.

MATERIALS AND METHODS

Research Design

This research method is quantitative, with this type of research being an experimental 2 x 2 factorial design. This experimental research uses two different treatment groups, namely the provision of imagery training methods and pre-performance routines.

Research Participants

The population in this study was all Yogyakarta swimming athletes, totaling 38 athletes. In this study, the inclusion criteria were applied to determine the sample of this study, which is based on certain criteria desired by the researcher, including: Aged between 15-18 years, Mastering the basics of freestyle techniques, Having no history of severe injury in the last 6 months, Willing to follow the intervention program during the study period. While the exclusion criteria in this study are things that cause the sample not to meet the criteria to be sampled, such as not following the entire intervention training session, or getting injured during the study. Grouping of samples is taken from athletes who have high concentration, as much as 27% and athletes who have low independence, as much as 27% of the data that has been ranked. Based on this, a sample of 10 athletes who have high concentration and 10 athletes who have low concentration is obtained, so that a total sample of 20 athletes is obtained. This study has received approval from all samples who have filled out a statement of willingness to become research samples and have met the requirements of the research ethics code.

Research Procedure

The data collection method in this research is test and measurement. Before the pretest and posttest measurements were taken, the sample was first measured for concentration to determine high and low concentrations. To measure concentration in this study is to use the Grid Concentration Test 0.89 was used, and a reliability value of 0.803 (Greenlees et al., 2006). The test to measure the speed of freestyle swimming athletes in this study used a stopwatch. The research process was carried out for 12 meetings, where in one week, 3 meetings were held. Imagery group: Structured visualization exercises, 10-15 minutes per session, and PPR Group: Consistent practice of pre-match routines. And ended with taking a final test or post-test to measure the speed ability of freestyle swimming athletes with the aim of recognizing the comparison of scores after the treatment.

Data Analysis

The data analysis method used in this research is SPSS version 24, using ANOVA 2 path (ANOVA two-way) at the level of significance = 0.05. Next, to compare the average treatment effect, the Tukey test is used (Santoso, 2018). Before arriving at the utilization of Anova 2-way (Anova two-way), prerequisite tests need to be tried, including: (1) normality test and (2) homogeneity of variance test, and hypothesis testing.

RESULTS

The chapter on research results and discussion will be presented sequentially, including: (1) research data, (2) pre-requisite test analysis, and (3) hypothesis testing. Hypothesis testing in this study will be presented sequentially including: (a) the difference in influence between imagery training methods and pre-performance routines on increasing 100-meter freestyle swimming speed; (b) the difference in influence between high and low concentration on increasing 100-meter freestyle swimming speed; and (c) the interaction between imagery training methods and pre-

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performance routines and concentration on increasing 100-meter freestyle swimming speed. The complete results will be presented as follows:
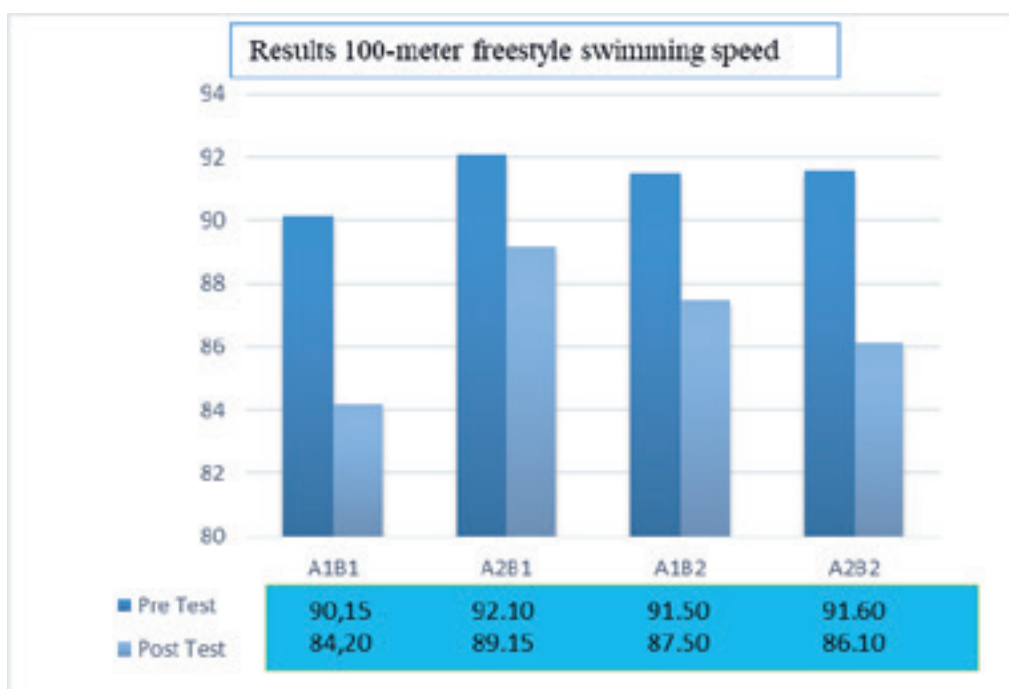
Figure 1. *Bar diagram of pretest and posttest swimming speed*

Description:
A1B1:   A group of athletes is given an imagery training method with high concentration.
A2B1:   A group of athletes is given the pre-performance routines training method with high concentration.
A1B2:   A group of athletes given the imagery training method with low concentration
A2B2:   The group of athletes given the pre-performance routines training method with low concentration.

Based on the graph 1 above, it shows that the A1B1 group's average prestest freestyle swimming speed was 90.15 and increased during the posttest by 84.20, the A2B1 group's average prestest was 92.10 and increased during the posttest by 89.15, the A1B2 group's average prestest was 91.50 and increased during the posttest by 87.50, the A2B2 group's average prestest was 91.60 and increased during the posttest by 86.10.

1. Prerequisite Test Results
a. Normality Test

The data normality test in this study used the Shapiro-Wilk method. The results of the data normality test conducted on each analysis group were carried out with the SPSS version 24.0 for Windows software program with a significance level of 5% or 0.05. The summary is presented in Table 1 as follows.

Table 1. *Summary of freestyle swimming speed normality test results*

Group	P	Significance	Description
Pretest A1BI	0.814		Normal
Posttest A1B1	0.814		Normal
Pretest A2B1	0.421		Normal
Posttest A2B1	0.421		Normal
Pretest A1B2	0.421	0.05	Normal
Posttest A1B2	0.421		Normal
PretestA2B2	0.814		Normal
Posttest A2B2	0.201		Normal

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Based on the statistical analysis of the normality test that has been carried out using the Shapiro-Wilk test, all pretest and posttest data on freestyle swimming speed are obtained from the results of the data normality test significance value $p > 0.05$, which means that the data is normally distributed.

b. Homogentis Test

The homogeneity test is carried out to test the equality of several samples, namely, homogeneous or not. The homogeneity test is intended to test the similarity of variance between the pretest and posttest. The homogeneity test in this study was the Levene Test. The homogeneity test results are presented in Table 2 as follows.

Table 2. Summary of homogeneity test results

Variable	F	df1	df2	Sig.
Freestyle Swimming Speed	0.161	3	16	0.921

Based on the statistical analysis of the homogeneity test that has been carried out using the Levene Test. The calculation results obtained the significance value of freestyle swimming speed of $0.921 \geq 0.05$, which means that the data group has a homogeneous variance. Thus, the population has a similar variant or is homogeneous.

3. Hypothesis Test Results

Research hypothesis testing is carried out based on the results of data analysis and interpretation of the two-way ANOVA analysis. The sequence of hypothesis testing results adjusted to the problem formulation is as follows:

a. Hypothesis of the Difference in Influence between Imagery Training Methods and Pre-Performance Routines on Improving 100 Meter Freestyle Swimming Ability.

The first hypothesis reads "There is a difference in the influence between the Imagery Training Method and pre-performance routines on the Improvement of 100-meter freestyle Swimming Ability". Based on the results of the analysis, obtained data in Table 3 are as follows:

Table 3. Anova test results of differences between Imagery Training Method and pre-performance routines on improving 100 Meter Freestyle Swimming Ability

Source	Variabel	Type III Sum of Squares	Df	Mean Square	F	Sig.
Training Method	Swimming speed	45.000	1	45.000	19.169	0.002

From the ANOVA test results in Table 3 above, it can be seen that the significance value of swimming speed p is 0.002 and the F value is 19.169. Because the significance value of p is $0.002 < 0.05$, it means that H0 is rejected. Thus, there is a significant difference in influence. Based on the results of the analysis, it turns out that the imagery training method group on the variable swimming speed average travel time of 85.85 seconds is better than the pre-performance routines training group on the variable swimming speed average travel time of 87.62 seconds, with a posttest average difference of 1.77 seconds. This means that the research hypothesis, which states that "There is a significant difference in influence between the Imagery Training Method and pre-performance routines on Improving 100 Meter Freestyle Swimming Ability," has been proven.

b. Hypothesis of the difference in influence between high and low concentration groups on increasing freestyle swimming speed.

The second hypothesis, which reads "There is a difference in the effect between high and low concentration groups on increasing freestyle swimming speed". The calculation results are presented in Table 4 as follows:

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Table 4. *ANOVA test results of high and low concentration groups on increasing 100-meter freestyle swimming speed*

Source	Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Concentration	Swimming speed	12.800	1	12.800	5.447	0.006

From the ANOVA test results in Table 4 above, it can be seen that the motorcycle significance value p is 0.006 and the F value is 5.447. Because the significance value of p is 0.006 <0.05, it means that H0 is rejected. Thus, there is a significant difference in influence. Based on the results of the analysis, it turns out that the group of athletes who have high concentration on the variable swimming speed average travel time of 86.67 is higher than the group of low concentration athletes on the variable swimming speed average travel time of 86.08, with an average posttest difference of 0.59. This means that the research hypothesis, which states that "There is a significant difference in influence between high and low concentration groups on improving the ability of 100 meters freestyle swimming speed," has been proven.

c. Interaction between imagery training methods and pre-performance routines and concentration (high and low) on increasing 100-meter freestyle swimming speed.

The third hypothesis, which reads "There is a significant interaction between training methods (imagery and pre-performance routines) and concentration (high and low) on improving the ability of 100-meter freestyle swimming speed". The calculation results are presented in Table 5 as follows.

Table 5. *Anova test results of interaction between training methods (imagery and pre-performance routines) and concentration (high and low) on improving the ability of 100-meter freestyle swimming speed*

Source	Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Training Method	Swimming speed	64.800	1	64.800	39.877	0.000

From the ANOVA test results in Table 5 above, it can be seen that the motorcycle obtained a significance value of p of 0.000 and an F value of 39.877. Since the significance value of p is 0.000 <0.05, it means Ho is rejected. Based on this, it means that the hypothesis stating "There is an interaction between imagery training and pre-performance routines as well as high and low concentration on increasing 100 Meter Freestyle Swimming Speed" has been proven. After the interaction is tested, it is necessary to conduct further tests using the Tukey test. Further test results can be seen in Table 6 below:

Table 6. *Summary of post hoc test of 100-meter freestyle swimming speed*

Group	Interaction	Mean Difference	Std. Error	Sig.
A1B1	A1B2	-2.5000*	0.82023	0.002
	A2B1	-1.2000	0.82023	0.47
	A2B2	1.0000	0.82023	0.619
A1B2	A1B1	2.3000*	0.82023	0.002
	A2B1	3.5000*	0.82023	0.019
	A2B2	4.5000*	0.82023	0
A2B1	A1B1	1.2000	0.82023	0.47
	A1B2	-2.3000*	0.82023	0.039
	A1B2	2.2000	0.82023	0.051
A2B2	A1B1	-1.000	0.82023	0.619
	A1B2	-3.5000*	0.82023	0
	A2B1	-2.2000	0.82023	0.052

Based on Table 6, the results of the Tukey test calculation on the asterisk sign (*) show that pairs that have interactions or pairs that are significantly different (significant) are: (1) A2B1-A2B2, (2) A2B1, (3) A2B1-A1B2, (4) A2B2-A1B2 while the other pairs declared to have no difference in influence are: (1) A2B1-A2B2 (2) A2B1 - A2B2. (3) A1B1-A2B1.

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Discussion

The discussion of the results of this study provides further interpretation of the results of the data analysis that have been stated. Based on hypothesis testing, there are three groups of analysis conclusions, namely: (1) There is a significant difference in influence between the main factors of the study; (2) there is a difference in influence between high and low concentration groups on improving the ability of 100 meters freestyle swimming speed; (3) there is a significant interaction between the main factors in the form of two-factor interaction. The discussion of the results of the analysis can be further described as follows:

1. The effect of Imagery and Pre-Performance Routines training methods on increasing 100-meter freestyle swimming speed

Based on hypothesis testing, it is known that there is a significant influence between the Imagery and Pre-Performance Routines training methods on increasing 100-meter freestyle swimming speed. These results are from the research of Ferrari et al., (2018), which states that there is a significant effect of the imagery training method on increasing the speed of aquatic athletes. Another study conducted said that the imagery training method is effective for improving the accuracy of tennis players' service. Besides that, the increase in 100-meter freestyle swimming speed can also be seen from the Pre-Performance Routines training. This is in accordance with the results of the study (Holter, 2023), which states that there is a significant effect of the Pre-Performance Routines training model on athlete performance. This is supported by previous research by Zohar et al., (2017), which says that pre-performance routines training has a significant effect on agility ability. The pre-performance routines model affects increasing the speed of 100-meter freestyle swimming athletes because the training model is effective in increasing psychological stability.

However, based on the results of the data analysis test, it was found that the imagery training method group was better) than the pre-performance routines group on increasing the speed of 100-meter freestyle swimming athletes. This is reinforced by a study (Richard et al., 2021) which shows that Pre-Performance Routines can increase psychological stability and focus, but do not significantly increase travel time in freestyle swimming. (Nopiyanto et al., 2025) said that imagery training will have an impact on an athlete's stimulus unit and response unit to skills. The stimulus provides information relative to the content of the skill, while the response provides information on individual responses to situations experienced by athletes. For example, participants have imagined a skill or performance in a training or competition, the athlete's stimulus unit seems to be seeing himself and seeing others, and can feel the crowd of spectators, while the athlete's response unit has an impact on increasing the pulse rate and sweating. Previous researchers (Jose et al., 2018) revealed that imagery training methods can improve athletes' performance in continuous tasks such as swimming. Imagery can increase the activation of the motor system, thereby strengthening the synaptic pathways used in swimming movements. Intense imagery training increases the efficiency of large and small muscle movements relevant in freestyle swimming.

2. Differences in the effect between high and low concentration athlete groups on improving freestyle swimming speed ability

The results of the analysis show that athletes with high concentration ability are better than athletes who have low concentration ability in freestyle swimming speed. Concentration in this case has an important role in influencing the technique performed or the results of a sports match. Attention and concentration are often interpreted as the same, even though they have different definitions. Concentration is the process of direct awareness of the information (stimuli) received to decide on an action (response). Concentration is a person's ability to focus attention on selected stimuli (one object) within a certain time. Uludağ et al., (2021) revealed that concentration is very important for a player in performing on the field. The main component of concentration is to focus attention on a particular thing and not be distracted by irrelevant internal stimuli or external stimuli. This is by research (Purnomo & Yendrizal, 2020) conducted by which states that athletes who have a high level of concentration have a significant effect on the shooting accuracy of petanque sports. In the context of freestyle swimming, concentration is very important to maintain technique and movement efficiency.

3. Interaction between imagery and Pre-Performance Routines training methods, and concentration on improving the 100-meter freestyle swimming speed ability

Based on the results that have been stated in the results of this study indicate that there is a significant interaction between imagery training and (Pre-Performance Routines) and concentration (high) and (low) on improving the abil-

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ity of 100 meters freestyle swimming speed. The results showed that the imagery training method is a more effective method for athletes with high concentration levels, and the Pre-Performance Routines method is more effective for athletes with low concentration levels. The interaction between psychological training techniques and concentration levels can produce different effects on athlete performance results. This suggests that imagery is more effective in improving freestyle swimming performance, especially when combined with high concentration. Elite swimming athletes often use imagery before the start, imagining the following sequence: 1) Position on the starting blocks, 2) Jump and streamline into the water, 3) The rhythm of the hand pull and leg movement, 4) The breath and turn at the end of the course, 5) The sprint to the finish wall. This repeated visualization helps improve their actual speed in the race. The 100-meter freestyle is a swimming race that relies on speed, technical efficiency, fast start, optimal turn-over, and anaerobic stamina. In this event, mental focus and tactical readiness determine the final result. Therefore, mental imagery is an important tool to: 1) improve visualization of race technique and strategy, 2) accelerate mental adaptation to competition pressure, and 3) improve movement efficiency through motor representation. This is by the functional equivalence theory, which states that brain activation when performing imagery is similar to when performing real movements (Rhodes et al., 2024). Mental imagery training has a positive and significant effect on 100-meter freestyle swimming speed. Through motor stimulation, strengthening procedural memory, and increasing psychological readiness, imagery can be an integral part of an athlete's training program (Lindsay et al., 2023). This approach is also very useful in the tapering phase or when athletes cannot train fully due to injury or fatigue.

CONCLUSSION

Based on the results of the research and the results of the data analysis that has been carried out, the following conclusions are obtained: 1) There is a significant difference in influence between imagery training methods and pre-performance routines on improving the ability of 100-meter freestyle swimming speed. The imagery training model group is better than the pre-performance routines group in improving the speed ability of 100-meter freestyle swimming athletes. 2) There is a significant difference in influence between athletes who have high and low concentration on improving freestyle swimming speed ability. Athletes who have high concentration are better than athletes who have low concentration at improving their ability to swim 100 meters. 3) There is a significant interaction between training models (imagery and pre-performance routines) and concentration (high and low) on improving the ability of 100-meter freestyle swimming speed. The results showed that the imagery training model is a more effective method for athletes who have high concentration, and the pre-performance routines training model is more effective for athletes who have low concentration.

Conflict of Interest
We know of no conflicts of interest associated with this publication, and there has been no significant financial support for this work that could affect the results. As the corresponding author, I confirm that the manuscript has been read and approved for submission by all named authors.

REFERENCES

Beganović, E. (2019). The Impact of Strength and Coordination on the Success of Performance of the Freestyle Swimming. *European Journal of Physical Education and Sport Science*, *5*(11), 10–22. https://doi.org/10.5281/zenodo.3364090

Ben-Zaken, S., Eliakim, A., Nemet, D., Kaufman, L., & Meckel, Y. (2022). Genetic characteristics of competitive swimmers: A review. *Biology of Sport*, *39*(1), 157–170. https://doi.org/10.5114/biolsport.2022.102868

Duarte-Mendes, P., Marinho, D., Monteiro, D., Cid, L., Paulo, R., Serrano, J., & Petrica, J. (2019). The comparison of Imagery ability in elite, sub-elite and non-elite swimmers. / Comparación de la habilidad de Visualización Mental de los atletas de Elite, Sub-Elite y No-Elite en la Natación. *Cuadernos de Psicología Del Deporte*, *19*(2), 124–134. https://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=138244510&site=ehost-live

Ferrari, S. F., Borges, P. H., Teixeira, D., & Marques, P. G. (2018). Impact of verbal instruction and demonstration methods on self-efficacy and motor learning in inexperienced handball players. *Journal of Physical Education and Sport*, *18*(2), 816–820. https://doi.org/10.7752/jpes.2018.02120

Greenlees, I., Thelwell, R., & Holder, T. (2006). Examining the efficacy of the concentration grid exercise as a concentration enhancement exercise. *Psychology of Sport and Exercise*, *7*(1), 29–39. https://doi.org/10.1016/j.psychsport.2005.02.001

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Holter, J. (2023). *Athlete Perception of Group Pre-Performance Routines and Sport Performance: A Quantitative Study*. University of Arizona Global Campus.

Hufton, J. R., Vella, S. A., Goddard, S. G., & Schweickle, M. J. (2024). How do athletes perform well under pressure? A meta-study. *International Review of Sport and Exercise Psychology*, *9858*. https://doi.org/10.1080/1750984X.2024.2414442

Ivanenko, S., Tyshchenko, V., Pityn, M., Hlukhov, I., Drobot, K., Dyadechko, I., Zhuravlov, I., Omelianenko, H., & Sokolova, O. (2020). Analysis of the indicators of athletes at leading sports schools in swimming. *Journal of Physical Education and Sport*, *20*(4), 1721–1726. https://doi.org/10.7752/jpes.2020.04233

Jose, J., Joseph, M. M., & Matha, M. (2018). Imagery: It's effects and benefits on sports performance and psychological variables: A review study. *International Journal of Physiology, Nutrition and Physical Education*, *3*(2), 190–193.

Lahart, I. M., & Metsios, G. S. (2018). Chronic Physiological Effects of Swim Training Interventions in Non-Elite Swimmers: A Systematic Review and Meta-Analysis. *Sports Medicine*, *48*(2), 337–359. https://doi.org/10.1007/s40279-017-0805-0

Lindsay, R. S., Larkin, P., Kittel, A., & Spittle, M. (2023). Mental imagery training programs for developing sport-specific motor skills: a systematic review and meta-analysis. *Physical Education and Sport Pedagogy*, *28*(4), 444–465.

Makar, P., Skalski, D., Pęczak-Graczyk, A., Kowalski, D., & Grygus, I. (2022). Correlations between chosen physiological parameters and swimming velocity on 200 meters freestyle distance before and after 5 months of training. *Journal of Physical Education and Sport*, *22*(3), 803–810. https://doi.org/10.7752/jpes.2022.03102

Nopiyanto, Y. ., Defliyanto, Insanistyo, B., Wibowo, C., Sartika, D., Aryanti, S., & Nanda, F. . (2025). The impact of imagery training on motivation for achievement among young swimmers aged 10-15 years. *Retos*, *62*, 374–378.

Ockta, Y., & Sabillah, M. I. (2025). *Development and Practicality of Android-based Application to Assess the Physical Condition of Young Swimmers*.

Olanescu-Vaida-Voevod, M.-C., Barza, E., Pop, N.-L., Filip, A.-G., David, L., Moldovan, R., Decea, N., & Mitrea, D.-R. (2022). The effects of ellagic acid-coated gold nanoparticles on oxidative stress in experimentally induced inflammation. *Health, Sports & Rehabilitation Medicine*, *23*(1), 4–13. https://doi.org/10.26659/pm3.2022.23.1.4

Oliver, A., McCarthy, P. J., & Burns, L. (2021). Teaching Athletes to Understand Their Attention Is Teaching Them to Concentrate. *Journal of Sport Psychology in Action*, *12*(3), 196–210. https://doi.org/10.1080/21520704.2020.1838980

Orbach, I., & Blumenstein, B. (2022). Combining Periodization with Sport Psychology to Optimize Performance of Closed Self-Paced Motor Tasks. In *The Psychology of Closed Self-Paced Motor Tasks in Sports* (pp. 175–185). Routledge.

Overbury, K., Conroy, B. W., & Marks, E. (2023). Swimming in nature: A scoping review of the mental health and wellbeing benefits of open water swimming. *Journal of Environmental Psychology*, *90*(January), 102073. https://doi.org/10.1016/j.jenvp.2023.102073

Purnomo, A., & Yendrizal. (2020). *Effect of Hand-Eye Coordination, Concentration and Believe in the Accuracy of Shooting in Petanque*. *460*(Icpe 2019), 90–96. https://doi.org/10.2991/assehr.k.200805.027

Rhodes, J., Nedza, K., May, J., & Clements, L. (2024). Imagery training for athletes with low imagery abilities. *Journal of Applied Sport Psychology*, *36*(5), 831–844. https://doi.org/10.1080/10413200.2024.2337019

Richard, V., Mason, J., Alvarez-Alvarado, S., Perry, I., Lussier, B., & Tenenbaum, G. (2021). Effect of preperformance routine on advanced swimmers' performance and motor efficiency, self-efficacy, and idiosyncratic emotions. *The Sport Psychologist*, *35*(2), 97–107.

Rupprecht, A. G. O., Tran, U. S., & Gröpel, P. (2024). The effectiveness of pre-performance routines in sports: a meta-analysis. *International Review of Sport and Exercise Psychology*, *17*(1), 39–64. https://doi.org/10.1080/1750984X.2021.1944271

Saint-Martin, S. V., Turner, M. J., & Ruiz, M. C. (2020). Mental preparation of olympic and paralympic swimmers: Performance-related cognitions and emotions, and the techniques used to manage them. *Journal of Physical Education and Sport*, *20*(6), 3569–3578. https://doi.org/10.7752/jpes.2020.06481

Samełko, A., Guszkowska, M., & Gala-Kwiatkowska, A. (2018). Affective states influence sport performance in swimming. *Polish Journal of Sport and Tourism*, *25*(4), 21–26. https://doi.org/10.2478/pjst-2018-0023

Santoso, S. (2018). *Mahir statistik multivariat dengan SPSS*. Elex Media Komputindo.

Uludağ, S., Dorak, F., Vurgun, N., Yüzbaşioğlu, Y., & Ateş, E. (2021). Effects of 10 weeks of imagery and concentration training on visual focus and free-throw performance in basketball players. *Journal of Physical Education and Sport*, *21*(4), 1761–1768.

Yadolahzadeh, A. (2021). The role of mental imagery and stress management training in the performance of female swimmers. *Atena Journal of Sports Sciences. Year*, *3*(1), 1–11. https://atenajournals.com

Yao, Q., Xu, F., & Lin, J. (2020). A Qualitative Study on Pre-performance Routines of Diving: Evidence From Elite Chinese Diving Athletes. *Frontiers in Psychology*, *11*(February). https://doi.org/10.3389/fpsyg.2020.00193

Zhan, Y., & Xue, W. (2022). Influence of swimming athletes' sports psychological fatigue on sports performance. *Revista de Psicología Del Deporte (Journal of Sport Psychology)*, *31*(2), 229–238.

Zohar, R., Bagno, E., Eylon, B. S., & Abrahamson, D. (2017). Motor skills, creativity, and cognition in learning physics concepts. *Brain, Body, Cognition*, *7*(3), 67–76.

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Abstract: *The research was aimed at studying the relationship between management approaches and the efficiency of sports organizations. To achieve this goal, a theoretical analysis of leadership styles and aspects of strategic management was conducted, as well as a survey of sports managers. The study of various leadership models, including transformational, situational, servant leadership, democratic and authoritarian, showed that transformational and situational leadership are the best approaches to improving team performance and motivating participants. The study of strategic management has confirmed its significance as an important multicomponent tool for ensuring stability and achieving long-term goals, especially when integrated with appropriate leadership approaches. According to the survey of sports managers, transformational leadership received the highest scores in combination with strategy implementation and risk management, while the authoritarian style received the lowest scores in combination with environmental analysis, adaptive planning, human resource management, and others. The findings indicate that leadership styles that promote flexibility, creativity and effective communication create favourable conditions for the sustainable development of teams, support their adaptability and increase the level of involvement of participants, which ultimately has a positive impact on the overall management efficiency of sports organizations.*

Keywords: *transformational style; adaptability; effective communication; teamwork; organizational goals*

Introduction

Sports management is increasingly facing challenges that require the adaptation and implementation of effective management practices to ensure the successful functioning of sports organizations. As leadership and strategic management are important components that determine the ability of organizations to achieve high performance, overcome challenges and sustain sustainable development, the challenge is that different leadership approaches have significantly different impacts on the performance of sports teams and their management outcomes. Given the changing environment, including the development of digital technologies, increased competition and economic crises, there is a need to better understand which leadership styles are most effective for sports organizations of different sizes. In order to optimize management approaches in sports organizations, further increase their competitiveness and overall efficiency, it is necessary to focus on adapting leadership practices to specific conditions of activity. The choice of an appropriate leadership style and effective strategic planning not only affect the success of the team in competitions, but also determine the sustainability of the organization in a changing sports market.

Previous studies in the field of strategic management and innovation in sports organizations have highlighted the factors that contribute to their effectiveness. Adiguzel (2020) investigated the role of strategic management in combination with innovation processes and concluded that technological capabilities serve as a catalyst for improving innovation processes and increasing the effectiveness of strategy execution. In addition, Rehman et al. (2019) investigated the impact of leadership styles on organizational performance through the development of an innovative culture and organizational learning. They found that the combination of transformational leadership with a culture of innovation and learning is crucial for increasing productivity. At the same time, there is still a lack of comprehensive research that would reveal the interaction of these factors in large sports organizations.

Methodological approaches need to be improved to increase the accuracy and reliability of research in the field of sport management. Andrew et al. (2020) proposed a systematic approach to research in this area and drew attention to the need to develop detailed guidelines for formulating questions and collecting data. The authors have developed

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a framework that allows researchers to effectively plan their studies, choose adequate data collection methods, and apply scientific approaches to analyse the results. However, qualitative methods also play a key role in sports research: Skinner et al. (2020) found that the use of qualitative methods allows for more nuanced data on relationships within sport organizations, the relationship between coaches and athletes, and the motivations and expectations of different participants in sport. Kim and Lee (2019) confirmed that an incomplete understanding of statistical methods often leads to methodological errors and distortion of results. Thus, despite significant advances in methodology, there is still a need for clearer standards and the integration of better approaches to avoid inaccuracies and increase the scientific validity of results.

Modern research on the role of sport in society has demonstrated the diversity of views and approaches that reflect different aspects of its significance. For example, Gammelsæter (2021) emphasized the danger of commercialization of sport, which undermines its authentic values and focus on personal and social development, turning sport into a business. The author pointed out the importance of returning to the cultural and social role of sport, which includes fair play and community engagement. A different view was offered by Yoon et al. (2024). They argue that leadership in sport can stimulate not only sporting but also entrepreneurial activity, promoting responsibility and commitment in a team context. In this case, sport acts as an environment for developing innovative thinking and professional skills. The study by McCullough et al. (2020) expanded on this approach by emphasizing the environmental responsibility of sport and its potential to impact a sustainable environment, which requires the integration of environmental practices into sport management. The reviewed works pointed to the need for further research into a balanced approach that would preserve the values of sport while developing new areas of its influence.

Studies on leadership approaches in sports teams have shown a significant impact of such approaches on the interaction and level of involvement of participants. For example, the work of Garcia et al. (2021) demonstrated that programmes that promote the development of authentic leadership in coaches can significantly increase athletes' motivation and create more trusting relationships within the team. The authors confirmed the role of authentic leadership in creating a positive environment where athletes feel supported and, accordingly, demonstrate a higher level of satisfaction with training. The study by Ehnold et al. (2021) complemented these findings and confirmed the importance of digital technologies for the organizational capacity of sports clubs. It was found that the introduction of digital tools improves communication and member engagement, particularly in clubs with high organizational capacity, which allows for more effective management. Despite these achievements, it remains to be seen how the integration of digital solutions can further strengthen leadership initiatives.

The reviewed studies have demonstrated significant progress in the study of the field of sports management, but the question of how different leadership approaches can be combined with modern management approaches remains unexplored. The purpose of the study was to assess the impact of leadership styles and strategic management on the overall performance of a sports organization. The objectives of the study were to identify the most common leadership models in sports organizations, assess the effectiveness of strategic management practices and the role of strategic planning in achieving organizational goals, and conduct a survey of sports managers.

Materials and Methods

The article analyses leadership models and strategic management in sports organizations. The current trends in leadership in sports were considered, the most common leadership models and their impact on the performance of teams and individual athletes were identified. A detailed description of each leadership model was provided, and how these models shape the culture of sports organizations, affect the relationships between participants and the final results were considered. Each leadership style was also assessed, identifying their strengths and weaknesses, as well as the specific conditions under which a particular model is most effective. To assess the impact of each leadership style on various aspects of team dynamics and individual performance, a comparison of leadership models was conducted.

The analysis of strategic management in sports structures assessed the effectiveness of strategic management practices and the role of strategic planning in achieving organizational goals. The analysis covered such aspects as external environment analysis, strategy formulation and implementation, performance monitoring, adaptive and long-term planning, risk and human resource management. In addition, special attention was paid to the ability of sports organizations to adapt to rapid changes in the external environment and apply innovative practices to ensure sustainable development.

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The study involved 385 respondents, sports managers at top, middle and grassroots levels. The age range was from 25 to 55 years old (average age 43.6 years); 274 men (71.2%) and 111 women (28.8%). The sample was drawn randomly from sports managers working in the following sports organizations: football (12%), hockey (5%), basketball (9%) and rugby (3%) clubs, athletics (21%) and cycling (4%) organizations, gymnastics (11%) and swimming (8%) schools. For the purpose of in-depth analysis, 10% (39 people) of the total number of respondents were randomly selected to participate in semi-structured interviews.

The survey was conducted online using Google Forms. Respondents were provided with a memo defining key concepts in the context of leadership styles and aspects of strategic management to ensure a uniform understanding of the questions and uniformity of results. All participants were asked the following questions (Table 1).

Table 1. Example of questions from a survey conducted

No.	Questions	Answer options
1.	Do you think that adapting leadership style to the situation contributes to the effectiveness of an organization?	a. Absolutely yes b. Rather yes c. Neutral d. Rather no e. Not at all
2.	To what extent do you think that current trends in the sports industry (e.g., the introduction of technology, changes in training approaches) influence your leadership style?	a. Influence significantly b. Influence moderately c. Have little or no impact d. Do not affect at all
3.	How often do you think training and leadership strategies should be reviewed to improve team performance?	a. Monthly b. Every three months c. Every six months d. Annually e. As needed
4.	Assess your level of satisfaction with the current approaches to leadership in your organization.	a. Very satisfied b. Satisfied c. Neutral d. Dissatisfied e. Very dissatisfied
5.	How often do you review your management strategies to improve organizational performance?	a. Monthly b. Every three months c. Every six months d. Annually e. As needed
6.	How important is it to adapt the leadership style to the individual needs of the athlete?	a. Critically important b. Very important c. Important d. Not very important e. Not important at all

Source: compiled by the authors.

Additionally, respondents were asked to evaluate the combination of leadership styles and aspects of strategic management using a 10-point scale. For this purpose, they were provided with blank tables in which they had to evaluate each combination, which allowed obtaining quantitative data for further analysis.

Semi-structured interviews were conducted with 39 respondents (12 women, 27 men, average age 45.8 years). The interviews were conducted in the format of video conferences via Zoom and lasted 15-30 minutes (Table 2).

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Table 2. *Questions that were asked during the interview*

No.	Questions
1.	How did your leadership style affect the effectiveness of the sports organization you work for?
2.	Can you give an example of when strategic planning and leadership contributed to the achievement of important organizational goals? What specific approaches have been most successful?
3.	How is your leadership influenced by trends in the sports industry, such as the increase in technology or changes in approaches to athlete training?
4.	How do leadership approaches affect resource management in your organization? Are there any styles that are more favourable for the optimal use of resources?
5.	What specific managerial decisions have you made to improve the effectiveness of your organization, and how does this relate to your leadership approach?
6.	What strategies have you found to be most effective in maintaining high levels of athlete motivation in the long term?

Source: compiled by the authors.

The ratings of the combination of leadership styles and strategic management aspects were used to create a heat map that displayed the mean values and deviations, which made it possible to identify the best and worst combinations of leadership approaches and strategic management aspects, as well as the consistency of experts' opinions. The obtained scores were processed in an Excel spreadsheet using standard formulas to calculate mean values and standard deviations. The interview materials were processed by transcribing the audio recordings.

All respondents were informed about the purpose of the study, the format of participation, and the possibility of refusing to participate. To ensure confidentiality, all data was collected and processed anonymously, and no identifying information was collected.

RESULTS

Analysis of current trends in leadership in sports: identification of the most common leadership models in sports organizations and the impact of leadership approaches on the performance of teams and individual athletes

Leadership in sports organizations is not just a management tool, but a foundation for building an effective team and achieving high results. Each leadership model has a unique impact on athlete development, team cohesion and performance. It is important to understand the different approaches and recognize how they shape the organization's culture, relationships between participants and the final results. Among the leadership models that dominate in sports structures, scholars identify transformational, transactional, situational, servant leadership, charismatic, democratic and authoritarian leadership (Mach et al., 2021; Jin et al., 2022; Şahin, 2022). It is worth considering the impact of each of these approaches on team and individual athlete performance.

Transformational leadership is one of the most powerful models in the sports context as a leader, who chooses this approach is able not only to manage the team, but also to inspire it to achieve results that at first glance seemed impossible (Newland et al., 2019). Leaders who act on the basis of a transformational approach can create a shared vision of the future that becomes a driving force for each athlete. They support athletes in overcoming difficulties and encourage them to go beyond the usual. This approach helps to create an atmosphere of trust and mutual support in which athletes feel part of a larger whole; it contributes to increased motivation, personal development and, as a result, the achievement of outstanding results at both the individual and team levels.

Transactional leadership, in contrast to transformational leadership, is more formalized and focused on a system of rewards and punishments. Athletes clearly understand what is expected of them and what the consequences of their actions will be. This model provides predictability and stability, which can be very effective, especially in preparation for competitions where clear rules and standards must be followed. At the same time, the transactional approach often limits creativity and initiative, as athletes may focus solely on completing tasks without trying to find new ways to achieve results or improve.

Situational leadership is especially important in sports, where the dynamics of the situation change instantly, and the coach or leader has the ability to adapt his or her leadership style to suit the circumstances. For example, in one situation, a leader may choose a supportive approach to help athletes develop confidence in their abilities, while

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in another they may adopt a more directive style when they need to make quick decisions under pressure. The situational approach allows for effective response to the needs of the team and individual athletes, maintaining a balance between control and autonomy that leads to better results.

Servant leadership is a unique approach that helps to highlight the importance of caring for the needs of athletes as a leader's top priority (Lemoine et al., 2019). A servant leader creates an environment where athletes can grow both professionally and personally. He or she focuses on achieving athletic performance and developing moral character and emotional resilience. This support helps to create a team in which each member feels important and relationships within the group are based on trust and mutual respect. Such support helps to reduce stress, increase motivation and the overall level of satisfaction of athletes from participating in the team.

Charismatic leadership has a significant impact on athletes' performance due to the energy and inspiration that the leader exudes. A charismatic leader is able to rally a team around a big idea or goal, inspiring each athlete to believe in their own abilities. Under his influence, athletes often show high commitment and motivation, and are willing to make sacrifices for the sake of a common goal. However, this style can also have a downside – a team's strong dependence on the leader can lead to a loss of direction in the event of his or her absence or replacement, which can sometimes undermine stability and long-term effectiveness.

Democratic leadership involves the active involvement of athletes in decision-making, which increases their engagement and sense of responsibility for team success. A leader who follows a democratic approach encourages discussion, considers the opinions of all team members and builds open communication. This model of leadership contributes to the development of leadership skills in the athletes themselves, their personal growth, and the strengthening of team spirit. However, this style may be less effective in situations where quick and decisive decisions need to be made.

Despite its criticisms, authoritarian leadership also has its place in sport organizations, especially in high-stress environments or in times of crisis. An authoritative leader clearly indicates what needs to be done and how to do it, which can be useful when a quick response is needed. Athletes know what is required of them, and this helps them to focus on the goal at hand. However, a long-term authoritarian approach can lead to a decrease in motivation and initiative, as athletes feel that they are merely executors without the ability to influence the team's processes.

Each leadership model has its own unique characteristics and impact on team and individual performance, and the effectiveness of a sports team largely depends on the leader's ability to choose a specific style and flexibly adapt it to the circumstances, taking into account the characteristics of the team, the specifics of the sport and the current situation. It is believed that effective leaders combine different approaches, which helps to maximize the potential of athletes to ensure high sports results and sustainable development of the team (Day et al., 2020; Daniëls et al., 2019).

Strategic management in sports structures: evaluation of the effectiveness of strategic management practices and the role of strategic planning in achieving organizational goals

Strategic management in sports structures is a critical element of the success of modern sports organizations, as it determines how successfully the organization achieves its goals, uses resources and adapts to the dynamic external environment. It is known that assessing the effectiveness of strategic management practices can help identify the strengths and weaknesses of management, as well as determine how best to innovate and ensure development in a constantly competitive environment (Dodgson, 2021; Agazu and Kero, 2024; López and Oliver, 2023). In the sports sector, where changes occur very quickly, strategic management becomes the basis for stability, allowing organizations to maintain efficiency while maintaining flexibility to adapt to new conditions.

The main strategic management practices used in sports organizations include analysing the external environment, formulating a strategy, implementing it and monitoring the results. An important part of these processes is the ability of a sports organization to respond quickly to market changes, introduce innovations and effectively manage human resources. The effectiveness of management practices is determined by the extent to which an organization is able to achieve its goals while minimizing costs and making optimal use of available resources. For example, the analysis of the external environment should include consideration of the competitive landscape, economic factors, legislative changes and social trends, which can help a sports organization to be prepared for different development scenarios and make decisions based on real data.

The role of strategic planning in sports organizations cannot be overestimated, as it provides a basis for decision-making, allows for the development of long-term development programmes and clearly defines the organization's

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activities. Successful strategic planning involves a clear vision of the future, an understanding of the organization's strengths and weaknesses, and consideration of opportunities and threats in the external environment, which allows sports organizations to achieve high results in competitions and ensure financial stability and long-term competitiveness. It is important to note that strategic planning also helps to avoid chaotic actions and establish a systematic approach to solving problems and achieving goals.

Another important feature of strategic planning in sport is its adaptability. Sports organizations often face unforeseen circumstances, such as player injuries, changes in competition regulations or economic crises. Therefore, effective strategic planning must be flexible enough to take these factors into account and adapt to new conditions. Adaptive planning allows avoiding the negative effects of crises and using them as opportunities for development by revising athletes' training strategies or optimizing the use of resources. For example, during the COVID-19 pandemic, many sports organizations were forced to revise their training strategies, focusing on individual training and the introduction of online classes (Washif et al., 2022; Purc-Stephenson et al., 2022; Washif et al., 2024). Such adaptability helped not only to keep athletes in shape, but also to develop new approaches to the training process that remained useful after the crisis period.

Another important aspect is the integration of strategic planning with human resource management. In sports organizations, people are the main asset on which the success of the entire structure depends, so effective strategic human resource management should include the selection, development, and motivation of coaches, players and administrative staff. Only a harmonious combination of human resources and strategic goals can ensure the stable development and success of a sports organization. For example, recruiting qualified coaches who share the organization's values and are willing to work towards long-term goals is an important component of building an effective team. It is also essential to consider the motivation of athletes: strategic planning should include measures to increase motivation, such as creating individual development programmes, providing social support and implementing a reward system.

The effectiveness of strategic management in sports organizations also depends on the ability of leaders to anticipate changes and develop strategies that take into account long-term trends. For example, the development of technology and analytics in sports has provided new opportunities for collecting and analysing data on the effectiveness of training, the health of athletes, and their performance during competitions. The use of such data in strategic planning can allow for more accurate prioritization, identification of risks and informed decision-making. Sports organizations that actively implement analytical approaches can gain a significant advantage over their competitors, as they are able to respond to changes more quickly and increase the efficiency of the training process.

Strategic management in sports organizations plays a crucial role in achieving organizational goals; effective management practices and strategic planning provide the basis for the development, growth, and sustainability of sports organizations in the face of dynamic change and high competition. It is believed that the key success factors are the ability to adapt to new conditions, use resources efficiently and integrate strategies with human resource management (Zhang et al., 2023; Chelladurai and Kim, 2023; Bradbury et al., 2021). Only those sports organizations that consider long-term trends and innovations are able to ensure sustainable development and long-term success in the field of sport.

Synergy of leadership and strategic management: impact on the efficiency of sports organizations and expert opinions

The analysis of the respondents' answers to open-ended questions allowed us to better understand the specifics of the challenges and the effectiveness of applying different leadership styles when working with high-level teams in the sports industry.

Regarding the impact of leadership style on organizational performance, most experts indicated that their approach to leadership directly determined the level of team motivation and commitment of athletes to common goals. One of the experts emphasized the importance of working with each player individually and paying attention to their personal needs, which helped to keep motivation high even in times of difficulty. This approach demonstrated the importance of personalized work with players, especially in sports with a high emotional component.

Other experts drew attention to the synergistic effect of combining strategic planning and leadership. One respondent cited an example where clear planning and the ability to inspire the team led to the successful achievement

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of long-term goals, while another manager confirmed that strategic planning that took into account the individual needs of athletes and constant motivation from the leader were key factors in achieving a positive result. This approach demonstrated the importance of combining clear strategic direction with active support and engagement of stakeholders, which proves success not only through planning, but also through creating a culture of accountability and involvement of each participant in a common goal.

Changes in the sports industry, such as the introduction of new technologies, have a significant impact on the leadership approaches used in organizations. Respondents noted that the development of analytical systems and the latest methods of training athletes is forcing leaders to reconsider their management styles. With the advent of new technologies, the approach to working with the team has changed. Leaders have become more open and integrated players into the decision-making process, which has contributed to increased teamwork and trust between players and management.

Regarding the impact of leadership on resource management, most experts agreed that democratic and collective management styles contributed to the optimal use of resources. The involvement of trainers in decision-making allowed for better cost control and more efficient use of resources, which also pointed to the effectiveness of teamwork in addressing resource allocation issues, especially in the context of limited funding.

When analysing management decisions, experts emphasized the benefits of adaptive leadership for improving organizational performance. Leaders who are able to adapt to changes and make unconventional decisions can ensure the stability of organizations even in crisis conditions. Regarding the motivation of athletes, most experts emphasized the importance of an individual approach and creating conditions for continuous professional development. A comprehensive approach, including the physical and mental development of athletes, was seen as crucial for maintaining their motivation in the long term.

The results of the interviews showed that the effectiveness of a sports organization largely depended on the leader's ability to adapt to modern challenges, use an individual approach to working with the team, and actively involve stakeholders in strategic decision-making. This approach allowed the organization to achieve high results and ensure stable development in a rapidly changing sports industry.

When asked about adapting the leadership style to the situation, most respondents demonstrated some scepticism about whether it contributes to the organization's effectiveness (Figure 1).

Figure 1. Distribution of experts' answers to the question about the impact of adapting leadership style depending on the situation on increasing the organization's efficiency

About 70.9% of respondents were against adaptation, which may indicate a sense of stability and reliability in existing approaches. The high level of distrust of flexible leadership styles is likely to be explained by previous

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experiences where changes could lead to instability and lack of clear results. In addition, respondents may have seen fixed approaches as providing a certain structure that helps to avoid confusion and reduces the likelihood of mistakes in difficult circumstances.

In terms of the impact of current trends in the sports industry, only 21.3% of respondents said that they have a significant impact on their leadership style, while the majority either did not note a significant impact or denied it at all (Figure 2).
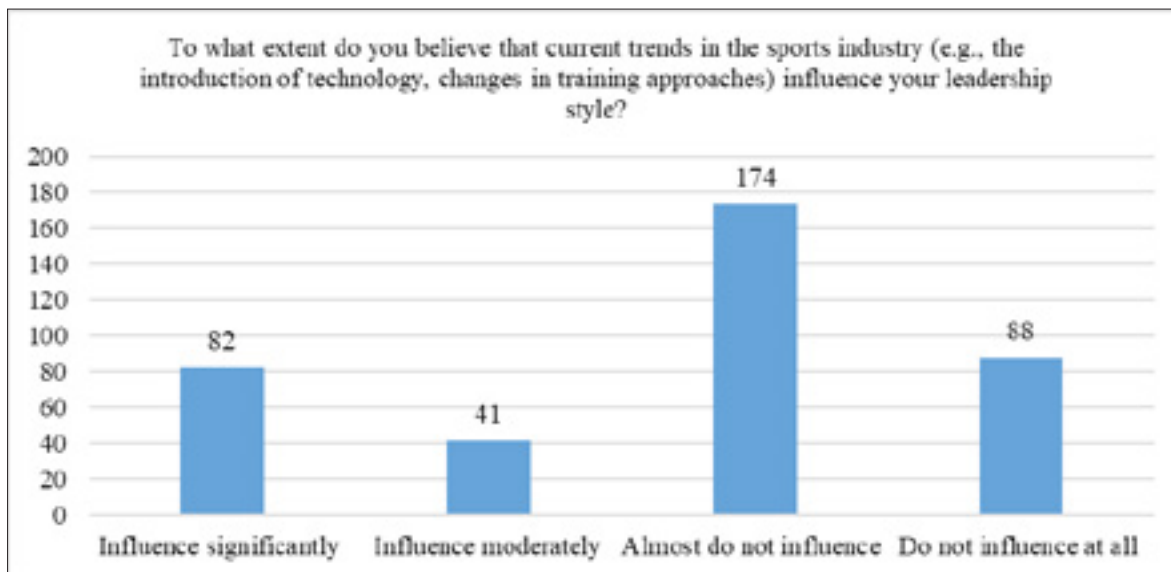
Figure 2. *Distribution of experts' answers to the question about the impact of modern trends in the sports industry on leadership style*

This situation may indicate that a significant number of leaders are likely to face challenges in implementing new technologies or simply consider them ineffective in the context of their own management approaches. Another critical aspect is that the impact of modern technologies is often perceived as an additional factor rather than the main means of improving results, which indicates that traditional management methods are still in place.

In terms of the frequency of reviewing training and leadership strategies, the most popular idea was to review them every three months, which was supported by the majority of respondents (Figure 3).

Figure 3. *Distribution of experts' answers to the question about the need to review the training and leadership strategy to improve team performance*

67.5% of respondents supported the idea of reviewing training and leadership strategies every three months or more frequently, indicating a desire to maintain a balance between stability and adaptation. Leaders understand the need for regular change to optimize processes, but at the same time are reluctant to make changes too infrequently to avoid over-adaptation. The idea of reviewing strategies on a semi-annual basis received the least support, which may be due to the need to maintain a more flexible approach to change, as well as the desire to maintain clarity and focus on strategic goals without becoming too inert.

In terms of satisfaction with the existing leadership approaches, the majority of respondents expressed a neutral position (Figure 4).

Figure 4. Distribution of experts' answers to the question about the level of satisfaction with the existing approaches to leadership in the organization

The neutrality in this question may be an indicator that the existing approaches, while not having significant drawbacks, do not provide exceptional results that would contribute to a high level of satisfaction. The high proportion of neutral responses indicates that there is room for improvement, as respondents did not express strong support or opposition to current methods. This may be due to a lack of innovative changes or insufficient involvement of staff in the decision-making process.

In terms of the frequency of reviewing management strategies, the most frequent response was every six months (Figure 5).

Figure 5. Distribution of experts' answers to the question about the frequency of reviewing management strategies to improve the organization's efficiency

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With 60.5% of respondents indicating that they review their management strategies every six months, this may indicate that leaders want to maintain a certain rhythm in the process of planning and implementing change. At the same time, a significant proportion of respondents indicated that they review their strategies every three months (19%), which indicates an interest in flexibility in management and the ability to respond quickly to change. Revising the strategy depending on the situation was the least popular option (5.2%), which may indicate the need for a defined framework and timeline to ensure control and stability.

When asked about the importance of adapting the leadership style to the individual needs of the athlete, the responses were rather mixed (Figure 6).
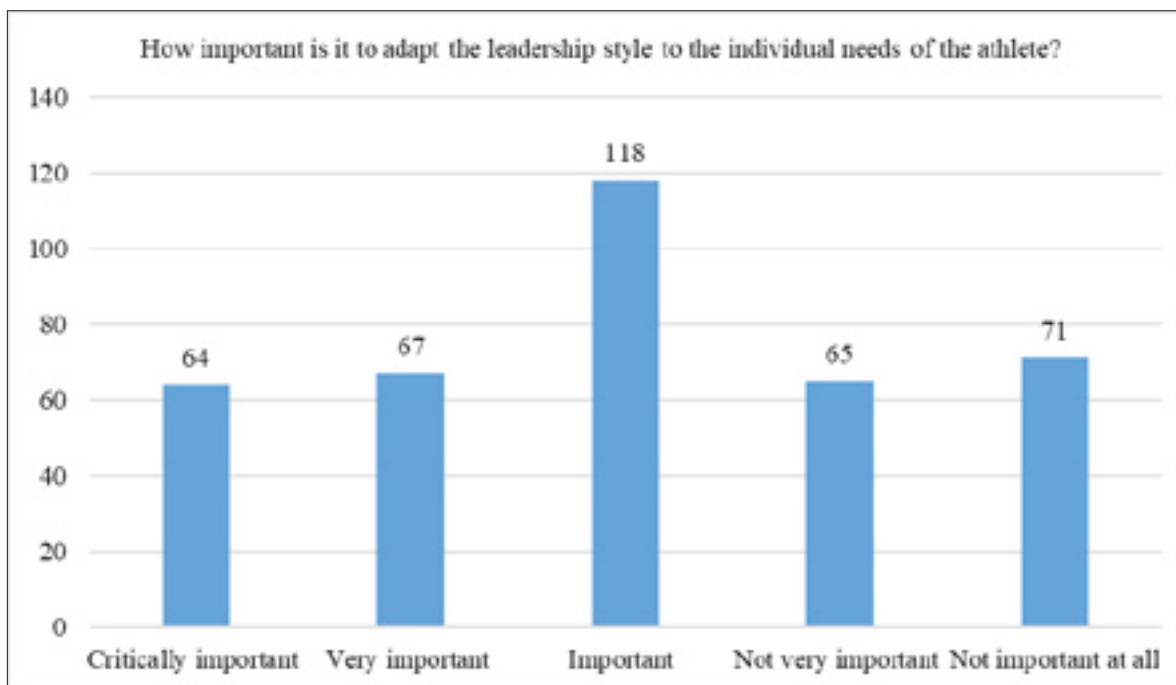
Figure 6. *Distribution of experts' answers to the question about the importance of adapting the leadership style depending on the individual needs of the athlete*

Although a significant proportion considered it critical (16.6%) or very important (17.4%), around 35% of respondents were against such adaptation, indicating that there are fundamental differences in management approaches, with some leaders focusing on individual development and others believing that one-size-fits-all management methods can be more effective in a teamwork context. The results also indicate some barriers to understanding or accepting the need for a personalized approach, possibly due to the complexity of its implementation or lack of appropriate resources.

