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- Moderne sportsko-rekreativne aktivnosti (fitnes, ekstremni sportovi i dr.) I zdravlje vježbača
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- Vrhunski sport i zdravlje
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- Modern school physical education in the function of proper growth and development of children and youth
- Modern physical education and youth health
- University sports as a