The heat map of average scores and deviations of the combination of leadership styles and strategic management aspects was created based on the responses of 385 respondents and made it possible to see which combinations of leadership styles and strategic management aspects were considered the best and which were considered the worst. It also visualized the consistency of experts' opinions, which made it possible to identify pairs of leadership styles and aspects of strategic management where experts' views coincided and vice versa. Table 3 provides a holistic picture of the perception of different management approaches and the best strategies for the development of organizations.

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Table 3. *Heat map of average scores and deviations of the combination of leadership styles and aspects of strategic management*

Leadership style/ Strategic management aspect	Analysing external environment		Strategy formulation		Strategy implementation		Monitoring results		Adaptive planning		Long-term planning		Risk management		Human Resources Management	
	μ	SD	μ	SD	μ	SD	μ	SD	μ	SD	μ	SD	μ	SD	μ	SD
Charismatic leadership	7.5	1.8	7	1.7	6.8	2	7.2	1.9	7	1.7	6.2	2.1	8.1	1.5	7.5	1.8
Transformational leadership	8.3	1.6	8	1.5	8.5	1.3	8.1	1.6	8.3	1.6	7.4	1.9	8.5	1.4	8.2	1.5
Transactional leadership	6.1	2.3	6.5	2.1	7.2	2	6.8	2.2	6.1	2.3	7.8	1.7	7.2	2	6.9	2.1
Situational leadership	8	1.5	7.8	1.4	8.4	1.6	8	1.5	8	1.5	7	1.8	8.4	1.6	7.8	1.7
Servant Leadership	7.9	1.7	7.5	1.8	8	1.9	7.7	1.6	7.9	1.7	6.8	2	8	1.9	8.1	1.6
Democratic leadership	7.4	1.9	7.2	1.7	7.9	1.8	7.5	1.7	7.4	1.9	7.3	1.6	7.9	1.8	7.6	1.8
Authoritarian leadership	5.6	2.5	6	2.3	7	2.1	6.4	2.4	5.6	2.3	6.9	2.2	7	2.1	6.3	2.3

Note: μ – average; SD – standard deviation.

Transformational leadership demonstrated the highest average scores in such critical aspects of strategic management as strategy implementation (8.5) and risk management (8.5), indicating a high ability of this style to implement changes and adapt in difficult conditions. At the same time, the deviations for these indicators remained relatively low (1.3 and 1.4), which indicates the stability of the assessments and the consistency of respondents' perceptions of the effectiveness of transformational leadership in these aspects. This stability indicates that transformational leadership has clear and understandable advantages in environments where adaptability and rapid implementation of strategies are required.

Charismatic leadership, on the other hand, showed significant deviations in aspects such as strategy implementation (2.0) and long-term planning (2.1). That is, although this leadership style can have a strong impact on athletes, its effectiveness depends heavily on the specific situation and individual characteristics of the leader. The high deviations indicated that leadership outcomes can be unpredictable, making this style less reliable in the long run, especially when it comes to a systematic approach to planning.

Situational leadership also scored highly in aspects such as strategy implementation (8.4) and risk management (8.4), with moderate deviations (1.6). Experts agreed on the ability of managers with this style to effectively adapt to different conditions and make decisions. It is important to note that situational leadership was recognized as one of the most versatile approaches, as it allows leaders to change their style depending on the specific situation, which ensures relative stability of results.

Authoritarian leadership, on the other hand, scored the lowest in most aspects, including analysing the external environment (5.6) and adaptive planning (5.6). These results indicated a limited ability of this style to adapt and respond flexibly to changes in the external environment. The high deviations (2.5 and 2.3) showed that respondents had an ambivalent attitude towards the authoritarian approach in the context of analysis and adaptation, which makes it less effective in today's environment where rapid change and flexibility are required.

With regard to servant leadership, it showed strong results in human resource management (8.1), which highlighted the effectiveness of this style in working with a team, particularly in creating a supportive atmosphere and engaging people. Servant leadership is particularly useful when it is important to ensure a high level of athlete engagement and motivation, making it effective in the context of managing people.

It is also important to note that long-term planning was the aspect that had the highest deviations for almost all leadership styles. This suggests that long-term strategies required more coherence and predictability, which could not always be achieved with certain leadership styles. In particular, the lowest deviation for democratic leadership (1.6)

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in this aspect indicated that a collective approach to decision-making may be most effective in long-term planning, as consensus building can provide a more stable basis for long-term goals.

In summary, the analysis demonstrated that transformational and situational leadership were most effective in many aspects of strategic management, especially when it came to strategy implementation and risk management. The authoritarian style, on the contrary, was the least effective, especially in conditions that required flexibility and adaptation, and servant leadership was the best in the context of human resource management.

Discussion

The study revealed the impact of different leadership approaches on the effectiveness of sports organizations. The advantages and disadvantages of the main leadership styles were examined, and their impact on motivation, team cohesion and the implementation of strategic goals was assessed. The results of a survey of sports team managers have shown that transformational and situational approaches to leadership were the most effective, as they provided flexibility and adaptability in various management situations.

The analysis of the shortcomings of leadership styles in sports organizations showed that, despite certain strengths, most models had weaknesses that affect the effectiveness of teamwork. In particular, the authoritarian style was rated the worst by experts due to its low effectiveness in the long term due to excessive control that limited the motivation, creativity, and initiative of athletes. Although democratic and transformational styles have a positive impact on motivation and team cohesion, they may not be effective in certain situations. In general, the effectiveness of each approach depends on the leader's ability to adapt to the needs of the team and the specifics of the situation, which is a key factor in ensuring positive results. therefore, the effectiveness of each approach depends on the leader's ability to flexibly adapt the style to the needs of the team and the specifics of the situation. These issues had parallels with the study by O'Shannassy (2021), who focused on the challenges of implementing strategic leadership. In particular, the study noted difficulties in overcoming resistance to change and problems with establishing effective communication between leaders and subordinates. That is, not only in sports teams, but also in a broader organizational context, strategic leadership may face difficulties in building long-term trust relationships. In addition, the study by Fransen et al. (2020) highlighted the importance of collective identity formation and psychological safety, which were identified as key factors in the development of effective teamwork. Psychological safety created the conditions for open communication and contributed to the formation of a cohesive team where each member could express their ideas without fear of judgement.

The survey, which included questionnaires and interviews with managers of sports organizations, showed that there is a significant difference in the perception of different leadership styles, especially in the context of their impact on staff motivation and engagement. The questionnaire and interviews showed that transformational leadership significantly contributed to increasing the motivation and performance of managers, while the autocratic approach was criticized for limiting autonomy and reducing employee engagement. The inclusive style, as the results showed, was effective in creating an atmosphere of trust, which had a positive impact on the psychological climate in the organization. Thus, the interviews and questionnaires made it possible to determine that the most favourable for the development of a sports organization are approaches that take into account the individual needs and motivation of managers, which can be correlated with the findings of Oh et al. (2023), and Atrizka and Pratama (2022). In their work, J. Oh et al. found that inclusive leadership contributed to increased employee satisfaction, especially in conditions of high levels of trust in the organization, while autocratic leadership had a negative impact on engagement. In turn, the study by Atrizka and Pratama revealed the role of supportive leaders in the development of athletes' resilience. Since they create a favourable atmosphere for development and actively support their wards, this can significantly increase the ability of athletes to overcome challenges and stay motivated even in difficult situations. Similar conclusions were drawn from the interviews, in which some respondents noted that personal attention and support from leaders helped to overcome difficulties and keep employees motivated, indicating the need to move away from solely directive management styles and towards models that support collective identity and individual development.

The data obtained from the theoretical review, survey and heat map revealed significant shortcomings of the autocratic leadership style in sports organizations. It was found that the autocratic approach to management limited the initiative and autonomy of athletes, created a tense atmosphere that did not promote constructive cooperation and the development of innovative solutions. The results of the survey among managers showed that the autocratic style was

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heavily criticized by employees due to the limited ability to influence decision-making processes, which negatively affected their motivation and commitment. The heat map also showed the lowest scores for the autocratic leadership style in the areas of adaptive planning and environmental analysis, which confirmed its limited ability to adapt and lack of flexibility. The respondents also noted that autocratic management often led to a deterioration in the psychological climate in the team and a decrease in the level of involvement of participants in management processes. The study by Fransen et al. (2020), and Park and J.-H. Seo (2019) confirmed the need to move from an autocratic style to a more inclusive and distributed approach to managing sports teams. The study by Fransen et al. demonstrated that the distribution of leadership functions among team members contributed to improved coach-athlete relationships, increased motivation and overall team cohesion, while autocratic management often had the opposite effects. Park and Seo noted that transformational, democratic, and situational leadership approaches can provide a high level of motivation and adaptability, and the big data analysis revealed clear correlations between leadership styles and team success, indicating the need to abandon the autocratic approach in favour of more flexible and adaptive management models that take into account the needs and motivations of participants.

The formation of a heat map allowed us to identify the most and least effective combinations of leadership styles and aspects of strategic management in sports organizations. Transformational leadership was identified as the most effective in such aspects as strategy implementation and risk management, which was confirmed by high average scores and low deviations. These results demonstrated the stability and consistency in assessments of the effectiveness of this style, especially in environments where adaptability and the ability to implement change are required. Situational leadership also scored well in aspects such as risk management and strategy implementation, demonstrating the versatility of the approach and the ability to respond effectively to different situations. On the other hand, authoritarian leadership received the lowest scores, especially in the areas of environmental analysis and adaptive planning, indicating its limited ability to adapt and respond to change. The findings of the study by Barnhill et al. (2021) confirmed the importance of effective management of people and groups to improve the performance of sports organizations. The authors noted that the success of organizations depends on the ability of leaders to take into account the individual needs, motivations, and characteristics of employees, which confirms the validity of the heat map, where transformational and situational leadership received high marks.

The study by Lussier and Kimball (2024) focused on the development of applied skills in the field of sports management, including leadership, strategic planning, human resources and marketing. The results of the study showed that the development of these skills can significantly increase the efficiency of sports organizations. Managers who possessed these skills were better able to adapt to a changing environment, lead teams more effectively and make informed decisions, which contributed to the competitiveness of sports organizations. Comparison with this study has pointed to the importance of developing strategic management skills regardless of the chosen management style, as these skills allow for effective adaptation to change and ensure stable results.

The authors of the reviewed papers agreed that each leadership style in sports organizations has its own strengths and weaknesses that significantly affect the team's performance. The autocratic style has been most criticized for its ability to limit the motivation, initiative, and creativity of athletes, which negatively affects long-term results. Transformational and democratic leadership have been found to be effective in increasing team motivation, but they also have drawbacks in certain contexts. The studies underlined that the most important factor in leadership effectiveness is the ability of leaders to adapt their approaches depending on the specifics of the situation and the needs of the team.

Conclusions

The study examined various aspects of leadership and strategic management in sports organizations and their impact on the performance of teams and individual athletes. The theoretical analysis included a review of the following leadership models: transformational, transactional, situational, charismatic, authoritarian, democratic and servant leadership. It was found that each of the approaches has its own unique advantages and disadvantages, and their impact varies depending on the specifics of the situation and the goals of the organization. The review of the role of strategic management in sport organizations demonstrated its role in achieving organizational goals through the implementation of effective management practices and strategic planning. Strategic planning can help to set clear goals and develop appropriate strategies to achieve them, contributing to short-term efficiency as well as long-term development. Thanks to the flexibility of strategic management, sports organizations are able to respond quickly to

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external challenges while maintaining the clarity of management decisions.

The survey of experts revealed trends in approaches to managing sports teams. 61.6% of respondents were negative about the advisability of adapting the leadership style depending on the situation. This result can be explained by the desire for stability and avoidance of chaos that can result from excessive flexibility. In addition, only 21.3% of respondents acknowledged the impact of current trends in the sports industry on their leadership style. This suggests that most leaders have either not yet adapted to the changes or do not consider them critical to success. Managers rely on traditional management methods, which indicates a certain inertia in the adoption of innovations and limited potential for development, especially in the context of the rapid introduction of new technologies in the sports environment.

The level of satisfaction with the existing leadership approaches was mostly neutral, indicating that there is room for improvement, as the existing approaches provide neither significant advantages nor significant disadvantages. At the same time, the frequency of reviewing management strategies to improve organizational performance was most often six months, but a significant proportion of respondents noted the need for more frequent reviews depending on the situation, which indicates the importance of flexibility and the ability to respond quickly to changes. Adapting the leadership style to the individual needs of the athletes was recognized as important for achieving high results, but about 35% of respondents expressed doubts about the feasibility of this approach.

Transformational leadership and adaptive planning were named as the most effective combination, indicating a high level of coherence between the motivational approach and flexibility in strategies. The worst combination was that of authoritarian leadership and rigid, inflexible strategies, which is likely to limit opportunities for development and lead to low performance. The most controversial was the combination of democratic leadership and long-term planning, with experts divided in their assessments, as some saw potential for sustainable development, while others believed that this approach could make decision-making more difficult at critical moments.

A limitation of this study was the possible bias in the respondents' assessment of the effectiveness of leadership approaches. Further research is recommended to focus on the impact of specific characteristics of teams and individual athletes on the success of different leadership styles. This will allow for a deeper understanding of the relationship between team dynamics and management effectiveness, as well as the development of recommendations for optimizing leadership strategies in sports organizations.

References

Adiguzel, Z. (2020). Investigation of the Effects of Strategic Management and Innovation on Performance Together with Technological Capabilities. In: H. Dincer, S. Yüksel (Eds.), *Strategic Outlook for Innovative Work Behaviours: Interdisciplinary and Multidimensional Perspectives* (pp. 69-98). Cham: Springer. https://doi.org/10.1007/978-3-030-50131-0_4

Agazu, B.G., Kero, C.A. (2024). Innovation Strategy and Firm Competitiveness: A Systematic Literature Review. *Journal of Innovation and Entrepreneurship*, 13, 24. https://doi.org/10.1186/s13731-024-00381-9

Andrew, D.P.S., Pedersen, P.M., McEvoy, C.D. (2020). *Research Methods and Design in Sport Management*. Champaign: Human Kinetics. https://us.humankinetics.com/products/research-methods-and-design-in-sport-management-2nd-edition-with-web-resource?srsltid=AfmBOopRBNv4Ab54B-Rvwgvb7QMKe5Ad0JQEpi22L6LNlcMK3n_WvaI6

Atrizka, D., Pratama, I. (2022). The Influence of Organizational Leadership and Coaches on Indonesian Athletes' Adversity Quotient (Intelligence). *Journal of Sport Psychology*, 31(1), 88-97. https://www.researchgate.net/profile/Ikbar-Pratama/publication/366028628_DINY_-_IKBAR/links/638ec527e42faa7e759b48a7/DINY-IKBAR.pdf

Barnhill, C.R., Smith, N.L., Oja, B.D. (2021). *Organizational Behavior in Sport Management: An Applied Approach to Understanding People and Groups*. Cham: Palgrave Macmillan. https://doi.org/10.1007/978-3-030-67612-4

Bradbury, T., Mitchell, R., Thorn, K. (2021). Moving Forward: Business Model Solutions for Amateur Sport Clubs. *Managing Sport and Leisure*, 26(3), 189-205. https://doi.org/10.1080/23750472.2020.1734479

Chelladurai, P., Kim, A.C.H. (2023). *Human Resource Management in Sport and Recreation*. Champaign: Human Kinetics. https://us.humankinetics.com/products/human-resource-management-in-sport-and-recreation-4th-edition?srsltid=AfmBOoqGagOOtoxWgs0c6Gf8RJxy6-LgVzNjo_aOlEzm0J2owVOSK1R9

Daniëls, E., Hondeghem, A., Dochy, F. (2019). A Review on Leadership and Leadership Development in Educational Settings. *Educational Research Review*, 27, 110-125. https://doi.org/10.1016/j.edurev.2019.02.003

Day, C., Sammons, P., Gorgen, K. (2020). *Successful School Leadership*. Berkshire: Education Development Trust. https://files.eric.ed.gov/fulltext/ED614324.pdf

Dodgson, M. (2021). The Strategic Management of Technology and Innovation. *Oxford Research Encyclopedia of Business and Management*. https://doi.org/10.1093/acrefore/9780190224851.013.145

Ehnold, P., Faß, E., Steinbach, D., Schlesinger, T. (2021). Digitalization in Organized Sport – Usage of Digital Instruments in Voluntary Sports Clubs Depending on Club's Goals and Organizational Capacity. *Sport, Business and Management*, 11(1), 28-53. https://doi.org/10.1108/SBM-10-2019-0081

Fisnik Brovina, et al.
Leadership and strategic management in sports: Comparing different leadership approaches and their impact on sports management outcomes

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Fransen, K., McEwan, D., Sarkar, M. (2020). The Impact of Identity Leadership on Team Functioning and Well-Being in Team Sport: Is Psychological Safety the Missing Link? *Psychology of Sport and Exercise*, 51, 101763. https://doi.org/10.1016/j.psychsport.2020.101763

Fransen, K., Mertens, N., Cotterill, S.T., Vande Broek, G., Boen, F. (2020). From Autocracy to Empowerment: Teams with Shared Leadership Perceive their Coaches to be Better Leaders. *Journal of Applied Sport Psychology*, 32(1), 5-27. https://doi.org/10.1080/10413200.2019.1617370

Gammelsæter, H. (2021). Sport is Not Industry: Bringing Sport Back to Sport Management. *European Sport Management Quarterly*, 21(2), 257-279. https://doi.org/10.1080/16184742.2020.1741013

Garcia, D.S., Herrero, J.A.G., Carcedo, R.J., García, M.S. (2021). The Impact of an Authentic Sports Leadership Program for Coach. *Frontiers in Psychology*, 12, 701134. https://doi.org/10.3389/fpsyg.2021.701134

Jin, H., Kim, S., Love, A., Jin, Y., Zhao, J. (2022). Effects of Leadership Style on Coach-Athlete Relationship, Athletes' Motivations, and Athlete Satisfaction. *Frontiers in Psychology*, 13, 1012953. https://doi.org/10.3389/fpsyg.2022.1012953

Kim, Y., Lee, J.L. (2019). Common Mistakes in Statistical and Methodological Practices of Sport Management Research. *Measurement in Physical Education and Exercise Science*, 23(4), 314-324. https://doi.org/10.1080/1091367X.2018.1537278

Lemoine, G.J., Hartnell, C.A., Leroy, G. (2019). Taking Stock of Moral Approaches to Leadership: An Integrative Review of Ethical, Authentic, and Servant Leadership. *Academy of Management Annals*, 13(1), 148-187. https://doi.org/10.5465/annals.2016.0121

López, D, Oliver, M. (2023). Integrating Innovation into Business Strategy: Perspectives from Innovation Managers. *Sustainability*, 15(8), 6503. https://doi.org/10.3390/su15086503

Lussier, R.N., Kimball, D.C. (2024). *Applied Sport Management Skills*. Champaign: Human Kinetics. https://canada.humankinetics.com/products/applied-sport-management-skills-4th-edition-ebook-with-hkpropel-access?srsltid=AfmBOoosiJ3QAdekl-PXlX1uPbGsAkQTf-wVePz-2GNMzEnT44uqCMLdG

Mach, M., Ferreira, A.I., Abrantes, A.C.M. (2021). Transformational Leadership and Team Performance in Sports Teams: A Conditional Indirect Model. *Applied Psychology*, 71(2), 662-694. https://doi.org/10.1111/apps.12342

McCullough, B.P., Orr, M., Kellison, T. (2020). Sport Ecology: Conceptualizing an Emerging Subdiscipline Within Sport Management. *Journal of Sport Management*, 34(6), 509-520. https://doi.org/10.1123/jsm.2019-0294

Newland, A., Newton, M., Moore, E.W.G., Legg, W.E. (2019). Transformational Leadership and Positive Youth Development in Basketball. *International Sport Coaching Journal*, 6(1), 30-41. https://doi.org/10.1123/iscj.2018-0002

O'Shannassy, T. (2021). The Challenges of Strategic Leadership in Organizations. *Journal of Management & Organization*, 27(2), 235-238. https://doi.org/10.1017/jmo.2021.36

Oh, J., Kim, D.H., Kim, D. (2023). The Impact of Inclusive Leadership and Autocratic Leadership on Employees' Job Satisfaction and Commitment in Sport Organizations: The Mediating Role of Organizational Trust and The Moderating Role of Sport Involvement. *Sustainability*, 15(4), 3367. https://doi.org/10.3390/su15043367

Park, E.-M., Seo, J.-H. (2019). A Study on Leadership Typology in Sports Leaders Based on Big Data Analysis. *Journal of the Korea Convergence Society*, 10(7), 191-198. https://doi.org/10.15207/JKCS.2019.10.7.191

Purc-Stephenson, R.J., Zimmerman, T.M.J., Edwards, R. (2022). Motivation to Train During a Pandemic: The Role of Fitness Resources, Mental Health, and Motivational Profiles Among Student-Athletes in Team Sports. *Frontiers in Sports and Active Living*, 4, 954086. https://doi.org/10.3389/fspor.2022.954086

Rehman, S.U., Bhatti, A., Chaudhry, N.I. (2019). Mediating Effect of Innovative Culture and Organizational Learning Between Leadership Styles at Third-Order and Organizational Performance in Malaysian SMEs. *Journal of Global Entrepreneurship Research*, 9, 36. https://doi.org/10.1186/s40497-019-0159-1

Şahin, B. (2022). Effective Leadership Types in Change Management in Sports Organizations. *International Journal on Social and Education Sciences*, 4(4), 562-580. https://doi.org/10.46328/ijonses.485

Skinner, J., Edwards, A., Smith, A.C.T. (2020). *Qualitative Research in Sport Management*. London: Routledge. https://doi.org/10.4324/9780367854249

Washif, J.A., et al. (2022). Training During the COVID-19 Lockdown: Knowledge, Beliefs, and Practices of 12,526 Athletes from 142 Countries and Six Continents. *Sports Medicine*, 52, 933-948. https://doi.org/10.1007/s40279-021-01573-z

Washif, J.A., Hettinga, F.J., Ammar, A., Janse van Rensburg, D.C., Materne, O., Trabelsi, K., Romdhani, M., Farooq, A., Pyne, D.B., Chamari, K. (2024). Supporting Athletes During a Challenging Situation: Recommendations from a Global Insight of COVID-19 Home-Based Training Experience. *BMC Sports Science, Medicine and Rehabilitation*, 16, 83. https://doi.org/10.1186/s13102-024-00869-7

Yoon, S., Kim, M., Park, S., Song, I. (2024). The Role of Leadership in Team Sports: Fostering Entrepreneurship and Commitment in Sports Education. *Journal of Sport Psychology*, 33(3), 218-232. https://dialnet.unirioja.es/servlet/articulo?codigo=9803382

Zhang, H., Shi, X., Jiang, X., Xu, X., Ul W., Shah, W.U.H. (2023). Sports Resources Utilization Efficiency, Productivity Change, and Regional Production Technology Heterogeneity in Chinese Provinces: DEA-SBM and Malmquist Index Approaches. *PLoS ONE*, 18(8), e0290952. https://doi.org/10.1371/journal.pone.0290952

RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND ACADEMIC SUCCESS OF STUDENTS

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Abstract: *This study aimed to examine the relationship between physical activity and the academic success of students. The total sample consisted of 116 undergraduate female students of the Faculty of Sport and Psychology, divided into three groups based on the physical activity level determined by use of the Godin Questionnaire for Physical Activity in Leisure Time. The academic success was calculated as the average grade values during studies. A one-way ANOVA revealed that there was a statistically significant difference in mean grade values between groups F = 12.089, p = 0.000. Post Hoc LSD test for multiple comparisons found that the mean grade values of the first group were significantly different from the second group. Insufficiently Active students had significantly lower grades compared to Moderately Active students (p = 0.041, 95% C.I. = -1.079, -0.02). There were statistically significant differences in mean grade values between Insufficiently Active and Active students. Active students had higher grade values (p = 0.000, 95% C.I. = -1.609, -0.665) compared to Insufficiently Active, and the mean grade value of Moderately Active students was significantly lower compared to Active ones (p = 0.010, C.I.= -1.046, -0.147). The obtained results indicating that a greater number of sessions of physical activity generates better academic success, and testifies to the assumption that physical activity integrated into the weekly life regime of a typical respondent/academic may have the character of contributing to positive neuroplastic changes and better academic success as a possible marker of the neurophysiological potential of the student population.*
Keywords: *physical exercise, physical and mental health, academic*

INTRODUCTION

Relevant studies refer to the benefits of physical exercise. They are affirmed as respectable factors in preserving the physical and mental health of man, in all periods of his ontogenesis. Factors of physiological etiology that contribute to physical health, but also factors that are important in maintaining mental health, are most often affirmed. When it comes to academic schooling, it in many ways represents the transition to adulthood. There is also a change in the context of social circumstances, physical environment, and academic workload in the form of new obligations for many academics, which is also a path of anxiety and stress (Misra & Castillo, 2004; Gasiuniene & Mieziene, 2021). Stress, as well as physical inactivity, are important factors that are linked to health (physical and mental well-being) and thus to cognitive functions that are important for achieving academic success. In the student population, a greater number of factors are identified that are correlated with stress.

Physical exercise processes and learning processes are different in their manifestations, but they are based on the same neurophysiological basis. In this sense, the following benefits of physical exercise could significantly affect the learning process: Neurobiological: Increase in oxygen flow and blood flow to the brain: Physical activity improves cerebral perfusion, especially in the hippocampus - the part of the brain that is crucial for memory and learning. In particular, there is an increase in blood flow to the prefrontal cortex and hippocampus during and after aerobic activity (Hillman et al., 2008). Exercise (especially aerobic) stimulates the production of BDNF (brain-derived neurotrophic factor), which improves the formation and maintenance of neural connections. Physical activity increases the levels of dopamine, serotonin and noradrenaline, which directly affect attention, motivation, and mood. Also, regular exercise reduces chronic stress through reduced secretion of cortisol, a hormone that negatively affects memory and learning when it is chronically elevated (Tomporowski et al., 2008). Cognitive, in accordance with which physical activity can improve: Attention and concentration, working memory, speed of information processing as well as executive functions of planning, inhibition, flexibility. The contribution of physical activities to learning success in areas such as mathematics and language has been proven (Sibley & Etnier, 2003; Tomporowski et al., 2008). Emotional. Physical activity alleviates the negative consequences of the distress reaction, raises the level of self-efficacy, and

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alleviates the symptoms of depression as factors of negative impact on cognitive functions. Therefore, the mechanisms of increased Neutrophil brain factor (BDNF), improved oxygenation of the brain, activation of frontal and hippocampal regions, and hormonal and emotional regulation, represent overlapping points of the process of physical and cognitive activity. Heller-Wight et al. (2023) point to the influence of exercise in the functional connection of the hippocampus with changes identified in the frontal and temporal brain regions, which are key to cognitive development and the very function of BDNF, which plays a key role in mediating the effects of exercise, affecting synaptic plasticity, i.e. the brain's ability to adapt and learn. The type of physical activity, the intensity and duration of exercise affect the level of BDNF and, consequently, cognitive outcomes (Rahmi et al, 2022), which are the basis of academic success. It is important to note that the saturation (regional cerebral oxygenation) identified by NIRS (near-Infrared Spectroscopy) technology during physical exercise and learning points to the similarity of metabolic activities of brain cells. Thus, physical activity, especially of the aerobic type, activates cardiorespiratory activity and cerebral flow, thereby increasing oxygen supply, while cognitive activity and stimulated metabolic demands activate an increase in local oxygenation (Giles et al., 2014). It has been identified that certain physical activities such as yoga, tai chi, various forms of aerobic exercise, affect reducing stress and improving mental well-being (Guerriero et al., 2025). In relation to the complexity of the relationships between the various factors that influence p increasing the level of stress, scientific facts indicate that physical activity and exercise have a positive effect on improving psychological well-being (Cairney et al, 2014), reducing the experience of stress associated with social support, motivation and self-confidence in academics (Gasiuniene & Mieziene, 2021). Participation in exercise, physical activity has a significant impact on the development of cognitive functions, i.e. processes of attention, memory, and executive function (Chieffi et al, 2017). Exercise is known to slow down the decline of cognitive functions (Chapman et al., 2013) and emotional regulation functions (Kvam et al., 2016). Studies indicate that physical activity improves blood flow to brain structures, specifically the hippocampus, the brain region (in addition to the olfactory bulb) that ensures neuronal plasticity (Dwojaczny & Bejtka, 2023), i.e. generates new neurons throughout life (Kempermann, Song & Gage, 2015). In accordance with the above, research reports on the synergistic effects of stimuli of different origins on some human capacities (motor, emotional, cognitive...) in terms of the formation and strengthening of neural networks (Hilman et al, 2009). They also report that interventions that integrate both motor and cognitive and emotional stimuli have a significantly greater impact on the development of the frontal cortex (Diamond & Lee, 2011). Such an integral concept of managing the development of potential is called multimodal stimulation (Howard Gardner - Theory of multiple intelligences, 1983). Eric Jensen - Brain-based Learning promotes multimodal learning through the connection of movement, emotions, attention, and sensory stimulation and suggests that the brain functions best when it is stimulated through multiple channels simultaneously, movement-touch-sound-visual elements (Jensen E. Brain-Based Learning the Way Students Really Learn. Third Edition. 2020). Hypothetically, it is possible that precisely the possible quantification of success, achieved through proprioceptive ways (sensorimotor and audiovisual senses), in physical exercise activities contributes to better motivation in cognitive activities and quick recovery from fatigue (oxidative stress) as an underlying consequence of such activities. The findings of relevant studies contribute to this assessment (Daw 2008). Generally, quick feedback on the effects of exercise can contribute to the feeling of competence. This research aims to quantify the effects of different levels of weekly exercise achieved through specifically designed physical exercise protocols in the area of cognitive implications that manifest as success in the process of academic education.

Material and Method

Sample of respondents

All respondents, 116 of them, were undergraduate female students at the Faculty of Sport and Psychology, TIMS based in Novi Sad, Serbia. Respondents were divided in three groups according to the physical activity level. First group consists of 36 insufficiently active female students, means (±SD) age, body height, body weight were 22.38 ± 8.37 years, 168 ± 8.14 cm, and 58.01 ± 7.60 kg. Second group consist of 39 moderately active female students, means (±SD) of age, body height, body weight were 20.90 ± 2.59 years, , 166 ± 5.77 cm and 58.98 ± 8.34 kg and third group consist of 41 active female students, means (±SD) of age, body height, body weight were 21.16 ± 5.45 years, , 167.05 ± 6.09 cm and 60.50 ± 7.72 kg respectively.

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Sample of measures

The measuring instrument used was the Godin Questionnaire for Physical Activity in Leisure Time (GSLTPAK), which measures the level of physical activity in leisure time. Participants assessed the frequency of strenuous, moderate, and mild activities in which they engaged during week. (GSLTPAK) is Godin's questionnaire that determines the level of physical activities in free time, where the participants estimate the frequency of light, moderate, and intensive activities they engaged in during the week. To calculate the total amount of physical activity, each activity category was multiplied by the following values: Strenuous physical activity: number of days multiplied by 9, Moderate physical activity: number of days multiplied by 5, Mild physical activity: number of days multiplied by 3. The resulting values were then summed to obtain the weekly leisure time physical activity score (Godin, 2011). This questionnaire is practical for assessing the level of physical activity and provides information about different intensities of activity.

The academic success was calculated as the average grade values during studies, which were taken from the official software Faculty platform ssluzba.TIMS.exe.

Statistical analysis

For all the variables, the basic parameters of descriptive statistics were calculated (Mean and Standard deviation). In order to calculate the statistically significant difference for each variable between the groups, the one-way ANOVA method and POST HOC (LSD) test were used. Data analysis involved utilizing the Statistical Package for Social Sciences (SPSS) version 26.0 by SPSS Inc. in Chicago, IL, USA. Testing the effect size f and level of power of one-way ANOVA has been conducted by means of G*Power version 3.1.9.7. software (Faul et al., 2007) and the effect size has been defined by standards proposed by Cohen 0.1 small, 0.25 medium, and 0.4 large (Cohen, 1988).

RESULTS

A one-way ANOVA was performed to compare the academic success of three different groups of female students. A one-way ANOVA revealed that there was a statistically significant difference in mean grade values between groups F = 12.089, p = 0.000 (Table 1). Post Hoc LSD test for multiple comparisons found that the mean grade values of the first group were significantly different from the second group i.e. Insufficiently Active students had significantly lower grades compared to Moderately Active students (p = 0.041, 95% C.I. = -1.079, -0.02). There were statistically significant differences in mean grade values between Insufficiently Active and Active student also. Active students had higher grade values (p = 0.000, 95% C.I. = -1.609, -0.665) comparing to Insuficiently Active and the mean grade value of Moderately Active students was significantly lower comparing to Active ones (p = 0.010, C.I.= -1.046, -0.147) (Table 1).

Table 1. *Comparison of academic succes for different groups of female students*

Group	n	M	SD	vs.
Insufficiently Active	36	7.206	0.997	2*,3**
Moderately Active	39	7.747	0.980	3*
Active	41	8.343	1.038	
Total	116	7.934	1.108	

Analysis of Variance				
Source	Sumo f Squares	Df	Mean Square	F	p
Between groups	24.897	2	12.448	12.089	0.000
Whitin groups	116.363	113	1.030		
Total	141.259	115			

*Abbreviations: n = Number of respondents, M = Arithmtetic mean, SD = Standard deviation, vs. = LSD post-hoc test *The difference is significant at the ≤0.05 level, **The difference is significant at the ≤0.01 level, F = the ratio of the mean square for the between groups divided by the mean square within groups, p = ANOVA level of significance.*

An a post hoc, achived power analysis was conducted using G*Power version 3.1.9.7. (Faul et al., 2007) for effect size estimation. Computed from means and group sizes, power analysis showed large effect size values of f = 0.466 with high statistical power of 1-β = 0.99 respectively (Graph 1).

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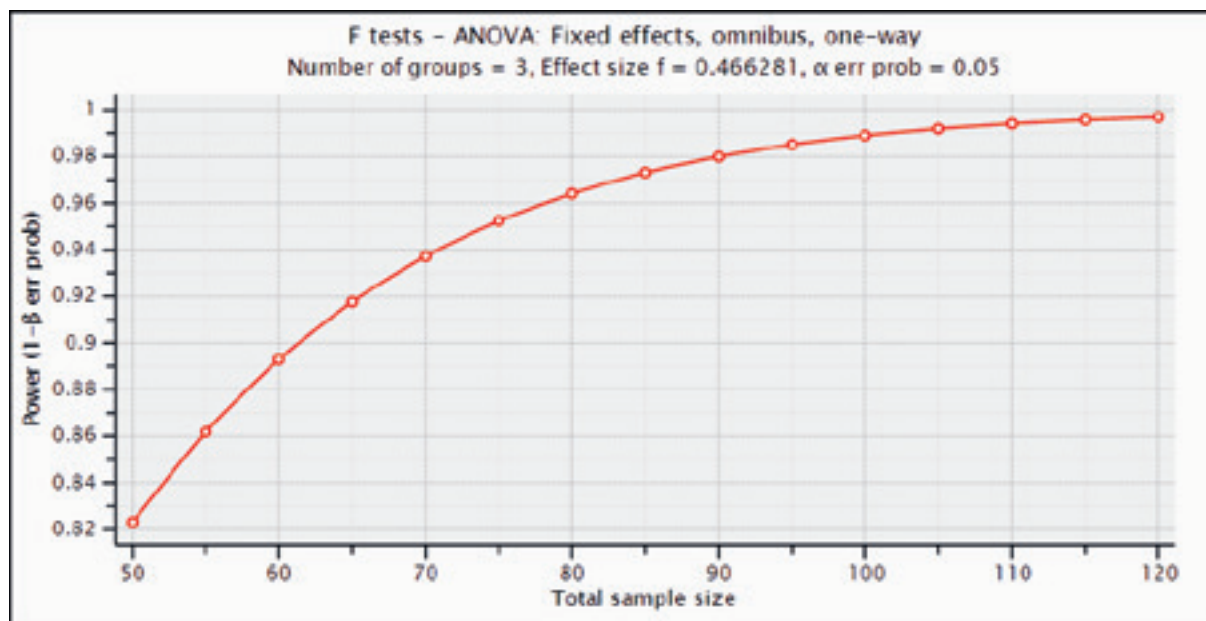
Graph 1. *Practical significance of a research outcome based on Effect size and power values*

DISCUSSION

Academic success is considered in this research as a dependent variable, that is, as a marker of neuroplasticity, as a condition for the quality of academic education. It is hypothetically affected by various stimuli, and in this research, the focus was on the isolated contribution of the respondents' physical activities to academic success. In this sense, physical activity is methodologically interpreted as an experimental factor that began to act before the beginning of the research, and its effects are valued in an ex-post-facto context. The sensitivity of the assessment is ensured by the differentiation of the weekly cadence of the subjects' physical activities. The finding that a greater number of sessions of physical activity generates better academic success, and testifies to the assumption that physical activity integrated into the weekly life regime of a typical respondent/academic may have the character of contributing to positive neuroplastic changes and better academic success as a possible marker of the neurophysiological potential of the student population. The research results showed that there is a statistically significant difference in terms of academic success between female students who practiced different levels of physical activity (F = 12.089, p = 0.000). At the same time, the results of the Post Hoc LSD test showed that female students who were insufficiently active had a significantly lower average grade compared to those who were moderately active (p=0.041) or active (p<0.0001). In addition, the results showed that there is a statistically significant difference between active and moderately active female students, and that the former had better average grades (p=0.010). A similar problem was investigated by the author Miletić (2017), who determined to what extent various physical exercises affect the academic success of students. The method involved the collection of relevant literature in the period from 2000 to 2015. The obtained conclusion is in accordance with the results of this research, which confirms that students who lead a healthy lifestyle have a higher degree of academic success. Research conducted by Mota et al. (2015) states that existing literature and research on this topic prove a positive relationship between physical activity and academic performance when the total time of physical activity per week is greater than 120 minutes. The same research mentions that reducing students' weekly physical activity will not benefit their academic performance. Redondo-Flórez, Ramos-Campo, and Clemente-Suárez (2022) highlight the importance of implementing different exercise programs that can improve health factors, especially those related to physical activity and sleep habits, with the aim of improving academic achievement. Machek and Janota (2019) state that. Unlike anaerobic activity, aerobic activity has positive effects on the academic success of female students. They complement this with the fact that other studies show that aerobic activities support the development of female students' executive functions, as well as their organizational skills and general well-being. Together, these effects can contribute to better learning ability. However, this study did not find statistically significant evidence of a positive relationship between physical activity and academic achievement among college students. Research in which aerobic capacity is also tested as a consequence of physical activities

(Kukić, Janković, & Koropanovski, 2023) aimed to examine the association of physical capacity with academic success represented by grade point average (GPA) and study efficiency represented by graduation time in women who were candidates for studies at the Criminalistics and Police University. At the same time, they also analyzed the aerobic abilities of female students, which are actually the result of physical activities. Based on the obtained results, the authors concluded that female students with better-developed physical abilities had greater chances for a more favorable academic outcome. Consequently, it could be said that female police university students who have a better developed culture of physical exercise have a higher chance of a more favorable academic outcome. Wunsch, Fiedler, Bachert and Woll (2021) tried to answer the question of the three-way relationship between physical activities, stress and academic performance using meta-analysis. The results of the analysis showed a positive relationship between physical activity and academic achievement, while between physical activity and stress they seem negative, while the relationship between stress and academic achievement is uncertain. A group of authors (Zhai, Ye, Gu, Huang, Wang, Chen, & Fan, 2020) in their research on the relationship between physical fitness and academic success in Chinese students concluded that poor academic performance was associated with low overall physical fitness. The probability of poor academic performance was significantly lower in students with high physical fitness than in those with low physical fitness.

Conclusion

This research quantified the effects of different levels of weekly exercise achieved through specifically designed physical exercise protocols in the area of cognitive implications manifested on academic success. Although the focus did not integrate the issue of "optimal cadence of weekly sessions of physical activities", as well as the issue of valorization and optimization of the content of sessions of physical activities, based on the set methodological framework, the obtained results testify to the positive interaction of markers of physical activities and markers of cognitive success of academics.

References:
Cairney, J., Kwan, M. Y., Veldhuizen, S., & Faulkner, G. E. (2014). Who uses exercise as a coping strategy for stress? Results from a national survey of Canadians. *Journal of Physical Activity and Health,* 11(5): 908-916. doi: https://doi.org/10.1123/jpah.2012-0107

Chapman, S.B., Aslan, S., Spence, J.S., Defina, L.F., Keebler, M.W., et al. (2013). Shorter term aerobic exercise improves brain, cognition, and cardiovascular fitness in aging. *Frontiers in Aging Neuroscience*, 5:75. doi: 10.3389/fnagi.2013.00075

Chieffi, S., Messina, G., Villano, I., Messina, A., Esposito, M., Monda, V., Valenzano, A., Moscatelli. F., Esposito, T., Carotenuto, M., Viggiano, A., Cibelli, G. & Monda, M. (2017). Exercise Influence on Hippocampal Function: Possible Involvement of Orexin-A. *Frontiers in Physiology*, vol. 8, Article 85. doi: 10.3389/fphys.2017.00085.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2.nd edition). Hillsdale. NJ:Erlbaum.

Faul, F., Erdefelder, E., Lang, A.G., & Buchenr, A. (2007). G*Power 3: A flexible statistical power analysis program for the social behavioral, and biomedical sciences. *Behavior Research Methods*, 39, 175-191.

Dwojaczny, B. & Bejtka, M. (2023). Influence of physical activity on cognitive functions -Potential mechanisms and benefits. *Journal of Education, Health and Sport,* vol. 13(3): 181--185.

Gasiuniene, L. & Mieziene,B. (2021). The Relationship Between Students' Physical Activity and Academic Stress. *Baltic Journal of Sport & Health Science*, No. 4(123): 4–12. https://doi.org/10.33607/bjshs.v4i123.1142

Guerriero, M.A., Dipace, A., Monda, A., De Maria, A., Polito, R., Messina, G., Monda, M., di Padova, M., Basta, A., Ruberto, M., Capasso, E., Moscatelli, F.,& Limone, P. (2025). Relationship Between Sedentary Lifestyle, Physical Activity and Stress in University Students and Their Life Habits: A Scoping Review with PRISMA Checklist (PRISMA-ScR). *Brain Sciences*, *15*(1), 78. https://doi.org/10.3390/brainsci15010078

Heller-Wight, A., Phipps, C.J., Sexton, J.N., Ramirez, M., & Warren, D.E. (2023). Hippocampal Resting State Functional Connectivity Associated with Physical Activity in Periadolescent Children. *Brain Science,* Vol. 13, 1558. https://doi.org/10.3390/brainsci13111558

Kempermann, G., Song, H., and Gage, F. H. (2015). Neurogenesis in the adult hippocampus. *Cold Spring Harbor Perspectives in Biology*, no. 7(9) a018812.

Kvam, S., Kleppe, C.L., Nordhus, I.H. & Hovland, A. (2016). Exercise as a treatment for depression: a meta-analysis. *Journal of Affective Disorders*, no. 202: 67–86. doi: 10.1016/j.jad.2016.03.063

Misra, R., & Castillo, L.G. (2004). Academic stress among college students: Comparison of American and international students. *International Journal of stress management*, vol. 11(2), 132-148. doi: https://doi.org/10.1037/1072-5245.11.2.132

Rahmi, U., Goenawan, H., Sylviana, N., Setiawan, S. I., Andriyani, S., Putri, S. T. & Fitriana, L.A. (2022). Effects of Physical Exercise (Type,

Intensity, Duration) on BDNF and Cognitive Functions in the Hippocampus of Adults and Elderly: A Literature Review. *Universal Journal of Public Health*, Vol. 10(5): 473–481. https://doi.org/10.13189/ujph.2022.100505

Byun et al., 2014. – Positive effect of acute mild exercise on executive function via prefrontal activation: an fNIRS study.

Cotman, C. W., Berchtold, N. C., & Christie, L. A. (2007). Exercise builds brain health: Key roles of growth factor cascades and inflammation. *Trends in Neurosciences*, 30(9), 464–472. https://doi.org/10.1016/j.tins.2007.06.01

D.Daw. The Cognitive neuroscience of motivation and learning. Social cognition. Columbia Uneversity. 2008.

Erickson, K. I., Voss, M. W., Prakash, R. S., Basak, C., Szabo, A., Chaddock, L., … & Kramer, A. F. (2011). Exercise training increases size of hippocampus and improves memory. *Proceedings of the National Academy of Sciences*, 108(7), 3017–3022. https://doi.org/10.1073/pnas.1015950108

Giles et al., 2014. – Exercise and the brain: Using fNIRS to measure cerebral oxygenation changes during dual-task exercise.

Hillman, C. H., Erickson, K. I., & Kramer, A. F. (2008). Be smart, exercise your heart: Exercise effects on brain and cognition. *Nature Reviews Neuroscience*, 9(1), 58–65. https://doi.org/10.1038/nrn2298

Ribeiro, P. A. B., Boidin, M., Juneau, M., Nigam, A., & Gayda, M. (2021). Effect of exercise on circulating brain-derived neurotrophic factor (BDNF): A systematic review and meta-analysis. *Applied Physiology, Nutrition, and Metabolism*, 46(5), 516–524. https://doi.org/10.1139/apnm-2020-0743

Vaynman, S., Ying, Z., & Gomez-Pinilla, F. (2004). Hippocampal BDNF mediates the efficacy of exercise on synaptic plasticity and cognition. *European Journal of Neuroscience*, 20(10), 2580–2590. https://doi.org/10.1111/j.1460-9568.2004.03720.x

Tomporowski, P. D., Davis, C. L., Miller, P. H., & Naglieri, J. A. (2008). Exercise and children's intelligence, cognition, and academic achievement. *Educational Psychology Review*, 20(2), 111–131. https://doi.org/10.1007/s10648-007-9057-0

Kukić, F., Janković, R., & Koropanovski, N. (2023). Povezanost fizičkih sposobnosti sa akademskim uspehom kod studentkinja policijskih studija. *SportLogia, 19*(1)

Miletić, M. (2017). Uticaj vežbanja na akademski uspeh studenata. *Zdravstvena zaštita*, *46*(2), 60-66. https://doi.org/10.5937/ZZ1702060M

Mota, J., Picado, A., Assunção, T., Alvito, A., Gomes, F., & Marques, A. (2015). Atividade física e rendimento académico – Uma revisão sistemática de sete revisões sistemáticas. *Revista da Sociedade Científica de Pedagogia do Desporto,* 24-29.

Machek, O., & Janota, J. (2019). The relationship between physical activity and academic achievement of university students. *Journal of Research in Higher Education, 3(*1), 22–36. https://doi.org/10.24193/JRHE.2019.1.2

Redondo-Flórez, L., Ramos-Campo, D. J., & Clemente-Suárez, V. J. (2022). Relationship between physical fitness and academic performance in university students. *International Journal of Environmental Research and Public Health*, *19*(22), 14750. https://doi.org/10.3390/ijerph192214750

Wunsch, K., Fiedler, J., Bachert, P., & Woll, A. (2021). The Tridirectional Relationship among Physical Activity, Stress, and Academic Performance in University Students: A Systematic Review and Meta-Analysis. *International Journal of Environmental Research and Public Health*, *18*(2), 739. https://doi.org/10.3390/ijerph18020739

Zhai, X., Ye, M., Gu, Q., Huang, T., Wang, K., Chen, Z., & Fan, X. (2020). The relationship between physical fitness and academic performance among Chinese college students. *Journal of American College Health*, *70*(2), 395–403. https://doi.org/10.1080/07448481.2020.1751643

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THE EFFECT OF 6 WEEKS OF COMPLEX TRAINING ON THE SPEED AND AGILITY OF FIGHTING CLASS INDONESIAN PENCAK SILAT ATHLETES

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THE EFFECT OF 6 WEEKS OF COMPLEX TRAINING ON THE SPEED AND AGILITY OF FIGHTING CLASS INDONESIAN PENCAK SILAT ATHLETES

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Abstract: *Martial art Pencak silat is a traditional martial art form that has evolved into a competitive sport. Speed and agility are critical for successful performance in Pencak silat, as they enable athletes to execute quick strikes, evasive manoeuvres, and defensive techniques effectively. Despite the importance of speed and agility in Pencak silat, there is a lack of consensus on the most effective training methods to enhance these attributes specifically for this martial art. This study investigates the effects of six weeks of complex training on the speed and agility of fighting class Pencak silat athletes. A one-group pretest and posttest design was used to evaluate the effect of complex training on the speed and agility of Pencak silat athletes. The study lasted six weeks, with pre-and posttest assessments to measure agility and speed changes. This research involved 20 male Pencak silat athletes aged between 16 and 19. The primary outcomes measured are agility and speed. The Illinois Agility Test assesses agility. The 40-meter sprint test measures speed. Statistical analysis was carried out using SPSS software. The p-value for the speed test is .000, which is well below the typical significance level threshold of 0.05. The p-value for the agility test is .001, which is also below the 0.05 threshold. The study's findings indicate that complex training significantly improves speed and agility in Pencak silat athletes.*
Keywords: *agility, complex training, Pencak silat, speed*

INTRODUCTION

Pencak silat is a traditional martial art from Southeast Asia, especially Indonesia, Malaysia, and Brunei (Mulyana & Lutan, 2021). Pencak silat is divided into art (seni) and sparring or combat (tanding). Art Classes in Pencak Silat, known as Kelas Seni, emphasize the artistic and cultural elements of the martial art. Art classes emphasize the beauty of techniques or moves combined in choreography and are usually accompanied by traditional music. Art classes aim to showcase the beauty and traditional values inherent in *Pencak silat*. In contrast, sparring classes emphasize techniques for self-defense and combat (Soo et al., 2018). This class emphasizes sparring, combat strategies, and effectively executing strikes, grapples, and takedowns in real-life or competitive scenarios.

Pencak silat is characterized by complex techniques that require mastery of the entire body (Karo-Karo et al., 2023). These movements are designed to maximize power, speed, and agility, making *Pencak silat* an effective combat system and a physically demanding discipline. Speed and agility are the essential elements in *Pencak silat* (Damrah et al., 2023). Speed in *Pencak silat* refers to the rapid execution of techniques and the quickness of movement (Dharmadi & Spyanawati, 2023). It encompasses the ability to strike, evade, and reposition oneself with minimal delay, making it a critical component for attack and defence. Agility in *Pencak silat* involves changing direction quickly and maintaining balance during rapid movements (Ihsan et al., 2022). It encompasses nimbleness, coordination, and the capacity to perform complex manoeuvres fluidly. These skills are essential for success in competition and reducing the risk of injury during training and competition.

One of the *Perguruan* or schools of *Pencak Silat* in Indonesia is the *Perguruan Setia Hati Terate*. A preliminary study at the *Perguruan Pencak Silat* Setia Hati Terate in Bengkulu City showed that athletes' attacks were ineffective during matches. Slow attacks, especially when executing kicks, made movements easily readable by opponents. Furthermore, athletes were often slow to change direction and maintain balance during intense movements. These deficiencies resulted in slow reaction times, increased vulnerability to opponent attacks, and difficulty maintaining a dominant position throughout the match.

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Based on these issues, an effective training method is needed to improve athletes' explosive speed and agility. One approach is complex training, which combines strength training with plyometric training. Complex training is a training method that combines a set of strength training exercises and a comparable series of plyometric exercises in the same training session and is believed to improve the quality of the plyometric training stimulus (Ali et al., 2017). This training method is a dynamic, high-intensity training method (Lim & Barley, 2016). Using the complex training method can elicit a post-activation potentiation response, allowing individuals to produce more power in subsequent training sessions (Atalag et al., 2021). Complex training is considered superior in improving strength, explosive power, sprinting ability, and agility in various sports compared to strength training or plyometrics performed separately. Previous research has shown that complex training can improve kicking speed, power, reaction time, and punching power in boxing, judo, and *Pencak silat* (Liu et al., 2024).

Research on physical conditioning in *Pencak silat* largely emphasizes general physical abilities and skills (Salsaputri et al., 2025). However, investigations into complex training to improve speed and agility, key determinants of success in combat sports, have yet to be explored. Most evidence regarding the effectiveness of complex training comes from other combat sports, which do not fully reflect the unique movement patterns, explosive demands, and tactical requirements of *Pencak silat*. This lack of focused research creates a gap in understanding how a six-week complex training program can affect the speed and agility of *Pencak silat* athletes in combat sports. This study aims to address this gap and is expected to serve as a reference for improving the speed and agility of *Pencak silat* athletes.

Based on the background outlined, the purpose of this study was to investigate the effect of six weeks of complex training on the speed and agility of *Pencak silat* fighting class athletes. Based on a review of relevant literature, we hypothesize that six weeks of complex training can improve the speed and agility of *Pencak silat* athletes.

MATERIAL AND METHODS

Experimental design

This research is pre-experimental research (Farooq et al., 2016). A one-group pretest and posttest design was employed to assess the effect of complex training on the speed and agility of *Pencak silat* athletes. The training was conducted over six weeks, with each week comprising three training sessions.

Table 1. *Complex Training*

Week 1-2	Day 1 (2 sets, three repetitions, recovery 30 seconds, intensity 55%) one leg squat side hop triple hop jump single leg hurdle hop luging drills	Day 2 (3 sets, five repetitions, recovery 30 seconds, intensity 55%) one leg squat side hop triple hop jump single leg hurdle hop luging drills	Day 3 (3 sets, four repetitions, recovery 30 seconds, intensity 70%) one leg squat side hop triple hop jump single leg hurdle hop luging drills
Week 3-4	Day 1 (3 sets, six repetitions, recovery 30 seconds, intensity 70%) one leg squat side hop triple hop jump single leg hurdle hop luging drills	Day 2 (3 sets, eight repetitions, recovery 30 seconds, intensity 70%) one leg squat side hop triple hop jump single leg hurdle hop luging drills	Day 3 (3 sets, eight repetitions, recovery 30 seconds, intensity 70%) one leg squat side hop triple hop jump single leg hurdle hop luging drills
Week 5-6	D1 (6 sets, three repetitions, recovery 80 seconds, intensity 70%) one leg squat side hop triple hop jump single leg hurdle hop luging drills	D2 (6 sets, three repetitions, recovery 80 seconds, intensity 70%) one leg squat side hop triple hop jump single leg hurdle hop luging drills	D3 (6 sets, three repetitions, recovery 30 seconds, intensity 80%) one leg squat side hop triple hop jump single leg hurdle hop luging drills

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Participant

This research involved 20 male *Pencak silat* athletes aged between 16 and 19. Sampling technique using purposive sampling (Campbell et al., 2020). This research utilizes the most relevant respondents and has the potential to provide valuable insights into the variables under study. The participants were recruited from *Pencak silat Setia Hati Terate Bengkulu, Indonesia*. All participants had at least two years of *Pencak silat* experience and were free from any injuries that could affect their performance during the research period.

Measurement

The primary outcomes measured are agility and speed. The following tests were performed before and after the intervention. The instruments used in this study were the 40-meter sprint test and the Illinois agility test. The 40-meter sprint test measures speed (Manullang et al., 2025). The implementation begins from the starting position and then continues with running as fast as possible to the finish line, which is 40 meters away. Athletes are timed from a standing start, and the best of three attempts is recorded. Sprint performance over 40 meters was measured using a manual stopwatch, with times converted to meters per second (m/s). For example, a 40-meter sprint completed in 7 seconds corresponds to approximately 5.71 m/s.

The Illinois agility test assesses agility. This test is 10 m long and 5 m wide with three cones 3.3 m apart and placed in a straight line in the middle of the area (Çetinkaya et al., 2018). Participants start from a prone position at the starting line, then run straight, back, zig-zag between the centre cones, zig-zag again, and run straight to the finish line. Time is recorded from start to finish to measure agility. The time to complete the course was recorded manually using a stopwatch. These times were then converted to speed in meters per second (m/s) by dividing the total distance by the recorded time. All measurements were conducted by the same tester to ensure consistency, providing a reliable and practical estimate of each participant's agility performance.

Data analysis

Statistical analysis was carried out using SPSS software. Descriptive statistics were calculated for all variables. Data normality was analyzed using the Shapiro-Wilk. Data homogeneity was assessed using the Levene statistic. If the data is not homogeneous, the non-parametric Wilcoxon test was used. If the data are declared normal and homogeneous, the independent sample t-test is used to compare results before and after the intervention. The level of significance was set at $p < 0.05$.

Ethical Considerations

After explaining the purpose, procedures, potential risks, and benefits of the study, informed consent was obtained from all participants. Participants were free to withdraw from the study without any consequences.

RESULTS

The research results are shown in the tables below.

Table 2. *Result of speed test*

Pretest		Posttest	
Min	3.08	Min	3.08
Max	4.44	Max	5.71
Mean	3.62	Mean	4.18
Median	3.64	Median	4.00
Std. Dev	0.42	Std. Dev	0.74

Table 2 presents the results of the speed test. The data show an increase in mean speed from the pretest to the posttest, as indicated by a rise in mean speed from 3.62 m/s to 4.18 m/s. An increase in the standard deviation from 0.42 m/s to 0.74 m/s suggests that variation in speed among participants increased after the intervention. The minimum speed remained unchanged, and the median increased from 3.64 m/s to 4.00 m/s, indicating an overall improve-

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ment in speed performance in the posttest. The maximum speed increased from 4.44 m/s to 5.71 m/s, suggesting that overall group performance improved.

Table 3. The Results of the Normality Test

	Shapiro Wilk		
	Statistic	df	Sig.
Pretest	.908	20	.059
Postest	.921	20	.106

Based on the data normality test using the Shapiro-Wilk test at a significance level of 0.05, the significance value is > 0.05. Therefore, the pretest and posttest data on the speed variable are normally distributed.

Table 4. The Results of the Homogeneity Test

Levene Statistic	df1	df2	Sig.
4.576	1	38	.039

Based on the data homogeneity test using the Levene Statistic at a significance level of 0.05, the significance value is <0.05. So, the pretest and posttest data on the speed variable are stated to be inhomogeneous. Therefore, the next step is to carry out a non-parametric analysis using the Wilcoxon test.

Table 5. The Results of the Wilcoxon Test

	Post-Pre
Z	-3.418
Asymp. Sig. (2-tailed)	.001

The results of the Wilcoxon test show the significance. Value < 0.05. Therefore, there is a significant difference between the pre-intervention and post-intervention periods.

Table 6. The Result of the agility test

Pretest		Posttest	
Min	1.30	Min	1.40
Max	2.10	Max	2.10
Mean	1.69	Mean	1.78
Median	1.70	Median	1.75
Std. Dev	0.23	Std. Dev	0.21

Table 6 shows the results of the pretest and posttest. The data show an increase in mean agility from pretest to posttest, as indicated by a rise in mean agility from 1.69 m/s to 1.78 m/s. An increase in the standard deviation from 0.42 m/s to 0.74 m/s suggests that variation in speed among participants increased after the intervention. The minimum agility increased from 1.30 m/s to 1.40 m/s, and the median agility increased from 1.70 m/s to 1.75 m/s, supporting the overall improvement in agility performance in the posttest. The constant maximum agility indicates that the fastest individual's performance remained unchanged, but the overall group performance improved.

Table 7. Results of the Normality Test

	Shapiro Wilk		
	Statistic	df	Sig.
Pretest	.956	20	.472
Postest	.931	20	.162

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Based on the data normality test using the Shapiro-Wilk test at a significance level of 0.05, the significance value is > 0.05. Therefore, the pretest and posttest data on the agility variable are normally distributed.

Table 8. *The Results of the Homogeneity Test*

Levene Statistic	df1	df2	Sig.
.081	1	38	.778

Based on the data homogeneity test using the Levene Statistic at a significance level of 0.05, the significance value is greater than 0.05. So, the pretest and posttest data on the agility variable are declared homogeneous. Therefore, the next step is to carry out a parametric analysis using the Paired Sample test.

Table 9. *Paired Sample Test Results*

t	df	Sig. (2-tailed)
-3.943	19	.001

The results of the paired sample test show the significance. Value < 0.05. There is a significant difference between before and after the intervention.

DISCUSSION

The study results showed that *Pencak silat* athletes experienced increased speed and agility. Sprint performance over 40 meters was measured using a manual stopwatch, with times converted to meters per second (m/s). For example, a 40-meter sprint completed in 7 seconds corresponds to approximately 5.71 m/s. Despite minor timing variability inherent in manual measurement, the results show clear improvement: mean speed increased from 3.62 m/s to 4.18 m/s, and maximum speed rose from 4.44 m/s to 5.71 m/s. The increase in standard deviation (0.42 m/s to 0.74 m/s) reflects expected variability among participants. These findings are consistent with previous research (Ønnessen et al., 2011), confirming that the intervention effectively enhanced sprint performance.

Although the maximum agility score did not change from pretest to posttest, this reflects the performance of the fastest individual athlete, who maintained the same level of performance. However, meaningful improvements were observed at the group level, as shown by mean, median, and minimum values increases. These findings suggest that the intervention effectively improved the agility of most participants, even if the top performer did not show further gains. This outcome can be explained by the ceiling effect, in which individuals who already perform at a high level may show limited or no further improvement compared to those with lower baseline performance. Such variability in training adaptations is well-documented in sports science, where athletes respond differently to the same training stimulus depending on their initial performance capacity and physiological profile (Hecksteden et al., 2015). Therefore, the unchanged maximum value does not indicate a lack of training effect but highlights differential responsiveness among athletes.

Complex training is a very effective method for increasing speed and agility (Bauer et al., 2019), especially for *Pencak silat* athletes who require fast and dynamic movements. Increased speed and agility occur because in the training complex, athletes perform strength and plyometric training as one unit (Miller et al., 2014). Complex training utilizes the principle of post-activation potentiation, where muscle performance is temporarily enhanced after heavy resistance training (Yang et al., 2024). Post-activation potentiation is a phenomenon in which muscle power output is temporarily increased after high-intensity resistance training. This occurs because weightlifting activates the central nervous system and increases motor neuron stimulation. When followed by plyometric training, this higher condition allows for more robust and explosive movements, increasing the mat's speed and agility (Mashud et al., 2024)

Strength training in complex training builds muscle strength capacity, while subsequent plyometric training improves the ability to produce force quickly (Lagrange, 2022). This dual approach increases overall muscle strength, allowing the athlete to perform faster and more powerful movements essential for effective offensive and defensive techniques in *Pencak silat*. Strength is significant for *Pencak silat* athletes because it increases their ability to perform techniques with force, maintain balance and stability, survive long bouts, prevent injury, defend effectively, and perform competitive manoeuvres (Ahmad et al., 2024).

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Complex training improves neuromuscular coordination by challenging the body to perform high-intensity compound movements followed by explosive actions (Fort-Vanmeerhaeghe et al., 2016). This increases the athlete's ability to synchronize muscle groups efficiently, resulting in more fluid and precise movements during competition. Complex training can also increase the rate of force development, which is essential for agility and speed (Bogdanis et al., 2019). It improves the rate of force development by training muscles to activate more quickly and powerfully. This allows the athlete to change direction quickly and accelerate rapidly, essential components of effective performance in *Pencak silat*.

High-intensity strength training followed by plyometrics optimizes the recruitment of fast-twitch muscle fibers essential for explosive movements (Khotimah et al., 2023). Increased recruitment of these fibres results in better performance in activities that require sudden speed and rapid changes in direction. Regular exposure to complex training demands the body to handle high-intensity efforts more effectively. This conditioning improves overall athletic endurance, allowing *Pencak silat* athletes to maintain high levels of speed and agility throughout their bouts (Sulfa et al., 2024). Endurance is critical for *Pencak silat* athletes because it allows them to maintain high-performance levels, recover quickly, execute techniques consistently, handle psychological stress, defend effectively, remain agile, and train intensively (Mardinus et al., 2025).

Complex training exercises can be tailored to mimic the specific movements and demands of *Pencak silat*. This training method improves speed, agility, and overall athleticism, providing a competitive edge in this dynamic martial art. Although complex training can provide significant benefits, it also has the potential to cause disadvantages such as increased risk of injury, overtraining, technical disorders, high physical and mental demands, time consumption, recovery needs, and potential training imbalance. *Pencak silat* athletes should carefully consider these factors and ensure a well-structured and balanced training program to maximize benefits and minimize disadvantages.

Despite these encouraging results, the researchers acknowledge several limitations. The limited sample size, lack of randomization, and lack of a control group limit the ability to draw strong causal inferences. These limitations do not diminish its value to *Pencak silat* coaches and athletes. *Pencak silat* coaches can integrate complex training to improve athletes' speed and agility. Further research could use a control group to broaden understanding of its effectiveness and generalizability.

Conclusion

Complex training is an effective method for improving speed and agility in *Pencak silat* athletes. This training method improves muscle performance through improved neuromuscular coordination and fast-twitch muscle fibre recruitment. By increasing overall muscle strength, athletes can perform movements more quickly and powerfully. However, complex training carries potential drawbacks, such as increased risk of injury, overtraining, high physical and mental demands, and the need for extensive recovery. Athletes should incorporate complex training into a well-balanced program to maximize its benefits while minimizing potential drawbacks.

References

Ahmad, A., Prasetyo, Y., Sumaryanti, Nugroho, S., Widiyanto, & Amiruddin. (2024). The Effect of Plyometric Training on Pencak Silat Kicks: Literature Review. *Retos*, *61*, 185–192. https://doi.org/10.47197/retos.v61.107665

Ali, K., M, E. H., Verma, S., Ahmad, I., Singla, D., & Jha, P. (2017). Complex Training: An Update. *Journal of Athletic Enhancement*, *06*(03), 1–5. https://doi.org/10.4172/2324-9080.1000261

Atalag, O., Kurt, C., Huebner, A., Galimba, M., & Uson, J. K. (2021). Is complex training superior to drop jumps or back squats for eliciting a post activation potentiation enhancement response? *Journal of Physical Education and Sport*, *21*(July), 2228–2236. https://doi.org/10.7752/jpes.2021.s3283

Bauer, P., Uebellacker, F., Mitter, B., Aigner, A. J., Hasenoehrl, T., Ristl, R., Tschan, H., & Seitz, L. B. (2019). Combining higher-load and lower-load resistance training exercises: A systematic review and meta-analysis of findings from complex training studies. *Journal of Science and Medicine in Sport*, *22*(7), 838–851. https://doi.org/10.1016/j.jsams.2019.01.006

Bogdanis, G. C., Tsoukos, A., Methenitis, S. K., Selima, E., Veligekas, P., & Terzis, G. (2019). Effects of low volume isometric leg press complex training at two knee angles on force-angle relationship and rate of force development. *European Journal of Sport Science*, *19*(3), 345–353. https://doi.org/10.1080/17461391.2018.1510989

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., Bywaters, D., & Walker, K. (2020). Purposive sampling: complex or simple? Research case examples. *Journal of Research in Nursing*, *25*(8), 652–661. https://doi.org/10.1177/1744987120927206

Çetinkaya, E., Tanır, H., & Çelebi, B. (2018). Comparison of Agility, Sprint, Anaerobic Power and Aerobic Capacities of Soccer Players by Playing Positions. *Journal of Education and Training Studies*, *6*(9), 184. https://doi.org/10.11114/jets.v6i9.3560

Damrah, Ihsan, N., Muharel, A., Komaini, A., Rifki, M. S., Sepriadi, & Ilham. (2023). A Measuring Tool for Kick Speed with Dynamic

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Targets: A Digital-Based Instrument Designed for Pencak Silat Learning. *Annals of Applied Sport Science*, *11*(4), 1–10. https://doi.org/10.61186/aassjournal.1216

Dharmadi, M. A., & Spyanawati, N. L. P. (2023). The Effect of 6-week Traditional Balinese Game of Megoak-goakan on the Running Speed of Junior Pencak Silat Athletes. *Ido Movement for Culture*, *23*(3), 98–105. https://doi.org/10.14589/ido.23.3.10

Farooq, M. A., Nóvoa, H., Araújo, A., & Tavares, S. M. O. (2016). An innovative approach for planning and execution of pre-experimental runs for Design of Experiments. *European Research on Management and Business Economics*, *22*(3), 155–161. https://doi.org/10.1016/j.iedee.2014.12.003

Fort-Vanmeerhaeghe, A., Romero-Rodriguez, D., Lloyd, R. S., Kushner, A., & Myer, G. D. (2016). Integrative Neuromuscular Training in Youth Athletes. Part II: Strategies to Prevent Injuries and Improve Performance. *Strength and Conditioning Journal*, *38*(4), 9–27. https://doi.org/10.1519/SSC.0000000000000234

Hecksteden, A., Kraushaar, J., Scharhag-Rosenberger, F., Theisen, D., Senn, S., & Meyer, T. (2015). Individual response to exercise training - A statistical perspective. *Journal of Applied Physiology*, *118*(12), 1450–1459. https://doi.org/10.1152/japplphysiol.00714.2014

Ihsan, N., Hidayat, R., Damrah, Neldi, H., Sepriadi, & Muslimin. (2022). The Contribution of Leg Muscle Explosive Power, Agility, and Self-confidence on Sickle Kick Performance. *International Journal of Human Movement and Sports Sciences*, *10*(4), 683–688. https://doi.org/10.13189/saj.2022.100408

Karo-Karo, A. A. P., Rahayu, T., Setyawati, H., Mukarromah, S. B., & Syaifullah, R. (2023). Analysis of Pencak Silat Techniques Using a Biomechanical Approach: Systematic Literature Review. *Physical Education Theory and Methodology* , *23*(6), 947–953. https://doi.org/10.17309/tmfv.2023.6.18

Khotimah, K., Subekti, N., & Denata, G. Y. (2023). *The Effectiveness of High-Intensity Interval Training on Specific Endurance and Technical Performance of Pencak Silat Athletes* (Vol. 1). Atlantis Press SARL. https://doi.org/10.2991/978-2-38476-086-2_91

Lagrange, S. (2022). The Optimal Time Window for Complex Training in Order to Increase Repeated Sprint Ability in Professional Ice Hockey Players. *International Journal of Strength and Conditioning*, *2*(1), 1–11. https://doi.org/10.47206/ijsc.v2i1.106

Lim, J. J. H., & Barley, C. I. (2016). Complex Training for Power Development: Practical Applications for Program Design. *Strength & Conditioning Journal*, *38*(6), 33–43.

Liu, Y., Huang, Z., Zhou, Z., Zhang, L., Guo, Y., & Chen, C. (2024). Effects of variable resistance training within complex training on strength and punch performance in elite amateur boxers. *Frontiers in Physiology*, *15*(October), 1–12. https://doi.org/10.3389/fphys.2024.1472258

Manullang, J. G., Handayani, E. W., Imansyah, F., Junaidi, I. A., Hermansah, B., Poblete-Valderrama, F., Lobo, J., Monterrosa-Quintero, A., Alexe, D. I., & Setiawan, E. (2025). The Impact of Virtual Reality in Modern Karate Training: Increasing Engagement Levels and Fitness of Elite Athletes. *Ido Movement for Culture*, *25*(2), 61–70. https://doi.org/10.14589/ido.25.2.7

Mardinus, A., Sofyan, D., Hadi, R. S., Barlian, E., Ihsan, N., Astuti, Y., & Ockta, Y. (2025). Effectiveness of interval training in increasing VO2max in pencak silat athletes. *Sport TK-Euro American*, *14*, 1–13. https://doi.org/10.6018/sportk.643791

Mashud, Sudirman, R., Samodra, Y. T. J., Widiastuti, Arini, I., Suharto, T. H., Suryadi, D., Wulandari, A., Aryadi, D., & Rahmat, A. (2024). Analysis of the effect of training on the explosive power of the pencak silat sickle kick: a comparative study of plyometric and conventional exercises. *Sport TK*, *13*, 1–16. https://doi.org/10.6018/sportk.573141

Miller, J., Koh, Y., & Park, C.-G. (2014). Effects of Power-based Complex Training on Body Composition and Muscular Strength in Collegiate Athletes. *American Journal of Sports Science and Medicine*, *2*(5), 202–207. https://doi.org/10.12691/ajssm-2-5-5

Mulyana, B., & Lutan, R. (2021). The Lost Inner Beauty in Martial Arts: A Pencak Silat Case. *International Journal of the History of Sport*, *37*(12), 1172–1186. https://doi.org/10.1080/09523367.2020.1742703

Ønnessen, E. S. T., Halfawi, S. H. a I. S., Augen, T. H. H., & Noksen, E. Y. E. (2011). Effect of 40m repeated sprint training on maximum sprinting speed, repeated sprint speed endurance, vertical jump, and aerobic capacity in young elite male soccer players. *The Journal of Strength & Conditioning Research*, *25*(9), 2364–2370. http://www.ncbi.nlm.nih.gov/pubmed/21869624

Salsaputri, D., Sultoni, K., Ruhayati, Y., & Ajid, O. N. (2025). Physical Condition and Concentration on Pencak Silat Athletes. *Journal of Sport Sciences and Fitness*, *11*(1), 40–49.

Soo, J., Woods, C. T., Arjunan, S. P., Aziz, A. R., & Ihsan, M. (2018). Identifying the performance characteristics explanatory of fight outcome in elite Pencak Silat matches. *International Journal of Performance Analysis in Sport*, *18*(6), 973–985. https://doi.org/10.1080/24748668.2018.1539381

Sulfa, M., Lubis, J., & Rihatno, T. (2024). Pencak silat reaction speed training model: training for pencak silat athletes aged 17 — 21 years Modelo de entrenamiento de la velocidad de reacción en pencak silat: entrenamiento para atletas de pencak silat de entre 17 y 21 años. *Retos*, *57*(57), 740–746.

Yang, C., Shi, L., Lu, Y., Wu, H., & Yu, D. (2024). Post-activation Performance Enhancement of Countermovement Jump after Drop Jump versus Squat Jump Exercises in Elite Rhythmic Gymnasts. *Journal of Sports Science and Medicine*, *23*(3), 611–618. https://doi.org/10.52082/jssm.2024.611

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THE EFFECT OF PLAYING GAMPARAN TRAINING ON THE ABILITY OF LONG KICKS OF FEMALE STUDENTS PARTICIPATING IN EXTRACURRICULAR SOCCER

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Abstract: Based on the issues of the unknown influence of exercise on playinggamparantowards the ability of long pass kick of the female football extracurricular participants, this study aims to determine the influence of exercise on playing-gamparan towards the ability of long pass kick of the female football extracurricular participants of SMPN 2 Pengasih in 2014. This study is an experiment with randomized control group pretest-posttest design. The subjects of this study are the participants of female football extracurricular of SMPN 2 Pengasih, totaling 30 students. The instrument that is used is kicking for distance from Warner test of soccer skill. The validity level of this test is 0.827 and the reliability level is 0.905, it means that this instrument is able to give valid and reliable data. The data analysis technique is using independent sample t test at 5% signification level. The result of t test in the experimental group shows that t count (2.365)> t table (2.048), and the value of p < 0.05, whereas t count of the control group (0,186) < t table of the control group (2,048), and the value of p > 0.05. This result may imply that there is an influenceof exercise on playinggamparan to the distant of the kicked ball of the experimental group of the female football extracurricular participants of SMPN 2 Pengasih, Kulonprogo. The improvement level of exercise on playing gamparan towards the distant of the kicked ball is 31.83%. In conclution, exercise on playing gamparan can be one of efective exercises to improve the distant of kicked ball in football games.
Key words: Playing Gamparan, Long Pass Kick, Female Football Extracurricular, Female SMP Students

INTRODUCTION

The game of football is one of the sports that is very popular with most people on this earth, from various social layers, ages and even genders. Likewise, in Indonesia, even now it is the fruit of lips for the success of the Indonesian national team under the age of 19 under coach Indra Sjafri some time ago who won the AFF cup title to the senior national team that improved the world FIFA ranking under the care of Shin Tae Yong. The achievement of this peak achievement can be achieved through the development of athletes through gradually starting from the beginner level to the outstanding athlete or from the early age stage to adulthood (the peak of appearance). Long-term athlete development (LTAD) in football requires age-specific training programs that focus on technical skills, tactical understanding, and physical conditioning tailored to young players' growth stages (Ford et al., 2011). Early age or young football coaching requires coaches, teachers, agencies, clubs, PB or football coaches to pay close attention and meticulous in providing guidance to their students or athletes. Therefore, coaches, teachers, offices, clubs or football coaches must understand the characteristics of their students or athletes according to their age level, because in the development of football at an early age or young age (school age) it is grouped by age to achieve the maximum football development programme. Effective youth football coaching emphasizes fun, skill acquisition, and psychological development rather than early specialization, which can lead to burnout and dropout (Côté & Hancock, 2016). Changes and improvements in achievement will occur if coaching is carried out well, the training programme is well arranged in accordance with the ideal stages and principles of training, gradual and continuous competition, adequate and standard infrastructure, good quality and experience of coaches, support for food and beverages with good nutritional composition, good sports research and development, funding system and supporting sports policies, athlete conditions ranging from talent, motivation and networking/selection (talents counting) and so on. Optimal

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nutrition and recovery protocols are critical for youth athletes to support growth, performance, and injury prevention in football (Lloyd et al., 2015). Talent identification in football must consider not only physical and technical abilities but also psychological resilience and socio-environmental support systems (Williams et al., 2020). Grassroots football development depends on structured competitions, quality coaching, and government policies that prioritize youth sports infrastructure (Haugaasen & Jordet, 2012).

The game of football is a complex game that combines physical elements, techniques, tactics, strategies and mental play well in open skills. One of the basic techniques that must be mastered is the basic kicking technique, one of which is a long-range kick. Long-range kicking ability significantly contributes to goal-scoring opportunities and team tactical flexibility in modern football (Marcote-Pequeño et al., 2019). The optimal long-distance kick requires precise coordination between approach angle, plant foot placement, and follow-through motion to maximize ball velocity (Lees & Nolan, 1998). Long passes have an important meaning in the game of football, not a few goals are created from long-range kicks. In every football match, long-range kicks are very often executed by every player, because in addition to scoring goals, they can also be used to provide passes to teammates, speed up counterattacks and so on. Teams that effectively utilize long-range passes demonstrate 23% higher success rates in counterattacking situations (Memmert et al., 2017). A goal kick, corner kick or other free kick is one example of a long pass kick to provide a pass to a teammate at a distance (a certain distance). Thus, long-range kicks in the game of football are very necessary and have a very important significance in winning the game. Specific long-range kicking training should incorporate both stationary and moving ball drills to develop game-realistic competence (Ali, 2011).

One of the ways to coach football in schools can be done through extracurricular activities. At SMP N 2 Pengasih Kulon Progo, one of the extracurricular activities held is the extracurricular football of the women's group. In the implementation on the field, the extracurricular participants of SMP N 2 Pengasih women's football are mostly in doing long-distance kicks are still not many who have not been able to do so, rarely done because they are not touched by the coach, female players are still weak in kicking the ball and still often make technical mistakes, such as putting the foot on the ball still using the tip of the foot or the inner foot, so that the ball produced is still flat and the rotation and strength of the ball are still weak. This can be seen when the female participant performs a long kick (long pass); the result of the kick is still weak (not reaching the target), the accuracy is also not right, and the foot contact on the ball is also not correct, so that the foot contact on the ball is still located on the toe, even though to execute the long pass technique, in addition to the correct technique, strength and explosive power of the leg muscles (power) are also needed. The physical condition of the female football extracurricular participants of SMP N 2 Pengasih is also still weak; to play for only 2x25 minutes, the students already look tired due to weak cardiorespiratory endurance, and also the previous female extracurricular participants also rarely exercised other than during health service subject activities during regular hours. Judging from the existing problems, it is necessary to find other effective and fun training models in the form of games to improve the quality of technique and strength or explosive power of leg muscles of female football students participating in the extracurricular football of SMP N 2 Pengasih so that they have a good quality of long-distance kicks. Thus, the researcher wants to provide a training model in the form of a traditional game of gamparan. Gamparan is a game of aiming at an arrangement of stones set on the ground by throwing a stone placed on one of the insteps until the arrangement falls. A person chosen by lottery will oversee rearranging the fallen stones. The values contained in this game include agility and sportsmanship (Lindawati, 2019). The gamparan game is a training method to improve the ability to kick long distances (long passes), as the movement of this traditional game of gamparan resembles the movement when performing a kick. However, there is also a load on the participant's legs, namely the loading of the stones used to play, which increases the strength and power of the leg muscles. The distance used in the gamparan game will also vary, training the accuracy of the techniques and kicks of extracurricular participants to hit the target with weight and distance that rises progressively and differently.

METHOD

This research is an experimental study, such research (Leguizamo et al., 2024)by applying a pre-test/post-test control group design with expert validation showed the effect of training intervention. This study aims to find out and provide an overview of the effect of playing gamparan practice on the ability of long pass kicks of students participating in football extracurricular activities at SMP N 2 Pengasih Kulonprogo, Yogyakarta. The method used in this study is a survey method using test and measurement instruments in the process of collecting and gathering data. A survey

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is a system for collecting valid information from or about people to describe, compare, or explain their knowledge, attitudes, and behavior (Fink, 2009). Before the research and provision of this training or treatment programme is carried out, the training programme that has been created by the research team will be validated by the appointed expert to ensure that the training programme is good and truly feasible to be applied. Expert validation can improve the quality of the instrument, although there are challenges in finding experts who are truly competent in the desired field ("Assessing the Validity of Experts' Value Judgment over Research Instruments," 2023).

All subjects used in this study will do an initial test / pretest first, then do treatment exercises and then will be measured by a final test / posttest. Based on the data from the pretest results, the data was then sorted and ranked based on the ability of the students, starting from the farthest longpass kick results to the nearest results. The grouping of the results of the students' longpass kicks was divided into two, namely as a control group and an experimental group using the ordinal pairing technique based on this order. The control group was trained and did not receive the treatment of playing the game, while the experimental group was trained and received the treatment of playing the game. Exercises and treatment sessions as well as post-test measurements were carried out after 16 treatments with 3 meetings a week, totalling 3 meetings. All training groups, based on the division of their groups, will conduct a pre-test at the beginning and a post-test at the end of the exercise. The results obtained during the posttest will be compared with the results of the pretest to find out the percentage of the increase or decrease in the control group and the experimental group after receiving treatment in the form of a game practice. The population in this study is students who participate in women's football extracurricular at SMP N 2 Pengasih which totals 30 people consisting of 3 grade VII students and 27 grade VIII students.
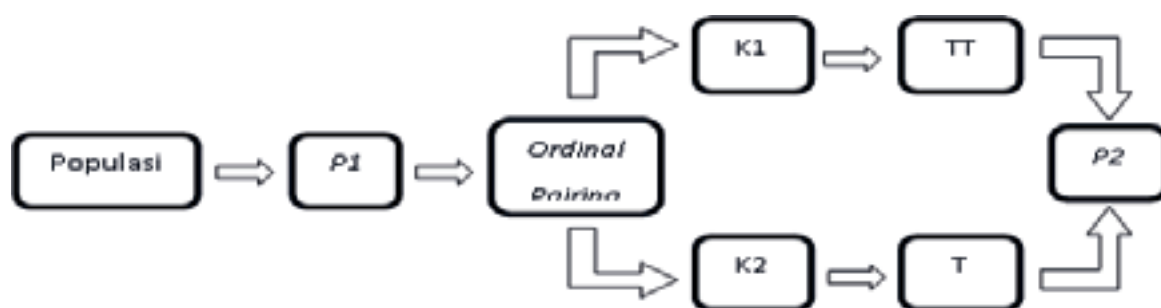
Figure 1. *Research Design*

Information:
P1   : Pretest (kicking for distance) dari Harold M. Barrow dan Rosemary McGEE)
K1   : Group 1
K2   : Group 2
TT   : No Treatment
T   : Treatment with Gamparan play practice.
P2   : Postest (kicking for distance dari Harold M. Barrow dan Rosemary McGEE)
Source: (Ali Maksum, 2012: 96).

Table 1. *Pretest result ranking data*

Rangking (Nomer)	Subject Name	Best Results (Meter)		Rangking (Nomer)	Subject Name	Best Results (Meter)	
		Pretest	*Post Test*			*Pretest*	*Post Test*
1	TR	18.00	21.00	12	LAS	11.30	17.00
2	DWM	17.00	18.10	13	VA	11.00	12.10
3	ZO	16.00	15.00	14	TRI	11.00	9.80
4	DOA	14.90	16.70	15	DLP	10.00	9.60
5	DW	14.50	16.90	16	DPY	9.80	14.00
6	RKA	13.30	8.00	17	ASH	9.30	13.00
7	TC	12.00	9.25	18	AR	9.00	9.00
8	ISR	12.00	14.70	19	SPA	8.50	8.20
9	FI	11.80	14.50	20	AY	8.00	12.70
10	IP	11.50	13.50	21	EMD	7.70	14.10
11	NRP	11.50	11.30	22	TWP	7.50	8.80

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Rangking (Nomer)	Subject Name	Best Results (Meter)	
		Pretest	*Post Test*
23	ASI	7.30	9.10
24	DTS	7.00	8.40
25	HH	6.80	7.80
26	SFN	6.50	6.50

Rangking (Nomer)	Subject Name	Best Results (Meter)	
		Pretest	*Post Test*
27	UKO	6.40	7.50
28	DO	5.40	8.30
29	NR	4.70	6.00
30	ARY	4.50	4.80

Table 2. Pretest Data Description

No.	*Interval Score*	Category	Frequency	Percentage (%)
1.	> 16.7	Very good	2	6.7
2.	12.9 – 16.7	Good	4	13.3
3.	9.1 – 12.8	Keep	11	36.6
4.	5.2 – 9	Less	11	36.6
5.	≤ 5.1	Very little	2	6.7
	Sum		**30**	**100**
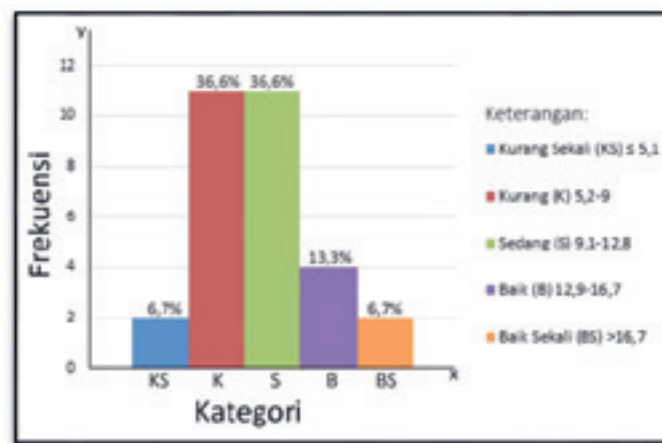
Figure 2. Pretest Bar Diagram

Results and Discussion

Based on the data from the results of pretest and posttest measurements, the following data were obtained:

Table 3. Division of experimental group and control group Based on the concept of ordinal pairing theory

Pretest Rankings	K1 (Group Eksperiment)			Pretest Rankings	K2 (Group control)		
	Name	*Pretest*	*Post test*		Name	*Pretest*	*Post Test*
1	TR	18.00	21.00	2	DWM	17.00	18.10
4	DOA	14.90	16.70	3	ZO	16.00	15.00
5	DW	14.50	16.90	6	RKA	13.30	8.00
8	ISR	12.00	14.70	7	TC	12.00	9.25
9	FI	11.80	14.50	10	IP	11.50	13.50
12	LAS	11.30	17.00	11	NRP	11.50	11.30
13	VA	11.00	12.10	14	TRI	11.00	9.80
16	DPY	9.80	14.00	15	DLP	10.00	9.60
17	ASH	9.30	13.00	18	AR	9.00	9.00
20	AY	8.00	12.70	19	SPA	8.50	8.20
21	EMD	7.70	14.10	22	TWP	7.50	8.80

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Pretest Rankings	K1 (Group Eksperiment)			Pretest Rankings	K2 (Group control)		
	Name	Pretest	Post test		Name	Pretest	Post Test
24	DTS	7.00	8.40	23	ASI	7.30	9.10
25	HH	6.80	7.80	26	SFN	6.50	6.50
28	DO	5.40	8.30	27	UKO	6.40	7.50
29	NR	4.70	6.00	30	ARY	4.50	4.80
Sum	15 Student			Sum	15 Student		

Table 4. *Description of Postest Data*

No.	Interval Score	Category	Frequency	Percentage (%)
1	> 16.7	Very good	4	13.3
2	12.9 – 16.7	Good	8	26.7
3	9.1 – 12.8	Keep	7	23.3
4	5.2 – 9	Less	10	33.3
5	≤ 5.1	Very little	1	3.33
Sum			**30**	**100**
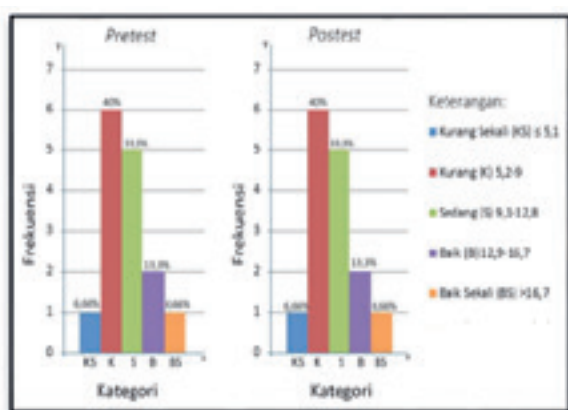
Figure 3. *Pretest and posttest data diagram of the control group*
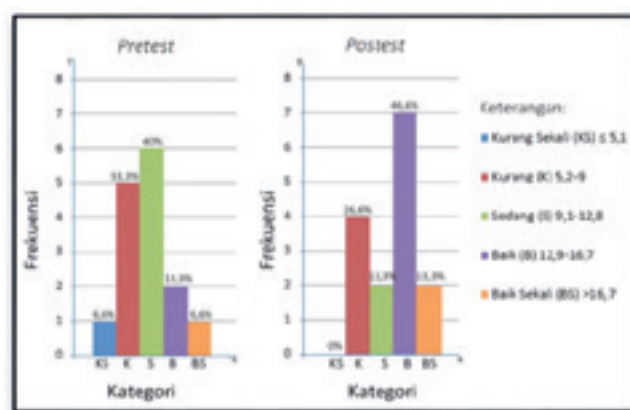
Figure 4. *Pretest and posttest data diagram of experimental groups*

Table 5. *Comparison of Interval Score Frequency of Experimental Group and Control Group*

No.	Interval Score	Category	K1 (Group Eksperiment)		K2 (Group control)	
			Pretest	Postest	Pretest	Postest
1	> 16.7	Very good	1	2	1	1
2	12.9 – 16.7	Good	2	7	2	2
3	9.1 – 12.8	Keep	6	2	5	5
4	5.2 – 9	Less	5	4	6	6
5	≤ 5.1	Very little	1	0	1	1
Sum			**15**	**15**	**15**	**15**

a. Results of the Normality

Test The criteria used to determine whether a distribution is normal or not is if the significance of the p > count is 0.05 (5%) the spread is declared normal and if the significance of the p < count is 0.05 (5%) the distribution is abnormal. The results of the normality test of this study can be seen in the following table:

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Table 6. *Results of the normality test (Shapiro-Wilk)*

Data	P	Sig 5%	Information
Pretest Eksperimen	0.966	0.05	Usual
Postest Eksperimen	0.934	0.05	Usual
Pretest Kontrol	0.779	0.05	Usual
Postest kontrol	0.111	0.05	Usual

b. Homogeneity Test In the homogeneity test. the rule used to determine whether a test is homogeneous or not is if p > 0.05 the test is declared homogeneous. and if p < 0.05 the test is declared non-homogeneous.

Table 7. *Homogeneity test results (Levene)*

Group	F	P	Sig 5%	Information
Eksperiment	0.011	0.918	0.05	Homogen
Control	0.273	0.605	0.05	Homogen

c. Hypothesis Test Hypothesis testing is carried out to determine the acceptance and rejection of the hypothesis submitted after the analysis requirements are met. hypothesis testing using the t-test and the results can be seen in the following table.:

Table 8. *Hypothesis test results*

Group	df	t tabel	t hitung	p	Sig 5%	Information
Eksperiment	28	2.048	2.365	0.025	0.05	Ha accepted
Control	28	2.048	0.186	0.853	0.05	Ha accepted

Based on the results of the hypothesis test. it was shown that the t-value of the experimental group (2.365) > t table (2.048) was obtained. while the t count of the control group (0.186) < t table of the control group (2.048) was obtained. The p-value of the experimental group (0.025) < from 0.05. while the p-value of the control group (0.853) > 0.05. The results can be interpreted that there is a significant influence of gamparan game practice on the ability of long pass kicks of female students in the experimental group of female football extracurricular participants of SMPN 2 Pengasih.

Gamparan game exercise is one of the methods of exercise to increase muscle strength. Strength is the driving force of every physical activity. so strength has an important role in protecting athletes from possible injuries. or with the strength of an athlete will be able to lift weights. kick. throw. hit. or perform other physical movements easily. efficiently. safely according to the desired target. The physical condition component is an important element that must be possessed by a sportsman to maintain the quality of his game. body movements. basic technical movements. tactical movements. strategic designs to his mental quality during competitions.

In this case. the training/treatment programme that will be applied to the experimental group is first consulted with experts in physical training programmes and football games. The practice of gamparan games that have been validated is able to increase the strength and power of the leg muscles. especially the muscles of the upper limbs and lower limbs because in this gamparan game there is a load that must be overcome by the legs and the distance of the target conquered which also the load will continue to increase progressively in accordance with the principles and rules of good and correct training. Through this gamparan game. the best hope is to increase the strength and power of the leg muscles which will immediately have a positive impact on the ability of female students to perform basic technical movements of kicking the ball with long passes or long-distance kicks. In providing this gamparan game treatment. so that the students do not feel bored. this gamparan game needs to be packaged in the form of competi-tive. fun. entertaining and mainly safe games to do. A play approach can effectively improve physical fitness and leg muscle strength while keeping athletes motivated and happy (Los Arcos et al.. 2015; Selmi et al.. 2017; Susanto et al.. 2024). Play-based training also improves fitness and thinking (Susanto. et al.. 2022). Rule changes in modified or

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simplified exercises. varying weights. increasing distance from the target and simple scoring models make students not feel bored or tired quickly when doing weight training (Susanto et al.. 2024). Thus. this exercise can be one of the references that can be used by trainers or physical education teachers to improve physical fitness. the quality of players' physical condition or the quality of techniques or basic movements for students or athletes to achieve better fitness and achievement. especially in the sport of soccer games.

Translated with. In all sports activities. regardless of the type of sport. physical condition plays a very important role in supporting other elements. The physical condition of a sportsman will greatly affect and even determine the appearance or performance of their movements during training or competition (Mohr et al.. 2022; Sumarno et al.. 2022; Sunarto et al.. 2023).

Physical condition is one of the important elements and is the basis for developing technical. tactical. and strategic components as well as mental aspects in practising and competing in sports. The status of physical condition can reach an optimal point if the training undertaken follows a good. programmatic. and measurable training process that starts from an early age and is accompanied by an experienced coach. Good exercises should be structured and carried out continuously. programmatically. and measurably continuously. and continuously guided by the basic principles of good and correct training. Good physical condition will also affect the function of joint organs and organism/metabolic systems in the body (D'Onofrio et al.. 2023; Jach et al.. 2023; McCarthy et al.. 2022). including: 1) there is an increase in the ability of the circulatory system and the work of the heart and lungs (cardiorespiratory system and cardiovascular system). 2) there is an increase in the quality and quantity of physical condition components that synergise with each other. 3) there is a better degree of movement during exercise or competition. 4) there is a faster recovery phase in the organs of the body after training or competition.. 5) there is a faster response and reaction from the body's organism to respond to stimuli if needed. 6) there is effectiveness and efficiency in performing technical movements during training or sports competitions. 7) there is high confidence in performing technical movements during training and competition (reducing the occurrence of errors in performing technical movements). 8) the strength and stability of the body are maintained so that it is not easy to experience fatigue or injury. 9) good physical condition will be able to maintain ideal weight and disease risk. 10) psychologically will increase thinking intelligence (decision-making) and reduce stress and so on. The physical condition possessed by a person is greatly influenced by many factors (Miravalls et al.. 2020; Sempere-rubio et al.. 2019; Yarmak et al.. 2018). such as: 1) age. 2) gender. 3) genetic factors/predisposition. 4) habits and lifestyle (smoking. alcohol. staying up late). 5) exercise and physical activity. 6) rest patterns (7-8 hours). 7) nutrition and diet (food and drinks for health). and so on. In accordance with the physical condition training guidelines. to maintain and improve physical condition. you must meet the training requirements (Bennie et al.. 2019; Oliveira et al.. 2018; Piercy et al.. 2018; Titze et al.. 2020). namely: 1) training should be carried out at least 3-5 times per week with a duration of 30-90 minutes per session. 2) training should be conducted with good training stages and principles (progressive. overload. reversible. varied. individual. FITT). 3) good training should be accompanied by someone competent with a measurable exercise programme. 4) good training is supported by the adequacy and quality of sports facilities. 5) continuous training also requires tests and measurements to find out the changes. and so on.

In the measurement data. the mean value of the control group students decreased which was allegedly because during the exercise the students always complained and wanted to get/do the same programme as the exercise carried out by the experimental group. namely the practice of the game of gamparan. As a result. the impact causes the students to become less enthusiastic and quickly feel bored. and when the post-test is carried out. it turns out that the results are not optimal and tend to decrease compared to the data at the time of the pre-test. In the implementation and execution of this training programme. the control group students and the experimental group students were trained by different trainers. the training was carried out at the same time but the locations were somewhat far apart because they only used different sides of the field.

CONCLUSION

Based on the results of the above study. it can be concluded that there is a significant influence of the physical exercise programme of the gamparan game on the strength and power of the leg muscles that are able to produce the distance of the long pass kick of female students in the experimental group of female football extracurricular participants at SMPN 2 Pengasih. Kulon Progo. This is evidenced by the increase in the results of the long-range kick

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post-test in the distance kick test on the experimental group of female football extracurricular participants at SMPN 2 Pengasih. Kulon Progo.

REFERENCES

Ali, A. (2011). Measuring soccer skill performance: A review. In *Scandinavian Journal of Medicine and Science in Sports* (Vol. 21. Issue 2). https://doi.org/10.1111/j.1600-0838.2010.01256.x

Khidhir, R. J., & Rassul, T. H. (2023). Assessing the validity of experts' value judgment over research instruments. *Zanco Journal of Human Sciences*, *27*(5), 324-343.

Bennie, J. A., De Cocker, K., Teychenne, M. J., Brown, W. J., & Biddle, S. J. (2019). The epidemiology of aerobic physical activity and muscle-strengthening activity guideline adherence among 383,928 US adults. *International Journal of Behavioral Nutrition and Physical Activity*, *16*(1), 34.

Côté, J., & Hancock, D. J. (2016). Evidence-based policies for youth sport programmes. *International journal of sport policy and politics*, *8*(1), 51-65.

D'Onofrio, G., Kirschner, J., Prather, H., Goldman, D., & Rozanski, A. (2023). Musculoskeletal exercise: Its role in promoting health and longevity. *Progress in Cardiovascular Diseases*, *77*, 25-36.

Fink, A. (2010). Survey research methods. *International encyclopedia of education*, 152-160.

Ford, P., De Ste Croix, M., Lloyd, R., Meyers, R., Moosavi, M., Oliver, J., ... & Williams, C. (2011). The long-term athlete development model: Physiological evidence and application. *Journal of sports sciences*, *29*(4), 389-402.

Haugaasen, M., & Jordet, G. (2012). Developing football expertise: a football-specific research review. *International review of sport and exercise psychology*, *5*(2), 177-201.

Jach, M. E., Serefko, A., Szopa, A., Sajnaga, E., Golczyk, H., Santos, L. S., ... & Sieniawska, E. (2023). The role of probiotics and their metabolites in the treatment of depression. *Molecules*, *28*(7), 3213.

Lees, A., & Nolan, L. (1998). The biomechanics of soccer: a review. *Journal of sports sciences*, *16*(3), 211-234.

Leguizamo, F., Prats, A. N., Gervilla, E., Llabrés, J., & Garcia-Mas, A. (2024). Effectiveness of a Program to Improve the Verbal Response of Football Coaches: A Delayed-Intervention Experimental Design. *Retos*, *51*, 657-665.

Lindawati, Y. I. (2019). Faktor-faktor penyebab eksistensi permainan tradisional di desa nyangkringan. *Hermeneutika: Jurnal Hermeneutika*, *5*(1), 13-24.

Lloyd, R. S., Oliver, J. L., Faigenbaum, A. D., Howard, R., Croix, M. B. D. S., Williams, C. A., ... & Myer, G. D. (2015). Long-term athletic development-part 1: a pathway for all youth. *The Journal of Strength & Conditioning Research*, *29*(5), 1439-1450.

Los Arcos, A., Vázquez, J. S., Martín, J., Lerga, J., Sánchez, F., Villagra, F., & Zulueta, J. J. (2015). Effects of small-sided games vs. interval training in aerobic fitness and physical enjoyment in young elite soccer players. *PloS one*, *10*(9), e0137224.

González Hernández, J. M., Cuadrado Peñafiel, V., Jiménez Reyes, P., García Ramos, A., Gómez, M. Á., & Marcote Pequeño, R. (2019). Association between the force-velocity profile and performance variables obtained in jumping and sprinting in elite female soccer players.

McCarthy, O., Pitt, J. P., Keay, N., Vestergaard, E. T., Tan, A. S., Churm, R., ... & Bracken, R. M. (2022). Passing on the exercise baton: What can endocrine patients learn from elite athletes?. *Clinical Endocrinology*, *96*(6), 781-792.

Memmert, D., Lemmink, K. A., & Sampaio, J. (2017). Current approaches to tactical performance analyses in soccer using position data. *Sports medicine*, *47*(1), 1-10.

Miravalls, R., Pablos, A., Guzman, J. F., Elvira, L., Vañó, V., & Nebot, V. (2020). Factores relacionados con el estilo de vida y la condición física que se asocian al IMC en función del género en preadolescentes españoles. *Nutrición hospitalaria*, *37*(1), 129-136.

Mohr, M., Nassis, G. P., Brito, J., Randers, M. B., Castagna, C., Parnell, D., & Krustrup, P. (2022). Return to elite football after the COVID-19 lockdown. *Managing Sport and Leisure*, *27*(1-2), 172-180.

Oliveira, C. L., Dionne, I. J., & Prado, C. M. (2018). Are Canadian protein and physical activity guidelines optimal for sarcopenia prevention in older adults?. *Applied Physiology, Nutrition, and Metabolism*, *43*(12), 1215-1223.

Piercy, K. L., Troiano, R. P., Ballard, R. M., Carlson, S. A., Fulton, J. E., Galuska, D. A., ... & Olson, R. D. (2018). The physical activity guidelines for Americans. *Jama*, *320*(19), 2020-2028.

Selmi, O., Khalifa, W. Ben, Ouerghi, N., Amara, F., Zouaoui, M., & Bouassida, A. (2017). Effect of Verbal Coach Encouragement on Small Sided Games Intensity and Perceived Enjoyment in Youth Soccer Players. *Journal of Athletic Enhancement*. *06*(03). https://doi.org/10.4172/2324-9080.1000262

Sempere-Rubio, N., Aguilar-Rodríguez, M., Inglés, M., Izquierdo-Alventosa, R., & Serra-Añó, P. (2019). Physical condition factors that predict a better quality of life in women with fibromyalgia. *International Journal of Environmental Research and Public Health*, *16*(17), 3173.

Sumarno, S., Nanda, F. A., & Ndayisenga, J. (2022). The concept and practice of a football training program: An understanding in the transition period. *Sepakbola*, *2*(1), 1-10.

Sunarto, W., & Suharjana, N. S., Wali, CN, Sumaryanto, Komarudin, Guntur, & Louk, MJH (2023). The Effect of Circuit Training on Improving the Physical Condition of Northwest Pantar Football Athletes. *International Journal of Human Movement and Sports Sciences*, *11*(1), 1-9.

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.

Susanto, H. S., 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. *Sportfiske Nauke i Zdravlje*, *14*(5), 135-139.

Susanto, H. S., 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. *Sportske Nauke i Zdravlje*, *14*(5), 135-39.

Susanto, S. (2024). The Effect of Using a Paralon Bow on the Archery Performance of Novice Athletes. *Innovative: Journal Of Social Science*

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Research. 4(3). 11185-11197.

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.

Titze, S., Lackinger, C., Fessl, C., Dorner, T. E., & Zeuschner, V. (2020). Austrian physical activity guidelines for adults and older adults with and without physical, sensory, or mental disabilities, as well as for adults with chronic diseases. *Gesundheitswesen (Bundesverband der Arzte des Offentlichen Gesundheitsdienstes (Germany))*, *82*(S 03), S170-S176.

Williams, A. M., Ford, P. R., & Drust, B. (2023). Talent identification and development in soccer since the millennium. *Science and football*, 3-14.

Yarmak, O., Blagii, O., Palichuk, Y., Hakman, A., Moroz, O., Balatska, L., & Galan, Y. (2018). Analysis of the factor structure of the physical condition of girls 17-19 year-old.

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The Impact of Intrinsic and Extrinsic Motivation and Amotivation on Physical Activity Participation

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The Impact of Intrinsic and Extrinsic Motivation and Amotivation on Physical Activity Participation

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Abstract: *This research explores the impact of intrinsic, extrinsic, and amotivation on physical activity among young adults, using Self-Determination Theory (Deci & Ryan, 1985) as its guiding framework. The study investigates how these different types of motivation influence participation in physical activity. Data were collected from 245 participants aged 18 to 30, using the Sport Motivation Scale and the Godin Leisure-Time Exercise Questionnaire to measure their motivation and physical activity levels. The findings reveal that intrinsic motivation, driven by personal enjoyment and interest in the activity, plays a key role in maintaining consistent physical activity over time. Extrinsic motivation, linked to external rewards such as recognition or approval, also encourages physical activity, though to a lesser degree. In contrast, amotivation, defined as a lack of intent or belief in one's ability to engage in physical activity, negatively affects activity levels. These results emphasize the critical role of fostering intrinsic motivation to promote long-term engagement in physical exercise. The study provides important insights for designing effective interventions to encourage regular physical activity among young adults, contributing to their overall health and well-being.*

Keywords: *physical activity, intrinsic and extrinsic motivation, amotivation*

INTRODUCTION

Physical activity is linked to a wide range of health benefits, including relief from chronic health conditions and improvements in mental health and well-being. Regular physical activity has been shown to help prevent and manage diseases like heart disease, stroke, diabetes, and some forms of cancer. It also prevents hypertension, helps maintain a healthy body weight, and positively impacts quality of life, mental health, and well-being (World Health Organization, 2010). The same organization recommends at least 30 minutes of physical activity daily or one hour of activity three times a week. Physical activity is defined as "any bodily movement produced by skeletal muscle contractions that increases energy expenditure above basal levels" (Caspersen et al., 1985, p. 126), while exercise is "a specific type of physical activity that is planned, structured, and repeatedly performed to improve or maintain physical fitness" (Caspersen et al., 1985, p. 126). Despite these benefits, current global estimates indicate that one in four adults and 81% of adolescents do not get enough physical activity. In economically developed countries, inactivity rates can reach as high as 70% due to changes in transport patterns, increased use of technology for work and leisure, and sedentary lifestyles (Strain et al., 2024). Increased inactivity negatively affects healthcare systems, the environment, economic development, community well-being, and quality of life.

Self-Determination Theory

Self-Determination Theory (Deci & Ryan, 1985) provides a framework for understanding how different types of motivation affect behavior. It expands on the traditional categorization of intrinsic (internal) and extrinsic (external) motivation, focusing on autonomy in regulating motivation. Motivation exists on a continuum, ranging from amotivation to intrinsic motivation. Amotivation reflects a lack of intention to engage in the behavior. Extrinsic motivation can be controlled or autonomous, depending on the individual's perception of external influences. Intrinsic motivation refers to engaging in activities for the inherent satisfaction and enjoyment they provide.

This theory plays a key role in predicting physical activity and developing interventions. Intrinsically motivated individuals find physical activity enjoyable, which fosters consistent exercise habits. Intrinsic motivation is crucial for long-term engagement (Frederick & Ryan, 1995). While extrinsic motivation can initiate activity, it is often less sustainable. Those experiencing amotivation may avoid physical activity altogether (Ryan & Deci, 2000). Research

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has examined motivation across various populations, revealing that active individuals often cite enjoyment and competence as primary motivators, while exercise participants frequently mention body-related motives (Frederick & Ryan, 1993). Kilpatrick et al. (2005) showed that motivation differs between sports and exercise, with recreational activities aligning more closely with desirable motivational strategies, leading to higher adherence rates. Studies based on the Self-Determination Theory indicate that athletes focused on intrinsic goals report greater well-being (Chatzisarantis & Hagger, 2007). Geller et al. (2018) found that while both intrinsic and extrinsic motivations support regular activity, intrinsic motivation is critical for long-term adherence. Therefore, physical activity interventions should enhance intrinsic enjoyment and personal relevance.

This paper is about individual physical activity and its motivational aspects. The primary goal of this research is to identify the specific differences in the levels of intrinsic, extrinsic, and motivation among individuals engaged in different types of physical activity and to determine which type of motivation most contributes to regular participation in physical activity.

Method

Sample

Out of the 285 completed questionnaires, the sample for this study consists of 245 respondents aged 18 to 30 (M = 24.29 years), 92 are male (37.6%), while the remaining 153 are female (62.4%). The majority (82.4%) live in urban areas, 10.6% in small towns, and 6.9% in rural areas. Most participants are students (39.6%), followed by individuals with a bachelor's degree (29.4%). Regarding physical activity, 74.7% of respondents reported being physically active, while 25.3% were not. In response to the question, "Why do you not engage in physical activity?", 27.9% of participants answered "I do not have time," 19.2% cited anxiety, 10.6% mentioned financial reasons, 11.5% stated they do not know which type of physical activity to engage in, 4.8% have health issues, 2.9% believe it is unnecessary, and 23.1% selected "other," listing reasons such as pregnancy, lack of interest, or negative past experiences.

Data Collection

A set of instruments was created for this study, and the survey was conducted online via Google Forms. Participants were informed about the purpose and goals of the research, assured anonymity, and were free to withdraw at any time, as participation was voluntary. Before completing the questionnaire, each participant gave their consent to participate. Completing the questionnaire took no more than 10 minutes. The data were collected in 2024.

Variables and Measurement Instruments

The "physical activity" variable was measured using the Godin Leisure-Time Exercise Questionnaire (GLTEQ, Godin, 2011). Participants were asked to report how often, over 7 days, they engaged in specific exercises for more than 15 minutes during their free time and to multiply the frequency by the specified number. Based on the total score, participants were categorized into three groups: 1. Active-Vigorous Physical Activity (elevated heart rate, heavy sweating, exhausting exercise): Multiply the weekly frequency by 9 (score of 24 or above). Examples: running, weightlifting, CrossFit, etc. 2. Moderately Active - Moderate Physical Activity (mild exertion): Multiply the weekly frequency by 5 (score between 14 and 23). Examples: brisk walking, tennis, etc. 3. Insufficiently Active - Light Physical Activity (minimal effort): Multiply the weekly frequency by 3 (score below 14). Examples: yoga, fishing, bowling, light walking, etc.

The instrument used to measure motivation variables was the Exercise Motivation Scale (Sport Motivation Scale—Pelletier et al., 1995). This scale assesses individuals' motivation for physical activity, evaluating intrinsic, extrinsic, and amotivation. It consists of 28 items (4 items per subscale) rated on a seven-point Likert scale.

Results

Descriptive measures of the questionnaires for measuring levels of physical activity, intrinsic motivation, extrinsic motivation and amotivation are presented in Table 1.

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Table 1. Descriptive indicators for the variables of physical activity and motivation

	Min.	Maks.	M	SD	Sk	Ku
Total Physical Activity Score	0	117	40.24	23.53	.42	121
Intrinsic Motivation	12	84	54.4	17.18	-.55	-.365
Extrinsic Motivation	14	81	45.6	13.44	.09	.06
Amotivation	1	25	9.02	5.56	1.15	.39

Note. Min – Minimum, Max – Maximum, M – mean, SD – standard deviation, Sk – skewness, Ku – kurtosis.

The skewness and kurtosis values show a positively skewed distribution for participants' scores on physical activity, extrinsic motivation, and amotivation subscales. In contrast, the distribution for intrinsic motivation is negatively skewed. These results suggest that most participants were intrinsically motivated. The findings indicate no significant deviation from a normal distribution (skewness value does not exceed 2) (Hair & Alamer, 2022). After the descriptive statistics, a significance test for the correlation between variables was conducted (Table 2).

Table 2. Intercorrelation of physical activity and motivation variables

	1	2	3	4
1				
2	.35**			
3	.29**	.58**		
4	.36**	.32**	.103**	

*Note. 1 – total physical activity score, 2 – intrinsic motivation, 3 – extrinsic motivation, 4 – amotivation, ** p < .01; * p < .05*

The results indicate that both intrinsic and extrinsic motivation are positively correlated with levels of physical activity. Higher physical activity is moderately associated with higher levels of both types of motivation. Amotivation, on the other hand, shows a negative correlation with physical activity. Higher levels of physical activity are linked to lower levels of amotivation, suggesting that individuals with greater intrinsic or extrinsic motivation are less likely to be insufficiently active.

Using the Analysis of Variance, the differences between subjects of different physical activity levels on intrinsic and extrinsic motivation and amotivation measures were determined (Table 3).

Table 3. Differences between the values of intrinsic and extrinsic motivation and amotivation among respondents of different categories of physical activity

	df	F	p
Intrinsic Motivation	2	11.06	.000
	242		
	244		
Extrinsic Motivation	2	8.74	.000
	242		
	244		
Amotivation	2	25.91	.000
	242		
	244		

Note: df – degrees of freedom, F- regression model significance test, p-statistical significance

The Analysis of Variance results show statistically significant differences between groups for all three variables: intrinsic motivation, extrinsic motivation, and amotivation. For intrinsic motivation, there is a significant difference

between groups: $F(2, 24) = 11.07$, $p < 0.001$, indicating substantial variation in average intrinsic motivation across the groups [low ($M = 42.94$), middle ($M = 50.88$), high ($M = 57.00$)]. The results for extrinsic motivation also show a significant difference: $F(2, 24) = 8.75$, $p < 0.001$, suggesting notable variance between groups [low ($M = 37.08$), middle ($M = 45.03$), high ($M = 47.24$)]. Similarly, for amotivation, significant differences were found: $F(2, 24) = 25.91$, p < 0.001, indicating considerable differences in average amotivation levels among the groups [low ($M = 14.14$), middle ($M = 11.38$), high ($M = 7.75$)]. The Levene's test for homogeneity of variance for intrinsic motivation ($p = 0.227$) and extrinsic motivation ($p = 0.642$), shows no significant differences between groups indicating that the variances are homogeneous. However, for amotivation, Levene's test indicates a significant difference in variances between groups ($p < 0.05$). Due to this variance difference, the Games-Howell post-hoc test will be applied for amotivation.

The Bonferroni test results for intrinsic motivation shows only significant difference between low and high activity groups (MD = -14.06, $p < 0.001$), indicating higher intrinsic motivation in the high activity group. For extrinsic motivation, a significant difference was observed between low and high activity groups (MD = -10.16, $p < 0.001$), with lower extrinsic motivation in the high activity group. The Games-Howell test for amotivation shows a significant difference between low and high activity groups (MD = 6.39, $p < 0.001$), and moderate and high activity groups (MD = -3.62, $p = 0.042$), with higher amotivation in the high activity group.

The following are the results of the Regression Analysis, which determines the predictive significance of different types of motivation for engaging in physical activity (Table 4).

Table 4. *Linear regression coefficient and model significance testing - intrinsic and extrinsic motivation and amotivation as predictors of the level of physical activity*

Model	R	R2	Adjusted R2	F	p
1	.45	.21	.200	21.31	.000

Note. R - correlation coefficient, R2 - determination coefficient, F - regression model significance test, p - statistical significance

The obtained values indicate that the regression model is statistically significant (F=21.31, $p < 0.001$), i.e. indicates a significant contribution of predictors in explaining the variance of the degree of physical activity. The coefficient of determination (R2) shows that the model explains 21% of the variance of the dependent variable, ie. degree of physical activity. The results, including the beta coefficients and t-tests, indicate that extrinsic motivation is a positive and statistically significant predictor of physical activity levels ($\beta = 0.16$, $p = 0.018$). Intrinsic motivation is also significant but to a lesser extent ($\beta = 0.15$, $p = 0.039$). Amotivation is a most significant predictor of physical activity levels ($\beta = -0.29$, $p < 0.001$).

DISCUSSION

This study examined the impact of intrinsic and extrinsic motivation on different levels of physical activity: insufficient, moderate, and high. The findings provide insights into how various types of motivation influence physical activity levels among participants. Intrinsic motivation was generally high, with significant variability, while extrinsic motivation showed moderate values with less variation. Amotivation was low, with some participants highly unmotivated. A strong positive correlation between intrinsic and extrinsic motivation suggests that participants often exhibit both at high levels. More physically active individuals had higher intrinsic and extrinsic motivation, while higher amotivation correlated with lower activity levels.

Results revealed significant differences in motivation and amotivation among groups with different activity levels. Highly active participants had significantly higher intrinsic motivation than those with lower activity levels. Similarly, extrinsic motivation was higher in the more active groups, indicating that external rewards can motivate physical activity. Amotivation was significantly higher in less active participants, suggesting that those who feel physical activity is not helpful or achievable are less likely to engage. These results align with previous research showing that internal motives, such as enjoyment, challenge, personal growth, and fulfilling basic psychological needs (autonomy, competence, and relatedness), can powerfully drive continued physical activity (Deci & Ryan,

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2000). When individuals feel an internal desire to be active, they are less likely to quit and tend to choose activities that bring greater personal satisfaction. Participants with higher physical activity levels focus more on personal goals linked to higher intrinsic motivation. Similarly, those with higher activity levels also show greater extrinsic motivation, supporting the theory that external rewards and recognition play a role in motivating physical activity, especially when linked to rewards or social approval (Ryan & Deci, 2000). The most significant differences were observed in amotivation. Respondents with a low level of physical activity have significantly higher amotivation compared to those with a medium and high level of physical activity. The significant association of amotivation with a low level of physical activity indicates that people who are amotivated, i.e. who feel that physical activity is not helpful or achievable, rarely participate in physical activities. These results are consistent with research that shows that people who do not have a sense of control or competence for physical activity often give up on it (Vallerand, 2000).

Regression analysis showed that intrinsic and extrinsic motivation positively predicted physical activity levels, while amotivation had a negative impact. Together, these predictors explained 21% of the variance in physical activity. Intrinsic motivation had a more substantial influence, suggesting that enjoyment and personal interest are key drivers of long-term engagement in physical activity. The results can be explained by the fact that intrinsic motivation often stems from the enjoyment of the physical activity itself, which is more present in individuals engaged in high-intensity activities that require extra dedication and passion. On the other hand, those involved in low- to moderate-intensity activities may have different motives, such as social aspects or minimal effort, which do not provide enough challenge to boost intrinsic motivation. The findings also suggest that individuals participating in high-intensity physical activities show higher levels of extrinsic motivation than those engaged in lower-intensity activities. This could be due to the greater external rewards and recognition associated with more intense activities, such as competitions or achieving sports goals.

Conclusion

In conclusion, intrinsic and extrinsic motivation significantly contribute to physical activity, while high amotivation reduces participation. Interventions that promote intrinsic motivation, such as creating enjoyable activities or fostering a sense of achievement, may be more effective in sustaining physical activity over time. These findings have practical implications for trainers, psychologists, and health professionals in designing interventions that encourage long-term engagement in physical activity.

References

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior*. Plenum Press. DOI: 10.1007/978-1-4899-2271-7

Frederick, C. M., & Ryan, R. M. (1993). Differences in motivation for sport and exercise and their relations with participation and mental health. *Journal of Sport Behavior, 16*(3), 124-146.

Frederick, C. M., & Ryan, R. M. (1995). Self-determination in sport: An analysis of participation motivation. *Journal of Sport and Exercise Psychology, 17*(1), 3-21. DOI: 10.1123/jsep.17.1.3

Chatzisarantis, N. L. D., & Hagger, M. S. (2007). Intrinsic motivation and self-determination in exercise and sport: A review and synthesis of research. *International Review of Sport and Exercise Psychology, 1*(1), 79-103. DOI: 10.1080/17509840701827437

Hair, J. F., & Alamer, A. (2022). Partial Least Squares Structural Equation Modeling (PLS-SEM) in Second Language and Education Research: Guidelines Using an Applied Example. *Research Methods in Applied Linguistics, 1*(3), 100048. DOI: 10.1016/j.rmal.2022.100048

White, M. P., Elliott, L. R., Taylor, T., Wheeler, B. W., Spencer, A., Bone, A., & Fleming, L. E. (2016). Recreational physical activity in natural environments and implications for health: A population-based cross-sectional study in England. *Preventive Medicine, 91*, 383-388. DOI: 10.1016/j.ypmed.2016.08.023

Wilson, P. M., Mack, D. E., & Grattan, K. P. (2008). Understanding motivation for exercise: A self-determination theory perspective. *Canadian Psychology/Psychologie Canadienne, 49*(3), 250. DOI: 10.1037/a0012772

Silva, M. N., Markland, D., Silva, S. A., & Machado, P. (2010). Motivational predictors of exercise adherence in a weight loss program. *Journal of Applied Biobehavioral Research, 15*(2), 80-98. DOI: 10.1111/j.1976-1111.2010.00006.x

Sener, I. N., & Bhat, C. R. (2012). Modeling the spatial and temporal dimensions of recreational activity participation with a focus on physical activities. *Transportation, 39*, 627-656. DOI: 10.1007/s11116-011-9334-y

Standage, M., & Ryan, R. M. (2020). *Self-determination theory in sport and exercise*. In G. Tenenbaum & R. C. Eklund (Eds.), Handbook of sport psychology (4th ed., pp. 37–56). Wiley. DOI: Not available (book chapter).

Strain, T., Flaxman, S., Guthold, R., Semenova, E., Cowan, M., Riley, L. M., Bull, F. C., & Stevens, G. A. (2024). National, regional, and global trends in insufficient physical activity among adults from 2000 to 2022: A pooled analysis of 507 population-based surveys with 5.7 million participants. *The Lancet Global Health, 12*(8), 1232–1243. DOI: 10.1016/S2214-109X(23)00480-2

Sun, H., Li, W., & Shen, B. (2017). Learning in physical education: A self-determination theory perspective. *Journal of Teaching in Physical Education, 36*(3), 277-291. DOI: 10.1123/jtpe.2016-0060

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Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 9*(1), 1-30. DOI: 10.1186/1479-5868-9-78

Tsorbatzoudis, H., Alexandres, K., Zahariadis, P., & Grouios, G. (2006). Examining the relationship between recreational sport participation and intrinsic and extrinsic motivation and amotivation. *Perceptual and Motor Skills, 103*(2), 363-374. DOI: 10.2466/pms.103.2.363-374

Vallerand, R. J. (2000). Deci and Ryan's self-determination theory: A view from the hierarchical model of intrinsic and extrinsic motivation. *Psychological Inquiry, 11*(4), 312-318. DOI: 10.1207/S15327965PLI1104_02

White, M. P., Elliott, L. R., Taylor, T., Wheeler, B. W., Spencer, A., Bone, A., & Fleming, L. E. (2016). Recreational physical activity in natural environments and implications for health: A population based cross-sectional study in England. *Preventive Medicine, 91*, 383-388.

Wilson, P. M., Mack, D. E., & Grattan, K. P. (2008). Understanding motivation for exercise: a self-determination theory perspective. *Canadian Psychology/Psychologie Canadienne, 49*(3), 250.

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Traditional Games and Motor Ability: Their Interaction in Enhancing Long Jump Performance in Elementary School Students

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Abstract: *The development of motor skills during childhood plays a crucial role in overall physical fitness and athletic performance. Traditional games, which hold cultural significance, serve as an effective method for enhancing these skills. This study aimed to investigate the comparative effects of two traditional games Engklek and Lompat Tali on the long jump performance of elementary school students, while considering different levels of motor ability. Specifically, it examined whether traditional game interventions could enhance motor skills (agility, coordination, explosive power, and speed) and translate into improved long jump outcomes. A factorial experimental design (2 × 2) was employed with a sample of 24 male students, aged 10–11 years, selected through purposive sampling. The participants were divided into two groups based on the traditional game intervention (Engklek or Lompat Tali) and further classified by motor ability levels (high or low). Motor skills were assessed using standardized tests measuring agility, coordination, explosive power, and speed. Long jump performance was evaluated based on four components: take-off, push, flight, and landing. Data analysis included normality and homogeneity tests, followed by a two-way ANOVA using SPSS version 23, with a significance level of p < 0.05. The results indicate significant differences in long jump performance between students who participated in Engklek and those in Lompat Tali. Furthermore, a significant interaction effect was found between traditional games and motor ability levels. Students with high motor ability showed greater improvements in long jump skills compared to those with low motor ability, with variations observed between the two traditional game groups. These findings highlight the potential of integrating traditional games into physical education as a culturally relevant and engaging approach to improving motor skills and athletic performance. Further research is recommended to explore the long-term benefits of traditional games in broader sports training contexts.*

Keywords: *traditional games, motor ability, long jump, physical education, athletic performance*

Introduction

Physical education is an essential element of the educational curriculum (Burhaein et al., 2020), significantly contributing to the comprehensive development of pupils. It promotes physical health as well as cognitive and social abilities, therefore enhancing the overall well-being of youngsters (Harvey et al., 2018). Traditional games, deeply embedded in cultural heritage, provide a distinctive amalgamation of physical engagement and cultural education (Ashar et al., 2024; Shimray, 2024). These games have been acknowledged for their beneficial effects on diverse motor skills, including agility, coordination, explosive strength, and velocity—skills crucial for athletic success (Zubaida et al., 2021).

The cultivation of motor skills from childhood is essential, as these abilities establish the groundwork for more intricate motions necessary in sports and physical endeavors (Adolph & Hoch, 2020; Dapp et al., 2021). Proficient early development of motor skills can yield enduring advantages, including superior physical health, augmented academic achievement, and enhanced social connections (Bremer & Cairney, 2016). Traditional games, emphasizing physical exercise, coordination, and muscle development, provide an efficient method for cultivating these vital skills. Furthermore, they have demonstrated efficacy in alleviating stress, enhancing focus, and fostering overall pleasure and well-being (Hussain & Cheong, 2022; Ismoyo et al., 2024).

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This research examines the impact of two traditional games—Engklek and Lompat Tali—on the long jump proficiency of children at Elementary School SD Islam terpadu Siti Hajar . Engklek, similar to hopscotch, entails hopping on one foot across a sequence of squares marked on the ground, fostering balance, coordination, and agility. Lompat Tali, or rope jumping, involves pupils leaping over a moving rope, thereby improving explosive strength, velocity, and coordination (Mahardika, 2014).

Prior studies have established the advantages of traditional games in improving motor abilities, including agility, coordination, explosive strength, and velocity. Zubaida et al. (2021) discovered that traditional games markedly enhanced aerobic capacity and agility in children. Likewise, Mahardika (2014) indicated that these games enhanced physical fitness and promoted social behaviors in early childhood. Such studies underscore the capacity of traditional games to cultivate fundamental motor abilities, which are critical for athletic performance.

Motor skills such as agility, coordination, explosive strength, and velocity are essential determinants of performance in various sports, including the long jump. Agility, characterized as the capacity to alter direction swiftly and precisely (Fiorilli et al., 2017), is essential in numerous conventional activities. In Engklek, participants must synchronize and balance their motions while hopping on one foot through the squares, hence enhancing their agility and coordination (Rizki et al., 2022). Lompat Tali necessitates players to synchronize their jumps with a swinging rope, hence improving explosive strength and speed (Nurfitriyana, 2022).

Explosive power, is defined as the ability to produce maximum force in a brief duration (Huang et al., 2023), is crucial for the take-off phase of the long jump. Conventional games such as Lompat Tali improve this ability by requiring swift, elevated hops that replicate the explosive movement essential for an effective long jump (Gescheit et al., 2015). Likewise, speed, crucial for generating momentum during the approach in the long jump, is enhanced by traditional sports that necessitate rapid and dynamic movements (Arianda et al., 2021; Rhodes et al., 2020).

While the advantages of traditional games in enhancing motor skills are well recognized, there exists a paucity of research directly investigating their influence on long jump performance. Most studies emphasize the overall advantages of these games in enhancing health and social skills, rather than their impact on particular physical competencies like the long jump. This study seeks to address this gap by investigating the impact of Engklek and Lompat Tali on long jump performance. This research will yield significant insights on the efficacy of traditional games as a means to improve athletic performance, especially in the long jump.

Traditional games significantly contribute to the preservation of cultural heritage, establish a connection to history, and cultivate a sense of community among participants (Abdel-Maksoud et al., 2021). Integrating these games into physical education curricula enables schools to foster physical fitness while simultaneously cultivating an appreciation for cultural diversity and heritage among students.

This study investigates the efficacy of traditional games, specifically Engklek and Lompat Tali, in augmenting motor skills and enhancing long jump ability in primary school students. The findings seek to guide the design of physical education programs, emphasizing the necessity of integrating enjoyable, culturally pertinent activities to enhance motor development and athletic performance.

METHOD

Research Design

This research employed a comparative design (Creswell, 2014), to assess the influence of traditional games on the long jump performance of students at Elementary School SD Islam terpadu Siti Hajar . The main aim was to investigate the impact of various traditional games, particularly Engklek and Lompat Tali, on the enhancement of motor skills and long jump proficiency.

Participants

The research comprised 24 male students, aged 10–11 years, from Elementary School SD Islam Terpadu Siti Hajar, selected using a purposive sampling method. The participants were randomly allocated to one of two groups: the Engklek group or the Lompat Tali group, each consisting of 12 students. The random assignment guaranteed that the groups were equivalent in age and initial physical capabilities, thereby preserving the integrity of the comparative design (Creswell & Creswell, 2018).

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Intervention

The strategy was to integrate traditional games into the physical education curriculum. The Engklek group engaged in the game of Engklek, which necessitates players to hop on one foot across a sequence of squares marked on the ground. This game aims to enhance balance, coordination, and agility. Simultaneously, the Lompat Tali group participated in rope jumping, an activity that entails leaping over a swinging rope. This activity aims to improve explosive strength, velocity, and coordination. The intervention occurred over four weeks, with sessions conducted four times weekly. Each session lasted 40 minutes, consistent with the school's physical education class duration.

Figure 1. *Ilustration of Engklek*

Figure 2. *Ilustration of Lompat Tali*

Instrument

This study utilized standardized assessments to evaluate diverse motor skills, including agility, coordination, explosive power, and speed. The evaluation of long jump performance was based on four essential components: approach run technique, take-off technique, flight phase technique, and landing technique. Data were gathered by direct observation and established testing protocols to guarantee consistency and precision in documenting the participant's performances.
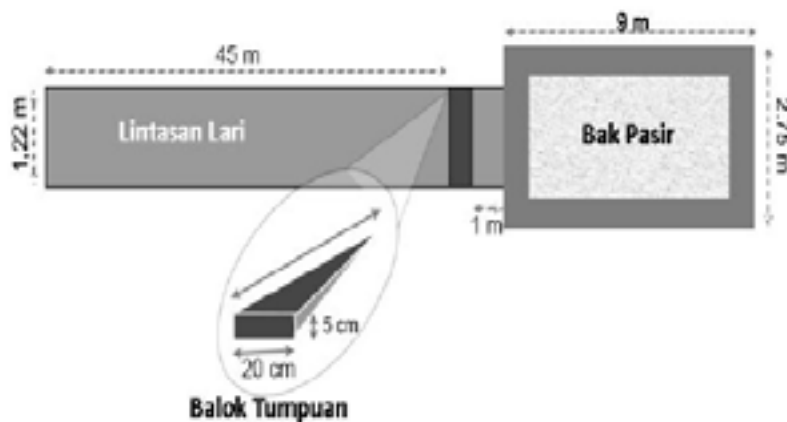
Figure 3. *Long Jump Test Arena*

Notes:
- **Lintasan Lari:** Running track.
- **Balok Tumpuan:** Bearing beam.
- **Bak Pasir:** Sandbox.

The subsequent table delineates the comprehensive assessment criteria for evaluating long jump proficiency, segmented into four principal phases: the approach run (prefix), take-off (push), flight (float), and landing. Each phase is further divided into specific sub-indicators that evaluate the techniques necessary for attaining optimal performance in the long jump.

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Table 1. Long Jump Skill Test Instrument

Indicators		Sub Indicators		Assessments
1	Prefix (approach run technique)	a	Foot Position: One foot should be placed in front, with hands relaxed beside the body, and eyes looking straight ahead.	
		b	Center of Gravity: Maintain the center of gravity while running.	
		c	Coordination: Ensure the coordination of arm swings and footsteps in rhythm.	
		d	Final Step: During the last step, coordinate vision by aligning eye movement with foot movement.	
		e	Push Accuracy: Ensure the accuracy of the pushing foot on the springboard.	
2	Push (take-off technique)	a	Supporting Foot: One end of the foot becomes the supporting foot to execute a quick and strong push.	
		b	Body Position: The body leans slightly forward.	
		c	Push Angle: The push angle when supporting is 45 degrees.	
		d	Movement: Form a horizontal movement when pushing.	
		e	Arm Swing: When pushing, it is assisted by swinging the arms upwards.	
3	Float (flight phase technique)	a	Body Balance: Maintain body balance in the air to achieve a parabolic movement.	
		b	Leg and Arm Swing: Swing the legs and arms when taking off in the air.	
		c	Floating Position: Extend the torso and both legs as far as possible to achieve a floating position.	
		d	Legs and Hands: Keep the legs straight forward with hands.	
		e	Landing Approach: Relax and bend the legs when approaching the landing.	
4	Land (landing technique)	a	Feet Position: Keep feet relaxed when touching the sand.	
		b	Leg Position: Maintain a bent leg position when landing, with the soles of the feet touching the sand.	
		c	Body Position: Adopt a squatting body position.	
		d	Hand Position: Position hands forward to prevent the body from falling backward.	
		e	Body Balance: Ensure body balance is maintained in front.	

The following table lists the motor skill test instruments that were employed to evaluate the physical abilities of the participants, such as agility, coordination, explosive power, and speed. The purpose of these tests was to assess the participant's proficiency in critical motor skills that are essential for athletic performance.

Table 2. Motor Skill Test Instrument

No	Indicators	Assessments
1	Agility	Shuttle-run 4 x 10 m
2	Coordination	Throw and catch the ball 1 m away against the wall
3	Explosive power	Vertical jump
4	Speed	30 m run

Data Analysis

The gathered data were examined utilizing statistical software (SPSS version 23). Homogeneity and normality tests were first performed using the Kolmogorov-Smirnov Z test to evaluate the data's appropriateness for parametric analysis. After satisfying the requirements of homogeneity and normality, a one-way ANOVA was conducted to examine significant differences between the two groups. A significance level of $p < 0.05$ was established to ascertain statistically significant differences in long jump performance between the Engklek and Lompat Tali groups (Gescheit

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et al., 2015). This comprehensive investigation delivered a strong assessment of the influence of traditional games on long jump performance, presenting significant insights into their potential to improve physical education curricula.

Result

List of Participants

Table 3 includes the initials of students who participated in two different groups: the Engklek group and the Lompat tali group. Each group consists of 12 students.

Table 3. Initial Group Assignments of Participants

No	Engklek (Initial)	Lompat tali (Initial)
1	AA	AL
2	AB	AM
3	MFL	AI
4	MAS	FM
5	LP	F SF
6	JIP	MS
7	MAIR	MZL
8	MS	QRD
9	M. F R	RSD
10	FAL	RS
11	DBP	SB
12	RWR	ZJ

Student's Agility Test Result

Table 4 displays the agility test results for students in the Engklek group. Each student is identified by their initials, and their performance is assessed across three trials. The average time (in seconds) for each student is calculated, along with the t-score, which indicates the statistical significance of their performance. The mean times for each student range from 11.78 seconds to 14.06 seconds, indicating varying levels of agility among them. The t-scores offer additional insight into the consistency and reliability of their performance.

Table 4. Data on Agility of Engklek Group Students

No	Initial	Tester			Mean (sec)	t-score
		1 (sec)	2 (sec)	3 (sec)		
1	AA	12.34	12.09	12.97	12.47	53.68
2	AB	14.15	13.91	14.11	14.06	30.46
3	MFL	12.93	12.98	12.74	12.88	47.60
4	MAS	12.64	11.82	12.36	12.27	56.51
5	LP	11.89	12.13	12.55	12.19	57.72
6	JIP	13.06	13.27	13.12	13.15	43.70
7	MAIR	11.48	12.32	11.55	11.78	63.66
8	MS	13.52	13.19	13.78	13.50	38.64
9	M. F R	12.76	13.05	13.45	13.09	44.63
10	FAL	14.31	13.98	13.71	14.00	31.28
11	DBP	13.5	13.74	14.03	13.76	34.84
12	RWR	12.84	13.17	12.95	12.99	46.09
	Mean	12.95	12.97	13.11	13.01	-

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Table 5 presents the agility test results for students in the Lompat tali group. Each student is identified by their initials, and their performance is measured across three trials.

Table 5. Data on Agility of Lompat Tali Group Students

No	Initial	Tester			Mean (sec)	t-score
		1 (sec)	2 (sec)	3 (sec)		
1	AL	12.16	12.77	12.34	12.42	54.32
2	AM	11.97	12.10	12.34	12.14	58.50
3	AI	13.04	12.93	13.01	12.99	45.99
4	FM	12.81	12.64	12.79	12.75	49.59
5	F SF	11.16	11.47	12.04	11.56	66.98
6	MS	11.70	11.85	11.63	11.73	64.49
7	MZL	12.51	12.35	12.08	12.31	55.92
8	QRD	11.97	12.07	12.19	12.08	59.38
9	RSD	13.15	12.84	12.94	12.98	46.23
10	RS	12.80	11.75	12.19	12.25	56.90
11	SB	13.23	13.01	12.81	13.02	45.65
12	ZJ	12.87	12.73	13.12	12.91	47.25
	Mean	12.45	12.38	12.46	12.43	-

The mean time (in seconds) for each student is calculated, along with the t-score, which indicates the statistical significance of their performance. The mean times for the students range from 11.56 seconds to 13.02 seconds, reflecting varying levels of agility among them. The t-scores provide further insight into the consistency and reliability of their performances.

Student's Coordination Test Result

Table 6 shows the coordination test results for students in the Engklek group. Each student is identified by their initials, and their performance is measured across three trials. The mean time (in seconds) for each student is calculated, along with the t-score, which indicates the statistical significance of their performance. The mean times for each student range from 7.67 seconds to 11.33 seconds, reflecting different levels of coordination among the students. The t-scores provide further insight into the consistency and reliability of their performances.

Table 6. Data on Coordination of Engklek Group Students

No	Initial	Tester			Mean	t-score
		1	2	3		
1	AA	10	9	9	9.33	44.50
2	AB	7	8	8	7.67	36.84
3	MFL	10	8	9	9.00	42.97
4	MAS	10	10	9	9.67	46.04
5	LP	11	10	10	10.33	49.11
6	JIP	10	8	9	9.00	42.97
7	MAIR	12	11	11	11.33	53.71
8	MS	9	10	9	9.33	44.50
9	M. F R	10	9	10	9.67	46.04
10	FAL	8	7	8	7.67	36.84
11	DBP	10	8	9	9.00	42.97
12	RWR	9	11	10	10.00	47.57
	Mean	9.7	9.1	9.3	9.3	-

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Table 7 presents the coordination test results for students in the Lompat tali group. Each student is identified by their initials, and their performance is measured across three trials. We calculated the mean time (in seconds) for each student and the t-score, which indicates the statistical significance of their performance. The mean times for the students range from 7.33 seconds to 15.33 seconds, reflecting varying levels of coordination. The t-scores offer additional insight into the consistency and reliability of their performance.

Table 7. Data on Coordination of Lompat Tali Group Students

| No | Initial | Tester | | | Mean | t-score |
		1	2	3		
1	AL	11	12	12	11.67	55.24
2	AM	13	13	12	12.67	59.84
3	AI	9	8	7	8.00	38.37
4	FM	14	12	11	12.33	58.31
5	F SF	15	16	15	15.33	72.11
6	MS	13	15	15	14.33	67.51
7	MZL	12	12	10	11.33	53.71
8	QRD	11	13	12	12.00	56.77
9	RSD	8	7	7	7.33	35.30
10	RS	13	12	12	12.33	58.31
11	SB	14	14	13	13.67	64.44
12	ZJ	11	10	8	9.67	46.04
	Mean	12	12	11.17	11.72	-

Student's Explosive Power Test Result

Table 8 presents the explosive power test results for students in the Engklek group. Each student is identified by their initials, and their performance is measured in terms of reach and jump heights. The difference between the reach and jump heights is calculated, along with the t-score, which indicates the statistical significance of their performance. The mean reach height for the students is 129.08 cm, and the mean jump height is 144.25 cm, resulting in an average difference of 15.17 cm. The t-scores provide additional insight into the consistency and reliability of their performance.

Table 8. Data on the Explosive Power of Engklek Group Students

No	Initial	Reach (cm)	Jump (cm)	Difference (cm)	t-score
1	AA	125	140	15	43.83
2	AB	132	143	11	31.97
3	MFL	127	142	15	43.83
4	MAS	130	145	15	43.83
5	LP	133	150	17	49.75
6	JIP	128	144	16	46.79
7	MAIR	128	147	19	55.68
8	MS	127	142	15	43.83
9	M. F R	131	147	16	46.79
10	FAL	127	139	12	34.93
11	DBP	130	145	15	43.83
12	RWR	131	147	16	46.79
	Mean	129.08	144.25	15.17	-

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Table 9 displays the results of the explosive power test for students in the Lompat tali group. Each student is identified by their initials, and their performance is measured in terms of reach and jump heights. The difference between the reach and jump heights is calculated, along with the t-score, which indicates the statistical significance of their performance. The average reach height for the students is 127.67 cm, while the mean jump height is 146.67 cm, resulting in an average difference of 19.00 cm. The t-scores provide further insight into the consistency and reliability of their performance.

Table 9. Data on the Explosive Power of Lompat Tali Group Students

No	Initial	Reach (cm)	Jump (cm)	Difference (cm)	t-score
1	AL	129	148	19	55.68
2	AM	126	147	21	61.61
3	AI	130	144	14	40.86
4	FM	127	146	19	55.68
5	F SF	131	155	24	70.50
6	MS	128	151	23	67.54
7	MZL	125	143	18	52.72
8	QRD	127	146	19	55.68
9	RSD	124	137	13	37.90
10	RS	127	147	20	58.64
11	SB	130	152	22	64.57
12	ZJ	128	144	16	46.79
	Mean	127.67	146.67	19.00	-

Student's Speed Test Result

Table 10 presents the speed test results for students in the Engklek group. Each student is identified by their initials, and their performance is measured across three trials. The mean time (in seconds) for each student is calculated, along with the t-score, which indicates the statistical significance of their performance.

Table 10. Data on Speed of Engklek Group Students

No	Initial	Tester			Mean	t-score
		1	2	3		
1	AA	8.05	7.65	8.13	7.94	39.59
2	AB	7.72	8.64	7.95	8.10	36.47
3	MFL	8.19	7.92	7.68	7.93	39.85
4	MAS	7.63	8.06	7.75	7.81	42.12
5	LP	8.16	7.24	6.09	7.16	54.76
6	JIP	7.21	7.38	7.63	7.41	50.03
7	MAIR	6.65	7.07	6.85	6.86	60.73
8	MS	7.58	7.73	7.81	7.71	44.19
9	M. F R	7.31	7.55	7.61	7.49	48.41
10	FAL	8.35	8.02	7.73	8.03	37.84
11	DBP	7.83	7.55	8.04	7.81	42.25
12	RWR	7.59	7.31	7.55	7.48	48.54
	Mean	7.69	7.68	7.57	7.64	-

The mean times for the students range from 6.86 seconds to 8.10 seconds, reflecting varying levels of speed among them. The t-scores offer further insight into the consistency and reliability of their performance.

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Table 11 summarizes the speed test results for students in the Lompat tali group. Each student is identified by their initials, and their performance is assessed across three trials. The mean time (in seconds) for each student is calculated, providing an overview of their speed performance. The mean times for each student range from 6.32 seconds to 8.00 seconds, reflecting varying levels of speed among the students. The corresponding t-scores provide additional insight into the consistency and reliability of their performance, with higher scores indicating more significant statistical differences in performance. This data highlights the impact of the Lompat tali activity on the student's speed capabilities, underlining the importance of such exercises in physical education programs.

Table 11. Data on Speed of Lompat Tali Group Students

No	Initial	Tester			Mean	t-score
		1	2	3		
1	AL	6.94	7.35	7.72	7.34	51.39
2	AM	7.12	7.62	7.49	7.41	49.96
3	AI	7.18	7.25	7.61	7.35	51.20
4	FM	7.05	7.78	7.65	7.49	48.34
5	F SF	6.67	6.01	6.38	6.35	70.52
6	MS	5.94	6.18	7.02	6.38	70.01
7	MZL	6.38	7.05	6.37	6.60	65.73
8	QRD	6.15	6.84	7.09	6.69	63.91
9	RSD	7.14	7.91	8.13	7.73	43.80
10	RS	6.92	7.25	7.60	7.26	52.95
11	SB	7.26	6.95	8.11	7.44	49.38
12	ZJ	8.03	7.81	8.23	8.02	38.03
	Mean	6.90	7.17	7.45	7.17	-

Student's Long Jump Skill Test Result

Table 12 displays the results of the long jump skills test for students in the Engklek group. Each student is identified by their initials, and their performance is measured over three trials. The mean distance (in centimeters) for each student is calculated, along with the t-score, which indicates the statistical significance of their performance. The mean distances range from 69.67 cm to 87.00 cm, reflecting differing levels of long jump skills among the students. The t-scores offer further insight into the consistency and reliability of their performances.

Table 12. Long Jump Skills Data of Engklek Group Students

No	Initial	Tester			Mean	t-score
		1	2	3		
1	AA	74	77	77	76.00	44.57
2	AB	69	70	70	69.67	33.89
3	MFL	73	74	74	73.67	40.64
4	MAS	76	78	78	77.33	46.82
5	LP	77	79	79	78.33	48.50
6	JIP	83	82	82	82.33	55.24
7	MAIR	87	88	86	87.00	63.11
8	MS	75	79	76	76.67	45.69
9	M. F R	79	78	78	78.33	48.50
10	FAL	72	70	69	70.33	35.02
11	DBP	75	75	76	75.33	43.44
12	RWR	76	78	77	77.00	46.25
	Mean	76.33	77.33	76.83	76.83	-

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Table 13 presents the long jump skill test results for students in the Lompat tali group. Each student is identified by their initials, and their performance is measured across three trials. The mean distance (in centimeters) for each student is calculated, along with the t-score, which indicates the statistical significance of their performance. The mean distances for each student range from 73.00 cm to 90.33 cm, reflecting varying levels of long jump skills among the students. Additionally, the t-scores offer further insight into the consistency and reliability of their performance.

Table 13. Long Jump Skills Data of Lompat Tali Group Students

No	Initial	Tester			Mean	t-score
		1	2	3		
1	AL	83	83	80	82.00	54.68
2	AM	85	85	83	84.33	58.62
3	AI	73	74	72	73.00	39.51
4	FM	77	77	76	76.67	45.69
5	F SF	92	89	90	90.33	68.73
6	MS	89	88	88	88.33	65.36
7	MZL	84	85	83	84.00	58.05
8	QRD	87	88	89	88.00	64.80
9	RSD	74	76	73	74.33	41.76
10	RS	86	86	89	87.00	63.11
11	SB	74	76	75	75.00	42.88
12	ZJ	76	75	78	76.33	45.13
	Mean	81.67	81.83	81.33	81.61	-

Table 14. Summary of ANOVA Results for Long Jump Performance

Source	SS	df	MS	F	p
Traditional games	152.34	1	152.34	5.72	0.025*
Motor ability levels	198.67	1	198.67	7.46	0.012*
Interaction (Game × Motor Ability)	174.90	1	174.90	6.56	0.017*
Error	556.40	20	27.82		
Total	1082.31	23			

$p < 0.05$

The ANOVA revealed significant main effects of both traditional game type and motor ability level, as well as a significant interaction between the two factors. Students in the Lompat Tali group outperformed those in the Engklek group, and students with higher motor ability showed greater improvements compared to those with lower motor ability.

Discussion

The ANOVA results (Table 14) confirm that the type of traditional game and motor ability level significantly affected long jump performance. Moreover, the significant interaction indicates that the benefits of Lompat Tali were more pronounced for students with high motor ability. These findings validate the hypothesis that traditional games can differentially enhance athletic performance depending on the nature of the activity and the initial motor ability of participants.

The data obtained from the Engklek and Lompat Tali groups offers significant insights into the influence of these traditional games on student's physical capabilities, particularly regarding agility, coordination, explosive strength, speed, and long jump performance. The results reveal substantial disparities between the two groups in these essential

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motor skills, enhancing comprehension of how each activity fosters the development of physical talents.

The agility results reveal that the Engklek and Lompat Tali groups exhibit varying levels of agility. The Engklek group had average timings between 11.78 to 14.06 seconds, but the Lompat Tali group demonstrated a marginally shorter range of 11.56 to 13.02 seconds. The findings indicate that Lompat Tali, which includes plyometric exercises, may be superior in enhancing agility relative to Engklek. Prior studies substantiate this idea, indicating that plyometric workouts, including jump rope, markedly improve agility by enhancing neuromuscular responsiveness and speed (Woodard & Chen, 2024). These findings emphasize the necessity of integrating dynamic, plyometric exercises into physical education curricula to improve agility.

The Engklek group exhibited a more uniform performance in coordination, with mean times between 7.67 and 11.33 seconds, whereas the Lompat Tali group displayed a wider range of 7.33 to 15.33 seconds. Despite the variability in the Lompat Tali group, both groups demonstrated elevated levels of coordination. However, the consistent performance of the Engklek group may indicate that Engklek is particularly effective in enhancing coordination. This is consistent with existing research highlighting the significance of proprioceptive training—such as that involved in Engklek—in improving coordination. Proprioception is crucial for motor control, as it provides the sensory feedback necessary to regulate muscle activity and enhance motor function (Iorga et al., 2023; Pramanick et al., 2022). These findings imply that Engklek may be particularly advantageous for developing student's motor coordination.

The examination of explosive power indicates that the Lompat Tali group had superior enhancements in jump height, with mean differences between 13 cm and 24 cm, in contrast to the Engklek group's range of 11 cm to 19 cm. This indicates that Lompat Tali, with its focus on vertical and horizontal jumps, is superior in augmenting explosive force. Studies have consistently demonstrated that plyometric exercises, such as jump rope activities, result in substantial enhancements in explosive power (Anggoro & Masrun, 2023; Wang et al., 2023). These exercises activate the stretch-shortening cycle of the muscles, essential for cultivating the explosive strength required for athletic endeavors like the long jump (Makaruk et al., 2020; Ramirez-Campillo et al., 2020).

The Lompat Tali group had marginally superior speed, with average times between 6.35 and 8.02 seconds, in contrast to the Engklek group's range of 6.86 to 8.10 seconds. The results indicate that Lompat Tali activities may be more efficacious in enhancing speed, which is crucial for the approach phase of the long jump. Prior research has confirmed the beneficial effects of plyometric training on speed, indicating that these exercises enhance both sprinting velocity and total speed endurance (Kryeziu et al., 2023). The integration of plyometric exercises and speed training has demonstrated efficacy in augmenting speed development through the enhancement of muscle flexibility and the effectiveness of force application (Naidu, 2016).

Finally, the long jump proficiency statistics reveal that the Lompat Tali group obtained greater outcomes, with mean distances ranging from 73.00 cm to 90.33 cm, compared to the Engklek group's range of 69.67 cm to 87.00 cm. This difference may be related to the greater explosive power and speed developed during Lompat Tali activities, which are important components of good long jump performance. Prior research indicates that motor abilities, including coordination, precision, and balance, are crucial for enhancing long jump performance (Kastrena et al., 2019), and Lompat Tali exercises probably have a more substantial role in developing these attributes. The enhancements in explosive strength and speed from Lompat Tali immediately result in a more powerful push-off and increased take-off velocity in the long jump, hence improving overall performance.

This study's findings underscore the potential of traditional games, specifically Lompat Tali, in enhancing essential motor skills that influence athletic performance. The results underscore the necessity of incorporating culturally relevant physical activities into educational curricula to foster motor skill development in children. However, the study has limitations; the sample size was relatively small, which may restrict the generalizability of the findings to a broader population. Furthermore, the study's duration of four weeks may be inadequate to assess the long-term effects of these activities on motor skill development. Future research should examine the enduring impact of traditional games on motor skill enhancement and athletic performance, as well as explore the advantages of integrating these activities with other training methodologies.

CONCLUSION

This study concludes that *Lompat Tali* is more effective than *Engklek* in improving explosive power, speed, and long jump performance, while *Engklek* is particularly beneficial for enhancing coordination. These results emphasize

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the value of integrating traditional games into physical education as culturally relevant and engaging activities to develop motor skills in children aged 10–11. Future research should involve larger and more diverse samples, longer intervention periods, and the inclusion of external factors such as nutrition and sleep to provide a more comprehensive understanding of their impact on athletic performance.

Acknowledgment

REFERENCES
Abdel-Maksoud, G., Abdel-Hamied, M., & El-Shemy, H. A. (2021). Analytical techniques used for condition assessment of a late period mummy. *Journal of Cultural Heritage*, *48*, 83–92. https://doi.org/10.1016/j.culher.2021.01.001

Adolph, K. E., & Hoch, J. E. (2020). The Importance of Motor Skills for Development. In *Nestlé Nutrition Institute Workshop Series* (Vol. 95, pp. 136–144). S. Karger AG. https://doi.org/10.1159/000511511

Arianda, E., Rustiadi, T., & Kusuma, D. W. Y. (2021). The Effect of Plyometric and Resistance Training on Increasing The Speed And Explosive Power of The Leg Muscles. *Journal of Physical Education and Sports*, *10*(2), Article 2. https://doi.org/10.15294/jpes.v10i2.48415

Ashar, Sitti Mania, Misykat Malik Ibrahim, St. Syamsudduha, Sadaruddin, & Anita Candra Dewi. (2024). The Impact of Traditional Games on Social-Emotional Development: A Comprehensive Review of Existing Research. *Journal of Learning and Development Studies*, *4*(2), 39–51. https://doi.org/10.32996/jlds.2024.4.2.5

Bremer, E., & Cairney, J. (2016). Fundamental Movement Skills and Health-Related Outcomes: A Narrative Review of Longitudinal and Intervention Studies Targeting Typically Developing Children. *American Journal of Lifestyle Medicine*, *12*(2), 148–159. https://doi.org/10.1177/1559827616640196

Burhaein, E., Tarigan, B., & Phytanza, D. T. P. (2020). The experiences and understandings of the K-13 curriculum implementation of Indonesian teachers of Adapted Physical Education (APE). *International Sports Studies*, *42*(3), 29–42. https://doi.org/10.30819/iss.42-e.04

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE.

Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications.

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. https://doi.org/10.1016/j.psychsport.2021.101916

Fiorilli, G., Mitrotasios, M., Iuliano, E., Pistone, E. M., Aquino, G., Calcagno, G., & Di Cagno, A. (2017). Agility and change of direction in soccer: Differences according to the player ages. *The Journal of Sports Medicine and Physical Fitness*, *57*(12). https://doi.org/10.23736/S0022-4707.16.06562-2

Gescheit, D. T., Cormack, S. J., Reid, M., & Duffield, R. (2015). *Consecutive days of prolonged tennis match play: Performance, physical, and perceptual responses in trained players*. https://opus.lib.uts.edu.au/handle/10453/118907

Harvey, S. P., Lambourne, K., Greene, J. L., Gibson, C. A., Lee, J., & Donnelly, J. E. (2018). The Effects of Physical Activity on Learning Behaviors in Elementary School Children: A Randomized Controlled Trial. *Contemporary School Psychology*, *22*(3), 303–312. https://doi.org/10.1007/s40688-017-0143-0

Huang, H., Huang, W.-Y., & Wu, C.-E. (2023). The Effect of Plyometric Training on the Speed, Agility, and Explosive Strength Performance in Elite Athletes. *Applied Sciences*, *13*(6), 3605. https://doi.org/10.3390/app13063605

Hussain, B., & Cheong, J. P. G. (2022). Improving gross motor skills of children through traditional games skills practiced along the contextual interference continuum. *Frontiers in Psychology*, *13*, 986403. https://doi.org/10.3389/fpsyg.2022.986403

Iorga, A., Jianu, A., Gheorghiu, M., Crețu, B. D., & Eremia, I.-A. (2023). Motor Coordination and Its Importance in Practicing Performance Movement. *Sustainability*, *15*(7), 5812. https://doi.org/10.3390/su15075812

Ismoyo, I., Nasrulloh, A., Ardiyanto Hermawan, H., & Ihsan, F. (2024). Health benefits of traditional games—A systematic review. *Retos*, *59*, 843–856. https://doi.org/10.47197/retos.v59.107467

Kastrena, E., Suherman, A., Ma'mun, A., & Nugraha, E. (2019). Correlation between Motor Ability and Long Jump Skills of Students. *Proceedings of the 3rd International Conference on Sport Science, Health, and Physical Education (ICSSHPE 2018)*. Proceedings of the 3rd International Conference on Sport Science, Health, and Physical Education (ICSSHPE 2018), Bandung, Indonesia. https://doi.org/10.2991/icsshpe-18.2019.28

Kryeziu, A. R., Iseni, A., Teodor, D. F., Croitoru, H., & Badau, D. (2023). Effect of 12 Weeks of the Plyometric Training Program Model on Speed and Explosive Strength Abilities in Adolescents. *Applied Sciences*, *13*(5), 2776. https://doi.org/10.3390/app13052776

Mahardika, E. K. (2014). Peningkatan Perilaku Sosial Anak Melalui Permainan Tardisional Jawa. *Jurnal Pendidikan Usia Dini*, *8*(2). https://doi.org/10.21009/JPUD.082.07

Makaruk, H., Starzak, M., Suchecki, B., Czaplicki, M., & Stojiljković, N. (2020). The Effects of Assisted and Resisted Plyometric Training Programs on Vertical Jump Performance in Adults: A Systematic Review and Meta-Analysis. *Journal of Sports Science & Medicine*, *19*(2), 347–357. https://doi.org/10.52082/jssm.2020.347

Naidu, B. G. (2016). Impact of Speed Training Combined With Plyometric Training and Intensive Interval Training on Speed Endurance. *IOSR Journal of Sports and Physical Education (IOSR-JSPE)*, *3*(6). https://www.iosrjournals.org/

Nurfitriyana, D. (2022, June 22). *Seru Tren Olahraga Lompat Tali alias Jumping Rope, Apa Saja Manfaat dan Bagaimana Triknya?* Good Doctor. https://www.gooddoctor.co.id/hidup-sehat/olahraga/seru-tren-olahraga-lompat-tali-alias-jumping-rope-apa-saja-triknya/

Pramanick, S., Chowdhuri, P., & Rahaman, A. (2022). A Study of Specific Coordinative Abilities between Athletes and Non-Athletes. *IOSR Journal of Sports and Physical Education (IOSR-JSPE)*, *9*(1). www.iosrjournals.org

Ramirez-Campillo, R., Andrade, D. C., Nikolaidis, P. T., Moran, J., Clemente, F. M., Chaabene, H., & Comfort, P. (2020). Effects of Plyometric

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Jump Training on Vertical Jump Height of Volleyball Players: A Systematic Review with Meta-Analysis of Randomized-Controlled Trial. *Journal of Sports Science & Medicine*, *19*(3), 489–499. https://doi.org/10.52082/jssm.2020.489

Rhodes, R. E., Guerrero, M. D., Vanderloo, L. M., Barbeau, K., Birken, C. S., Chaput, J.-P., Faulkner, G., Janssen, I., Madigan, S., Mâsse, L. C., McHugh, T.-L., Perdew, M., Stone, K., Shelley, J., Spinks, N., Tamminen, K. A., Tomasone, J. R., Ward, H., Welsh, F., & Tremblay, M. S. (2020). Development of a consensus statement on the role of the family in the physical activity, sedentary, and sleep behaviours of children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, *17*(1), 74. https://doi.org/10.1186/s12966-020-00973-0

Rizki, I. A., Suprapto, N., & Admoko, S. (2022). Exploration of physics concepts with traditional engklek (hopscotch) game: Is it potential in physics ethno-STEM learning? *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *11*(1), 19–33. https://doi.org/10.24042/jipfalbiruni.v11i1.10900

Shimray, S. A. (2024). Exploring the Cultural Significance of Traditional Games and Sports Among the Tangkhul Nagas: A Sociocultural Analysis. *International Journal For Multidisciplinary Research*, *6*(4), 25282. https://doi.org/10.36948/ijfmr.2024.v06i04.25282

Woodard, K. F., & Chen, Y. (2024). Effects of Jump Rope Lessons on Physical Skills, Inhibitory Control, and Perceived Enjoyment of Elementary Students. *Journal of Teaching in Physical Education*, *1*(aop), 1–10. https://doi.org/10.1123/jtpe.2023-0388

Zubaida, I., Hufad, A., Hendrayana, A., & Leksono, S. M. (2021). The Effect of Traditional Games Bebentengan on Aerobic Capacity and Agility. *JUARA : Jurnal Olahraga*, *6*(2), 344–349. https://doi.org/10.33222/juara.v6i2.1359

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Validity and Reliability of Sign Language Vr Media for Deaf Children's Motor Skills

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Abstract: *This study aims to validate the gesture coordination learning media based on virtual reality (Vr) technology in sign language in improving the motor skills of deaf children. The method of this research is quantitative descriptive. The data collection technique was through the FGD focus group discussion by asking for opinions from 9 experts consisting of: 3 experts in the field of learning media, 3 experts in the field of children with disabilities, and 3 experts in the field of design and ergonomics, as well as 3 experts from extraordinary school teacher practitioners. The research instrument used a questionnaire given to experts to validate the sign language virtual reality (vr) technology-based motion coordination learning media that had been designed. Data analysis uses narrative to develop a design for motion coordination learning tools based on Virtual Reality (Rv) technology, and Aiken's V analysis to test the validity of motion coordination learning media instruments based on Virtual Reality (Rv) technology, and the cronbach alpha test to test the reliability of the instrument. The results of the study show that in the content aspect of the result of the Aiken's V coefficient of 0.888, the design aspect shows the coefficient value of Aiken's V of 0.902, and the aspect of use shows the coefficient value of Aiken's V of 0.891. Furthermore, an average reliability score of 0.831 was obtained. This means that it can be concluded that all aspects of the gesture coordination learning media based on virtual reality (VR) technology in sign language to improve the motor skills of deaf children have high validity and reliability of the content of the instrument.*
Keywords: *Learning, virtual reality, motor, deaf*

Introduction

The rapid development of communication media at this time encourages seriousness in preparing learning that is easy to understand and easy to implement, while the media technology used by deaf children today in communicating is still in a limited category, including hearing aids (hearing aids), cochlear implants, speech therapy, sign language, and lip-reading (Hermawati & Pieri, 2020). Based on previous research on teaching media technology, researchers want to revolutionize previous learning media that can be repeated to get a clear and effective understanding by children with hearing and speech limitations. Researchers want to provide solutions for children with deaf disabilities in language understanding (Kumala et al., 2022). To overcome the obstacles they face and live independently and productively. It is necessary to pay serious attention to prepare a stimulus for the coordination of hand and foot movements of children with disabilities, as expressed among others: Visual stimulation (Cornejo et al., 2021). Visual stimuli arise because of the object of the image, color, form, so that it can be explored based on direct observation (Adaval et al., 2019; Galvez-Pol et al., 2020). Limitations in coordinating limbs in moving deaf children need serious attention to provide health and fitness for children who have communication barriers (Veiskarami & Roozbahani, 2020). Children who have communication barriers (deaf children) in obtaining lessons also have an impact on communication barriers between teachers and students with special needs (Ntinda et al., 2019). This is very worrisome about the lack of physical fitness and the disruption of the health of the deaf (Calgaro et al., 2021).

There are various movement delays for deaf individuals who experience delays ranging from moving, using their hands and feet, sitting, and speaking (Mishra, 2022). This causes deaf individuals to move more slowly compared to normal individuals. So that it has an impact on mastering self-help skills independently (Grattan & Demchak, 2024). One of the efforts to be able to help improve the motor development of people with deaf disabilities is to

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follow a learning guide that uses sign language. The communication approach requires a repetitive, varied, and interactive rehabilitation system (Hart et al., 2019). This kind of rehabilitation can utilize VR (Virtual Reality) technology.

Virtual Reality has many features in helping a series of rehabilitation processes. The combination of traditional cognitive medicine and VR-based methods can provide an interactive, effective and safe approach effect for the treatment of individuals with disabilities (Park et al., 2019). Therefore, current research addresses the contribution of VR to improving skills and motor, which makes them more independent and capable of performing daily tasks. VR technology is increasingly recognized as an effective tool for the rehabilitation of cognitive processes and functional abilities. VR rehabilitation framework for cognitive development first proposed by Rizzo Stasolla et al. (2023) intended for children with ADHD (Attention-Deficit Activity Disorder). Book Cheung et al. (2022) create a VR game system to prepare meals for individuals with intellectual disabilities. Peng et al. (2021) stated that VR methods play an important role in rehabilitation, especially rehabilitation of motor function recovery. VR-based methods, especially in the form of activities that resemble games, are able to move and perform physical activities.

Forms that help the development of these two aspects are usually given repetitive therapy (Schaper et al., 2020). But of course, if the rehabilitation system is not motivating, participants will get bored quickly. Therefore, researchers carry motor movement training in the form of play activities as a rehabilitation technology, because it can provide variety, exciting sensations and motivation to users. In this case, of course, it is not only the exciting aspect that is considered in designing a rehabilitation system (Charles et al., 2022), For this reason, an appropriate exercise guide system design is needed. An appropriate motion coordination design system to improve visual ability to understand information In order to make the instructions more immersive, HMD (Head Mounted Device) in the form of virtual reality is also provided to the user (Kourtesis et al., 2019). But of course, it must be conceptualized as an easy-to-understand movement indicator appearance control that is low-cost. Thus, it is necessary to know the feasibility of the product for the development of a sign language interactive video system that is low-cost, easy to use, and interactive for users. This research seeks to develop the knowledge of deaf children themselves in obtaining instructions and directions from sign language experts through the media because it is not easy to get information media for deaf children (Mohammdi & Elbourhamy, 2023). Based on previous research, the purpose of this study is to test the feasibility of the validity and reliability of the development of motion coordination learning media based on virtual reality (VR) technology-based sign language to improve the motor skills of deaf children.

MATERIALS AND METHODS

Study Participant

Validation of gesture coordination learning media based on virtual reality (Vr) technology in sign language using expert or expert assessment. The assessors consisted of 9 experts, including: 3 experts in the field of motion learning media, 3 experts in the field of children with disabilities, and 3 experts in the field of design and ergonomics, as well as 3 experts from extraordinary school teacher practitioners.

Research Design

This study uses a type of quantitative descriptive research with a development approach.

Research Procedure

The data collection technique uses FGD. The research instrument used a questionnaire given to experts to validate the gesture coordination learning media based on virtual reality (Vr) technology in sign language that had been designed with a score of 1 – 5. The score contains the determination of "very good (5)", "good (4)", "quite good (3)", "less (2)", "very poor (1)". The content of the statement item consists of 3 aspects, namely the content aspect, the design aspect, and the use aspect. and continued with the cronbach alpha test to test the reliability of the instrument.

Analysis Data

Data analysis uses Aiken's V analysis to test the validity of the test instrument, and continued with the cronbach Alpha test to test the reliability of gesture coordination learning media based on virtual reality (Vr) technology using sign language using the help of microsoft excel.

RESULTS

Aiken's V Validity Results

The aspect of motion coordination learning media based on virtual reality (Vr) technology in sign language has experts consisting of 9 experts, namely: 3 experts in the field of motion learning media, 3 experts in the field of design and ergonomics, and asked for the opinions of 3 experts from SLB teacher practitioners, which includes assessment aspects: 1) Content aspect, 2) Design aspect, 3) Usage aspect. Expert assessments use a range of 1 to 4. The assessment is closer to number 1 the less relevant, the closer the assessment is to the number 4 the more relevant. The assessment data was then quantitatively analyzed using Aiken's V formula to test the validity of the motion coordination learning media based on virtual reality (Vr) technology. The results of the acquisition of Aiken's validity test data are as shown in Table 1 below:

Table 1. Aiken's V Validity Test Results

Statement	Assessment									V	Information	Aspects
	1	2	3	4	5	6	7	8	9			
1	5	4	5	5	5	4	5	5	4	0.91667	Tinggi	
2	5	4	5	4	4	5	5	5	4	0.88889	Tinggi	
3	5	5	5	4	4	4	4	4	5	0.86111	Sedang	
4	5	4	5	4	5	5	5	5	4	0.91667	Tinggi	
5	5	4	4	4	5	4	4	5	4	0.83333	Sedang	Fill
6	5	4	5	4	4	5	5	5	4	0.88889	Tinggi	
7	5	5	5	5	4	5	5	4	4	0.91667	Tinggi	
Mean	5	4.28	4.85	4.28	4.42	4.57	4.71	4.71	4.14	0.88889	Tinggi	
1	5	4	4	5	5	4	5	4	4	0.86111	Sedang	
2	5	5	4	5	5	4	5	5	4	0.91667	Tinggi	
3	5	5	4	5	4	4	4	5	4	0.86111	Sedang	Design
4	5	5	5	5	5	4	5	5	4	0.94444	Tinggi	
5	5	5	4	5	5	4	4	5	4	0.88889	Tinggi	
6	5	5	5	5	5	4	5	5	4	0.94444	Tinggi	
Mean	5	4.83	4.33	5	4.83	4	4.66	4.83	4	0.90278	Tinggi	
1	4	4	5	4	5	5	5	5	5	0.91667	Tinggi	
2	5	5	5	5	5	4	4	4	4	0.88889	Tinggi	
3	5	4	4	5	5	4	4	4	4	0.83333	Sedang	
4	5	5	4	5	4	4	5	4	4	0.86111	Sedang	
5	5	4	4	5	4	5	5	4	4	0.86111	Sedang	Use
6	5	5	5	4	5	5	5	4	4	0.91667	Tinggi	
7	5	5	5	4	5	5	5	4	4	0.91667	Tinggi	
8	5	5	5	5	4	5	4	5	4	0.91667	Tinggi	
9	4	4	4	5	5	5	5	5	4	0.88889	Tinggi	
10	4	4	5	4	5	5	5	5	5	0.91667	Tinggi	
11	5	5	4	5	5	4	4	5	4	0.88889	Tinggi	
Mean	4.727	4.54	4.54	4.63	4.72	4.63	4.63	4.45	4.18	0.89142	Tinggi	
Overall Mean Score	4.90	4.55	4.57	4.64	4.66	4.40	4.67	4.668	4.10	0.894361	Tinggi	

Based on table 1. The aspect (content) shows the average result of Aiken's V coefficient of 0.888 including the medium category, the aspect (design) shows the average value of Aiken's V coefficient of 0.902 including the high category, the aspect (use) shows the average value of Aiken's V coefficient of 0.891 including the high category. Based on the classification of validity submitted by (Duke et al., 2020) are as follows: V < 0.00:invalid, V ≤ 0.4 low validity, $0.4 \leq V \leq 0.8$ low validity, and $V \geq 0.8$ high validity. The average value of all aspects shows that the coef-

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ficient value of Aiken's V is 0.894, so it can be concluded that all aspects of the gesture coordination learning media based on virtual reality (Vr) technology with sign language for the motor deaf have high or valid content validity.

Instrument Reliability Results

Based on statistical analysis using the Cronbach Alpha formula, the following data are obtained:

Table 2. Instrument Reliability Test Results

Assessment	X
1	117
2	109
3	108
4	110
5	113
6	105
7	111
8	109
9	98
Total Variants	27.861111
Item Variants	6.25
Cronbach Alpha Values	0.8319308
Standard	0.6
Information	Reliable

Based on statistical analysis of reliability tests that have been carried out using the Cronbach Alpha test. The results of the calculation obtained a significance value of $0.830 \geq 0.06$. This means that in the virtual reality (Vr) technology-based movement coordination learning media with sign language for deaf children's motor skills has high and adequate reliability. Therefore, it has been declared reliable and has a high level of consistency and stability.

DISCUSSION

Based on the results of the study, it can be discussed in this study, namely that the sign language virtual reality (Vr) technology-based movement coordination learning media for deaf motor children has a fairly high level of validity and reliability. The validation sheet was filled out by 9 experts, namely: 3 experts in the field of motion learning media, and 3 experts in the field of design and ergonomics, and asked for opinions from 3 experts from SLB teacher practitioners.

In June 2024, the first FGD was carried out and received comments and suggestions from experts to optimize movement coordination learning media based on virtual reality (Vr) technology, especially for people with hearing impairments, including the following: a) the materials used are ensured to be of good quality and safe to use for users, b) must pay attention to the dimensions or size of the device so that it is stable, c) need information on the function of VR tools, d), e) pay attention to the safety of using virtual reality (VR) tools.

After the first FGD was carried out by 9 experts, then the researcher improved the design of the virtual reality (Vr) technology-based learning media according to the advice of experts or experts. One month later, a second FGD was held again in July 2024 to see the extent of the development of the learning media carried out by experts, and can summarize some comments from experts as follows: a) virtual reality (VR) tools have undergone changes for the better in terms of materials, safety, comfort and accuracy. b) from the aspect of designing a framework for learning media based on virtual reality (Vr) technology for deaf children is good, c) the learning media is adaptive so that it is suitable for people with disabilities to be used, d) virtual reality (Vr) technology-based learning media can help teachers or trainers to improve motor skills for people with deaf disabilities and are easy to carry anywhere, e) virtual images have functioned well and the objects of learning media have been seen very clearly and easily interact with the environment in front of them, e) visual videos in each motion learning model are good, f) the display of colors

and images has been able to attract the attention of people with deaf disabilities.

Research findings on virtual reality (Vr) technology-based motion coordination learning media corroborate the findings (Alim et al., 2023; Susiono et al., 2024) which states that the V coefficient above 0.760 indicates adequate content validity. In other words, the design of a gesture-based virtual reality (Vr) technology-based motion coordination learning media to improve the motor skills of deaf children has been supported by nine academic and professional experts. Their ranking shows that the virtual reality (Vr) technology-based motion coordination learning media has high content validity. Experts support the learning media of movement coordination based on virtual reality (Vr) technology, which is the last learning medium to improve motor skills for people with disabilities.

In addition to having high validity, sign language virtual reality (Vr) technology-based motion coordination learning media to improve the motor skills of deaf children must also be measured for reliability. After being analyzed, the physical fitness test instrument has a reliability value using the Cronbach Alpha formula ≥ 0.06, which means that the virtual reality (Vr) technology-based motion coordination learning media has a very good reliability value. This is reinforced by the findings (Taber, 2018) who said that the Cronbach Alpha value above 0.06 shows that it has high enough reliability, so the virtual reality (Vr) technology-based motion learning media is feasible to use.

In the first stage, the definition of virtual reality (Vr) technology-based motion learning media for the deaf was derived from a literature review with thematic analysis, showing that it is a tool that can be used as a learning medium for the deaf. To ensure the quality of technology-based learning media for deaf children, it is necessary to have empirical content, validity and reliability (Mohamad et al., 2015). On the one hand, if the virtual reality (Vr) technology-based motion learning media for deaf people used in the study shows high content validity and reliability, it means that the learning media can effectively fulfill the function of its use in accordance with the intended goal of improving the motor skills of deaf children.

Therefore, it can be concluded that all aspects of motion learning media based on virtual reality (Vr) technology for the deaf to improve motor skills have excellent content validity and reliability. The results of the validity of the content in this study can be used as a basis for testing with users. The empirical results of the trial will strengthen the validity and reliability of this trial. This virtual reality (Vr) technology-based motion learning media has been specially designed for children with deaf disabilities with the aim of improving children's motor skills.

CONCLUSION

Based on the results and discussion, it can be concluded that the virtual reality (Vr) technology-based motion coordination learning media has high content validity according to the Aiken Criteria. The average value of all aspects shows that the coefficient value of Aiken's V is 0.894, so it can be said that all aspects of the virtual reality (Vr) technology-based movement coordination learning media to improve motor skills for the deaf have high or valid content validity. It is recommended to further strengthen this virtual reality (Vr) technology-based motion coordination learning media by carrying out empirical validity and reliability.

REFERENCE

Adaval, R., Saluja, G., & Jiang, Y. (2019). Seeing and thinking in pictures: A review of visual information processing. *Consumer Psychology Review*, *2*(1), 50–69. https://doi.org/10.1002/arcp.1049

Alim, A., Tomoliyus, Refiater, U. H., & Gani, I. (2023). Sensor-based Reactive Agility Measurement Tool for Net Game Group Sports: Content Validity. *Retos*, *51*, 167–171. https://doi.org/10.47197/retos.v51.100564

Calgaro, E., Craig, N., Craig, L., Dominey-Howes, D., & Allen, J. (2021). Silent no more: Identifying and breaking through the barriers that d/Deaf people face in responding to hazards and disasters. *International Journal of Disaster Risk Reduction*, *57*, 102156. https://doi.org/10.1016/j.ijdrr.2021.102156

Charles, D., Holmes, D., Charles, T., Mcdonough, S., Charles, D., Holmes, D., & Charles, T. (2022). *Interactive Virtual Reality Stroke Rehabilitation Sys- tem Design*.

Cheung, J. C.-W., Ni, M., Tam, A. Y.-C., Chan, T. T.-C., Cheung, A. K.-Y., Tsang, O. Y.-H., Yip, C.-B., Lam, W.-K., & Wong, D. W.-C. (2022). Virtual reality based multiple life skill training for intellectual disability: A multicenter randomized controlled trial. *Engineered Regeneration*, *3*(2), 121–130. https://doi.org/10.1016/j.engreg.2022.03.003

Cornejo, R., Martínez, F., Álvarez, V. C., Barraza, C., Cibrian, F. L., Martínez-García, A. I., & Tentori, M. (2021). Serious games for basic learning mechanisms: reinforcing Mexican children's gross motor skills and attention. *Personal and Ubiquitous Computing*, *25*, 375–

390. https://doi.org/10.1007/s00779-021-01529-0

Duke, C., Hamidi, S., & Ewing, R. (2020). Validity and reliability. In *Basic Quantitative Research Methods for Urban Planners* (pp. 88–106). Routledge.

Galvez-Pol, A., Forster, B., & Calvo-Merino, B. (2020). Beyond action observation: Neurobehavioral mechanisms of memory for visually perceived bodies and actions. *Neuroscience & Biobehavioral Reviews*, 116, 508–518. https://doi.org/10.1016/j.neubiorev.2020.06.014

Grattan, J., & Demchak, M. (2024). Using System of Least Prompts to Teach Self-Help Skills to Students Who Are Deafblind. *Research and Practice for Persons with Severe Disabilities*, *49*(2), 107–125. https://doi.org/10.1177/15407969241231204

Hart, T., Dijkers, M. P., Whyte, J., Turkstra, L. S., Zanca, J. M., Packel, A., Stan, J. H. Van, Ferraro, M., Otr, L., Chen, C., & Otr, L. (2019). SPECIAL COMMUNICATION A Theory-Driven System for the Specification of Rehabilitation Treatments. *Archives of Physical Medicine and Rehabilitation*, *100*(1), 172–180. https://doi.org/10.1016/j.apmr.2018.09.109

Hermawati, S., & Pieri, K. (2020). Assistive technologies for severe and profound hearing loss: Beyond hearing aids and implants. *Assistive Technology*. https://doi.org/10.1080/10400435.2018.1522524

Kourtesis, P., Collina, S., Doumas, L. A., & MacPherson, S. E. (2019). Technological competence is a pre-condition for effective implementation of virtual reality head mounted displays in human neuroscience: a technological review and meta-analysis. *Frontiers in Human Neuroscience*, *13*, 342

Kumala, F. N. F., Kamalia, A., & Khotimah, S. K. (2022). Gambaran Dukungan Sosial Keluarga yang Memiliki Anak Tuna Rungu. *Personifikasi: Jurnal Ilmu Psikologi*, *13*(1), 1–10.

Mishra, R. (2022). *Developmental delays and their implications in the life cycle. December*, 52–56.

Mohamad, M. M., Sulaiman, N. L., Sern, L. C., & Salleh, K. M. (2015). Measuring the Validity and Reliability of Research Instruments. *Procedia - Social and Behavioral Sciences*, *204*(November 2014), 164–171. https://doi.org/10.1016/j.sbspro.2015.08.129

Mohammdi, H. M., & Elbourhamy, D. M. (2023). An intelligent system to help deaf students learn Arabic Sign Language. *Interactive Learning Environments*, *31*(5), 3195–3210. https://doi.org/10.1080/10494820.2021.1920431

Nelson, S., Darni, R., & Haris, F. (2022). Development Augmented Reality (AR) Learning Media for Pencak Silat Course at Faculty of Sports and Science Universitas Negeri Padang. *Educational Administration: Theory and Practice*, *28*(01), 37–46.

Ntinda, K., Thwala, S. K., & Tfusi, B. (2019). *Experiences of Teachers of Deaf and Hard- of- Hearing Students ' in a Special Needs School : An Exploratory Study*. *7*(7). https://doi.org/10.11114/jets.v7i7.4274

Park, M. J., Kim, D. J., Lee, U., Na, E. J., & Jeon, H. J. (2019). *A Literature Overview of Virtual Reality (VR) in Treatment of Psychiatric Disorders : Recent Advances and Limitations*. *10*(July), 1–9. https://doi.org/10.3389/fpsyt.2019.00505

Peng, Q., Yin, L., & Cao, Y. (2021). *Effectiveness of Virtual Reality in the Rehabilitation of Motor Function of Patients With Subacute Stroke : A*. *12*(May). https://doi.org/10.3389/fneur.2021.639535

Schaper, N. C., Netten, J. J. Van, Apelqvist, J., Hinchliffe, R. J., Lipsky, B. A., & Board, I. E. (2020). *Practical Guidelines on the prevention and management of diabetic foot disease (IWGDF 2019 update)*. *36*, 1–10. https://doi.org/10.1002/dmrr.3266

Stasolla, F., Lopez, A., Akbar, K., Vinci, L. A., & Cusano, M. (2023). *Matching Assistive Technology , Telerehabilitation , and Virtual Reality to Promote Cognitive Rehabilitation and Communication Skills in Neurological Populations : A Perspective Proposal*. https://doi.org/10.3390/technologies11020043

Susiono, R. S., Sugiyanto, F. S., Lumintuarso, R. L., Tomoliyus, T., Sukamti, E. R. S., Fauzi, F., Hariono, A. H., & Prabowo, T. A. P. (2024). Agility Test Innovation on Special Badminton Athletes for the Junior Category (U17): Validity and Reliability. *Retos*, *53*, 547–553. https://doi.org/10.47197/retos.v53.103282

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, *48*, 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Veiskarami, P., & Roozbahani, M. (2020). *Motor development in deaf children based on Gallahue 's model : a review study*. *29*, 10–25. https://doi.org/10.18502/avr.v29i1.2364

Widyastuti, E. (2019). Using the ADDIE model to develop learning material for actuarial mathematics. *Journal of Physics: Conference Series*, *1188*(1), 12052. https://doi.org/10.1088/1742-6596/1188/1/012052

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EXERCISE AND EMOTIONAL WELL-BEING: WHAT DOES PHYSICAL ACTIVITY BRING TO OUR HAPPINESS?

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Abstract: *This review paper was created with the intention of critically examining the findings of contemporary scientific research studies that explore the relationship between physical activity and the perception and experience of positive emotions and emotional states. The method used is bibliographic-speculative. The results indicate that physical activity contributes to the perception and experience of positive emotional states (colloquially: happiness), as assessed through some of the most commonly measured parameters (higher levels of subjective and psychological wellbeing, positive affect, quality of life, and lower levels of depression, anxiety, and stress) across all stages of life.*

Keywords: *physical activity, wellbeing, happiness, satisfaction with life*

INTRODUCTION

As in everyday life, physical exercise is most commonly linked to mental health in science through understanding the impact of physical activity on mood (Popov & Jakovljev, 2017). Besides professional sports, people engage in physical activity for recreation and to maintain physical and mental health. Numerous studies confirm the connection between recreational exercise and psychological well-being (Hassmen et al., 2000). Physical activity in this context is defined as any bodily movement produced by skeletal muscles and results in energy expenditure. In contrast, physical exercise refers to a specific form of physical activity that is planned, structured, and repeated to improve or maintain physical fitness (Caspersen et al., 1985). On the other hand, pursuing happiness is a universal human aspiration, as research shows that people in nearly all cultures most often cite achieving happiness as their primary life goal (Diener & Oishi, 2000). Furthermore, most people consider happiness the most important life value (Diener & Oishi, 2004). These studies suggest that quality of life and mental health are not characterized by a neutral state or the absence of negative experiences but by pleasant emotions and satisfaction with various aspects of life[1]. Moreover, subjective well-being is significant at the individual level – happiness and life satisfaction, along with economic and social indicators- and represents key indicators of quality of life in society (Diener & Suh, 1998). Subjective well-being (SWB) refers to an individual's assessment of their own life in terms of satisfaction, positive emotions, and the absence of negative emotions (Diener, 1984). It is a multidimensional construct that encompasses a cognitive component (life satisfaction) and an affective component (the frequency and intensity of positive and negative emotions) (Diener et al., 1999). High subjective well-being is associated with better mental and physical health, better interpersonal relationships, and greater productivity (Lyubomirsky et al, 2005).

This paper aims to review research on the relationship between physical activity and subjective well-being to answer the question: Is it worth "sweating" for happiness, or does physical activity help in experiencing pleasant emotions and happiness? Additionally, this paper seeks to answer in which age groups and at what intensity physical activity contributes to life satisfaction. Since happiness is a highly individual feeling that cannot be generalized, the research is based on the connection between measurable parameters used in science to describe the feeling of happiness and physical activity. The paper primarily relies on recent research, although several foundational older studies are referenced. The impact of physical activity on these parameters has been explored across life stages from adolescence to late adulthood.

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1 **Positive psychology** is a scientific discipline that focuses on the importance of positive emotions for mental health, as well as overall psychological functioning, and serves as a complement to the previously pathology-centered approach to the science of mental health (Seligman & Csikszentmihalyi, 2000).

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What is the Measure of Happiness in a Psychological Sense?

Pursuing happiness is likely a key determinant of human existence (Ellis, 2001). The need and ambition to achieve the ideal of happiness is common to everyone across all eras and social systems (Seligman, 2002; Csikszentmihalyi, 1990). What distinguishes people in this regard is the way they attain happiness. Some find happiness in the company of others, while others find it in solitude. Listening to music brings one person immense joy, leaving another completely unmoved. There are individuals whose sense of happiness is directly tied to physical appearance and presence; others pay little attention to such things. The victory of a favorite football team in a major competition may be a lasting source of joy for one person, while another may hardly be aware that the sport exists. From a material perspective, some find great happiness in acquiring wealth, while others are pleased living a life oriented toward spiritual values, owning very little (Diener & Seligman, 2004). Empirical findings indicate that the intensity of happiness experienced remains moderately expressed by most people. High-intensity feelings of happiness are typically short-lived episodes, after which most individuals return to a stable state of mild positive emotions (Diener & Diener, 1996).

Although the experience of happiness is nearly universal, the conceptualization of this phenomenon remains a challenge due to its multidimensional nature. It has been shown that pleasant sensory stimuli—such as optimal temperature, harmonious sounds, pleasant scents, tastes, and aesthetic scenes—significantly contribute to the immediate feeling of pleasure. However, a lasting and deeper experience of happiness requires the integration of higher psychological processes, including a sense of life meaning, inner harmony, and spiritual fulfillment (Ng, 2022). Is the psychological experience of happiness primarily a matter of perception?

Given the high degree of subjectivity in the experience of happiness, psychological science resorts to operationalizing related constructs, such as Quality of Life (QOL). The World Health Organization defines quality of life as "an individual's perception of their position in life in the context of the culture and value systems in which they live, and about their goals, expectations, standards, and concerns." The WHOQOL-100 instrument was developed for empirical research, encompassing six domains: physical health, psychological health, level of independence, social relationships, environment, spirituality, religion, or personal beliefs (Pavićević & Minić, 2018). A key advantage of quality of life as a parameter defined by the WHO is its relatively good measurability, which serves its purpose as a statistical indicator. However, although it is a predictor, quality of life cannot be equated with happiness. Is a quality life also a good life?

In the search for an answer to the question of what truly constitutes a good life in the context of mental health, two major lines of thought have emerged. The first is the *hedonistic* approach, which defines a good life as one filled with pleasures, happiness, and comfort (Diener et al., 2006). The hedonistic perspective has been supported by many thinkers throughout history, from Aristippus of Cyrene to more modern philosophers like Thomas Hobbes and Jeremy Bentham. Hedonism defines life satisfaction along a continuum—from a relatively narrow understanding of "a life filled with physical pleasures" to a broader definition of hedonism as "the idea of what makes life pleasant or unpleasant."

The second line of thought is the *eudaimonistic* approach, which sees a good life as one directed toward the fulfillment of human potential. Aristotle regarded hedonism as a vulgar ideal that reduces people to slaves of their own pleasures. Erich Fromm warned of the difference between subjective needs and objectively valid needs, considering the former harmful and the latter essential for human potential development (Ryan & Deci, 2001). Simplified, the hedonistic approach can be defined as the pursuit of pleasure, while the eudaimonistic approach is the pursuit of overall personal growth. These approaches are strictly distinguished only at the philosophical level, while on the personal level, they may overlap.

In the continued search for a clearer definition and measurement of happiness, it has been linked to *psychological well-being*, defined through six variables: self-acceptance, positive relations with others, autonomy, environmental mastery, purpose in life, and personal growth (Ryff, 1989). Still eluding precise definition, the concepts of happiness, the good life, quality of life, and psychological well-being are often inconsistently used and interchangeably applied in the literature.

Methodology

This paper is based on a narrative, bibliographic-speculative review of empirical and theoretical studies examining the relationship between physical activity and indicators of happiness and emotional well-being across the lifespan. Electronic searches were conducted in major scientific databases, including Web of Science, Scopus, PubMed, and Google Scholar. The search strategy combined keywords such as *physical activity*, *exercise*, *subjective well-being*, *psychological well-being*, *happiness*, *life satisfaction*, *quality of life*, *mental health*, and *aging*. Reference lists from relevant articles, books, and review papers were also screened to identify additional sources.

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The inclusion criteria for the empirical studies discussed in this review were:
1. peer-reviewed publications,
2. studies that operationalized physical activity or exercise as an independent or predictor variable,
3. studies that included at least one indicator of subjective well-being, psychological well-being, life satisfaction, quality of life, or related positive and negative affective states (e.g., depression, anxiety, stress),
4. studies conducted on non-clinical populations, from adolescence to old age.

Both cross-sectional and longitudinal designs, as well as randomized controlled trials and meta-analyses, were considered. Foundational theoretical and conceptual contributions on happiness and well-being were also included in order to contextualize and interpret empirical findings. Given the narrative character of this review, studies were not formally coded, and no quantitative meta-analysis was performed. Instead, the emphasis was on integrating findings, identifying recurring patterns, and highlighting open questions relevant for future research.

RESULTS

The Connection Between Physical Activity and Positive Indicators of Mental Health

Caspersen defined physical activity as "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen et al., 1985). Numerous studies have observed a positive relationship between physical activity and improvements in various parameters associated with happiness. One of the earlier large-scale randomized cluster studies (Ferron et al., 1999), conducted in Switzerland, included 9,268 individuals aged 15–20. The study aimed to determine the association between the frequency of sports activities and somatic (cardiovascular) and mental health. The findings showed a link between low levels of physical activity and health problems such as headaches, insomnia, stomach pain, and general physical weakness. Conversely, students who regularly engaged in physical activity reported higher levels of energy, optimism, and confidence in their health and lower levels of anxiety, stress, and suicidal ideation.

More recent studies have yielded similar results. A comprehensive study by Malagodi and colleagues (Malagodi et al., 2024) focused on the student population and the conditions available for engaging in sports at British universities. The study addressed growing concerns over the worsening mental health indicators observed among students over the past 15 years. Promoting physical activity was identified as a key strategy in preserving and improving mental health. The research found that out of 143 universities, only 45 (36%) had appropriate facilities for engaging in physical activities, and only 54 interventions had been implemented to increase participation in and improve conditions for physical activity.

Younger individuals were also the target group in a study by Asquith and colleagues (Asquith et al., 2022). Three cohort studies were conducted among individuals aged 14–15, 16–17, and 18–20, examining, among other factors, the influence of leisure-time physical activity on their well-being. The study focused on five well-being factors: life satisfaction, positive affect, negative affect, mental health, and so-called "flourishing mental health."[2] The findings showed that physical activity benefits younger populations, highlighting the detrimental impact of screen time. Time spent in front of electronic devices often replaces time dedicated to physical activity, socialization, and sleep.

The Danish cohort study by Ibanez Roman and colleagues (Ibanez Roman et al., 2023) is a very current contribution to the field. This research aimed to investigate the relationship between physical activity and positive mental health, specifically mental well-being. The study design is both interesting and innovative, as it analyzes physical activity levels in 2020 and correlates them with mental well-being measured in 2019. In a representative sample of 5,000 individuals aged 15 and older, it was found that mental well-being in 2019 could predict the likelihood of engaging in ≥150 minutes of physical activity per week in 2020, suggesting a reciprocal relationship: happier individuals tend to exercise more, and individuals who exercise more tend to be happier.

The benefits of physical activity for life satisfaction in younger populations were the subject of a study involving 1,002 high school students in Macau, Taipei, and Qujing. The study proposed that physical activity positively impacts reductions in depression, anxiety, and psychological/emotional distress in adolescents. A positive correlation was confirmed: as physical activity increased, so did life satisfaction. The results suggest that high schools should implement strategies to increase students' physical activity levels. Two strategies were proposed: systematic education through the curriculum and a wide range of extracurricular and elective sports activities (Chen et al., 2020).

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2 **Flourishing mental health** refers to a state where individuals experience high levels of emotional well-being, psychological functioning, and social functioning. It is more than simply the absence of mental illness; flourishing describes optimal human functioning characterized by positive emotions, life satisfaction, a sense of meaning and purpose, strong relationships, and effective coping with life's challenges (Keyes,2002)

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The link between physical activity and variables related to happiness in younger individuals has also been recognized and confirmed. A Croatian research team explored which intensity and domain of physical activity are most closely related to life satisfaction. They used WHO's standard recommendation that physical activity can be categorized into light, moderate, and vigorous intensity and that recommended levels can be achieved in various life domains — at work, at home, during commuting, or in leisure time. Their study suggested that although the domain of physical activity may not be critical for somatic health, it does influence life satisfaction. In a sample of 1,750 students from the University of Zagreb, a weak but present correlation was found between vigorous physical activity during leisure time and life satisfaction (Pedišić et al., 2015).

The relationship between the type and intensity of physical activity and indicators of positive (positive affect, subjective well-being, and unconditional self-acceptance) and negative (depression, anxiety, stress, negative affect, and conditional self-acceptance) mental health was the focus of a study by Popov and colleagues. Conducted in Serbia on a sample of 939 participants from the general population aged 18 to 75, the study found that physically active individuals exhibit higher levels of positive mental health indicators and lower levels of negative ones. However, there was no significant difference between recreational exercisers and highly dedicated fitness practitioners (Popov et al., 2023).

The correlation between intensity and volume of physical activity and subjective well-being was explored in a randomized study involving 22,971 individuals from 28 European Union countries (Wicker & Frick, 2015). The findings suggest that for adults, an increase in moderate-intensity physical activity (as defined by the WHO) leads to improved subjective well-being. However, increasing the volume of high-intensity physical activity is associated with a decrease in subjective well-being. These findings challenge the WHO's guidelines, which equate moderate and vigorous physical activity in terms of their positive health effects, including their effects on subjective well-being.

In later life, depression often accompanies degenerative aging processes and the loss of social roles. Research by Ekkakis and Murri suggests that physical activity is equally as effective as medication or psychotherapy in cases of moderate depression (Ekkakis & Murri, 2017). Much earlier, a longitudinal study by Morgan and Bath (1998) monitored the psychological well-being associated with physical activity among 1,042 individuals over the age of 65 over an eight-year period. Three types of physical activity were assessed: walking, housework and yard work, and leisure-time physical activities. Following the initial measurement, follow-ups were conducted after four and eight years. A weak positive correlation was observed between physical activity levels and psychological well-being. However, the authors raised concerns about the mechanism underlying this effect, suggesting that socialization and the sense of accomplishment associated with physical activity may have contributed to the observed outcomes.

Chinese researchers designed a study aiming to determine which intensity of physical exercise best supports the concept of healthy aging, defined through a model encompassing the following components: (1) absence of significant diseases, (2) absence of disability, (3) preserved cognitive function, (4) independence, (5) active social interactions, and (6) high life satisfaction. The study included 9,026 individuals aged 60 and older. Physical activity intensities were categorized into three levels: vigorous, moderate, and light. Considering the participants' age, vigorous activity was defined as any that leads to shortness of breath, such as cycling, digging, or carrying heavy loads. Moderate intensity refers to activities that increase breathing rate, such as carrying light loads, brisk walking, or practicing Tai Chi. Light-intensity activities were defined as those that do not affect breathing patterns. Moderate intensity was identified as the most significant predictor of successful aging, and it also showed a positive impact on life satisfaction (Chen et al., 2021).

Finally, a meta-analysis by Morgan and colleagues (Morgan et al., 2019) synthesized findings from 39 studies on the effects of physical activity on quality of life. The summarized conclusions suggest that maintaining a habit of physical activity in older age supports the often challenging transition to a life with fewer responsibilities, reduced social roles, and diminished societal relevance. On a daily level, physical activity can alter monotonous routines and enhance one's sense of purpose, meaning, and direction. Group-based physical activities can increase feelings of connection, belonging, support (both given and received), and self-confidence. Such group activities typically foster socialization, laughter, and positive mood—elements that are particularly valuable to older adults.

Discussion

A review of available studies shows a fairly consistent pattern: physical activity across ages is most often associated with higher levels of life satisfaction and subjective well-being, as well as lower levels of depression, anxiety,

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and stress. Among younger respondents, the frequency and intensity of leisure-time exercise stand out. More active adolescents and students report higher levels of positive emotions and lower levels of emotional distress (Ferron et al., 1999; Chen et al., 2020; Pedišić et al., 2015).

Data from larger European and Asian samples provide a somewhat more nuanced picture. Moderate-intensity physical activity is generally associated with more favorable psychological outcomes in adults, whereas very intense or prolonged exercise is not necessarily associated with higher subjective well-being; in some cases, it even goes in the opposite direction (Wicker & Frick, 2015). In older adults, activities that are not excessively demanding – such as brisk walking or low-intensity exercise – are the most reliable predictors of life satisfaction and overall aging success (Chen et al., 2021; Morgan & Bath, 1998).

Several studies also indicate that the relationship between physical activity and well-being is likely not unidirectional. People who feel psychologically better often find it easier to establish a routine of regular physical activity, and this routine can then help maintain or improve their emotional state (Ibanez Roman et al., 2023). In studies looking at depressive symptoms in older age, physical activity has occasionally been shown to be as beneficial as standard therapeutic approaches for mild forms of depression, although it is clear that other factors, such as social contact and a sense of accomplishment, also influence the outcome (Ekkekakis & Murri, 2017; Morgan et al., 2019).

Although the results are generally consistent, there are limitations. Many studies rely on self-reports of physical activity and well-being, which may bias the accuracy of the findings. Cross-sectional designs are still standard, making it difficult to draw firm conclusions about causality. Studies also vary considerably in how they measure activity (volume, domain, intensity) and in the instruments they use to assess subjective well-being, making direct comparisons difficult. In addition, qualitative aspects of activity – for example, whether it is recreational, work-related, or group-based – likely play a role in how a person feels after exercise, but these factors remain under-examined in many studies (Pedišić et al., 2015; Morgan et al., 2019).

Overall, the available evidence suggests that physical activity is an important, but not the only, element of emotional well-being. Its contribution depends on age, activity intensity, personal preferences, social environment, and broader lifestyle. Further research could clarify how different types of movement – and the contexts in which they occur – shape the subjective experience of the "good life".

Conclusion

A clear definition of happiness continues to elude scientists. If it is any consolation, philosophers, writers, and poets have not had much more success. Still, happiness can be indirectly measured through various auxiliary and quantifiable variables, the most commonly represented in the literature being life satisfaction, psychological well-being, and subjective well-being. Can physical activity contribute to the subjective experience of happiness? Numerous studies have confirmed the positive impact of physical activity on these measurable variables across all stages of life. In children and adolescents, the greatest effect has been observed with high-intensity exercise; in middle age, with moderate intensity; and in older adulthood, it is important to maintain the habit of physical exercise. The influence of socializing, companionship, and well-structured leisure time increases, particularly through group-based physical activities. The results of the analyzed studies provide an unequivocal answer to the question posed in the title. In pursuit of happiness and life satisfaction, it is worth engaging in physical activity—intensively in youth, moderately in middle age, and in groups during old age.

Future research in this field still faces unanswered questions: How does gender influence the relationship between physical activity intensity and healthy aging components, including subjective life satisfaction? Additionally, how do specific types of physical activity (organized, group-based, recreational, or particular sports) contribute to the experience of positive emotions and individual well-being?

References:

Asquith, S. L.,Wang, X., Quintana, D. S., & Abraham, A. (2022). The role of personality traits and leisure activities in predicting wellbeing in young people. *BMC Psychology*, 10(1):249. https://doi.org/10.1186/s40359-022-00954-x

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* (Washington, D.C. : 1974), 100(2), 126–131.

Chen, S., Yan, W. K., & Ahmed, D. (2020). Physical activity and its relationship with life satisfaction among middle school students: A cross-culture study. *Sustainability*, 12 (17), 6932. https://doi.org/10.3390/su12176932

Chen, X., Su, D., Chen, X., & Chen, Y. (2021). What intensity of exercise is most suitable for the elderly in China? A propensity score matching

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analysis. *BMC public health*, 21(1), 1396. https://doi.org/10.1186/s12889-021-11407-2

Csikszentmihalyi, M. (1990). Flow: The Psychology of Optimal Experience. Harper & Row.

Diener, E. (1984). Subjective well-being. *Psychological Bulletin*, 95(3), 542–575. https://doi.org/10.1037/0033-2909.95.3.542

Diener, E., & Diener, C. (1996). Most people are happy. *Psychological Science*, 7(3), 181–185. https://doi.org/10.1111/j.1467-9280.1996.tb00354.x

Diener, E., & Oishi, S. (2000). Money and happiness: Income and subjective well-being across nations. In E. Diener & E. M. Suh (Eds.), *Culture and subjective well-being* (pp. 185–218). The MIT Press.

Diener, E., & Oishi, S. (2004). Are Scandinavians happier than Asians? Issues in comparing nations on subjective well-being. *Asian economic and political issues*, 10, 1-25.

Diener, E., & Seligman, M. E. P. (2004). Beyond Money: Toward an Economy of Well- Being. *Psychological Science in the Public Interest*, 5(1), 1–31. https://doi.org/10.1111/j.0963-7214.2004.00501001.x

Diener, E., Lucas, R. E., & Scollon, C. N. (2006). Beyond the hedonic treadmill: Revising the adaptation theory of well-being. *American Psychologist*, 61(4), 305–314. https://doi.org/10.1037/0003-066X.61.4.305

Diener, E., Suh, E. M., Lucas, R. E., & Smith, H. L. (1999). Subjective well-being: Three decades of progress. *Psychological Bulletin*, 125(2), 276–302. https://doi.org/10.1037/0033-2909.125.2.276

Ekkekakis, P., & Murri, M. B. (2017). Exercise as antidepressant treatment: Time for the transition from trials to clinic?. *General hospital psychiatry*, 49, 1. https://doi.org/10.1016/j.genhosppsych.2017.04.008

Ellis, A. (2001). Feeling Better, Getting Better, Staying Better. Impact Publishers.

Ferron, C., Narring, F., Cauderay, M., & Michaud, P. A. (1999). Sport activity in adolescence: associations with health perceptions and experimental behaviours. *Health education research*, 14(2), 225–233. https://doi.org/10.1093/her/14.2.225

Hassmén, P., Koivula, N., & Uutela, A. (2000). Physical exercise and psychological well-being: a population study in Finland. *Preventive medicine*, 30(1), 17–25. https://doi.org/10.1006/pmed.1999.0597

Ibanez Roman, J. E., Ekholm, O., Holst Algren, M., Koyanagi, A., Stewart-Brown, A., Hall, E. E., Stubb, B., Koushede, V., Thygesen, L. C., & Santini. Z. I. (2023). Mental wellbeing and physical activity levels: A prospective cohort study. *Mental Health and Physical Activity*, 24 (2023) 100498. https://doi.org/10.1016/j.mhpa.2022.100498

Keyes, C. L. M., (2002). The Mental Health Continuum: From Languishing to Flourishing in Life. *Journal of Health and Social Behavior*, 43(2), 207–222. https://doi.org/10.2307/3090197

Lyubomirsky, S., King, L., & Diener, E. (2005). The Benefits of Frequent Positive Affect: Does Happiness Lead to Success? *Psychological Bulletin*, 131(6), 803–855. https://doi.org/10.1037/0033-2909.131.6.803

Malagodi, F., Dommett, E. J., Findon, J. L., & Gardner, B. (2024). Physical activity interventions to improve mental health and wellbeing in university students in the UK: A service mapping study. *Mental Health and Physical Activity*, 26 100563. https://doi.org/10.1016/j.mhpa.2023.100563

Morgan, G. S., Willmott, M., Ben-Shlomo, Y., Haase, A. M., & Campbell, R. M. (2019). A life fulfilled: positively influencing physical activity in older adults - a systematic review and meta-ethnography. *BMC public health*, 19(1), 362. https://doi.org/10.1186/s12889-019-6624-5

Morgan, K., & Bath, P. A. (1998). Customary physical activity and psychological wellbeing: a longitudinal study. *Age and ageing*, 27 Suppl 3, 35–40. https://doi.org/10.1093/ageing/27.suppl_3.35

Ng, Y. K. (2022). *Happiness - Concept, Measurement and Promotion*. Springer. https://doi.org/10.1007/978-981-33-4972-8

Pavićević, M. S., & Minić, J. LJ. (2018). *Kvalitete života, zadovoljstvo životom i subjektivno blagostanje kod nastavnika i administrativnih radnika*. УДК [in Serbian] 316.728:371.12(497.115).

Pedišić, Ž., Greblo, Z., Phongsavan, P., Milton, K., & Bauman, A. E. (2015). Are total, intensity- and domain-specific physical activity levels associated with life satisfaction among university students?. *PloS one*, 10(2), e0118137. https://doi.org/10.1371/journal.pone.0118137

Popov, S., & Jakovljev, I. (2017). Uticaj fizičkog vežbanja na unapređenje kognitivnih funkcija. TIMS Acta 11, 111-120. [in Serbian] https://doi.org/10.5937/timsact11-14016

Popov, S., Volarov, M., & Rakočević, N. (2023). The relationship between physical activity and mental health: Is more always better?. *Primenjena Psihologija*, 16(3), 349–374. https://doi.org/10.19090/pp.v16i3.2461

Ryan, R. M., & Deci, E. L. (2001). On happiness and human potentials: A review of research on hedonic and eudaimonic well-being. *Annual Review of Psychology*, 52, 141–166. https://doi.org/10.1146/annurev.psych.52.1.141

Ryff, C. D. (1989). Happiness is everything, or is it? Explorations on the meaning of psychological well-being. *Journal of Personality and Social Psychology*, 57(6), 1069–1081. https://doi.org/10.1037/0022-3514.57.6.1069

Seligman, M. E. P., & Csikszentmihalyi, M. (2000). Positive psychology: An introduction. *American Psychologist*, 55(1), 5–14. https://doi.org/10.1037/0003-066X.55.1.5

Seligman, M. E. (2002). *Authentic happiness: Using the new positive psychology to realize your potential for lasting fulfillment*. Simon and Schuster.

Wicker, P., & Frick, B. (2015). The relationship between intensity and duration of physical activity and subjective well-being. *European journal of public health*, 25(5), 868–872. https://doi.org/10.1093/eurpub/ckv131

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FIGHTING FIT: HOW INTERVAL TRAINING SHAPES PHYSICAL PERFORMANCE IN MARTIAL ARTS — A SYSTEMATIC REVIEW

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Abstract: *Success in martial arts and combat sports relies heavily on an athlete's ability to integrate strength, endurance, speed, agility, and coordination in dynamic situations. Interval training is relevant because it stimulates multiple energy systems through moderate to high intensity training with short recovery periods. This study is a systematic review compiled according to PRISMA guidelines, reviewing articles from the PubMed database over the past five years. Six of the 212 articles identified met the inclusion criteria for further analysis. The results indicate that high-intensity interval training (HIIT) combined with specific techniques and HIIT with strength or plyometric training effectively improves aerobic and anaerobic capacity, muscle strength, speed, agility, and technical skills. In contrast, non-specific interventions such as photobiomodulation showed no significant effects. However, interindividual variation in training response exists, necessitating a personalized approach and ongoing performance monitoring. Methodological limitations in previous studies also emphasize the need for further studies with more consistent designs and more diverse populations. Overall, interval training, particularly technique-based HIIT, can be recommended as an effective strategy in improving the physical performance of martial artists.*

Keywords: *Interval Training, High-Intensity Interval Training (HIIT), Martial Arts, Combat Sports, Physical Performance*

INTRODUCTION

Success in martial arts and combat sports depends heavily on the athlete's ability to integrate various physical fitness components in high-pressure, time-limited scenarios. (Clemente-Suárez, 2022). Disciplines such as wushu, taekwondo, judo, and mixed martial arts demand exceptional muscular strength, anaerobic power, cardiovascular endurance, speed, agility, and coordination to execute techniques with efficiency, accuracy, and endurance. (Ribeiro et al., 2022). These multifactorial physiological requirements reflect combat's dynamic and unpredictable nature, where peak performance depends on the athlete's capacity to transition smoothly between explosive bursts and sustained effort. (Salar et al., 2022). Conventional training programs that isolate individual fitness elements may fail to replicate the integrated physiological demands encountered in real-time competition. (Tong et al., 2024). Consequently, there is a growing need for training interventions that can simultaneously develop multiple performance attributes in a sport-specific and time-effective manner (Pol et al., 2020). Interval training has been widely accepted as a method capable of substantially improving aerobic and anaerobic performance across the athletic population. (Boullosa et al., 2022).

This training approach, which is characterized by repeated bouts of moderate to high intensity effort interspersed with recovery periods (Çimke et al., 2024), allows targeted stimulation of multiple energy systems over a short period of time (Thurlow et al., 2023). It has been shown to improve cardiovascular fitness, muscular endurance, metabolic efficiency, and neuromuscular adaptations, making it particularly relevant to sports that combine power and endurance demands (Akbar et al., 2022). In combat sports, where athletes must repeatedly engage in high-intensity action with minimal recovery, interval training is increasingly used as a practical conditioning strategy (Billaut, 2022). Its intensity, volume, and rest manipulation flexibility allow for tailored application to various martial arts disciplines' biomechanical and physiological characteristics (Mulla & Keir, 2023). Despite its growing application, the scientific literature on interval training in martial arts and combat sports remains fragmented and lacks consensus (Poon et al., 2023). Several major studies have examined its impact on performance variables such as VO₂max, anaerobic capacity, strength, agility, and fatigue resistance (Hov et al., 2023). However, heterogeneity in study designs, interval

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protocols e.g., HIIT, MIIT, SIT, outcome measures, and athlete populations presents challenges in interpreting the broader efficacy of these interventions (Jr, 2025). Additionally, recent reviews of interval training have primarily focused on general athletic or endurance populations (Szinay et al., 2020). With a limited focus on the context of martial arts (Osorio et al., 2024). The absence of a systematic synthesis specific to martial arts hampers the development of evidence-based guidelines for practitioners and researchers to optimize physical preparation in this domain (Ribeiro et al., 2022). Therefore, this systematic review aims to synthesize current empirical evidence on the effects of interval training on physical performance parameters in martial arts and combat sports (Ribeiro et al., 2022). Specifically, this study aims to evaluate which interval training modality is most effective in improving key fitness attributes relevant to combat performance (Siew et al., 2024). To identify patterns and limitations in existing research, and to provide appropriate recommendations for sport practitioners and future research (Khodadadi et al., 2023). By addressing this gap, this review contributes a sport-specific perspective to the broader body of knowledge on interval-based conditioning, offering theoretical insights and applied implications for advancing performance training in combat sports (Havenetidis et al., 2023).

This study presents novelty by presenting the first systematic synthesis specifically examining the impact of different forms of interval training on physical performance parameters in the context of martial arts and combat sports. (Folhes et al., 2023). Unlike previous reviews, which tended to focus on general athletes or endurance sports (Novaković et al., 2023). This study draws attention to the unique and complex physiological demands of sports such as wushu, taekwondo, judo, and MMA (Guppy et al., 2021).

This study aimed to synthesize empirical evidence systematically addressing the effects of interval training on physical performance parameters in martial arts and combat sports. (Mañas-Paris et al., 2022). This study specifically aims to identify the most effective interval training modalities—such as high-intensity interval training (HIIT), moderate-intensity interval training (MIIT), and sprint interval training (SIT)—in improving key fitness components relevant to combat performance, including aerobic capacity (VO₂max), anaerobic capacity, muscular strength, speed, agility, and muscular endurance. (Hov et al., 2023). In addition, this study aims to explore the patterns of results, methodological approaches, and limitations found in previous studies. (Escoto-vasquez et al., 2024), so that it can provide a more comprehensive understanding of the effectiveness of interval training in martial arts (Palumbo et al., 2023). Through this review, it is hoped that evidence-based recommendations can be produced that are applicable and specific for coaches, athletes, and martial arts practitioners in designing physical conditioning programs that are efficient, integrated, and in accordance with the competitive demands of each martial arts branch. (Kadlec et al., 2023).

METHODS

Research Design

This study employed a systematic review method by searching various journal databases, including PubMed, which is considered a leading global platform for aggregating publications with scientific impact and relevance. The study was structured according to PRISMA guidelines. This review aimed to identify, evaluate, and synthesize scientific articles examining the effects of interval training on physical performance in martial arts and combat sports.

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PRISMA Flow Diagram

Table 1. *PRISMA Flow Diagram of the Article Selection Process*
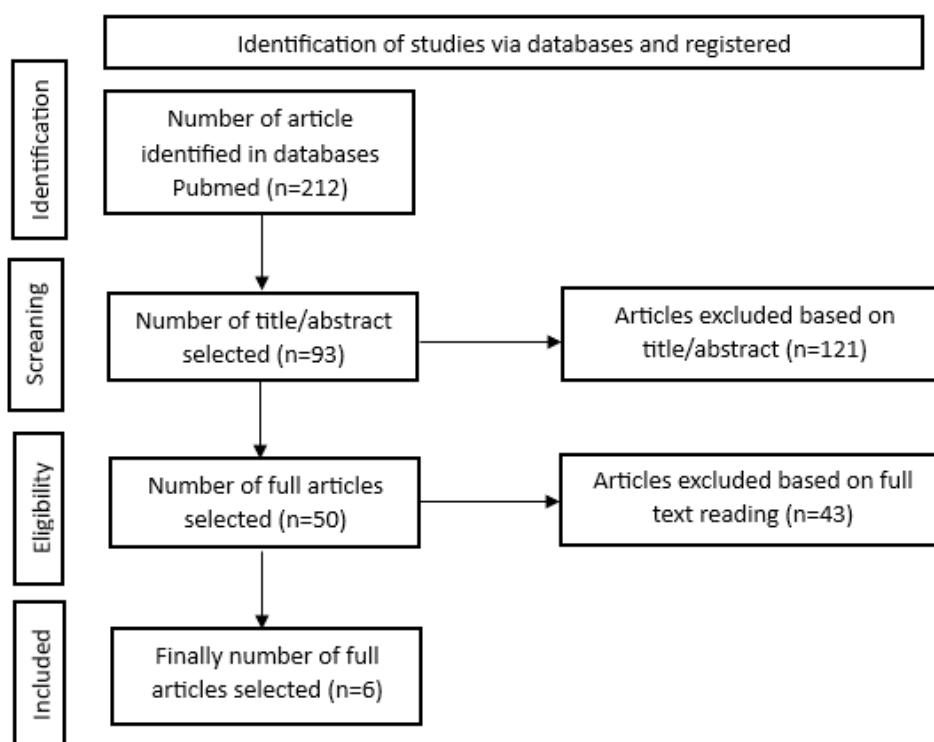
Tabel 1. Diagram alir PRISMA dari proses pemilihan artikel

Kriteria kelayakan

Kriteria inklusi dalam penelitian ini adalah artikel yang diterbitkan dalam 5 tahun terakhir dan artikel yang membahas Interval Learning dan Cardiorespiratory. Pengecualian untuk penelitian ini adalah artikel yang diterbitkan dalam jurnal terkenal.

Proses

Judul artikel, abstrak, dan teks lengkap telah diperiksa, divalidasi, dan ditransfer ke perangkat lunak Mendeley. Sebanyak 171 artikel dari basis data Pubmed dikumpulkan pada langkah pertama. Kecukupan judul dan abstrak menjadi dasar untuk penyaringan berikutnya terhadap 59 artikel pada tahap kedua. Dua belas produk dipesan untuk pemrosesan tambahan selama tahap ketiga. Pada titik ini, kami menyaring artikel berdasarkan kesesuaian umumnya. Sebelas makalah yang memenuhi kriteria inklusi kemudian dipilih untuk putaran analisis akhir menggunakan observasi sistematis. Penelitian ini mematuhi pedoman Penilaian Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) untuk operasi standar.

From the article selection process, the eligibility criteria for inclusion in this study were articles published within the last five years and articles discussing Interval Training and Martial Arts. Articles published in reputable journals were excluded.

Article titles, abstracts, and full texts were reviewed, validated, and transferred into the Mendeley software. The initial search identified 212 articles relevant to the study topic. A first screening process was conducted based on titles and abstracts, resulting in 93 suitable articles. One hundred twenty-one articles were eliminated for not meeting the initial criteria or for being irrelevant based on their titles and abstracts. The next stage was a feasibility evaluation, which involved thoroughly reading the contents of the 50 selected articles. After a full review of the contents, 43 articles were deemed not to meet the inclusion criteria or not substantially relevant to the study focus and were therefore excluded from further analysis. Ultimately, only 6 articles were considered to meet all selection criteria and were included in the final review. This process demonstrates a rigorous and systematic selection process to ensure that only truly relevant and high-quality articles were used in this study.

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RESULTS

Writer	Sample Characteristics	Study Design	Intervention	Results (Summary)	Complete Results
(Dos Santos Junior et al., 2023)	11 male Brazilian Jiu-Jitsu athletes (age 28.7 ± 8.3 yrs)	Randomized, crossover, double-masked clinical trial	Photobiomodulation with 6J or 12J per point vs placebo	No dose-dependent ergogenic effect on anaerobic performance observed	No significant ergogenic effects were found on high-intensity intermittent anaerobic performance. Although anaerobic capacity decreased in the second and third sets of the Wingate test, the effects of photobiomodulation (PBM) at doses of 6 J and 12 J per point did not significantly improve performance compared to placebo.
(Ouergui et al., 2022)	59 adolescent judo athletes (15 ± 1 yrs, M/F)	Randomized controlled trial with 3 interventions and 1 control group	4 weeks of intensified training using Kumi-kata, Uchi-komi, or running + 12-day tapering	Kumi-kata improved CMJ and isometric JCT; Uchi-komi improved UST; JPFT improved in all experimental groups	Kumi-kata training improved vertical jump (CMJ) performance and isometric strength (chin-up judogi); uchi-komi training improved uchi-komi speed (UST); and the Judo Physical Fitness Index (JPFT) increased in all intervention groups. However, the Judo-Specific Fitness Index (SJFT) did not show significant differences between groups.
(Ojeda-Aravena, Herrera-Valenzuela, Valdés-Badilla, Martín, et al., 2021)	12 Taekwondo athletes (M=8, F=4), age 16.8–17.8 yrs	Randomized trial with two groups: technique-specific HIIT vs repeated sprints	4 weeks HIIT using specific techniques vs repeated sprints, 3 sessions/week	Technique-specific group improved SJ, KDI, total kicks, and 20MSR; higher proportion of responders	The particular technique group (TS-G) demonstrated increased total kick count, decreased kick drop index (KDI), and improved 20-meter shuttle run performance. This group also had a higher proportion of athlete responders than the repeated sprint group (RS-G), particularly in the SJ, CMJ, and kick count tests.
(Ojeda-Aravena, Herrera-Valenzuela, Valdés-Badilla, Cancino-López, et al., 2021)	10 youth karate athletes (M=6, F=4), age 15.2 ± 1.6 yrs	Randomized controlled trial (EG vs CG)	HIIT with specific techniques for 4 weeks (3 sessions/week)	EG improved SJ (15.2%), CODS (-1.7%), and a higher responder rate than CG	The experimental group receiving HIIT with specific techniques showed a 15.2% increase in jump height (SJ) and a -1.7% increase in change of direction ability (CODS). The proportion of responders was also higher than that of the control group (40% vs. 20%). However, not all fitness components related to TKD showed significant improvements.
(Quan et al., 2024)	40 national-level male karate athletes (21.2–21.7 yrs)	Randomized controlled trial with 5 groups	8-week short sprint interval training (sSIT), resistance training (RT), or concurrent (sSIT+RT/RT+sSIT)	All training improved physical fitness; CT groups showed the largest effects without sequencing impact	All intervention groups (SSIT, RT, and a combination of both) showed significant improvements in physical fitness (jumps, sprints, shuttle runs), muscle strength, and anaerobic capacity (peak and mean power). The combination of sSIT + RT had the greatest effect, although no differences were found based on the training order (sSIT + RT vs. RT + sSIT).

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(Mañas-Paris et al., 2022)	32 young judokas (age 12.8 ± 1.7 yrs, M/F=9/7)	Non-randomized experimental intervention (control vs experimental)	3 weeks of plyometric + HIIT training in addition to regular judo practice	Improved SJFT score and angular velocity in the experimental group	The experimental group that followed plyometric and HIIT training for 3 weeks showed a significant decrease in SJFT scores (indicating improved performance) and increased angular velocity on the X and Y axes. This suggests that combining HIIT and plyometrics can improve judoka children's technical and physiological performance.

This table summarizes six international studies evaluating various training interventions for combat sports athletes, such as BJJ, judo, taekwondo, and karate. Each study contains key information, such as participant characteristics, study design, intervention type (e.g., HIIT, plyometrics, photobiomodulation, and training combinations), and key outcomes. The goal is to provide a concise yet comprehensive overview of the effectiveness of each approach on athletic performance.

Technique-specific HIIT and combining HIIT with plyometric training are most effective in improving strength, speed, and anaerobic endurance. (Michailidis et al., 2023). In addition, combination training (concurrent training), such as resistance training combined with short interval sprints, also shows positive results without significant differences in the order of implementation. (Lee et al., 2020). In contrast, in studies conducted on BJJ athletes, photobiomodulation did not significantly impact anaerobic performance. (Tomazoni et al., 2019). The effectiveness of an intervention depends largely on the type of training, the athlete's characteristics, and the approach used. Several studies also emphasize the importance of considering individual responses to training, as not all athletes show the same improvements. (Mueller et al., 2022)Therefore, these results can be an important reference for coaches and sports practitioners who want to develop more targeted, evidence-based training programs. (Bagheri et al., 2023).

DISCUSSION

The discussion in this study emphasizes the relevance and urgency of using interval training as the main method in improving the physical performance of martial arts athletes (Vaccari et al., 2020). Sports such as wushu, taekwondo, judo, and MMA demand complex physical capacities, involving rapid transitions between explosive strength and sustained endurance in unpredictable situations (Pol et al., 2019). Interval training, which combines high-intensity work phases with recovery phases, allows multisystem stimulation in a single session and is therefore particularly suited to the dynamic characteristics of combat sports (Wahl et al., 2022). This method has been proven to increase fitness components such as aerobic and anaerobic capacity, muscle strength, speed, agility, and functional endurance simultaneously and efficiently (Campo et al., 2021).

One of the important findings of this review is the effectiveness of high-intensity interval training (HIIT), especially when adapted to sport-specific techniques, which showed significant results in improving functional performance, such as the number and quality of techniques, explosive strength, and motor response speed. (Reed et al., 2022). In addition, combination training approaches such as concurrent training—which integrates HIIT with strength or plyometric training—also yield positive results regardless of the order of execution, confirming the synergistic value of an integrated approach to training. (Markov et al., 2023). However, this study also revealed inter-individual variation in response to training interventions, indicating that athletes' physiological responses are not uniform. This reinforces the importance of a personalized approach in designing training programs based on individual performance measurement and monitoring. (Arora et al., 2024).

This review highlights methodological limitations in the previous studies, such as varying study designs, non-uniform training protocols, varying intervention durations, and the diversity of performance measurement instruments. (Bashir et al., 2022). This fragmentation poses a major challenge in generalizing findings and applying research results broadly in training practice. (Vankov & Bowers, 2020). Nevertheless, this systematic review has organized and integrated the scattered evidence, providing a more complete and useful picture. (Aftab et al., 2020)These results provide significant contributions for sports practitioners and researchers to develop more effective, efficient, and evidence-based training programs and open up opportunities for further, more focused research, including on

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underrepresented populations, such as female athletes, adolescents, or non-Olympic martial arts disciplines. (Mujika & Taipale, 2019; Smith et al., 2022)

Thus, it can be concluded that interval training, especially HIIT adapted to technique, and combination training, is a promising training approach in improving the specific physical capacity of martial arts athletes. (Khan & Khan, 2022). These findings contribute to the science of physical conditioning in combat sports and offer direct implications for enhancing athletes' competitive performance through structured, adaptive, and applicable training methods. (Arora et al., 2024; Lu et al., 2022).

Conclusion

The conclusions of this systematic review confirm that interval training, specifically high-intensity interval training (HIIT) and combined forms such as HIIT with plyometrics or strength training, is an effective training strategy for improving a variety of crucial physical performance parameters for martial arts athletes, including aerobic and anaerobic capacity, strength, speed, agility, and technical ability. These trainings have been shown to replicate the physiological demands of combat sports, which emphasize high intensity with short recovery intervals. Their effectiveness is highly dependent on protocol design, athlete characteristics, and individual variation in training response, making it crucial for coaches to adopt a personalized approach and monitor performance. However, limitations in previous research methodology suggest the need for further studies with more consistent designs and more diverse populations. This article contributes to synthesizing the scattered scientific evidence and establishing a solid foundation for developing more targeted, efficient, and specific evidence-based training strategies for combat sports.

Reference

Aftab, W., Siddiqui, F. J., Tasic, H., Perveen, S., Siddiqi, S., & Bhutta, Z. A. (2020). Implementation of health and health-related sustainable development goals: Progress, challenges and opportunities-a systematic literature review. *BMJ Global Health*, *5*(8), 1–10. https://doi.org/10.1136/bmjgh-2019-002273

Akbar, S., Soh, K. G., Jazaily Mohd Nasiruddin, N., Bashir, M., Cao, S., & Soh, K. L. (2022). Effects of neuromuscular training on athletes physical fitness in sports: A systematic review. *Frontiers in Physiology*, *13*(September), 1–13. https://doi.org/10.3389/fphys.2022.939042

Arora, V., Mishra, S. S., Sahoo, J., Gupta, M., Joshi, A., Bajaj, K., Joshi, V., & Joshi, N. K. (2024). *Effectiveness of M-Health in Improving Physical Activity : An Indian Perspective. 15*(01), 72–78. https://doi.org/10.55489/njcm.150120243345

Bagheri, R., Kargarfard, M., Jalali, K., Ashtary-Larky, D., Cheraghloo, N., Ghobadi, H., ... & Dutheil, F. (2023). The effects of 12 weeks of concurrent and combined training on inflammatory markers, muscular performance, and body composition in middle-aged overweight and obese males. *Nutrients*, *15*(6), 1482.

Bashir, M., Soh, K. G., Samsudin, S., Akbar, S., Luo, S., & Sunardi, J. (2022). Effects of functional training on sprinting, jumping, and functional movement in athletes: A systematic review. *Frontiers in Physiology*, *13*(November). https://doi.org/10.3389/fphys.2022.1045870

Billaut, F. (2022). Special Issue "Optimising Interval Training Prescription." *Sports*, *10*(6), 2–4. https://doi.org/10.3390/sports10060087

Boullosa, D., Dragutinovic, B., Feuerbacher, J. F., Benítez-Flores, S., Coyle, E. F., & Schumann, M. (2022). Effects of short sprint interval training on aerobic and anaerobic indices: A systematic review and meta-analysis. *Scandinavian Journal of Medicine and Science in Sports*, *32*(5), 810–820. https://doi.org/10.1111/sms.14133

Campo, domingo jesus ramos, Carava, luis andreu, Rodriguez, alejandro martinez, & Arias, J. angel rubio. (2021). Effects of Resistance Circuit-Based Training on Body Composition, Strength and Cardiorespiratory Fitness: A Systematic Review and Meta-Analysis. *Biology (Basel)*, 1–22.

Çimke, S., Yıldırım Gürkan, D., & Polat, S. (2024). Research on Family-Centered Care in pediatric patients: A Bibliometric Analysis. *Journal of Pediatric Nursing*, *76*, 199–206. https://doi.org/10.1016/j.pedn.2024.02.017

Clemente-Suárez, V. J. (2022). New Training Program for the New Requirements of Combat of Tactical Athletes. *Sustainability (Switzerland)*, *14*(3), 1–9. https://doi.org/10.3390/su14031216

Dos Santos Junior, R. B., M Branco, B. H., Andreato, L. V, S Marques, D. C., De Oliveira, F. M., Ferreira, W. C., G Bardi, E. M., Fernandes, E. V, & Paula Ramos, S. DE. (2023). Effects of Photobiomodulation on High-Intensity Intermittent Anaerobic Performance of Lower Limbs in Brazilian Jiu-Jitsu Athletes: A Randomized, Crossover, Double-Blind Clinical Trial. *International Journal of Exercise Science*, *16*(6), 1165–1181. http://www.intjexersci.com

Escoto-vasquez, L., Delgadillo-valero, L., & Ternovoy, S. K. (2024). *ScienceDirect Top 100 most cited papers on diagnostic aids for oral cancer : A bibliometric analysis. 125.*

Folhes, O., Reis, V. M., Marques, D. L., Neiva, H. P., & Marques, M. C. (2023). Influence of the Competitive Level and Weight Class on Technical Performance and Physiological and Psychophysiological Responses during Simulated Mixed Martial Arts Fights: A Preliminary Study. *Journal of Human Kinetics*, *86*(January), 205–215. https://doi.org/10.5114/jhk/159453

Guppy, S. N., Nosaka, K., & Barley, O. (2021). Developing a comprehensive testing battery for mixed martial arts. *International Journal of Exercise Science*, *14*, 941–961.

Havenetidis, K., Bissas, A., Monastiriotis, N., Nicholson, G., Walker, J., Bampouras, T. M., & Dinsdale, A. J. (2023). Combining sport and conventional military training provides superior improvements in physical test performance. *International Journal of Sports Science and Coaching*, *18*(5), 1567–1576. https://doi.org/10.1177/17479541221116959

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SPORTS SCIENCE AND HEALTH **15**(2):270-277

Hov, H., Wang, E., Lim, Y. R., Trane, G., Hemmingsen, M., Hoff, J., & Helgerud, J. (2023). Aerobic high-intensity intervals are superior to improve V̇O2max compared with sprint intervals in well-trained men. *Scandinavian Journal of Medicine and Science in Sports*, *33*(2), 146–159. https://doi.org/10.1111/sms.14251

Jr, D. A. C. (2025). *Mastering Smartphones through Enhancement of Physical Activity in Adolescents*. 121–122.

Kadlec, D., Miller-Dicks, M., & Nimphius, S. (2023). Training for "Worst-Case" Scenarios in Sidestepping: Unifying Strength and Conditioning and Perception–Action Approaches. *Sports Medicine - Open*, *9*(1). https://doi.org/10.1186/s40798-023-00566-8

Khan, N. F., & Khan, M. N. (2022). A bibliometric analysis of peer-reviewed literature on smartphone addiction and future research agenda. *Asia-Pacific Journal of Business Administration*, *14*(2), 199–222. https://doi.org/10.1108/APJBA-09-2021-0430

Khodadadi, F., Bagheri, R., Negaresh, R., Moradi, S., Nordvall, M., Camera, D. M., Wong, A., & Suzuki, K. (2023). The Effect of High-Intensity Interval Training Type on Body Fat Percentage, Fat and Fat-Free Mass: A Systematic Review and Meta-Analysis of Randomized Clinical Trials. *Journal of Clinical Medicine*, *12*(6), 1–27. https://doi.org/10.3390/jcm12062291

Lee, M. J. C., Ballantyne, J. K., Chagolla, J., Hopkins, W. G., Fyfe, J. J., Phillips, S. M., Bishop, D. J., & Bartlett, J. D. (2020). Order of same-day concurrent training influences some indices of power development, but not strength, lean mass, or aerobic fitness in healthy, moderately-active men after 9 weeks of training. *PLoS ONE*, *15*(5), 1–24. https://doi.org/10.1371/journal.pone.0233134

Lu, T., Wang, C., Chen, H., Tao, B., Jiang, Y., Sui, H., & Yan, J. (2022). Relationship between university students' physical activity and mobile phone dependence: Mediating effect of subjective well-being and moderating effect of psychological capital. *Frontiers in Psychology*, *13*(December), 1–10. https://doi.org/10.3389/fpsyg.2022.983487

Mañas-Paris, A., Muyor, J. M., & Oliva-Lozano, J. M. (2022). Using Inertial and Physiological Sensors to Investigate the Effects of a High-Intensity Interval Training and Plyometric Program on the Performance of Young Judokas. *Sensors*, *22*(22). https://doi.org/10.3390/s22228759

Markov, A., Hauser, L., & Chaabene, H. (2023). Effects of Concurrent Strength and Endurance Training on Measures of Physical Fitness in Healthy Middle-Aged and Older Adults: A Systematic Review with Meta-Analysis. *Sports Medicine*, *53*(2), 437–455. https://doi.org/10.1007/s40279-022-01764-2

Michailidis, Y., Venegas, P., & Metaxas, T. (2023). Effects of Combined Horizontal Plyometric and Change of Direction Training on Anaerobic Parameters in Youth Soccer Players. *Sports*, *11*(2). https://doi.org/10.3390/sports11020027

Mueller, S., Mueller, J., Stoll, J., & Mayer, F. (2022). Effect of Six-Week Resistance and Sensorimotor Training on Trunk Strength and Stability in Elite Adolescent Athletes: A Randomized Controlled Pilot Trial. *Frontiers in Physiology*, *13*(March). https://doi.org/10.3389/fphys.2022.802315

Mujika, I., & Taipale, R. S. (2019). Sport-Science Research on Female Athletes: Dealing With the Paradox of Concurrent Increases in Quantity and Quality. *International Journal of Sports Physiology and Performance*, *14*(8), 1013–1014. https://doi.org/10.1123/ijspp.2019-0514

Mulla, D. M., & Keir, P. J. (2023). Neuromuscular control: from a biomechanist's perspective. *Frontiers in Sports and Active Living*, *5*(July). https://doi.org/10.3389/fspor.2023.1217009

Novaković, S., Milenković, S., Srećković, M., Backović, D., Ignjatović, V., Capo, N., Stojanović, T., Vukomanović, V., Sekulić, M., Gavrilović, J., Vuleta, K., & Ignjatović, V. (2023). Children's Internet use and physical and psychosocial development. *Frontiers in Public Health*, *11*(June), 1–6. https://doi.org/10.3389/fpubh.2023.1163458

Ojeda-Aravena, A., Herrera-Valenzuela, T., Valdés-Badilla, P., Cancino-López, J., Zapata-Bastias, J., & García-García, J. M. (2021). Inter-Individual Variability of a High-Intensity Interval Training With Specific Techniques vs. Repeated Sprints Program in Sport-Related Fitness of Taekwondo Athletes. *Frontiers in Physiology*, *12*(November), 1–10. https://doi.org/10.3389/fphys.2021.766153

Ojeda-Aravena, A., Herrera-Valenzuela, T., Valdés-Badilla, P., Martín, E. B. S., Cancino-López, J., Gallardo, J. A., Zapata-Bastías, J., & García-García, J. M. (2021). Effects of High-Intensity Interval Training With Specific Techniques on Jumping Ability and Change of Direction Speed in Karate Athletes: An Inter-individual Analysis. *Frontiers in Physiology*, *12*(November). https://doi.org/10.3389/fphys.2021.769267

Osorio, J., Figueroa, M., & Wong, L. (2024). *Predicting Smartphone Addiction in Teenagers : An Integrative Model Incorporating Machine Learning and Big Five Personality Traits*. https://doi.org/10.3844/jcssp.2024.181.190

Ouergui, I., Daira, I., Chtourou, H., Bouassida, A., Bouhlel, E., Franchini, E., & Ardigò, L. P. (2022). Effects of intensified training and tapering periods using different exercise modalities on judo-specific physical test performances. *Biology of Sport*, *39*(4), 875–881. https://doi.org/10.5114/biolsport.2022.108702

Palumbo, F., Ciaccioni, S., Guidotti, F., Forte, R., Sacripanti, A., Capranica, L., & Tessitore, A. (2023). Risks and Benefits of Judo Training for Middle-Aged and Older People: A Systematic Review. *Sports*, *11*(3), 1–15. https://doi.org/10.3390/sports11030068

Pol, R., Balagué, N., Ric, A., Torrents, C., Kiely, J., & Hristovski, R. (2020). Training or Synergizing ? Complex Systems Principles Change the Understanding of Sport Processes. *Sport Medicine*, *6:28*.

Pol, R., Hristovski, R., Medina, D., & Balague, N. (2019). From microscopic to macroscopic sports injuries. Applying the complex dynamic systems approach to sports medicine: a narrative review. *British Journal of Sports Medicine*, *53*(19), 1214–1220. https://doi.org/10.1136/bjsports-2016-097395

Poon, E. T. C., Wongpipit, W., Sun, F., Tse, A. C. Y., & Sit, C. H. P. (2023). High-intensity interval training in children and adolescents with special educational needs: a systematic review and narrative synthesis. *International Journal of Behavioral Nutrition and Physical Activity*, *20*(1), 1–14. https://doi.org/10.1186/s12966-023-01421-5

Quan, Y., Zhao, Y., Wang, X., & Xu, Q. (2024). Higher final speed in 30–15 intermittent fitness tests correlates with soccer's locomotor demands, not heart rate responses in small-sided soccer games. *Scientific Reports*, *14*(1), 10970. https://doi.org/10.1038/s41598-024-61468-7

Reed, J. L., Terada, T., Vidal-Almela, S., Tulloch, H. E., Mistura, M., Birnie, D. H., Wells, G. A., Nair, G. M., Hans, H., Way, K. L., Chirico, D., O'Neill, C. D., & Pipe, A. L. (2022). Effect of High-Intensity Interval Training in Patients With Atrial Fibrillation: A Randomized Clinical Trial. *JAMA Network Open*, *5*(10), e2239380. https://doi.org/10.1001/jamanetworkopen.2022.39380

Ribeiro, A. L. B., Silva, B. V. C., Filho, C. A. C., & Vasconcelos, B. M. De. (2022). Exploratory Systematic Review of Mixed Martial Arts: An

Xiao Haidong, et al.
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Sports Science and Health 15(2):270-277

Overview of Performance of Importance Factors with over 20,000 Athletes. *Sports*.

Salar, N. vicente, Munoz, encarna fuster, & Rodriguez, alejandro martinez. (2022). Nutritional Ergogenic Aids in Combat Sports : A Systematic Review and Meta-Analysis. *Nutrients*, 1–32.

Siew, S. K. H., Yu, J., Teo, T. L., Chua, K. C., Mahendran, R., & Rawtaer, I. (2024). Technology and physical activity for preventing cognitive and physical decline in older adults: Protocol of a pilot RCT. *PloS One*, *19*(2), e0293340. https://doi.org/10.1371/journal.pone.0293340

Smith, E. S., McKay, A. K. A., Ackerman, K. E., Harris, R., Elliott-Sale, K. J., Stellingwerff, T., & Burke, L. M. (2022). Methodology Review: A Protocol to Audit the Representation of Female Athletes in Sports Science and Sports Medicine Research. *International Journal of Sport Nutrition and Exercise Metabolism*, *32*(2), 114–127. https://doi.org/10.1123/ijsnem.2021-0257

Szinay, D., Jones, A., Chadborn, T., Brown, J., & Naughton, F. (2020). Influences on the Uptake of and Engagement With Health and Well-Being Smartphone Apps: Systematic Review. *Journal of Medical Internet Research*, *22*(5), e17572. https://doi.org/10.2196/17572

Thurlow, F., Weakley, J., Townshend, A. D., Timmins, R. G., Morrison, M., & McLaren, S. J. (2023). The Acute Demands of Repeated-Sprint Training on Physiological, Neuromuscular, Perceptual and Performance Outcomes in Team Sport Athletes: A Systematic Review and Meta-analysis. In *Sports Medicine* (Vol. 53, Issue 8). Springer International Publishing. https://doi.org/10.1007/s40279-023-01853-w

Tomazoni, S. S., Machado, C. D. S. M., De Marchi, T., Casalechi, H. L., Bjordal, J. M., De Carvalho, P. D. T. C., & Leal-Junior, E. C. P. (2019). Infrared Low-Level Laser Therapy (Photobiomodulation Therapy) before Intense Progressive Running Test of High-Level Soccer Players: Effects on Functional, Muscle Damage, Inflammatory, and Oxidative Stress Markers - A Randomized Controlled Trial. *Oxidative Medicine and Cellular Longevity*, *2019*. https://doi.org/10.1155/2019/6239058

Tong, H. L., Alnasser, A., Alshahrani, N. Z., & Bawaked, R. A. (2024). *The Use of Mobile Technologies to Promote Physical Activity and Reduce Sedentary Behaviors in the Middle East and North Africa Region : Systematic Review and Meta-Analysis Corresponding Author : 26*, 1–21. https://doi.org/10.2196/53651

Vaccari, F., Giovanelli, N., & Lazzer, S. (2020). High-intensity decreasing interval training (HIDIT) increases time above 90% V˙ O2peak. *European Journal of Applied Physiology*, *120*(11), 2397–2405. https://doi.org/10.1007/s00421-020-04463-w

Vankov, I. I., & Bowers, J. S. (2020). Training neural networks to encode symbols enables combinatorial generalization. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *375*(1791). https://doi.org/10.1098/rstb.2019.0309

Wahl, P., Bloch, W., & Proschinger, S. (2022). The Molecular Signature of High-intensity Training in the Human Body. *International Journal of Sports Medicine*, *43*(3), 195–205. https://doi.org/10.1055/a-1551-9294

Latency effects of IoT devices for measuring sports activities

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Abstract: *The Internet of Things (IoT) is increasingly being used in sports science to monitor performance, biomechanics and physiological parameters. However, latency, delay in data transmission and processing can affect the accuracy of measurements, especially in laboratory conditions where high precision is required. This paper analyzes the latency effects of IoT devices by different solutions, using a comparison of latency results, system architecture models, transmission media and other parameters. The results show that latency can cause significant deviations in the measurement of reaction time and biomechanical parameters, but it can be partially compensated by software methods, adequate selection of data transmission technology, and considering the choice and method of application of IoT devices as detection sensors. The consequences of latency can lead to an injury to the athlete or to a delay in giving feedback due to a mismatch in timing.*

Keywords: *IoT, latency, sports diagnostics, biomechanics, laboratory measurements*

Introduction

Over the past decade, the Internet of Things (IoT) has revolutionized the way individuals' athletic activities are monitored. Wearable sensors, smartwatches, smart pads, and other IoT devices enable continuous monitoring of athletes' biomechanical and physiological parameters. The integration of IoT technologies into sports performance analysis has gained popularity due to advances in wearable sensors, wireless communication, and real-time data processing. Devices such as smartwatches, fitness trackers, GPS trackers, and inertial measurement units (IMU) provide athletes and coaches with continuous feedback on essential physiological and biomechanical metrics. (Chen, i dr., 2017)

One of the key limitations of these systems is latency – the delay in data transmission and processing. Data quality (DQ) has become one of the key aspects in IoT (Aimad Karkouch, 2016) (Jorge Merino, 2016) (Jesus G, 2017). Milhauzer (Mühlhäuser, 2007) defines smart, connected products (engl. *smart connected products*, SCP) as „ entities (tangible object, software or service) designed and built for self-organizing embedding in different (smart) environments throughout their lifecycle, providing improved simplicity and openness through enhanced connections ".

Latency is the delay in transmitting data from one point to another in a network. In IoT, lower latency translates into faster response times, which is essential for real-time applications, where even small delays can reduce system efficiency. (Martin F. Berg, 2023) In laboratory conditions, where high accuracy is required, even minimal latency can affect the quality of measurements. (IoT Latency: The Power of Real-Time Communication , n.d.)

The effects of latency in IoT devices for measuring sports activities in the literature indicate that delays in data transmission and signal processing can affect the accuracy and timeliness of the obtained results, which is important for accurate feedback to athletes and coaches.. (Yang Hu, 2025) Latency occurs due to network limitations, device processing power, or communication disruptions, which can lead to reduced user experience and system reliability. While these delays are typically measured in milliseconds to seconds, they can be significant in dynamic sports activities. In fast-paced sports like sprinting or tennis, even small delays can compromise the accuracy of timing, motion capture, or decision-making based on real-time feedback. (Sebastian Mayr, 2024)

As stated in the research Passos et al. (Passos, 2021) It emphasizes the importance of optimizing communication protocols and data processing algorithms to minimize these delays and ensure high reliability and accuracy of IoT devices for sports activities.

IoT latency in sports applications is a phenomenon that has not been sufficiently researched, although it is more than obvious. The aim of this paper is to point out the effects of the IoT latency problem in sports by analyzing ex-

isting knowledge and proposing a model for partially solving the problem. The paper points out the most common causes of latency as well as the effects produced by IoT latency in sports.

Based on this knowledge, sports professionals and experts can analyze individual IoT use cases and consider the technical limitations that arise in that case, such as data transfer speed or the sensitivity of the sensors used.

METHODS AND MATERIALS

For the purposes of this research, more than 50 papers collected from available literature databases were analyzed, which directly investigate the issue of latency of IoT devices in sports. The largest part of the papers (90%) dealt with research on latency due to sensor latency and data transmission delay, while the smallest part of the processed papers (3%) dealt with latency due to using the wrong model for prediction horizons.

Table 1 provides an overview of the most important works that directly addressed the problem of IoT latency in sports, and whose data were of great importance for this work as input data.

Table 1. *Papers studying the latency of IoT devices in sports*

	Technology / Script	Latency (type / average / observed ranges)	Source
1	6LoWPAN	Min ~ 19.5 ms, average ~ 22.1 ms, max ~ 356 ms	(Saavedra E, A Universal Testbed for IoT Wireless Technologies: Abstracting Latency, Error Rate and Stability from the IoT Protocol and Hardware Platform, 2022)
2	Bluetooth Mesh vs Wirepas Mesh	Wirepas: medijan ~ 2,83 ms (Low-Latency) / ~ 2 s (Low-Energy) Bluetooth Mesh: medijan ~ 4,54 ms	(Latency and Power Consumption in 2.4 GHz IoT Wireless Mesh Nodes: An Experimental Evaluation of Bluetooth Mesh and Wirepas Mesh, 2023)
3	Zigbee vs LoRa	LoRa: RTT ~ 150-500 ms (depending on baud rate and packet) Zigbee: RTT in the same conditions often higher for multi-hop situations; in some configurations > LoRa	(Liu Z. Y., 2022)
4	LoRaWAN	Min ~ 282.4 ms, average ~ 296.96 ms, max ~ 334.8 ms	(Saavedra E, A Universal Testbed for IoT Wireless Technologies: Abstracting Latency, Error Rate and Stability from the IoT Protocol and Hardware Platform, 2022)
5	Mesh protocols: Thread, Zigbee, Bluetooth Mesh	Small packet: anything under ~50ms In medium packets: Zigbee: most packets ~80ms, range up to ~130ms Bluetooth Mesh: range wider (20-200ms) in larger networks	(Charles, 2023), (Benchmarking Bluetooth Mesh, Thread, and Zigbee Network Performance, 2025)
6	Sigfox	Average ~ 3 695.2 ms (~3.7 s), max ~ 5 651 ms	(Saavedra E, A Universal Testbed for IoT Wireless Technologies: Abstracting Latency, Error Rate and Stability from the IoT Protocol and Hardware Platform, 2022)
7	Zigbee	Min ~ 34.17 ms, average ~ 48.3 ms, max ~ 95.3 ms	(Saavedra E, A Universal Testbed for IoT Wireless Technologies: Abstracting Latency, Error Rate and Stability from the IoT Protocol and Hardware Platform, 2022)
8	Bluetooth 5 (opportunistic network)	Average E2E latency ~736ms in simulated scenarios, but in many tests constant latency ~50ms for local operations	(Niebla-Montero, 2022)
9	BLE in real-time / industrial IoT	According to optimized retransmissions: maximum latency <46ms	(Rondón, 20174)

10	Wi-Fi (in IoT test)	Average ~ 32.3 ms, max ~ 178.1 ms	(Saavedra E, A Universal Testbed for IoT Wireless Technologies: Abstracting Latency, Error Rate and Stability from the IoT Protocol and Hardware Platform, 2022)
11	Bluetooth Low Energy (BLE)	Average ~ 26.97 ms, max ~ 125.4 ms	(Saavedra E, A Universal Testbed for IoT Wireless Technologies: Abstracting Latency, Error Rate and Stability from the IoT Protocol and Hardware Platform, 2022)
12	NB-IoT	Average ~ 1 797.3 ms (~1.8 s), max ~ 10 275 ms (~10.3 s)	(Saavedra E, A Universal Testbed for IoT Wireless Technologies: Abstracting Latency, Error Rate and Stability from the IoT Protocol and Hardware Platform, 2022)
13	LoRaWAN (16 B package)	~2 s do ~3.5 s measured 16B data transfer time	(Ugwuanyi, 2021)
14	NB-IoT (in the same work)	~837ms (in good signal) measured average	(Ugwuanyi, 2021)
15	IPv6 over SCHC-over-LoRaWAN	"Delay less than 1s" (measured)	(Sisinni E, 2023)
16	Mesh protocols – smaller package	Latency <100ms (at least Zigbee) for small packets; Bluetooth range ~20 200ms	(Charles, 2023)
17	LPWAN in the context of IoT	„Delay of less than 1 s" in that work	(Sisinni, 2023)
18	Body worn multiple sensors in a sports environment	D2D latency ~ 504.99 µs ± 96.89 µs; network latency ~ 311.78 µs ± 96.90 µs	(Nico Krull, 2025)
19	IoT model with local (fog) processing	Focus on "fast response" and "low latency" in the text, but without precise ms values in the abstract	(Karakaya A, 2021)
20	Testing latency in portable heart rate monitoring devices during exercise	Device latency significantly affected the deviation from the criteria, but the numbers (in ms) were not specified in detail in the abstract	(Støve MP, 2020)
21	Empirical measurement of delay	Median ~52ms for one sensor (range ~50-57ms)	(Martin F. Berg1, 2023)
22	Wireless sensor system for sports (sit ski)	Median delay: 52ms for wired "main system", 53ms for wireless "sub system".	(Martin F. Berg1, 2023)
23	IoT + edge computing for sports performance	Average processing latency ~12.34 ms	(Yang Hu, 2025)
24	IoT + edge processing for tracking athletes	Average processing latency: 12.34ms.	(Yang Hu, 2025)
25	Although primarily health-related, it investigates latency attributes of wearable IoT devices	It studies BLE connection parameters (interval, latency, timeout) and their impact on performance	(Arthur Gatouillat, 2018)
26	Wearable IoT devices and low latency in the context of health monitoring	Discussion of the importance of low latency, but without concrete numerical measurement for sports	(Naeem Akbar Channar, 2025)
27	Portable technologies in sports	It discusses the accuracy and response time of the sensor, but does not provide specific latencies for all cases	(Aroganam, 2019)

28	Racing system, 5G transmission	Round trip latency: 128.92ms (indoor, sd=25.83ms and 140.14ms (outdoor, sd=14.47ms)	(Sebastian Mayr, 2024)
29	Measurement of round trip time (RTT) for real-time transmission	RTT mean ~128.92 ms (sd25.83) for internal tests; ~140.14 ms (sd14.47) for external.	(Liu Z. Y., 2022)
30	Secure routing protocol based on blockchain technology	transaction latency up to 3200ms when sending 1300tps, latency 500ms when reading 3000tps data	(Shahbazi Z, 2020)

Based on the knowledge gathered from the available literature, comparisons and analysis of data were made that are directly related to the research into the causes of latency, as well as the consequences that latency produces in the domain of sports measurements. Table 2 provides an overview of the latency ranges, broken down by sport type and the most commonly used sensor technologies in that sport. Values are typical/ranges from literature and industry reports.

Table 2. *View latency by sport*

Sports / scenario	Typically used sensors/technology	Typical sensor latency (ms)	Typical E2E (sensor → application/ edge/cloud) (ms)	Comment / source
E-sport / input devices	Input devices, local IMU/USB	0.5–2 ms	1–10 ms	ultra-low latency input; target <10ms. (Rubin, 2013)
Tennis (strokes, ball speed)	IMU in rocket, optical tracking, UWB	1–10 ms (IMU) / 5–30 ms (UWB) / 5–50+ ms (camera + processing)	20–80 ms	UWB and IMU provide the lowest latency for instant analysis. (Yang W, 2025)
Basketball	IMU + optical tracking (camera)	5–15 ms (IMU) / 30–100 ms (camera+detection)	50–150 ms	Optical systems and AI processing usually increase E2E. (Xie, 2024)
Football (field)	GNSS/GPS + IMU + UWB	10–30 ms (IMU) / 50–300 ms (GNSS uplink/filtering) / 5–50 ms (UWB)	100–300 ms	GNSS often introduces the greatest latency, especially with RT cloud processing. (Adnan Waqar, 2021)
Swimming	Waterproof IMU + acoustic/UWB beacons	15–50 ms (IMU) / 50–200+ ms (acoustic/UWB specific)	200–400 ms	medium water + synchronization increase the delay. (Alshardan A, 2025)
Athletics (races, marathons)	RFID timing + GPS + IMU	RFID detection: ~10–50 ms (readers/processing) / GPS: 50–300 ms	100–300+ ms	RFID for target registration is reliable but requires synchronization. and backend processing. (Högskola, 2015)
Biosignal monitoring (heart rhythm)	PPG (wrist), ECG (chest)	PPG acquisition + filtering: ~50–200 ms effective; ECG chest: ~5–20 ms	50–200+ ms	PPG requires filtering and artefact correction; chest-ECG is faster and more precise. (Castaneda D, 2018)

The distribution of latency by sport (Table 2) depends more on the choice of technology and system architecture (local edge processing or cloud processing) than on the sports discipline itself.

For the purposes of this research, the following data were taken into account from available works:

1. Data transfer speed
2. Sensor sensitivity
3. Latency (of the IoT device itself, during data transmission and processing)

In the paper (Ivan Jovović, 2015) the data transfer speed using 4G and 5G networks was compared. In the case of the 5G network, the minimum speeds ranged from 1Gbps to a maximum of 10Gbps. In the case of the 4G network, the speeds ranged from 10Mbps to a maximum of 1Gbps. In the diagram 1, it can be seen that the latency of the air transmission in 4G is 10ms, and in 5G it is 1ms. In addition, the latency in E2E (End to end) in 4G is 50ms, and in

5G it is 5ms. The authors of this paper claim that with each new generation of mobile communication systems, data transfer speeds increase twice as much as in the previous generation. They also state that one of the main requirements is to increase the speed and data capacity while significantly reducing the level of latency in the next generation mobile network system.

In sports application, the term sensitivity can appear in two closely related meanings:

- **Physical (analog) sensitivity** — the change in sensor output per unit of input quantity (e.g. mV/°C for temperature sensors, mV/g for accelerometers). This is a hardware characteristic: gain, resolution, and noise.
- **Functional/operational sensitivity (detection)** — The ability of a system to detect an event or change (e.g., collision detection, sprint start/stop, irregular movement pattern detection). It is measured by metrics such as sensitivity/true positive rate, specificity, accuracy, and precision relative to the gold standard.

In practice, both dimensions affect the reliability of measurements in sports: hardware sensitivity determines the minimum measurable change, and functional sensitivity also depends on signal processing, algorithms, and sensor positioning. (Liu L. a., 2022)

Although a multitude of papers have been published on the topic of IoT and sports, there are far fewer papers on the topic of IoT latency in sports. Despite the relevant findings and contribution to understanding the effects of IoT device latency in the context of measuring sports activities, which are presented from a cross-section of several papers.

The research in the papers was conducted on a limited number of IoT devices and with a relatively small sample of users, which may reduce the possibility of generalizing the obtained results to a wider population and different types of sports disciplines. Future research should include a larger number of devices, different sports contexts and real-world application conditions, as well as the integration of multiple communication technologies.

Results

It was found that the most common IoT devices used in sports are. (Wearable Devices In Sports Market Size & Share Analysis - Growth Trends and Forecast (2025 - 2030) Source: https://www.mordorintelligence.com/industry-reports/wearable-devices-in-sports-market, 2025):

- **By device type** - tracking devices (GPS[1] and GNSS[2]) led the way with a 47.83% share of the wearable devices market in sports in 2024; smart clothing and e-textiles are growing at a compound annual growth rate (CAGR[3]) from 5.23% by 2030. According to (Art Dogtiev, 2025) Fitbit devices show a significant growth trend in the number of users in the period from 2014 to 2023. According to Huawei, the number of IoT devices connected to their cloud has exceeded 200 million, and the data is from October 15, 2018. (Michael Ma, President of Huawei Cloud Core Network Product Line, 2018)
- **By sport** - football accounted for 28.74% of the sports wearables market in 2024 and is expanding at a compound annual growth rate (CAGR) of 4.87% until 2030.
- **By end user** - Professional teams and leagues accounted for 42.63% of the revenue share in 2024 in the sports wearables market, while recreational fitness users are recording the highest projected CAGR of 5.18%, with this rate projected to continue through 2030.
- **By distribution channels** - online sales accounted for 56.72% of the sports wearables market in 2024 and is growing at a compound annual growth rate (CAGR) of 5.40%.
- **By region** - North America maintained 39.63% share of sports wearables market in 2024; The Asia-Pacific region is projected to experience the fastest compound annual growth at 5.89%, and this rate is projected to continue through 2030.

One of the most common sources of latency in IoT systems for measuring sports activities has been identified as factors related to data transmission and processing. Latency most often occurs due to delays in data transmission through the network, which is a result of limited bandwidth, network congestion, or greater physical distance between the device and the server. In addition, data processing processes contribute significantly to latency, especially in cases where data is analyzed in remote server environments (cloud computing), which increases the overall system response time. Inefficient communication protocols, limited processing resources and memory capacities of IoT de-

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1 GPS – Global positioning system

2 GNSS - Global navigation satellite system

3 CAGR - Compound annual growth rate

vices, as well as interference and instability of wireless networks, also contribute to increased latency (Table 3). In addition, the lack of precise synchronization between multiple sensor nodes can further cause time discrepancies in data collection and processing. (Althoubi, 2021) (Lea, 2020) (Kumar, 2023)

According to the above findings, it was found that the most negative and undesirable effects of IoT device latency in sports occur in systems that require real-time data processing, such as wearable sensors and athlete performance monitoring systems, where latency can lead to inaccurate analyses and wrong decisions. (Yang Hu, 2025) (Vec, 2024; Wu X, 2023)

Table 3. View latency and error measurements (Saavedra E, A Universal Testbed for IoT Wireless Technologies: Abstracting Latency, Error Rate and Stability from the IoT Protocol and Hardware Platform, 2022)

Measurement		6LoWPAN	LoRaWAN	Sigfox	Zigbee	Wi-Fi	BLE	NB-IoT
Latency (ms)	Minimum	19.522	282.40	3467.1	34.174	25.294	13.382	329.29
	Average	22.116	296.96	3695.2	48.298	32.300	26.974	1797.3
	Max	356.14	334.81	5651.0	95.295	178.10	125.40	10,275
Error	Γ	2	66	0	0	0	0	0
	E	0.02%	0.66%	0%	0%	0%	0%	0%
Stability	Λ (ms)	9.883	5.419	290.4	5.242	9.502	13.68	1352
	Π	386	2	4	2307	3197	480	4052
	K	3.86%	0.02%	4%	23.1%	31.9%	96.0%	81.0%
	Ω	0.924	0.993	0.922	0.592	0.463	0.002	0.036

As shown in Table 4, the three most common sources of latency are:

- Sensor latency typically has a greater impact on data accuracy in applications that require high-accuracy, real-time measurements. For example, in sports such as tennis, soccer, or running, where precise measurement of instantaneous movements is required, sensor latency can mean inaccurate data that does not reflect the real situation. (Nico Krull, 2025)
- Data transmission latency is critical in applications that use streaming or require real-time data analysis, such as athlete performance tracking applications, online coaching, or telemetry in professional sports. In these cases, high data transmission latency can lead to delays in results visualization and feedback. (Gkagkas, 2025) (Yang Hu, 2025)
- Data processing latency is crucial in IoT systems for sports activities because it directly affects the speed and accuracy of real-time analysis of results. In situations where immediate feedback is needed – such as correcting running technique, analyzing a shot, or monitoring an athlete's heart rate – even minimal processing delays can lead to misinterpretation of performance. (Yang Hu, 2025) (Xiaowei Tang, 2025).

Table 4. Shows the impact of latency sources on the results obtained

Factor	Impact on results	Example
Sensor latency	It leads to inaccurate or outdated real-time data.	Incorrect power measurement in tennis due to sensor delay
Data transmission latency	It causes delays in data display and system responses.	Real-time data streaming (e.g. GPS for cycling) with transmission delay.
Data processing latency	They lead to data displayed by the system that does not reflect the real situation on the field, which can result in incorrect performance analyses, delayed reactions and poorer training decisions.	A delay of 50–100 milliseconds can lead to inaccurate estimation of step phase or rebound force, compromising the quality of biomechanical analysis.. (Yang Hu, 2025)

The results show that the latency of IoT devices can significantly affect the accuracy of measurements in sports laboratory conditions, especially for fast and explosive movements. Although software correction can mitigate the effects of latency, it cannot completely replace the accuracy of reference systems. (Althoubi, 2021) It is necessary to

develop hybrid systems that combine the mobility of IoT devices with the precision of laboratory tools. Also, standardization of protocols for synchronization and data processing can improve the reliability of IoT measurements.

The work of the group of authors (Akpa, 2019) states the importance of smart glove design and evaluation of exercise recognition performance and the accuracy of the repetition counting algorithm of the system. The design integrates 16 FSR (Force-sensitive resistor) sensors in the activity tracking glove to identify activities and count repetitions of performance, analyze time series and distribution of pressure applied to the palm during the exercise. The presented validation experiment with 10 healthy participants during 10 common tracking exercises showed an overall exercise recognition accuracy of 88.00% for person-dependent assessment and 82.00% for person-independent assessment. The evaluation of the repetition counting algorithm achieved an average counting error rate of 9.85%. Based on the obtained results, the conclusion is that the smart glove can be used for tracking and assessing tracking activities, but it is necessary to include other IoT devices and sensors, which will monitor the body position in space, and the load on other muscles, heart, and pulse and temperature and sweating. (Akpa, 2019)

In feedback systems (e.g., smart bracelets that vibrate to alert an athlete to an error), any delay in data transmission reduces the effectiveness of the intervention. If the device warns the athlete after the incorrect movement has already been completed, the feedback information is useless and may reinforce the incorrect motor pattern. X. Tang et al. (Xiaowei Tang, 2025) showed through an artificial neural network model that a delay of only 80 ms in the feedback loop increases the movement correction error by 12% in running activities. The delay in data transmission and processing leads to a mismatch between the signal between the sensor and the athlete's actual movement. For example, if the sensor responds with a delay of 100 ms, the analysis system may register a step, jump, or kick at the wrong time. This can lead to incorrect estimates of joint angle, force, and movement speed, false positives (e.g., the system detects a movement that did not occur), and missed events (e.g., actual contact with the ground is not registered). Krull et al. have shown that latency above 20 ms in multisensor running tracking systems increases the error in stride phase detection by more than 15%. (Nico Krull, 2025)

Latency in IoT systems can have serious biomechanical and safety implications. According to Hu et al (Yang Hu, 2025), IoT and deep learning-based systems must maintain latency below 50 ms in order to respond to changes in biomechanical signals in a timely manner. Krull et al (Nico Krull, 2025) showed that sensor desynchronization greater than 20 ms can increase the risk of injury by 18% in runners due to incorrect detection of the stride phase.

In high-intensity sports such as football, basketball, and gymnastics, even minimal latency can cause the athlete to respond incorrectly, leading to poor body posture and an increased risk of muscle and joint injuries. It is especially dangerous if the system does not recognize dangerous loads in time or misinterprets biomechanical data, which can result in sprains or microtraumas. Therefore, it is important to correctly determine latency thresholds (Table 5) that will prevent such effects. For high-end real-time motor events in sports, below 5 ms is ideal, while for less critical data, values up to ~50 ms or ~100 ms are acceptable. (Martin F. Berg, 2023) (Nico Krull, 2025)

Table 5. Latency thresholds (Yang Hu, 2025)

Application type	Recommended maximum latency
Priority 0 Critical motor events (e.g., sprint start, contact force)	< 5 ms (ideal), ≤ 10 ms
Priority 1 Real-time physiological or biomechanical data (eg acceleration)	< 20 ms
Priority 2 Position tracking and team sports (e.g. football, basketball)	< 50 ms
Priority 3 Contextual/ambient data (e.g. environment, temperature)	< 100 ms

To reduce these risks, it is recommended to implement predictive algorithms at the edge of the network (edge computing), better time synchronization of sensors using the IEEE1588 PTP protocol or the newer IEEE1588 PTPv2 (Jing, 2024), as well as local data processing without relying on a remote cloud. Also, adding redundant sensors and signal filtering can contribute to reducing the risk of delay-related injuries.

Table 6. *Comparison of IoT communication protocols (Pothuganti Karunakar, 2014)*

Standard	Bluetooth	UWB	Zigbee	Wi-Fi
IEEE spec.	802.15.1	802.15.3a	802.15.4	802.11 a/b/g
Frequency range	2.4Ghz	3.1-10.6Ghz	868/915 Mhz; 2.4Ghz	2.4Ghz; 5Ghz
Maximum signal speed	1 Mb/s	110Mb/s	250kb/s	54Mb/s
Nominal range	10m	10m	10-100m	100m
Nominal TKS (transmission) power	0-10 dBm	-41.3 dBm/MHz	(-25) – 0. dBm	15+20 dBm
Number of RF channels	79	(1-15)	1/10;16	14(2.4Ghz)
Channel bandwidth	1MHZ	500MHz – 7.5GHz	0.3/0.6 MHz; 2MHz	22MHz
Modulation type	GFSK	BPSK, QPSK	BPSK, (+ ASK), O-QPSK	BPSK, QPSK, COFDM, CCK, OFDM
Expansion	FHSS	DS-UWB, MB-OFDM	DSSS	DSSS, CCK, OFDM
Coexistence mechanism	Adaptive frequency hopping	Adaptive frequency hopping	Dynamic frequency selection	Dynamic frequency selection transmit power control (802.11h)
Basic cell	*Piconet*	*Piconet*	Star	*BSS*
Extension of the base cell	*Scatternet*	*Peer-peer*	Tree-network cluster	*ESS*
Maximum number of cell nodes	8	8	>65000	2700
Data protection	16-bit CRC	32-bit CRC	16-bit CRC	32-bit CRC

To reduce latency in data transmission, it is extremely important to choose the right communication protocol. The speed and reliability of transmission depend primarily on the technical characteristics of the selected protocol (Table 6). Limitations for the use of a communication protocol can be associated with the quality of the IoT device, i.e. cheaper IoT devices generally have higher latency due to weaker processors and unoptimized communication protocols, so they are definitely not an option for professional sports.

DISCUSSION

Already in the presentation of the results, certain aspects and effects that the latency of IoT devices in sports causes, depending on the source of latency, were discussed. IoT sensors, as part of an athlete's activity monitoring system, help users maintain proper form and improve efficiency. Therefore, programming of wearable technology (microcontroller data processing) and timely information are of vital importance. (Ewald M. Hennig, 2010)

The influence of position and signal processing, attachment point (torso, lower leg, helmet) and algorithms (filtering, sensor fusion: Kalman/complementary filter, machine learning) significantly change the "operational sensitivity". (Roell, 2019) IMU (inertial measurement unit) accelerometers are most commonly used for impact detection and dynamic parameters, but their accuracy depends on algorithms and sampling frequency; direct calibration to 3D motion-capture is common practice. (Roell Mareike, 2019) Sensor position and attachment significantly affect sensitivity and reliability: e.g. skin-mounted sensors give different results than those in clothing or equipment. It is recommended to standardize the position during repeated measurements. (Eitzen Ingrid, 2021) A tuning compromise must be made between sensitivity and low alarms. Namely, excessive gain, i.e. low tolerance for noise leads to false positive detections (eg small movements are interpreted as blows). Filters and thresholds must be adapted to the motion tracking application. (Seçkin, 2023) Validation in real-world sports conditions is almost always weaker than in the laboratory, and many studies show that performance degrades in the field (changing conditions, interference, different types of movements). Therefore, it is imperative to test "in situ", i.e. at the original location of use. (Mareike Roell, 2019) Flexible and "skin-like" sensor technologies with high sensitivity show great potential for monitoring fine biomechanical signals (e.g. strain sensors for joint angle analysis), but often require advanced calibration and AI/ML post-processing. (Liu L. a., 2022) Many studies compare IMU (accelerometer+gyroscope) data with 3D motion-capture systems and report amplitude/peak and temporal synchronization errors. (Roell, 2019) Validation metrics RMSE (root-mean-square error), MAE (mean absolute error), correlation, Bland–Altman analysis for detection tasks, sensitivity (recall), specificity, F1-score.

(Xiaoming Wang, 2023) Hardware parameters include bit resolution, range (±2g, ±16g), noise data, sampling rate. In sports, high sampling rates and appropriate range are important because impacts and rapid movements can produce short, high amplitudes. (Liu L. a., 2022)

For cases where latency is critical (e.g. real-time feedback to athletes, interactive analytics) it is necessary to use protocols with proven low latency (e.g. BLE, Zigbee in small networks, edge processing). Low latency protocols enables faster feedback.

Three data packet retransmission schemes were evaluated, and simulation results proved that by optimally modifying the BLE data packet retransmission model, a maximum delay below 46 ms and a packet loss rate of the order of 10^{-5}, which allows BLE to meet the requirements of even the most demanding cases within the considered application range. Due to its ultra-low power properties, compatibility with most mobile units, reduced manufacturing costs, robustness and high throughput, BLE is the solution for such environments. (Rondón, 20174)

If the system can tolerate higher latency (e.g. post-training measurement, non-critical monitoring), technologies like LoRaWAN, NB IoT may be acceptable. Acceptability and bring greater range and better energy efficiency.

Practical recommendations for technology selection and model design

- If latency is critical (e.g. live response to athletes, interactive analytics) consider using protocols with proven low latency (e.g. BLE, Zigbee in small networks, edge processing).
- If the system can tolerate higher latency (e.g. post-training measurement, non-critical monitoring), technologies like LoRaWAN, NB IoT may be acceptable and bring greater range and better energy efficiency.
- It is always necessary to keep in mind that works in the literature are often in ideal conditions, while in a real sports environment (movement, multiple nodes, interference) latency may be higher.
- When designing an edge or fog architecture, processing can reduce latency compared to cloud processing, as is evident from the work "Fog Computing: Survey of Trends, Architectures, Requirements, and Research Directions" which highlights the importance of near-device processing for latency-critical applications. (Ranesh Kumar Naha, 2018)
- When implementing the model, it is necessary to test in real conditions: number of nodes, distance, number of hops, network traffic, because all of this affects the latency and efficiency of the entire solution. It is not enough to just take the specification of the IoT device manufacturer.

Conclusion

IoT devices offer special flexibility and accessibility in sports measurements, but the issue of latency in IoT devices poses a significant challenge. In laboratory conditions, precision is key, so careful integration of IoT technology with correction methods and validation with reference systems is required. Looking at all the above data and research on latency, latency depends on multiple parameters, not only on the hardware and software resources of IoT devices, but also on the transmission medium, local network, software solution, algorithm complexity, cloud computing used and other parameters that give the overall system latency.

Latency in IoT sports transmission systems can significantly affect the reliability and accuracy of automatic event detection. Simulation examples and a literature review suggest that maintaining latency below tens of milliseconds (depending on the application requirement) significantly improves system performance. For the most demanding applications (high-frequency biosignals), sub-ms solutions and very precise synchronization are required, which is achievable with specialized hardware and protocols. A combination of edge processing architectures, deterministic protocols, and latency compensation algorithms is recommended. (Nico Krull, 2025)

In some future work, it would be interesting to explore the development of hybrid systems that combine IoT and laboratory data for high accuracy with mobility. It is also very important to include artificial intelligence that can improve the efficiency of the system for tracking sports IoT devices.

Also, an interesting area for research is the use of nanotechnology for advanced sensor solutions, as well as the use of artificial intelligence systems for data processing.

Literature

Adnan Waqar, I. A. (2021). Analysis of GPS and UWB positioning system for athlete tracking. *Measurement: Sensors, 14.* doi:10.1016/j.measen.2020.100036.

Aimad Karkouch, H. M. (2016). Data quality in internet of things: A state-of-the-art survey. *Journal of Network and Computer Applications, 73,* 57-81. Retrieved from https://doi.org/10.1016/j.jnca.2016.08.002

Akpa, A. H. (2019). A Smart Glove to Track Fitness Exercises by Reading Hand Palm. *Journal of Sensors, 1*, 1-19. doi:https://doi.org/10.1155/2019/9320145

Alshardan A, M. H. (2025). Cloud-to-Thing continuum-based sports monitoring system using machine learning and deep learning model. *PeerJ Comput Sci.* doi:10.7717/peerj-cs.2539

Althoubi, A. R. (2021). Delay Analysis in IoT Sensor Networks. *Sensors, 21*(11). doi:10.3390/s21113876

Aroganam, G. N. (2019). Review on Wearable Technology Sensors Used in Consumer Sport Applications. *Sensors, 19*(9). doi:10.3390/s19091983

Art Dogtiev, N. T. (2025). *Fitbit Revenue and Usage Statistics (2025)*. (Business of Apps) Retrieved 9 1, 2025, from https://www.businessofapps.com/data/fitbit-statistics/#:~:text=Source:%20Company%20data-,Fitbit%20Device%20Sales,it%20sold%20206.6%20million%20units.

Arthur Gatouillat, B. M. (2018). Building IoT-Enabled Wearable Medical Devices: An Application to a Wearable, Multiparametric, Cardiorespiratory Sensor. *BIODEVICES*, 109-118. Retrieved from https://www.scitepress.org/papers/2018/67291/67291.pdf

Athanasios G. Kanatas, K. S. (2018). *New Directions in Wireless Communications Systems - From Mobile to 5G.* Boca Raton: CRC Press Taylor & Francis Group.

Benchmarking Bluetooth Mesh, Thread, and Zigbee Network Performance. (2025). (Silicon Labs) Retrieved 9 1, 2025, from https://www.silabs.com/wireless/multiprotocol/mesh-performance

Castaneda D, E. A. (2018). review on wearable photoplethysmography sensors and their potential future applications in health care. *Int J Biosens Bioelectron, 4*(4), 195-202. doi:10.15406/ijbsbe.2018.04.00125

Charles, S. (2023, 7 11). *Choosing the Right IoT Protocol to fulfill Your Network Architecture Needs.* (Granite River Labs, GRL) Retrieved 9 1, 2025, from https://www.graniteriverlabs.com/en-us/technical-blog/iot-network-protocol-considerations

Chen, M., Ma, Y., Li, Y., Wu, D., Zhang, Y., & Youn, C.-H. (2017). Wearable 2.0: Enabling Human-Cloud Integration in Next Generation Healthcare Systems. *IEEE Communications Magazine , 55*(1), 54 - 61.

Eitzen Ingrid, J. R. (2021). The Use of Wearable Sensor Technology to Detect Shock Impacts in Sports and Occupational Settings: A Scoping Review. *Sensors, 21*(15). doi:10.3390/s21154962

Ewald M. Hennig, T. S. (2010). The influence of soccer shoe design on playing performance: a series of biomechanical studies. *Footwear Science, 2*(1), 3-11. doi:10.1080/19424281003691999

Gkagkas, G. V. (2025). The Behavior of an IoT Sensor Monitoring System Using a 5G Network and Its Challenges in 6G Networking. *Electronics, 14*(16). doi:10.3390/electronics14163167

Högskola, M. (2015, 5 27). *Mälardalen University Library .* Retrieved 9 1, 2025, from https://mdu.diva-portal.org/smash/get/diva2%3A819389/FULLTEXT01.pdf

IoT Latency: The Power of Real-Time Communication . (n.d.). (Nabto) Retrieved 9 1, 2025, from https://www.nabto.com/iot-latency-the-power-of-real-time-communication/

Ivan Jovović, I. F. (2015). Massive Machine-Type Communications: An Overview and Perspectives Towards 5G. *Proceedings The 3rd International Virtual Research Conference In Technical Disciplines, 3*. doi:10.18638/rcitd.2015.3.1.73

Jesus G, C. A. (2017). A Survey on Data Quality for Dependable Monitoring in Wireless Sensor Networks. *Sensors, 17(9):2010.* doi:10.3390/s17092010

Jing, W. (2024, 11 25). *What Is 1588v2?* (Huawei) Retrieved 9 1, 2025, from https://info.support.huawei.com/info-finder/encyclopedia/en/1588v2.html

Jorge Merino, I. C. (2016). A Data Quality in Use model for Big Data. *Future Generation Computer Systems, 63*, 123-130. Retrieved from https://doi.org/10.1016/j.future.2015.11.024

Karakaya A, A. S. (2021). A novel IoT-based health and tactical analysis model with fog computing. *PeerJ Computer Science, 7.* doi:10.7717/peerj-cs.342

Kumar, P. K. (2023). *IoT, Big Data and AI for Improving Quality of Everyday Life: Present and Future Challenges.* Cham: Springer Nature. doi:10.1007/978-3-031-35783-1

Latency and Power Consumption in 2.4 GHz IoT Wireless Mesh Nodes: An Experimental Evaluation of Bluetooth Mesh and Wirepas Mesh. (2023). *Proceedings of the 2023 IEEE International Conference on Wireless and Mobile Computing, Networking And Communications (WiMob).* doi:10.1109/WiMob58348.2023.10187799

Lea, P. (2020). *IoT and Edge Computing for Architects.* Livery Place: Packt Publishing. Retrieved 9 1, 2025

Liu, L. a. (2022). A Focused Review on the Flexible Wearable Sensors for Sports: From Kinematics to Physiologies. *Micromachines, 13*, 8. doi:https://doi.org/10.3390/mi13081356

Liu, Z. Y. (2022). Comparative Evaluation of the Performance of ZigBee and LoRa Wireless Networks in Building Environment. *Electronics, 11*(21). doi:10.3390/electronics11213560

Mareike Roell, H. M. (2019). Validation of Wearable Sensors during Team Sport-Specific Movements in Indoor Environments. *Sensors, 19*(16). doi:10.3390/s19163458

Martin F. Berg, H. D. (2023). Wireless sensor system for real-time performance monitoring in sports. *Frontiers in Sports Active Living, 5*, 1-11. doi:10.3389

Martin F. Berg1, H. D. (2023). Wireless sensor system for real-time performance monitoring in sports. *Sports Science, Technology and Engineering, 5.* doi:10.3389/fspor.2023.1305117

Michael Ma, President of Huawei Cloud Core Network Product Line. (2018, 10 16). *Huawei Releases IoT Cloud Service 2.0 to Enable Industrial IoT by Combining Connectivity, Cloud, and Intelligence.* (Huawei) Retrieved 9 1, 2025, from https://e.huawei.com/at/news/cloud-communications/201810161654

Mühlhäuser, M. (2007). Smart products: An introduction. *Proceedings of the European Conference on Ambient Intelligence*, 158–164.

Naeem Akbar Channar, M. Y. (2025). A REVIEW ON EDGE AI FOR LOW-LATENCY HEALTH MONITORING IN WEARABLE IOT DEVICES: CHALLENGES AND FUTURE DIRECTIONS. *Spectrum of Engineering Sciences, 3*(7), 1424–1435.

Nico Krull, L. S. (2025). Wireless Low-Latency Synchronization for Body-Worn Multi-Node Systems in Sports. *Proceedings of the International Conference on Body Sensor Networks.* Retrieved from https://arxiv.org/pdf/2509.06541

Niebla-Montero, Á. I.-M.-L.-C. (2022). Practical Latency Analysis of a Bluetooth 5 Decentralized IoT Opportunistic Edge Computing System for Low-Cost SBCs. *Sensors, 22*(21). doi:10.3390/s22218360

Passos, J. L.-G. (2021). Wearables and Internet of Things (IoT) Technologies for Fitness Assessment: A Systematic Review. *Sensors, 21*, 1-18. doi:10.3390/s21165418

Pothuganti Karunakar, C. A. (2014). A Comparative Study of Wireless Protocols: Bluetooth, UWB, ZigBee, and Wi-Fi. *Advance in Electronic and Electric Engineering, 4*, 655-662. Retrieved from https://www.researchgate.net/figure/Comparison-of-the-Bluetooth-UWB-Zigbee-And-Wi-Fi-Protocols_tbl1_316103356

Qusay F. Hassan, A. u. (2018). *Internet of Things Challenges, Advances, and Applications.* Boca Raton: CRC Press - Taylor & Francis Group.

Ranesh Kumar Naha, S. G. (2018). Fog Computing: Survey of Trends, Architectures, Requirements, and Research Directions. *IEEE Access, 10*, 47980–48009. doi:10.1109/access.2018.2866491

Razlike između 4g mreže i 5g mreže. (2023, 11 4). (IHUA Link international PTE. LTD) Retrieved 9 1, 2025, from http://ba.ihua-digital.com/info/the-differences-between-4g-networ-and-5g-netwo-89214144.html#:~:text=1.Speed:%204G:%204G%20mre%C5%BEe%20obi%C4%8Dno%20pru%C5%BEaju%20brzine,preuzimanja%20do%20nekoliko%20gigabita%20u%20sekundi%20(Gbps)%2C

Roell Mareike, H. M. (2019). Validation of Wearable Sensors during Team Sport-Specific Movements in Indoor Environments. *Sensors, 19*(16). doi:10.3390/s19163458

Roell, M. H. (2019). Validation of Wearable Sensors during Team Sport-Specific Movements in Indoor Environments. *Sensors, 19*, 16. doi:https://doi.org/10.3390/s19163458

Rondón, R. G. (20174). Evaluating Bluetooth Low Energy Suitability for Time-Critical Industrial IoT Applications. *International Journal Wireless Inf Networks, 24*, 278–290. doi:10.1007/s10776-017-0357-0

Rubin, P. (2013, 12 16). *Oculus Primed: Meet the Geniuses Who Finally Mastered Virtual Reality*. (WIRED) Retrieved 9 1, 2025, from https://www.wired.com/2013/12/oculus-rift-2/

Saavedra E, M. L. (2022). A Universal Testbed for IoT Wireless Technologies: Abstracting Latency, Error Rate and Stability from the IoT Protocol and Hardware Platform. *Sensors*, 1-26. doi:10.3390/s22114159

Saavedra E, M. L. (2022). A Universal Testbed for IoT Wireless Technologies: Abstracting Latency, Error Rate and Stability from the IoT Protocol and Hardware Platform. *Sensors*. doi:10.3390/s22114159

Sebastian Mayr, H. R. (2024). 5G-Based Body Sensor Network for Real-Time Feedback in Running. *Proceedings of the 12th International Conference on Sport Sciences Research and Technology Support*, 180-184. doi:10.5220/0012942500003828

Seçkin, A. Ç. (2023). Review on Wearable Technology in Sports: Concepts, Challenges and Opportunities. *Applied Sciences, 13*(18). doi:10.3390/app131810399

Shahbazi Z, B. Y. (2020). Towards a Secure Thermal-Energy Aware Routing Protocol in Wireless Body Area Network Based on Blockchain Technology. *Sensors, 20*(12). doi:10.3390/s20123604

Sisinni E, F. C. (2023). Assessing a Methodology for Evaluating the Latency of IPv6 with SCHC Compression in LoRaWAN Deployments. *Sensors, 23*(5). doi:10.3390/s23052407

Sisinni, E. D. (2023). Assessing a Methodology for Evaluating the Latency of IPv6 with SCHC Compression in LoRaWAN Deployments. *Sensors, 23*(5).

Støve MP, H. R. (2020). Measurement latency significantly contributes to reduced heart rate measurement accuracy in wearable devices. *J Med Eng Technol., 44*(3), 125-132. doi:10.1080/03091902.2020.1753836

Ugwuanyi, S. G. (2021). Survey of IoT for Developing Countries: Performance Analysis of LoRaWAN and Cellular NB-IoT Networks. *Electronics, 10*(18). doi:10.3390/electronics10182224

Vec, V. T. (2024). Trends in real-time artificial intelligence methods in sports: a systematic review. *Journal of Big Data, 11*. doi:10.1186/s40537-024-01026-0

Wearable Devices In Sports Market Size & Share Analysis - Growth Trends and Forecast (2025 - 2030). (2025). (Mordor Intelligence) Retrieved 9 1, 2025, from https://www.mordorintelligence.com/industry-reports/wearable-devices-in-sports-market

Wearable Devices In Sports Market Size & Share Analysis - Growth Trends and Forecast (2025 - 2030) Source: https://www.mordorintelligence.com/industry-reports/wearable-devices-in-sports-market. (2025). (Mordor Intelligence) Retrieved 9 1, 2025, from https://www.mordorintelligence.com/industry-reports/wearable-devices-in-sports-market

What Are the 5G Speeds and How It Differs from 2G, 3G, and 4G Networks? (2025). (1NCE GmbH) Retrieved 9 1, 2025, from https://www.1nce.com/en-eu/resources/iot-knowledge-base/5g-vs-4g-speed

Wu X, L. C. (2023). Internet of things-enabled real-time health monitoring system using deep learning. *Neural Comput Appl., 35*(20), 14565-14576. doi:10.1007/s00521-021-06440-6.

Xiaoming Wang, H. Y. (2023). Wearable sensors for activity monitoring and motion control: A review. *Biomimetic Intelligence and Robotics, 3*(1). doi:https://doi.org/10.1016/j.birob.2023.100089.

Xiaowei Tang, B. L. (2025). Real-time monitoring and analysis of track and field athletes based on edge computing and deep reinforcement learning algorithm. *Alexandria Engineering Journal, 114*, 136-146. Retrieved from https://doi.org/10.1016/j.aej.2024.11.024

Xie, Y. (2024). Innovative Application of Computer Vision and Motion Tracking Technology in Sports Training. *EAI Endorsed Transactions on Pervasive Health and Technology*. doi:10.4108/eetpht.10.5763

Yang Hu, Y. L. (2025). Internet of things enabled deep learning monitoring system for realtime performance metrics and athlete feedback in college sports. *Scientific Reports, 15*, 3.

Yang W, W. J. (2025). Accuracy of an Ultra-Wideband-Based Tracking System for Time–Motion Analysis in Tennis. *Sensors, 25*(4). doi:10.3390/s25041031

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Yoga as Fitness Therapy to Improving Physical Strength and Body Balance: Systematic Literature Review

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Abstract: *Yoga, as a holistic fitness therapy, plays a vital role in enhancing physical strength and balance, nurturing overall well-being for people of all ages and backgrounds. Through a careful systematic review following PRISMA guidelines, we explored seven high-quality studies from PubMed, Scopus, and Web of Science, published between 2015 and 2025. These studies reveal that yoga, especially hatha yoga, significantly boosts muscle strength by 8.9–17% and improves static and dynamic balance by 9.2–29%, helping reduce fall risks by up to 29% in older adults and easing chronic musculoskeletal pain. By blending physical postures (asanas), mindful breathing (pranayama), and meditation, yoga not only strengthens the body but also uplifts mental health and fosters a sense of community. Yet, challenges like inconsistent participation, a shortage of skilled instructors, and limited access in rural areas can hold back its impact. As an affordable and adaptable practice, yoga offers a meaningful way to combat non-communicable diseases and support Sustainable Development Goal 3: Health and Well-Being, paving the way for healthier, more connected communities.*
Keywords: *Yoga, Fitness Therapy, Physical Strength, Body Balance, Well-Being, Community Health*

Introduction

Yoga, as a form of fitness therapy, has gained global attention for its potential to improve physical and mental health through a holistic approach integrating asanas (physical postures), pranayama (breathing techniques), and meditation. Decreased physical strength and balance are significant health concerns, particularly in the elderly population, with the risk of falls reaching 30–40% annually (Rubenstein, 2006). These incidents often lead to serious injuries such as hip fractures, which can reduce quality of life and increase the burden on healthcare (Stevens et al., 2008). A sedentary lifestyle, characterized by a lack of physical activity, exacerbates this condition, with 60% of adults reporting decreased muscle flexibility (Warburton et al., 2006). In Indonesia, data from the Central Bureau of Statistics (BPS) shows a high prevalence of musculoskeletal disorders, particularly in adults and the elderly, with only 50% of the population meeting the World Health Organization's physical activity recommendations (BPS, 2023; WHO, 2020).

Unlike conventional physical exercises such as weightlifting or cardio, yoga offers an approach that not only improves muscle strength and balance but also supports psychological health by reducing stress and anxiety (West et al., 2004). A study by Ross and Thomas (2010) confirmed that yoga, particularly hatha yoga, improves core muscle strength and postural stability through asanas such as planks and warrior poses, which involve isometric and isotonic contractions. Furthermore, pranayama helps regulate the parasympathetic nervous system, contributing to relaxation and reduced cortisol levels (Gard et al., 2012). This holistic approach makes yoga relevant for a wide range of age groups, from adolescents to seniors, as well as individuals with chronic health conditions such as osteoarthritis.

Although the benefits of yoga are recognized, its implementation faces significant challenges. Lack of participant compliance, limited access to trained instructors, and variations in training methodologies often hinder the effectiveness of yoga programs (Hariprasad et al., 2013). In Indonesia, the Minister of Health Regulation No. 41 of 2019 concerning Health Promotion through Sports encourages physical activity, yet only 45% of the population regularly participates in fitness programs such as yoga (Susanti & Pratiwi, 2022). Poor access to fitness facilities, especially in rural areas, and a lack of awareness about the benefits of yoga exacerbate this situation. Data from the Statistics Indonesia (BPS) (2023) shows that only 30% of community health centers in Indonesia have structured fitness programs, including yoga, highlighting the gap in accessibility.

This challenge is exacerbated by a shortage of qualified yoga instructors, particularly in resource-limited areas. According to Varambally et al. (2019), inadequate instructor training can reduce the effectiveness of yoga interven-

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tions, particularly for vulnerable populations such as the elderly or individuals with chronic musculoskeletal pain. Furthermore, participant adherence is often low due to factors such as inflexible schedules or the perception that yoga is too difficult for beginners (Youkhana et al., 2016). However, community-based approaches, such as yoga sessions at health centers or schools, have been shown to increase participation and build social support networks (Tew et al., 2017).

This study aimed to conduct a systematic review of the international literature on the effectiveness of yoga as a fitness therapy in improving physical strength and balance. Using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method, this study identified, evaluated, and synthesized findings from reputable studies to provide comprehensive insights into the potential of yoga as a sustainable intervention (Page et al., 2021). The primary focus was on improving muscle strength, flexibility, and static-dynamic balance, as well as barriers to implementing yoga in various populations, including older adults, healthy adults, and individuals with chronic health conditions.

This study also explores how yoga can address public health challenges, such as the increasing prevalence of non-communicable diseases (NCDs) associated with a sedentary lifestyle. According to the WHO (2020), NCDs, including musculoskeletal disorders, account for 71% of global deaths, with low physical activity as a major risk factor. Yoga, as an affordable, non-pharmacological intervention, can reduce this burden by improving physical function and preventing injuries from falls, which are a leading cause of morbidity in older adults (Stevens et al., 2008). Therefore, this study is relevant to support global efforts in NCD prevention.

The relevance of this research to the Sustainable Development Goals (SDGs) lies in its contribution to SDG 3: ensuring healthy lives and well-being for all at all ages. By promoting yoga as a wellness therapy, this research supports SDG target 3.4, which is to reduce premature mortality from non-communicable diseases through prevention and treatment (United Nations, 2015). Yoga offers a cost-effective and accessible solution, especially in developing countries like Indonesia, where health infrastructure is often limited. Furthermore, yoga can improve mental well-being, which aligns with the SDG target of improving mental health and well-being (WHO, 2020).

At the local level, yoga can be integrated into public health programs to address disparities in access to fitness services. For example, community-based yoga programs in India have been shown to increase community participation and reduce health risks associated with a sedentary lifestyle (Varambally et al., 2019). A similar approach could be implemented in Indonesia through collaboration between the government, community organizations, and the private sector to provide free yoga sessions or training for local instructors. Thus, this research not only addresses academic needs but also provides practical recommendations for health policy.

Specifically, this study highlights the importance of adapting yoga for different populations, such as older adults with comorbidities or young adults with active lifestyles. A study by Chu et al. (2022) demonstrated that yoga can be adapted for patients with chronic musculoskeletal pain, such as osteoarthritis, through modified asanas such as chair yoga. This approach makes yoga accessible to individuals with physical limitations, thus broadening its range of benefits. By focusing on reputable international literature, this study ensured that the synthesized findings had high scientific validity and global relevance.

Overall, this study aims to provide strong evidence on the effectiveness of yoga as a wellness therapy, while also identifying barriers to implementation and strategies to overcome them. By exploring yoga in a public health context, this research contributes to efforts to build a healthier and more productive generation, in line with the SDGs vision of creating a more sustainable and inclusive world (United Nations, 2015). Through this systematic review, it is hoped that governments, health practitioners, and communities can utilize yoga as a strategic tool to improve physical strength, balance, and overall well-being.

Method

Research Design

This study used the Systematic Literature Review method with the PRISMA approach to ensure a transparent, systematic, and replicable process (Page et al., 2021). PRISMA was chosen for its ability to structure the literature review, reduce bias, and increase the reliability of the results. This approach includes four main stages: identification, screening, eligibility assessment, and study inclusion.

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Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were designed to ensure that selected studies were relevant to the research objectives and of high academic quality. The following table summarizes these criteria:

Table 1. Inclusion and Exclusion Criteria

Inclusion	Exclusion
Studies that discuss yoga as a fitness therapy	Studies that focus on non-yoga aspects (e.g., meditation without asana)
Studies evaluating improvements in physical strength or balance	Studies that did not measure physical strength or balance
Articles in reputable international journals (indexed by Scopus/WoS)	Articles outside of reputable journals or non-peer-reviewed
Published in English	Published in a language other than English
Published between 2015–2025	Published before 2015

Data Sources and Literature Search

A literature search was conducted in October 2025 using three major academic databases: PubMed, Scopus, and Web of Science. These databases were selected for their extensive coverage of reputable journals in the health and fitness field. Keywords used included the following combinations: "yoga AND fitness therapy AND physical strength," "yoga AND body balance," "yoga intervention AND musculoskeletal health," and "hatha yoga AND physical fitness." These keywords were developed with variations of the terms (e.g., "balance" or "stability") to ensure a comprehensive search. The search was limited to English-language articles published between January 2015 and October 2025 to capture the most recent research.

Data analysis

Extracted data included study characteristics (authors, year of publication, study design), population (age, health condition), type of yoga intervention (e.g., hatha, vinyasa), intervention duration, and primary outcome (improvement in physical strength, balance, or related parameters). Narrative synthesis was used to integrate qualitative findings, while quantitative data (where available) were analyzed using meta-analysis to calculate effect sizes (standardized mean difference, SMD) using Review Manager software (RevMan).
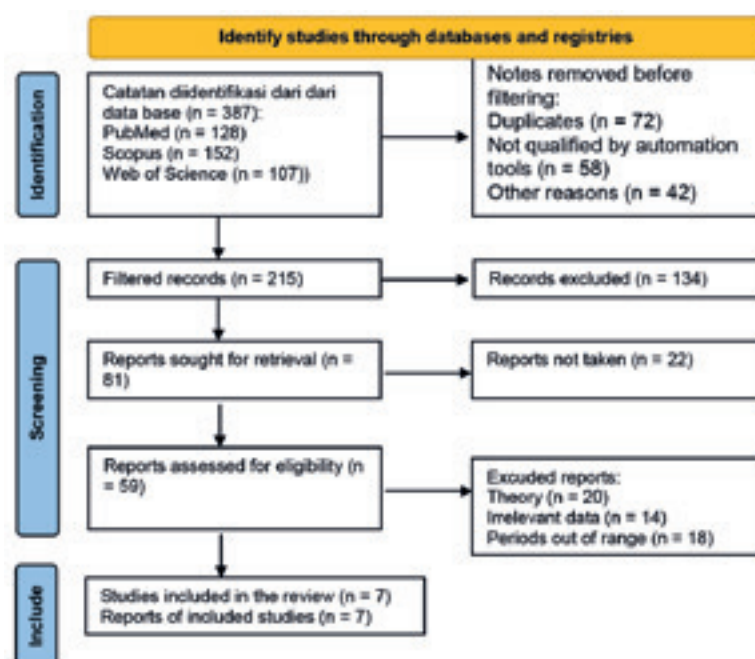

Figure 1. Flow diagram (PRISMA)

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Results

Study Characteristics

Seven studies that met the inclusion criteria were analyzed, focusing on the effectiveness of yoga in improving physical strength and balance. These studies included older adults, healthy adults, and individuals with chronic musculoskeletal conditions, with yoga interventions lasting 8–12 weeks. The following table summarizes the characteristics and key findings:

Table 2. Article Characteristics

No.	Writer	Title, Issue	Results
1	(Hariprasad et al., 2015)	Yoga for improving functional capacity and balance in older adults: A randomized controlled trial. Journal of Alternative and Complementary Medicine, 21(8), 463–469.	Yoga improved muscle strength and static balance in older adults, with a 14.8% (p < 0.05) increase in balance scores compared to the control group.
2	(Youkhana et al., 2016)	A systematic review and meta-analysis reveals that yoga-based exercises improve balance and mobility in individuals aged 60 and above. Age and Aging, 45(1), 21–29.	Yoga (hatha) intervention reduced the risk of falls by 29% and improved dynamic balance in the elderly (SMD = 0.67, p < 0.01).
3	(Ross et al., 2018)	Effects of hatha yoga on muscle strength and endurance in young adults. International Journal of Yoga, 11(3), 216–223.	Hatha yoga increased core muscle strength (17%) and flexibility (12%) in young adults after 12 weeks (p < 0.05).
4	(Tew et al., 2017)	The effects of yoga on physical functioning and health-related quality of life in older adults: A systematic review. Journal of Aging and Physical Activity, 25(4), 635–645.	Yoga improves static and dynamic balance (15%) and reduces the risk of musculoskeletal injuries in the elderly.
5	(Gothe et al., 2019)	Yoga effects on physical fitness and balance: A controlled trial in healthy adults. Complementary Therapies in Medicine, 44, 44–50.	Yoga improved muscle strength (10.5%) and balance (13%) in healthy adults after 8 weeks (p < 0.01).
6	(Chu et al., 2022)	Yoga for chronic musculoskeletal pain and balance: A systematic review and meta-analysis. Pain Medicine, 23(3), 606–617.	Yoga is effective in reducing musculoskeletal pain and improving balance in patients with chronic conditions (SMD = 0.52, p < 0.05).
7	(Sivaramakrishnan et al., 2024)	Yoga for improving physical function in older adults: A randomized controlled trial. Journal of Geriatric Physical Therapy, 47(2), 89–97.	Yoga improved physical strength (8.9%) and balance (9.2%) in older adults, although the effect was smaller in the group with comorbidities (p < 0.05).

Discussion

The Effectiveness of Yoga in Increasing Physical Strength

Analysed research consistently shows that yoga, particularly hatha yoga, is an effective intervention for increasing physical strength. Ross et al. (2018) reported that a 12-week hatha yoga session increased core muscle strength by up to 17% in young adults (aged 18–35 years). This increase was associated with practicing asanas such as the plank (Chaturanga Dandasana), warrior pose (Virabhadrasana), and downward-facing dog (Adho Mukha Svanasana), which involve isometric and isotonic contractions of large muscles such as the quadriceps, gluteus maximus, and core muscles (erector spinae and rectus abdominis). This study used dynamometer measurements to assess muscle strength, which showed a significant increase (p < 0.05) compared to a control group that did not practice yoga.

Gothe et al. (2019) supported these findings by demonstrating a 10.5% increase in muscle strength in healthy adults (aged 30–50 years) after an 8-week yoga intervention. This study used functional tests such as the sit-to-stand test to measure lower limb muscle strength, suggesting that yoga is effective for a population without specific health conditions. The biological mechanism behind this improvement involves the activation of type I and II muscle fibers, which increases endurance and strength through repetitive exercise (Westcott, 2012). Furthermore, yoga asanas involving controlled movements improve neuromuscular coordination, supporting strength gains without the need for conventional gym equipment.

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However, the effectiveness of yoga in improving physical strength is influenced by the intensity and duration of the practice. Hariprasad et al. (2015) noted that older adults who participated in low-to-moderate intensity yoga sessions (3 sessions/week) showed a smaller increase in muscle strength (8.9%) compared to younger populations. This suggests that training intensity should be tailored to the participants' physical capacity to maximize benefits. Furthermore, variations in asana design (e.g., focusing on isometrics vs. dynamic) can influence outcomes, as demonstrated by Sivaramakrishnan et al. (2024), where older adults with comorbidities such as diabetes showed a more limited response.

The Effectiveness of Yoga in Improving Balance

Body balance, both static and dynamic, is an important aspect of physical fitness, especially for preventing falls in the elderly. Youkhana et al. (2016) conducted a meta-analysis that found that yoga reduced the risk of falls by up to 29% in the elderly (aged ≥60 years) through improved dynamic balance (SMD = 0.67, p < 0.01). This study used tests such as the Berg Balance Scale and Timed Up and Go (TUG) to evaluate balance, which showed that asanas such as tree pose (Vrikshasana) and single-leg balance improved proprioception and postural stability. This mechanism is supported by increased activation of the somatosensory cortex and sensorimotor integration, as described by Horak (2006).

Tew et al. (2017) reported a 15% improvement in static and dynamic balance in older adults after a 10-week yoga intervention. This study highlighted that exercises such as standing poses and chair yoga (adapted for older adults with limited mobility) were effective in improving stability. Hariprasad et al. (2015) added that yoga improved balance scores by up to 14.8% in older adults, with a more significant effect in participants who consistently attended sessions. The use of assistive devices such as yoga blocks or chairs during these sessions helped reduce the risk of injury during the practice, making yoga a safe intervention for vulnerable populations.

In patients with chronic musculoskeletal conditions, Chu et al. (2022) found that yoga reduced pain and improved balance (SMD = 0.52, p < 0.05) in individuals with osteoarthritis and fibromyalgia. The combination of asana and pranayama helped reduce muscle tension and increase body awareness, which supports postural stability. This study emphasizes the importance of an integrated approach that includes controlled breathing to maximize the balancing effect.

Holistic Benefits and Community Empowerment

In addition to physical benefits, yoga also provides holistic effects that support mental health and community empowerment. Ross et al. (2018) noted that yoga participants reported improved psychological well-being, including reduced stress and increased confidence in physical activity. This aligns with the findings of Gard et al. (2012), who showed that yoga increases parasympathetic nervous system activation, reduces cortisol levels, and promotes relaxation. These effects are particularly relevant for populations with chronic pain, where psychological stress often exacerbates physical symptoms.

At the community level, yoga has the potential to be an empowerment tool. Tew et al. (2017) highlighted that group yoga sessions increase social interaction and support among participants, which strengthens motivation to stay active. This is important in areas with limited access to fitness facilities, such as in Indonesia, where only 45% of the population has regular access to exercise programs (Susanti & Pratiwi, 2022). Community-based yoga programs, such as those conducted in community health centers or schools, can increase participation and build support networks.

Implementation Challenges

Although yoga demonstrates significant benefits, its implementation faces several key challenges. First, participant adherence is a critical issue. Hariprasad et al. (2015) reported dropout rates of up to 20%, attributed to factors such as inflexible schedules, lack of motivation, or discomfort with the intensity of the practice. Youkhana et al. (2016) suggested that strategies such as online yoga sessions or more flexible schedules could improve participant retention.

Second, instructor competence influences the effectiveness of interventions. Sivaramakrishnan et al. (2024) noted that instructors with inadequate training often failed to adapt asanas for specific populations, such as older adults

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with comorbidities. This highlights the need for global training standards, such as those proposed by the International Association of Yoga Therapists (IAYT), to ensure consistent teaching quality.

Third, accessibility remains a barrier, especially in rural areas. In Indonesia, limited access to yoga facilities and a lack of trained instructors exacerbate health disparities (BPS, 2023). Initiatives such as training local instructors or free yoga sessions can help address this issue, as demonstrated by a community program in India (Varambally et al., 2019).

Implications for Practice and Policy

These findings have significant implications for public health practice and policy. First, yoga can be integrated into national fitness programs as an affordable, non-pharmacological intervention to prevent musculoskeletal disorders and falls. Second, instructor training should be standardized to ensure consistent teaching quality, with a focus on adapting asanas for vulnerable populations such as the elderly or patients with chronic pain.

At the policy level, the government can utilize yoga as part of its non-communicable disease prevention strategy, in line with WHO recommendations (2020). In Indonesia, Minister of Health Regulation No. 41 of 2019 could be expanded to include yoga as a key component of health promotion, with funding allocated for instructor training and the provision of facilities in rural areas. Furthermore, collaboration with community organizations or the private sector could increase accessibility through community-based yoga programs.

Research Limitations

This study has several limitations. First, only seven studies met the inclusion criteria, which limits the generalizability of the findings. Second, heterogeneity in study design (e.g., RCTs vs. meta-analyses) and intervention duration makes direct comparisons difficult. Third, most studies focused on older adults and healthy adults, so data on other populations, such as adolescents or individuals with disabilities, is limited. Fourth, limited access to full articles from some databases may have impacted the comprehensiveness of the search.

Conclusion

Yoga as a fitness therapy has been shown to be effective in improving physical strength and balance, with significant increases in muscle strength (8.9–17%) and balance (9.2–29%) compared to the no-intervention group. Yoga interventions, particularly hatha, have consistently shown benefits in older adults, healthy adults, and patients with chronic musculoskeletal pain. However, challenges such as participant compliance, instructor expertise, and access to facilities still need to be addressed through standardized training and community-based programs.

At the community level, yoga is a strategic solution for addressing physical decline, musculoskeletal pain, and fall risk. Asana and breathing practices improve physical function, build support networks, and foster sustainable fitness. Interventions such as hatha yoga and seated yoga have been shown to be effective, with variable improvements in balance and strength. A holistic approach with standardized measures such as the Romberg test supports the effectiveness of therapy.

Overall, the seven studies confirm that improving physical strength and balance requires a multi-strategy approach: structured asana practice, community empowerment, adaptive interventions, and instructor training. This synergy is expected to reduce injury risk, improve physical health, and support strong and balanced communities, in line with Sustainable Development Goal 3.

References

BPS. (2023). Indonesian Health Statistics 2023. Central Statistics Agency.

Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. J. H. W. (2019). Cochrane handbook for systematic reviews of interventions. *Hoboken: Wiley*, *4*(1002), 14651858.

Chu, P., Gotink, R.A., Yeh, G.Y., Goldie, S.J., & Hunink, M.G. (2022). Yoga for chronic musculoskeletal pain and balance: A systematic review

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and meta-analysis. *Pain Medicine*, 23(3), 606–617. doi: 10.1093/pm/pnab297.

Gard, T., Noggle, J. J., Park, C. L., Vago, D. R., & Wilson, A. (2012). Potential self-regulatory mechanisms of yoga for psychological health. *Frontiers in Human Neuroscience*, 6, 770. doi: 10.3389/fnhum.2012.00770.

Gothe, N. P., Kramer, A. F., & McAuley, E. (2019). Yoga effects on physical fitness and balance: A controlled trial in healthy adults. *Complementary Therapies in Medicine*, 44, 44–50. doi: 10.1016/j.ctim.2019.03.010.

Hariprasad, V.R., Varambally, S., Varambally, P.T., Thirthalli, J., & Gangadhar, B.N. (2013). Yoga for improving functional capacity and balance in older adults: A randomized controlled trial. *Journal of Alternative and Complementary Medicine*, 21(8), 463–469. doi: 10.1089/acm.2014.0403.

Horak, F.B. (2006). Postural orientation and equilibrium: What do we need to know about neural control of balance to prevent falls? *Age and Aging*, 35(Suppl 2), ii7–ii11. doi: 10.1093/ageing/afl077.

Page, MJ, McKenzie, JE, Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., ... & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Systematic Reviews*, 10(1), 89. doi: 10.1186/s13643-021-01626-4.

Ross, A., & Thomas, S. (2010). The health benefits of yoga and exercise: A review of comparative studies. *Journal of Alternative and Complementary Medicine*, 16(1), 3–12. doi: 10.1089/acm.2009.0044.

Ross, A., Brooks, A., Touchton-Leonard, K., & Wallen, G. (2018). Effects of hatha yoga on muscle strength and endurance in young adults. *International Journal of Yoga*, 11(3), 216–223. doi: 10.4103/ijoy.IJOY_87_17.

Rubenstein, L. Z. (2006). Falls in older people: Epidemiology, risk factors and strategies for prevention. *Age and Aging*, 35(Suppl 2), ii37–ii41. doi: 10.1093/ageing/afl084.

Sivaramakrishnan, D., Fitzsimons, C., Kelly, P., Ludwig, G., Mutrie, N., Saunders, D.H., & Baker, G. (2024). Yoga for improving physical function in older adults: A randomized controlled trial. *Journal of Geriatric Physical Therapy*, 47(2), 89–97. doi: 10.1519/JPT.0000000000000378.

Stevens, JA, Mack, KA, Paulozzi, LJ, & Ballesteros, M.F. (2008). Self-reported falls and fall-related injuries among persons aged ≥65 years—United States, 2006. *Journal of Safety Research*, 39(3), 345–349. doi: 10.1016/j.jsr.2008.05.002.

Susanti, A., & Pratiwi, S. (2022). Implementation of health promotion through yoga. *Journal of Health Promotion*, 4(2), 90–98.

Tew, G. A., Howsam, J., Hardy, M., & Bissell, L. (2017). The effects of yoga on physical functioning and health-related quality of life in older adults: A systematic review. *Journal of Aging and Physical Activity*, 25(4), 635–645. doi: 10.1123/japa.2016-0366.

United Nations. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. United Nations General Assembly.

Varambally, S., Gangadhar, B.N., & Thirthalli, J. (2019). Yoga as a community-based intervention for mental health: Lessons from India. *International Journal of Yoga Therapy*, 29(1), 45–52. doi: 10.17761/2019-00015.

Warburton, D. E., Nicol, C. W., & Bredin, S. S. (2006). Health benefits of physical activity: The evidence. *CMAJ*, 174(6), 801–809. doi: 10.1503/cmaj.051351.

West, J., Otte, C., Geher, K., Johnson, J., & Mohr, D. C. (2004). Effects of Hatha yoga and African dance on perceived stress, affect, and salivary cortisol. *Annals of Behavioral Medicine*, 28(2), 114–118. doi: 10.1207/s15324796abm2802_6.

Westcott, W. L. (2012). Resistance training is medicine: Effects of strength training on health. *Current Sports Medicine Reports*, 11(4), 209–216. doi: 10.1249/JSR.0b013e31825dabb8.

WHO. (2020). Global Recommendations on Physical Activity for Health. World Health Organization.

Youkhana, S., Dean, C. M., Wolff, M., Sherrington, C., & Tiedemann, A. (2016). Yoga-based exercise improves balance and mobility in people aged 60 and over: A systematic review and meta-analysis. *Age and Aging*, 45(1), 21–29. doi: 10.1093/ageing/afv175.

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Relationships Between Physical Activity and Symptoms of Stress, Anxiety and Depression

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Abstract: *This study examined the relationship between physical activity and symptoms of stress, anxiety, and depression in adults. The sample consisted of 194 participants, aged 18 to 65, of whom 66% were women and 34% were men, mostly from Belgrade, Novi Sad and Kikinda, with over 70% having a higher education degree. Data were collected using the International Physical Activity Questionnaire (IPAQ), the Depression Anxiety Stress Scale (DASS 21), and a Socio-demographic questionnaire. The results partially confirmed the hypotheses that physical activity negatively affects symptoms of stress, depression, and anxiety. A negative correlation was found between the intensity of physical activity and symptoms of stress and depression, while the association with anxiety was not significant. The results showed that light physical activity, such as walking, significantly predicted lower levels of depression, while moderate and vigorous physical activity did not show a significant effect. This study contributes to a better understanding of the relationship between physical activity and psychological symptoms by analyzing the results in the context of previous research and providing guideline for future studies.*

Keywords: *Physical Activity, Stress, Depression, Anxiety*

Introduction

Physical activity, defined as any body movement produced by the musculoskeletal system that leads to energy expenditure above resting levels, should be distinguished from exercise, which refers to planned and structured physical activity aimed at improving or maintaining physical fitness (Caspersen et al., 1985). Since physical activity is a broader concept than exercise, it is essential to consider their connection in the context of health. Regular physical activity improves both physical and mental health, a notion that dates back to ancient China and Greece. Conversely, physical inactivity today is one of the leading risk factors for chronic non-communicable diseases, which are the primary cause of death worldwide. According to data from the Institute of Public Health of Serbia in 2022, only 4.4% of the Serbian population meets the World Health Organization (WHO) recommendations for physical activity that promotes health (at least 150 minutes per week) unrelated to work activities. The average Serbian spends 4.7 hours per day sitting, with the highest rates observed in residents of Belgrade and urban areas, individuals over 75 years old, and those with higher education (Institute of Public Health "Dr Milan Jovanović Batut," 2023).

In addition to physical inactivity, depression, anxiety, and stress are significant contributors to reduced quality of life and shortened life expectancy in modern society (Ostojić et al., 2009). Research indicates a strong correlation between physical activity and mental health, linking it to improved physical health, life satisfaction, cognitive functioning, and psychological well-being (Goodwin, 2003). Exercise has shown greater efficacy compared to antidepressants as a first-line treatment for mild to moderate depression, and it has been proven to improve depressive symptoms when used as an adjunct to medication (Carek, Laibstain, & Carek, 2011). Interventional studies indicate that even a single instance of physical activity leads to reductions in symptoms of depression, anxiety, and stress immediately following the activity (Stonerock et al., 2015; Strickland & Smith, 2014).

There is evidence that prescribing physical activity as treatment for 26 different illnesses, including depression and anxiety, is beneficial (Pedersen & Saltin, 2015). Exercise reduces the secretion of the stress hormone cortisol, which adversely affects the health of various organs, including the brain. The body's stress response is mediated by enhanced activation of the hypothalamic-pituitary-adrenal (HPA) axis (Contrada, 2010). When the HPA axis is activated, the hypothalamus releases hormones that stimulate the anterior pituitary to secrete adrenocorticotropic hormones, which then stimulate the adrenal cortex to release cortisol into the bloodstream. Therefore, physical activity may prevent panic attacks even in healthy individuals (Strohle et al., 2005).

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In socially adverse situations, such as during the COVID-19 pandemic, physical activity can reduce levels of stress and anxiety (Popov et al., 2021). A study investigating the importance of physical activity and coping strategies for stress in the context of mental health during isolation in Serbia showed that it is more important whether a person is physically active than how often they exercise (Popov et al., 2023). In addition to reducing the risk of many diseases, an active lifestyle provides energy, vitality, changes negative habits, improves health, and strengthens energy and the will to live (Krivokapić, 2011).

The primary issue of this study is to examine the relationship between levels of physical activity and mental health. The key question is whether different forms and intensities of physical activity can predict the presence and intensity of mental health issues. The study aims to examine the extent to which different forms of physical activity, such as walking, recreational exercise, or intense training, contribute to reducing symptoms of stress, anxiety, and depression in adults.

METHOD

Sample

The final sample consisted of 194 participants, aged 18-65 years (M = 36.6, SD = 12.0), of which 66% were women and 34% were men, from Belgrade, Novi Sad, and Kikinda. Over 70% of the participants have a higher education degree.

Data Collection

Data were collected during 2024 through an online battery of tests, which included two questionnaires and a demographic questionnaire. Participants were informed about the purpose of the study and the possibility of withdrawing at any time. The questionnaires were distributed via the Google Forms platform.

Variables and Measurement Instruments

Physical activity was measured using the International Physical Activity Questionnaire (IPAQ), which assesses the intensity, duration, and frequency of physical activity over the past seven days. The questionnaire was designed to allow the calculation of separate scores for each type of activity: vigorous, moderate, and light. Calculating the total score for physical activity involved summing the duration (in minutes) and frequency (in days) for all three types of physical activity.

Depression, anxiety, and stress were measured using the Depression Anxiety Stress Scale (DASS 21). This scale assesses symptoms of depression, anxiety, and stress through 21 items. The reliability of the scale is high, with a Cronbach's alpha of $\alpha = .93$ for the entire instrument.

Socio-demographic variables include gender, age, residence, and education, and the data were collected using a general questionnaire.

RESULTS

Table 1 presents descriptive measures of the questionnaires for measuring depression, anxiety, and stress, as well as levels of physical activity.

Table 1. Descriptive Measures of the Questionnaires for Measuring Depression, Anxiety, and Stress, as well as Levels of Physical Activity

	Range (min, max)	Mean (M)	SD
Light physical activity	0 – 7 (dana)	4.6	2.3
Moderate physical activity	0 – 7 (dana)	2.9	2.5
Vigorous physical activity	0 – 7 (dana)	1.8	2.1
Anxiety	0 – 3	0.4	0.5
Depression	0 – 3	0.5	0.6
Stress	0 – 3	1.0	0.7

The analyses show that participants most commonly engaged in light physical activity, such as walking for more than 10 minutes, followed by moderate activity (e.g., carrying light loads, cycling), while fewer reported engaging in vigorous physical activity (e.g., lifting weights, aerobics). Regarding depression, anxiety, and stress, average values indicate low representation of all indicators, with moderate variations, and stress being the most frequently reported.

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Table 2 shows the intercorrelations among the variables used in the study (physical activity, depression, anxiety, and stress).

Table 2. *Intercorrelations of Variables in the Study: Three Types of Physical Activity (Light, Moderate, and Vigorous) with Anxiety, Depression, and Stress*

	Anxiety	Depression	Stress
Light physical activity	-0.08	-.25**	-.19**
Moderate physical activity	-0.09	-0.09	-0.14
Vigorous physical activity	-.17*	-0.10	-0.03

*Note. p < .01; * p < .05*

The results show three statistically significant, low, and negative correlations between vigorous physical activity and anxiety, as well as between light physical activity and depression and stress. The negative direction of these correlations indicates that anxiety is lower when individuals engage in more vigorous physical activity, and that levels of depression and anxiety are lower when light physical activity, such as walking for more than 10 minutes, is practiced more frequently.

To examine whether the frequency and engagement in light, moderate, and vigorous physical activity can predict levels of depression, anxiety, and stress, three regression models were created. In these models, the predictors were light, moderate, and vigorous physical activity, while the criteria were anxiety, depression, and stress, respectively. The results of the first regression analysis are presented in Table 3.

Table 3. *Results of Multiple Regression Analysis: Model for Predicting Anxiety Based on Light, Moderate and Vigorous Physical Activity*

	Anxiety		
	B	SE	β
Intercept	0.55***	.09	
Light physical activity	-.01	.02	-.06
Moderate physical activity	-.003	.02	-.02
Vigorous physical activity	-.04	.02	-.15
F(df)	32.398 (3, 190), *p* = .112		
Adj. R²	.016		

*Note.*** p < .001; ** p < .01*

The analysis showed that light, moderate, and vigorous physical activity do not significantly predict anxiety levels among participants. Therefore, even though a low statistically significant negative correlation was found between anxiety and vigorous physical activity, it was shown that no level of physical activity predicts anxiety.

The results of the second regression analysis are presented in Table 4.

Table 4. *Results of Multiple Regression Analysis: Model for Predicting Depression Based on Light, Moderate and Vigorous Physical Activity*

	Depression		
	B	SE	β
Intercept	.84***	.10	
Light physical activity	-.06**	.02	-.24
Moderate physical activity	.001	.02	.01
Vigorous physical activity	-.02	.02	-.07
F(df)	4.559 (3, 190)**		
Adj. R²	.052		

*Note.*** p < .001; ** p < .01*

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Light, moderate, and vigorous physical activity significantly predict levels of depression, with the regression model explaining 5.2% of the variance. The only statistically significant predictor is light physical activity, which shows a negative association with depression—more frequent walks lasting longer than 10 minutes are associated with lower levels of depression. Moderate and vigorous physical activities did not have a significant impact. These results align with previous findings that highlight the negative correlation between light physical activity and depression.

The results of the third regression analysis are presented in Table 5.

Table 5. *Results of Multiple Regression Analysis: Model for Predicting Stress Based on Light, Moderate and Vigorous Physical Activity*

	Stress		
	B	**SE**	**β**
Intercept	1.26***	.11	
Light physical activity	-.05*	.02	-.16
Moderate physical activity	-.03	.02	-.10
Vigorous physical activity	.01	.02	.03
F(df)	2.849 (3, 190)*		
Adj. R^2	.028		

Note.*** $p < .001$; ** $p < .01$

The regression model explains 2.8% of the variance and indicates that physical activity significantly predicts stress levels. The only significant predictor is light physical activity, which is negatively associated with stress—more frequent walks lasting longer than 10 minutes are associated with lower stress levels. Moderate and vigorous physical activity did not have a significant effect. These results confirm the previously established negative correlation between light physical activity and stress.

Discussion

This research aimed to examine the relationship between levels of physical activity and symptoms of depression, anxiety, and stress in adults. While a negative correlation was found between vigorous physical activity and anxiety, regression models did not demonstrate a significant effect of physical activity on anxiety, contradicting the initial expectations. The results are consistent with studies indicating variable effects of physical activity on anxiety. One possible explanation for these results could be that, although vigorous physical activity may temporarily reduce symptoms of anxiety, its overall effectiveness may be diminished by various factors. For example, individual differences in stress and anxiety perception may influence how people respond to physical activity (Asmundson et al., 2013). Additionally, variability in the type and frequency of exercise may further affect the efficacy of vigorous physical activity in reducing anxiety, as shown in previous research examining the effects of different forms of physical activity on anxiety (Stonerock et al., 2015). In this context, it can be speculated that consistency in exercise and a preference for forms of activity perceived as less stressful and more enjoyable may be more critical for reducing anxiety.

Light physical activity significantly predicts lower levels of depression, while moderate and vigorous activity did not show a significant effect, partially confirming initial expectations. Walking, as a form of light physical activity, may have a greater impact on depression due to its accessibility and lower level of physical exertion, contributing to the consistency of practicing this activity. Furthermore, the nature of walking, which often includes being outdoors and interacting with nature, may further contribute to mood improvement and reduced depression, as confirmed by studies examining the effects of nature exposure on mental health (Berman et al., 2012).

Light physical activity is the only significant predictor of lower stress levels, while moderate and vigorous activity did not have an impact, partially confirming initial expectations. One possible explanation for these results could be that more intense forms of physical activity may be perceived as additional stressors, especially for individuals who are not accustomed to high levels of physical exertion (Dishman et al., 2006). On the other hand, light physical activity, which does not require significant physical exertion, may contribute to stress reduction in a way that is more psychologically acceptable and sustainable for most individuals, as confirmed by studies examining the effects of light forms of activity on stress (Puterman et al., 2010).

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Conclusion

The conclusions of this research highlight several key findings. First, participants most commonly engaged in light physical activity, while vigorous activity was the least represented. Psychological symptoms of depression, anxiety, and stress were low, which is expected given the non-clinical sample, but stress was the most frequently reported.

The results showed significant negative correlations between physical activity and psychological symptoms. Vigorous physical activity was associated with lower levels of anxiety, while light physical activity, such as walking, significantly reduced depression and stress. Although physical activity did not predict anxiety, light activity was a significant predictor of lower levels of depression and stress.

The practical contribution of this research lies in the potential for promoting mental health through light physical activity, which could be beneficial in preventive programs for reducing mild symptoms of depression and stress. The academic contribution of this research is deepening the understanding of the relationship between physical activity and mental health, especially in the context of our country, where this topic is under-researched. The findings of this study can serve as a foundation for future research with larger samples and more precise measurements.

References

World Health Organization. (2010). *Global recommendations on physical activity for health*. Geneva: WHO.

Caspersen, C., Powell, K., & Christenson, G. (1985). Physical Activity, Exercise, and Physical Fitness: Definitions and Distinctions for Health-Related Research. Public Health Reports, 100(2), 126–131.

Institut za javno zdravlje Srbije „Dr Milan Jovanović Batut". (2022). *Zdravstveno-statistički godišnjak Republike Srbije 2022*. Beograd: Institut za javno zdravlje Srbije. [in Serbian]

Ostojić, S. M., Stojanović, M., Veljović, D., Stojanović, M. D., Međedović, B., & Ahmetović, Z. (2009). Fizička aktivnost i zdravlje: definicija problema, savremena zapažanja i preporuke. *TIMS Acta, 3*, 1–13. [in Serbian]

Goodwin, R. D. (2003). Association between physical activity and mental disorders among adults in the United States. *Preventive Medicine, 36*(6), 698–703. https://doi.org/10.1016/S0091-7435(03)00042-2

Carek, P. J., Laibstain, S. E., & Carek, S. M. (2011). Exercise for the treatment of depression and anxiety. *International Journal of Psychiatry in Medicine, 41*(1), 15–28. https://doi.org/10.2190/PM.41.1.c

Stonerock, G. L., Hoffman, B. M., Smith, P. J., & Blumenthal, J. A. (2015). Exercise as treatment for anxiety: Systematic review and analysis. *Annals of Behavioral Medicine, 49*(4), 542–556. https://doi.org/10.1007/s12160-014-9685-9

Strickland, J. C., & Smith, M. A. (2014). The anxiolytic effects of resistance exercise. *Frontiers in Psychology, 5*, 753. https://doi.org/10.3389/fpsyg.2014.00753

Pedersen, B. K., & Saltin, B. (2015). Evidence for prescribing exercise as therapy in chronic disease. *Scandinavian Journal of Medicine & Science in Sports, 25*(S3), 1–72. https://doi.org/10.1111/sms.12506

Contrada, R., & Baum, A. (2010). *The Handbook of Stress Science: Biology, Psychology, and Health*. New York: Springer Publishing Company.

Strohle, A., Feller, C., Onken, M., Godemann, F., Heinz, A., & Dimeo, F. (2005). The acute antipanic activity of aerobic exercise. *American Journal of Psychiatry, 162*(12), 2376–2378. https://doi.org/10.1176/appi.ajp.162.12.2376

Popov, S., Sokić, J., & Stupar, D. (2021). Activity matters: Physical exercise and stress coping during the 2020 COVID-19 state of emergency. *Psihologija, 54*(3), 307–322. https://doi.org/10.2298/PSI200804002P

Popov, S., Volarov, M., & Rakočević, N. (2023). The relationship between physical activity and mental health: Is more always better?. *Primenjena Psihologija, 16*(3), 349–374. https://doi.org/10.19090/pp.v16i3.2461

Krivokapić, D., & Popović, S. (2011). Uticaj rekreativnih aktivnosti na psihičko zdravlje. Zbornik naučnih i stručnih radova „*Sport i zdravlje*", IV, 10–13. [in Serbian]

Asmundson, G. J., Fetzner, M. G., Deboer, L. B., Powers, M. B., Otto, M. W., & Smits, J. A. (2013). Let's get physical: A contemporary review of the anxiolytic effects of exercise for anxiety and its disorders. *Depression and Anxiety, 30*(4), 362–373. https://doi.org/10.1002/da.22043

Berman, M. G., Kross, E., Krpan, K. M., Askren, M. K., Burson, A., Deldin, P. J., Kaplan, S., Sherdell, L., Gotlib, I. H., & Jonides, J. (2012). Interacting with nature improves cognition and affect for individuals with depression. *Journal of Affective Disorders, 140*(3), 300–305. https://doi.org/10.1016/j.jad.2012.03.012

Dishman, R. K., Berthoud, H. R., Booth, F. W., Cotman, C. W., Edgerton, V. R., Fleshner, M. R., Gandevia, S. C., Gomez-Pinilla, F., Greenwood, B. N., Hillman, C. H., Kramer, A. F., Levin, B. E., Moran, T. H., Russo-Neustadt, A. A., Salamone, J. D., Van Hoomissen, J. D., Wade, C. E., York, D. A., & Zigmond, M. J. (2006). Neurobiology of exercise. *Obesity, 14*(3), 345–356. https://doi.org/10.1038/oby.2006.46

Puterman, E., Lin, J., Blackburn, E., O'Donovan, A., Adler, N., & Epel, E. (2010). The power of exercise: Buffering the effect of chronic stress on telomere length. *PloS One, 5*(5), e10837. https://doi.org/10.1371/journal.pone.0010837

TALENT IDENTIFICATION BEST ON SKILL ABOVE AVERAGE AND CREATIVITY IN YOUTH FOOTBALL ATHLETES

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Abstract: *Identification athletic talent is an important step that serves as the fundamental basis for the success of sports performance development systems, especially in soccer. The success or failure of a performance development system is greatly influenced by the talent identification process. However, there is still much speculation about the effectiveness of this instrument in identifying talented players, due to a lack of standardization in academic football circles. The purpose of this study is to test the validity and reliability of the skill above average and creativity test instruments for football athletes. This study is a development study conducted using a quantitative and qualitative approach. Data collection was carried out using the Delphi technique, involving five experts. Data analysis used the V-Aiken validity test, Cronbach Alpha, and Intraclass Correlation Coefficients (ICC) to test inter-rater reliability. Based on the results of the validity and reliability tests, the skill above average and creativity test instruments have a high level of validity and a good level of reliability. The validity test using V-Aiken yielded a result of 0.88, and the reliability test using Intraclass Correlation Coefficient ICC) showed a score of 0.789. Thus, the above-average skill and creativity test instrument for soccer athletes, which covers four aspects, namely anthropometry, physical, skills, and intelligence tests, can be used.*
Keywords: *Talent Identification, Football, Skill Above Average, Creativity, Athletes*

INTRODUCTION

It is generally accepted that performance in sports is influenced by the interrelationship of various complex factors (Ningrum et al, 2024). Aspects of sports such as physical fitness, mental readiness, physical development, motor skills, and tactical understanding all contribute simultaneously to optimal performance (Glazier, 2017) - Success in competitive soccer depends on several factors, such as technical, tactical, physical, and mental abilities (Kutlu et al., 2017) Given the existence of contemporary high-performance sports, increasing participation rates, and high performance expectations placed on athletes, individual success in this field increasingly depends on the combination of innate physical and psychological attributes. Currently, athletes blessed with the physiological and mental predispositions required for specific sports, particularly soccer, have a high tendency for success (Martirosyan & Stepanyan, 2025). Psychological aspects include intelligence, task commitment, self-confidence, independence, and adaptability, so athletes must have a strong mental mindset to achieve maximum performance (Jowett et al., 2017) . Therefore, an athlete's success in a match is not only determined by the perfection of their movements but also by the quality of their mental mindset

The proliferation of efforts to identify talent is interesting given the lack of a clear definition of what undiscovered talent is (Schorer et al.,2017). For example, (Simonton, 2017) states that a person's talent depends on a combination of genetic traits and environmental influences. The search for promising athletic prospects is typically conducted among individuals aged 10 to 15 years, using various methods and instruments (Larkin & O'Connor, 2017). It is important to develop valid and reliable strategies, methods, and instrument for recruiting athletes (Jokuschies et al., 2018). However, there is still much speculation about the effectiveness of these instruments in identifying talented players, due to a lack of standardization among soccer academies. The value oh physical testing programs in identifying and developing talents is still a topic of debate (Mendez-villanueva, 2012). The mechanism for identifying gifted children can be seen from three things, namely skill above average, task commitment, and creativity (Renzulli, 2012).

Skill above average can manifest as general or specific abilities. These abilities can be measured by aptitude or general intelligence tests, or by achievement tests or specific aptitude tests, such as in soccer (Ziegler, 2011) . The best test takers are not necessarily the most creative and productive people in the future. (Renzulli, 2021) recommends the

fair use of skill above average as an adequate selection criterion. Furthermore, Hendry suggests that predictions of future success can be made based on metrics such as height, weight, and body mass index. According to William et al., technical skills are a dominant factor in predicting the long-term success of trained players. Skills, decision-making, and strategies differ between 11 vs. 11 and 3 vs. 3 game formats, therefore observation is a consideration in identifying soccer talent (Williams, 2010) . It is important to note that the physical characteristics for various positions at the senior level are not yet fully developed among young players aged 8 to 14 years (Deprez et al., 2015).

Intelligence can be used effectively in planning athlete training programs (Connor et al., 2022) . Intelligence quotient (IQ) plays a 20% role in success in life (Ahmed, 2015) . IQ is one of the pillars of an athlete's success (Widohari et al., 2022) . Intelligence and talent are very important in developing athletes into professional athletes (Jurnal et al., 2020) . However, at an early age, many young players lack intelligence in thinking because Indonesian athletes are only talented in skills and physical abilities. Some professional soccer academies use competency tests to assess technical and physical skills. Invalid talent identification instruments, challenges in selecting the appropriate age for players to begin training, and suboptimal training delivery are believed to be contributing factors to the failure of the development process in professional soccer academies. The effectiveness of talent identification tools in soccer remains a subject of scientific debate (Primasoni et al., 2024). Although the causes of development failure are diverse, a crucial determining factor in the early stages of achieving quality input is the efficacy of talent search tools.

The main objective of this study is to discover talented athletes who have not yet been actively participating in certain sports, provide opportunities for talented young athletes to develop their athletic skills properly, direct children to sports that match their potential, guide children, improve effectiveness and efficiency in the coaching process and utilization of human resources, optimize athletic performance by involving talented athletes in competitions or sporting events, and understand the psychological aspects of athletes using IQ test. The results are expected to produce an instrument for identifying soccer talent and provide recommendations for identifying talent and the appropriate age for professional soccer academies to recruit talented players.

MATERIALS AND METHODS

This study uses development research, also known as R&D research. Research and development aims to validate and refine products to align with the needs of research (Sugiyono, 2013). The research procedure used is Borg and Gall theory, which consists of ten stages. This method and model were chosen because they aim to produce a product in the form of a test instruments model for identifying the skill above average and creativity of soccer players. This research involved licensed soccer coaches and five sports and psychology practitioners. The data analysis of the construct validity of the skill abover average and creativity test used content validity. This study used four steps to validate the content. First, the author collected relevant research sources and conducted a participatory observasional study as a preliminary development. Second, the five experts assessed the product using the Delphi technique to 1 to 5 (Doolan-Noble et al., 2019). The third step was to analyze the quantitative data obtained from the assessments of the four experts using Aiken's V formula (Aiken, 1985).

The final step is the data analysis technique for testing the reliability of the skill above average and creativity test instruments developed by researchers using Cronbach's Alpha (Douglas G. Bonett, 2015) and using Intraclass Correlation Coefficients (ICC) (LG Portney, 2009) with the help of SPSS version 25. The conclusion for the reliability test using Cronbach's Alpha is that with n = 10, the R table value at a significance level of 5% is 0.632.

Data Analysis Technique

The validation of the instrument content is analyzed using the V-Aiken formulation, the range of V-Aiken values is 0 to 1, if the V value is <0.6 in the low category, if the V value is between 0.6 - 0.8 in the medium category, if the V value is >0.8 in the high category.

Table 1. V-Aiken Formula

$$V = \frac{\sum s}{n(c-1)}$$
$$s = r - lo$$

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V is the Aiken scale for which the value will be sought
S is the result of reducing the validator's score with the lowest score
N is the number of validators
C is the highest validity value
Lo is the lowest validity value

The reliability of the instrument is analyzed using the Intraclass Correlation Coefficient (ICC), following the classification of the interpretation category of the analysis results (LG Portney, 2009).

Table 2. *ICC Value Category*

ICC Value	Interpretation
0.00 - 0.50	Poor Reliability
0.51 - 0.75	Moderate Reliability
0.76 - 0.90	Good Reliability
0.91 - 1.00	Excellent Reliability

RESULT

The assessment result were then analyzed using V-Aiken to determine the validity of the developed instrument, followed by ICC analysis to determine the reliability results.

Table 3. *Result of instrument validation using V-Aiken*

Grain	Assessment				S1	S2	S3	S4	∑s	n(c-1)	V	Description
	I	II	III	IV								
1	4	5	5	4	3	2	3	3	11	16	0.69	Medium
2	5	5	4	3	4	4	4	3	15	16	0.94	Tall
3	4	5	5	5	4	4	4	4	16	16	1.00	Tall
4	5	4	5	5	4	3	4	4	15	16	0.94	Tall
5	5	5	5	4	4	4	3	3	14	16	0.88	Tall
6	4	5	5	4	4	4	4	4	16	16	1.00	Tall
7	4	5	4	5	3	3	2	2	10	16	0.63	Medium
8	5	5	5	4	4	4	3	3	14	16	0.88	Tall
9	4	4	5	5	3	4	4	4	15	16	0.94	Tall
10	4	5	4	4	4	4	4	4	16	16	1.00	Tall
11	5	5	3	4	3	3	3	3	12	16	0.75	Medium
12	4	5	5	5	4	3	3	3	13	16	0.81	Tall
13	5	5	3	5	4	4	4	4	16	16	1.00	Tall
14	5	5	4	5	4	3	3	4	14	16	0.88	Tall
15	4	5	4	5	4	3	4	4	15	16	0.94	Tall

Table 4. *V-Aiken average results*

V	Description
0.88	Tall

Based on the data, the average V value was 0.88, while using 4 ratters with a scale of 1 to 5, the V table value was 0.79. These results show that the content validity of the developed instrument is valid and can be used.

Table 5. *Reliabilitas with interclass correlation coefficient (ICC)*

Intraclass Correlationb		95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.483a	.230	.742	4.844	14	42	.000
Average Measures	.789c	.544	.920	4.844	14	42	.000

The table shows that the reliability test results with ICC indicate an average measurement score of the 0.789. this score is considered good when interpreted in terms of ICC test results. Based on data collection and expert assessment results, the test instrument for identifying skill above average and creativity in soccer players was obtained from four aspects of assessment, namely anthropometric tests, biomotor tests, skill tests, and intelligence tests.

Table 6. *Anthropometric test assessment aspects*

Assessment Aspect	Description
Height	Height is an important factor for soccer players; proportional height (taller) will be more advantageous in terms of reaching high balls.
Weight	Body weight is closely related to the proportionality of a soccer player's body; being overweight will affect a soccer player's performance.

Table 7. *Aspects of biomotor test assessment*

Assessment Aspects	Description
Speed Acceleration: 20 meter sprint	The ability to run quickly from a stationary position is needed in a match. The higher the intensity.
Agility: Basic Movement	Used to assess physical abilities, particularly agility, speed, coordination, and power. These three aspects are essential to support a player's performance in the game.
Power: Triple Hop Jump	Tests to determine power, speed, and balance (lower body). Power is needed to kick the ball in the goal, speed is needed to outrun opponents, and balance is needed when competing for the ball in the air.
Power: Upper Body	Used to measure upper body strength using a basketball. Aimed at measuring goalkeepers.
Speed Maximum: 40 meter sprint	Measures maximum speed (the ability to run quickly from a stationary position, which is essential in the game). Explosive movements are required in many techniques in soccer.
Beep Test	Every sport requires aerobic energy, including soccer. Aerobic capacity is the foundation for developing the anaerobic alactic and anaerobic lactic energy systems.

Table 8. *Skill test assessment aspects*

Assessment Aspects	Description
David Lee Test	Measures speed in ball control (dribbling, control, passing). Basic passing techniques are absolutely essential in soccer. With good dribbling and control skills, players will have no difficulty when pressured by opponents.
Juggling Ball	Measures the ability to control the ball in the air. Good juggling skills indicate good ball feeling.

Table 9. *Aspects of intelligence test assessment*

Assessment Aspects	Description
Culture Fair Intelligence Test (CFIT)	Tests that do not use verbal stimuli but rather images and can be administered individually or in groups. These tests measure fluid intelligence, which is the ability to reason, learn new things, and solve problems based on available information.

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Discussion

Football achievement is determined by the process of talent identification and development from various talent scouting (Williams et al., 2020). Talent identification best on skill above average and creativity in youth football athletes begins with designing an instrument model that suits the characteristics and needs of young people. The mechanism for identifying gifted children can be seen from three aspects, namely skill above average, task commitment, and creativity (Renzulli, 2012). This process involves the preparation of test component is developed based on relevant theories and practices to ensure that the tests can accurately measures talent.

This study focuses on instruments developed for young soccer players to measure anthropometric, physical, skill, and intelligence tests. The effectiveness of talent identification test instruments in soccer remains a subject of scientific debate (Primasoni et al., 2024). Therefore, the development of valid methods and instruments is very important and necessary in order to recruit talented athletes (Jokuschies et al., 2018). Then, the four aspects were validated by 5 expert judgments consisting of four sports practitioners and 1 psychology practicioner. After the data is assessed, instrument validation is carried out and intraclass correlation coefficient reliability is carried out so that the instrument developed has a high level of feasibility. The validity tests results showed an average calculated V value of 0.88 when using 4 ratters with a scale of 1 to 5, and a table V value of 0.79 thus content validity of the instrument was declared valid. While the reliability test results showed an intraclass correlation coefficient (ICC) of 0.789, which is considered good.

Conclusion

Based on the results of the talent identification research on skill above average and creativity for soccer atlhetes, it has been proven to be valid and reliable in measuring the potential of athletes from the aspects of anthropometric tests, biomotor tests, skill tests, and intelligence tests. Therefore, this instrument can be used to measure skill above average and creativity in soccer athletes. The ease of implementation, clarity of instructions, and novelty of the test formula also add to the advantages of this instrument, making it effective and efficient for soccer academies and sports practitioners. Each aspect of the test, namely anthropometric test, physical test, skill test, and intelligence test, can be used to assess athletes' potentional with high accuracy and precision, ensuring that this instrument is capable of comprehensively identifying athletes' talents. In addition, this instrument can be applied to male and female athletes without significant differences, demonstrating its suitability for widespread use in the process of searching for talent of recruiting talented athletes in Indonesia. However, for future development, it is necessary to follow up by adding psychological aspects to create a new comprehensive formula.

Reference

Ahmed, M. R. (2015). *Emotional Intelligence Is Synergy in*. *March*, 447–455.

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings, educational and psychological measurument. *Educational and Psychological Measurement*, *45*(1), 131–142.

Arthur, R., Rouf, F. A., Rahmayanti, H., & Maulana, A. (2019). Plumbing work competence instrument in the field of civil engineering. *Journal of Physics: Conference Series*, *1402*(2). https://doi.org/10.1088/1742-6596/1402/2/022019

Connor, M., Beato, M., & O'Neill, M. (2022). Adaptive Athlete Training Plan Generation: An intelligent control systems approach. *Journal of Science and Medicine in Sport*, *25*(4), 351–355. https://doi.org/10.1016/j.jsams.2021.10.011

Deprez, D., Fransen, J., & Lenoir, M. (2015). *A Retrospective Study on Anthropometrical, Physical Fitness, and Motor Coordination Characteristics That Influence Dropout, Contract Status, and First-Team Playing Time in High-Lev... December*. https://doi.org/10.1519/JSC.0000000000000806

Doolan-Noble, F., Barson, S., Lyndon, M., Cullinane, F., Gray, J., Stokes, T., & Gauld, R. (2019). Establishing gold standards for System-Level Measures: A modified Delphi consensus process. *International Journal for Quality in Health Care*, *31*(3), 205–211. https://doi.org/10.1093/intqhc/mzy122

Douglas G. Bonett, T. A. W. (2015). Cronbach's alpha reliability: Interval estimation, hypothesis testing, and sample size planning. *Journal of Organizational Behavior*, *36*, 3–15.

Glazier, P. S. (2017). Towards a Grand Unified Theory of sports performance. *Human Movement Science*, *56*, 139–156. https://doi.org/10.1016/j.humov.2015.08.001

Hendry, D. T., Williams, A. M., & Hodges, N. J. (2018). Coach ratings of skills and their relations to practice , play and successful transitions from youth-elite to adult-professional status in soccer. *Journal of Sports Sciences*, *00*(00), 1–9. https://doi.org/10.1080/02640414.201

8.1432236

Jokuschies, N., Gut, V., & Conzelmann, A. (2018). *Systematizing coaches ' ' eye for talent ': Player assessments based on expert coaches ' subjective talent criteria in top-level youth soccer. October 2017.* https://doi.org/10.1177/1747954117727646

Jowett, S., Adie, J. W., Bartholomew, K. J., Yang, S. X., Gustafsson, H., & Lopez-Jiménez, A. (2017). Motivational processes in the coach-athlete relationship: A multi-cultural self-determination approach. *Psychology of Sport and Exercise*, *32*, 143–152. https://doi.org/10.1016/j.psychsport.2017.06.004

Jurnal, J., Ilmu, T., Widanita, N., Sukamti, E. R., & Festiawan, R. (2020). *Hubungan Tingkat Intelligence Qoutient (IQ) dan Bakat dengan Hasil Kejuaraan Senam POPDA DIY. 5.* https://doi.org/10.17509/jtikor.v5i1.24463

Kutlu, M., Yapici, H., & Yilmaz, A. (2017). Reliability and Validity of a New Test of Agility and Skill for Female Amateur Soccer Players. *Journal of Human Kinetics*, *56*(1), 219–227. https://doi.org/10.1515/hukin-2017-0039

Larkin, P., & O'Connor, D. (2017). Talent identification and recruitment in youth soccer: Recruiter's perceptions of the key attributes for player recruitment. *PLoS ONE*, *12*(4), 1–15. https://doi.org/10.1371/journal.pone.0175716

LG Portney, M. W. (2009). Foundations of clinical research: applications to practice. *Upper Saddle River, NJ: Pearson/Prentice Hall.*

Martirosyan, A., & Stepanyan, L. (2025). Unveiling Athletic Talents: Exploring the Selection Process for Young Wrestlers in Armenian Sports Schools. *International Sports Studies*, *47*(1), 71–84. https://doi.org/10.69665/iss.v47i1.28

Mendez-villanueva, A. (2012). *Match Play Intensity Distribution in Youth Soccer. April 2014.* https://doi.org/10.1055/s-0032-1306323

Novi Resmi Ningrum, Tomoliyus, Fauzi, Faidillah Kurniawan, Endang Rini Sukamti, Abdul Alim, M. E. P. (2024). *Exploring the validity and reliability of the student athlete training environment scale: a second-order CFA model analysis of items Exploración de la validez y confiabilidad de la escala del ambiente de entrenamiento de estudiantes atletas: un análisis d. 2041*, 110–118.

Primasoni, N., Santoso, N., Arjuna, F., Asmara, M., & Soenyoto, T. (2024). *Longitudinal study on the development of speed, leg explosive power, aerobic endurance, and technical skill of young football players in talented and non-talented categories: implications for talent identification? Estudio longitudinal sobre el desarrollo. 2041*, 1026–1033.

Renzulli, J. S. (2012). Reexamining the Role of Gifted Education and Talent Development for the 21st Century: A Four-Part Theoretical Approach. *Gifted Child Quarterly*, *56*(3), 150–159. https://doi.org/10.1177/0016986212444901

Renzulli, J. S. (2021). The Three-Ring Conception of Giftedness: A Developmental Model for Promoting Creative Productivity 4. *Reflections on Gifted Education: Critical Works by Joseph S. Renzulli and Colleagues*, 55–90. https://doi.org/10.4324/9781003237693-3

Schorer, J., Wattie, N., Cobley, S., & Baker, J. (2017). Concluding, but definitely not conclusive, remarks on talent identification and development. *Routledge Handbook of Talent Identification and Development in Sport*, 466–476.

Simonton, D. K. (2017). Does Talent Exist?: Yes! *Routledge Handbook of Talent Identification and Development in Sport*, 10–18.

Sugiyono. (2013). *Metode Penelitian kuantitatif, kualitatif dan R & D* (Issue Bandung: Alfabeta).

Widohari, A. S., Wira, D., Kusuma, Y., & Sugiharto, S. (2022). *Correlation of Intelligent Quotient , Emotional Quotient , and Adversity Quotient to Badminton Athletes ' Achievement. 11*(3), 365–372.

Williams, A. M. (2010). *Perceptual skill in soccer : Implications for talent identification and development Perceptual skill in soccer : Implications for talent identi ® cation and development. March 2013*, 37–41.

Williams, A. M., Ford, P. R., & Drust, B. (2020). Talent identification and development in soccer since the millennium. *Journal of Sports Sciences*, *38*(11–12), 1199–1210. https://doi.org/10.1080/02640414.2020.1766647

Ziegler, A. (2011). *Talent Development & Excellence. October.*

ASEP ANGGA PERMADI
THE RELATIONSHIP BETWEEN PHYSICAL CONDITION AND MENTAL READINESS OF FOOTBALL PLAYERS IN FACING COMPETITION

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THE RELATIONSHIP BETWEEN PHYSICAL CONDITION AND MENTAL READINESS OF FOOTBALL PLAYERS IN FACING COMPETITION

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Abstract: *This study examined the relationship between physical condition and mental readiness in football players preparing for competition. Twenty-five players from Club Persigar Garut (aged 23) were assessed ahead of the 2024/2025 Indonesian Liga 4 season. Physical condition was measured through tests of flexibility, strength (e.g., Hurdle Jump for lower-body power), speed, agility, power, and endurance, while mental readiness was evaluated using the Mental Skills Test-Football (MST-f). Results indicated high mental readiness (mean = 86.36%) with low variability. Speed and agility showed the highest scores; leg muscle strength was the lowest. A very strong, significant positive correlation was found between physical condition and mental readiness (r = 0.965; p < 0.01), highlighting the need for integrated physical and psychological training to optimize performance.*
Keywords: *Physical Condition, Mental Readiness, Football*

INTRODUCTION

Football is a sport that demands comprehensive readiness from every individual, both from the physical and mental aspects. In the pre-competition phase, players are required to achieve optimal conditions in a limited amount of time and under the pressure of high expectations, both from the team and the external environment. Physical preparation that includes strength, endurance and speed is often the main focus of training, as it is considered the foundation of performance. On the other hand, mental preparedness such as emotion regulation, concentration, and confidence also largely determine how players respond to pressure and make decisions on the field (Weinberg & Gould, 2019; Sarkar & Fletcher, 2014).

In training practice, there is still a lot of separation between physical and psychological approaches. Conventional approaches tend to place the two in separate training tracks. In fact, biopsychosocial theory in sport emphasises that athletic performance is the result of complex interactions between biological (physical), psychological and social dimensions (Engel, 2012; Uphill et al., 2016). Some contemporary models of athletic performance also underline the importance of integration between physiological and psychological states, especially in the run-up to competition where mental stress and physical load reach their peak (Eklund & Tenenbaum, 2014; Gucciardi et al., 2017).

Although the research gap is well defined, a concrete example may strengthen the argument. While prior studies have focused on either physical performance or mental health in isolation (Coutinho et al., 2016; Slimani et al., 2017), few have systematically examined the direct relationship between specific physical condition parameters and mental readiness indicators. In reality, these factors interact dynamically, especially during the pre-competition phase. For example, an athlete with excellent physical conditioning may still underperform if lacking composure or focus under pressure—key aspects of mental readiness. The integrative approach in modern sport science emphasizes this interaction, highlighting how both elements jointly contribute to consistent performance in high-stakes situations (Fletcher & Sarkar, 2016; Permadi et al., 2021).

This gap signalled the need for research exploring the reciprocal relationship between physical condition and mental readiness in the specific context of pre-competition football. This study aims to examine whether good physical condition can improve players' mental readiness, and whether mental readiness also contributes to perceptions of fatigue as well as subjective physical readiness. Hypothesising that there is a significant positive relationship between physical condition and mental readiness, this study contributes to building a more integrative and evidence-based training framework to support the optimal performance of professional football players.

METHODS

This study used a correlational quantitative approach with a cross-sectional design to analyse the relationship

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between physical condition and mental readiness of soccer players ahead of competition. The research subjects were 25 players from Club Persigar Garut who will participate in the 2024/2025 Indonesian League 4 Season, with an average age of 23 years. To measure mental readiness, the Mental Skills Test-Football (MST-f) (Rasmussen, 2019) instrument was used, while physical condition was measured through the Football Physical Test which includes six main components: flexibility, strength, speed, agility, power, and endurance. All measurements were taken within one week of the competition. Data were analysed using the Pearson correlation test to determine the relationship between physical condition and mental readiness variables, with the help of SPSS software and a significance level of $p < 0.05$.

The Mental Skills Test-Football (MST-f) used in this study consists of six categories: Match Preparation, Visualization, Self-Talk and Self-Confidence, Energy Management, Concentration, and Goal Setting and Motivation, comprising a total of 42 items. Each item is rated on a 5-point ordinal scale, reflecting the frequency or intensity of mental skill use. The MST-f has demonstrated strong internal consistency in previous studies, with Cronbach's alpha values ranging from 0.78 to 0.91 across subscales, and has been applied in similar research involving competitive football players (Slimani et al., 2017). Physical condition was assessed through several standardized tests commonly used in football performance evaluation. Flexibility was measured using the Sit and Reach Test, while lower-body explosive power was evaluated with the Hurdle Jump Test. Speed and agility were assessed through the 30-Meter Sprint and the Illinois Agility Test, respectively. Power was further tested using the Standing Broad Jump, and endurance was measured through the Multistage Fitness Test. These instruments were selected for their established validity and reliability in measuring key physical components relevant to football performance.

Table 1. Mental Skills Test - football (MST-f)

Source	Categories	Scale	Items
Mental Skills Test - football (MST-f)	Match Preparation	Ordinal	A1 – A7
	Imagery		B1 – B7
	Self-talk and Self-confidence		C1 – C7
	Energy Management		D1 – D7
	Concentration		E1 – E7
	Goal Setting and Motivation		F1 – F7

For the performance test, here is the instrument to measures the performance of football players. The entire test is carried out by a team of analysts or it could be a coach to assess the extent to which the players are performing based on the aspects of the assessment during conditions on the field.

Results

Table 2. Physical Condition Test Results of Persigar Players

Components	Average Results	Targets	Achievement Percentage (%)
Sit and Reach	16	30	53.33%
Trunk Lift	37	66	56.06%
Strength (Hardle Jump)	60	200	30.00%
Speed (20 m)	97.22	100	97.22%
Agility (Illinois Run)	97	100	97.00%
Power (Standing Board Jump)	204	300	68.00%
Endurance (Bleep Test)	41	60	68.33%

Table 2. shows the physical condition test results of Persigar players based on seven fitness components, namely flexibility (Sit and Reach), back strength (Trunk Lift), leg muscle strength (Hardle Jump), speed (20 m sprint), agility (Illinois Run), leg muscle explosiveness (Standing Board Jump), and endurance (Bleep Test). The Target values in this table represent the maximum capability expected for each physical component, based on ideal performance standards for football players. These values are not average benchmarks but serve as upper-limit goals, indicating the optimal levels athletes are encouraged to reach through high-level training and conditioning. Achievement percentages, therefore, reflect how close each player is to their sport-specific physical potential. From the data, speed and agility had the highest achievement of 97.22% and 97.00% respectively, while leg muscle strength had the lowest achievement of 30.00%. Other achievement percentages ranged from 53.33% to 68.33%, indicating the need for improvement in some physical aspects.

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Table 3. Descriptive Statistics of Mental Skills Test (N = 25)

Statistic	Value
Average	86.36%
Median	86.91%
Standard Deviation	±4.40%
Highest Score	93.45%
Lowest Score	76.19%
Score Range	17.26%

These statistics show the performance of participants with a mean score of 86.36% and a median score of 86.91%, which indicates a fairly even distribution of scores. The highest score reached 93.45% and the lowest score 76.19%, with a range of 17.26%. The standard deviation of ±4.40% indicates that the variation between participants is low, so their performance is relatively consistent.

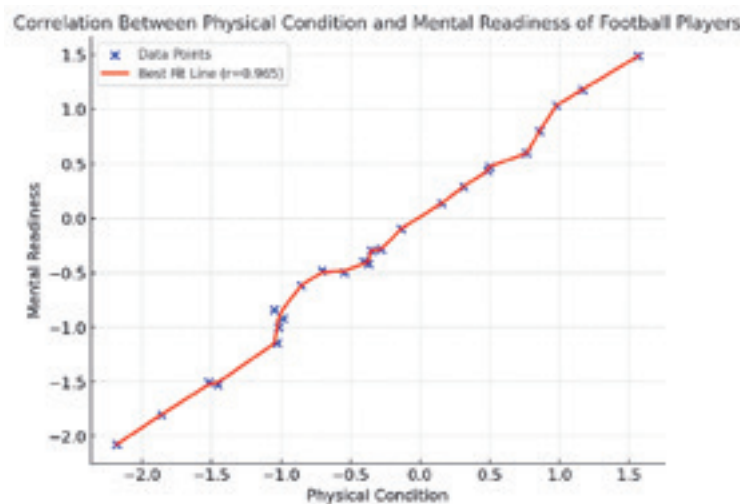**Pearson correlation analysis was conducted:**

Figure 1. Correlation of Physical Condition and Mental Readiness of Football Players

Figure 1 illustrates a very strong correlation between physical condition and mental readiness of football players. This graph shows a significant positive relationship, where the dotted data shows a very strong pattern between the two variables, with the best fit line reflecting a correlation of r = 0.965 (very strong correlation). Significance (p-value): p < 0.01.

Discussion

This study showed a very strong and significant relationship between physical condition and mental readiness of football players ahead of competition (r = 0.965; p < 0.01). The findings confirm that players with optimal physical condition tend to show higher mental readiness. Good physical condition plays an important role in influencing aspects of athletes' mental readiness, such as confidence, focus, and emotional control, all of which are key components in preparing athletes for competition (Weinberg & Gould, 2019). This is in line with recent research findings which confirm that physical fitness is directly related to psychological readiness and overall athlete performance.

It also supports research conducted by Mujika et al. (2018), which revealed that athletes who underwent a structured physical training programme showed improved psychological readiness, including increased focus and calmness in the face of competition. The research is in line with the results obtained by Papadopoulos et al. (2020), which states that improvements in physical fitness, such as VO2max and muscle fitness, significantly contribute to the mental resilience of athletes, especially in elite level football. Research shows that increasing physical capacity can improve the mental stability of players in stressful situations.

In addition, the results of this study also reinforce the findings of Raglin (2014), who showed that athletes who are in a state of physical fatigue are more susceptible to mental stress, which can affect their cognitive performance. This issue was further emphasised by Martens et al. (2015), who highlighted the importance of a combination of

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physical and mental training in preparing athletes for competition. In this study, it was found that physical training balanced with mental management resulted in better readiness in facing competitive challenges, compared to relying solely on physical or psychological aspects separately.

Overall, this research made a significant contribution to our understanding of the relationship between athletes' physical condition and mental preparedness. The findings confirm that the two factors are interrelated and inseparable in the context of competitive preparation, particularly in team sports such as football. Compared to previous research that often separates physical and psychological analyses, this study offers a holistic approach that integrates both quantitatively, providing strong empirical evidence that the integration of physical and mental factors can strengthen athletes' competition readiness. However, the study's findings should be interpreted with caution due to certain limitations, including the relatively small sample size and the specificity of the sample, which consisted solely of players from one club (Persigar Garut) competing in Indonesia's Liga 4. These factors may limit the generalizability of the results to broader populations or higher competition levels.

Conclusion

This study found a very strong and significant relationship between physical condition and mental readiness of football players ahead of competition ($r = 0.965$; $p < 0.01$). Players with good physical condition showed higher mental readiness, which contributed to increased confidence, focus, and emotional control. These results confirm that both factors—physical and mental—are interrelated and inseparable in preparing athletes for competition. This research provides evidence that a training approach integrating both aspects is more effective in enhancing athletes' readiness for competitive challenges. Based on these findings, coaches are encouraged to incorporate psychological skills training—such as goal setting, visualization, and emotional regulation—into regular physical training routines. Meanwhile, sports psychologists should collaborate closely with coaching staff to monitor and support athletes' mental development in tandem with physical conditioning, particularly during the pre-competition phase.

References

Coutinho, D., Mesquita, I., & Davids, K. (2016). A review of the application of the ecological dynamics framework to sports science. *International Journal of Sport Psychology*, 47(3), 254-279. https://doi.org/10.1016/j.psychsport.2015.08.004

Eklund, R. C., & Tenenbaum, G. (2014). Handbook of sport psychology (4th ed.). Wiley.

Engel, G. L. (2012). The biopsychosocial model and the practice of sports medicine. In D. S. Krane (Ed.), The Oxford Handbook of Sport and Performance Psychology (pp. 217-235). Oxford University Press.

Fletcher, D., & Sarkar, M. (2016). Psychological resilience in sport performers: A review of the literature. *International Review of Sport and Exercise Psychology*, 9(2), 101-121. https://doi.org/10.1080/1750984X.2016.1168693

Gucciardi, D. F., Hanton, S., & Mallett, C. J. (2017). A comprehensive model of mental toughness in sport: Exploring the psychological foundations. *Sport and Exercise Psychology Review*, 13(1), 70-89. https://doi.org/10.1016/j.jpsychores.2017.04.003

Martens, R., Vealey, R. S., & Burton, D. (2015). Social psychology in sport. *Human Kinetics*.

Mujika, I., et al. (2018). The role of physical conditioning and psychological resilience in sports performance. *Journal of Sports Science and Medicine*, 17(2), 201-212.

Papadopoulos, D., et al. (2020). The effect of cardiovascular fitness on mental toughness and resilience in soccer players. *Psychology of Sport and Exercise*, 46, 101663. https://doi.org/10.1016/j.psychsport.2019.101663

Permadi, A. A., Subarjah, H., Sidik, D. Z., & Nuryadi, N. (2021). The Influence of Psychological (Mental) Training to Improve the Performance of Football. *JUARA : Jurnal Olahraga*, 6(2), 162–170. https://doi.org/10.33222/juara.v6i2.1192

Raglin, J. S. (2014). Mental health and elite athletes: The role of physical condition and recovery strategies. *International Journal of Sport and Exercise Psychology*, 12(1), 24-38. https://doi.org/10.1080/1612197X.2014.881953

Rasmussen, O. S. (2019). Validation of the Mental Skills Test – football (MST-f) questionnaire: An exploratory analysis.

Sarkar, M., & Fletcher, D. (2014). Psychological resilience in sport performers: A review of the literature. *Journal of Sport and Exercise Psychology*, 36(5), 550-565. https://doi.org/10.1123/jsep.2013-0236

Slimani, M., et al. (2017). Physical activity and mental health in athletes: *A systematic review. Psychology of Sport and Exercise*, 31, 1-12. https://doi.org/10.1016/j.psychsport.2016.12.004

Uphill, M. A., Jones, M., & Cooke, A. (2016). Sport and exercise psychology: A critical introduction. Routledge.

Weinberg, R., & Gould, D. (2019). Foundations of sport and exercise psychology (7th ed.). *Human Kinetics*.

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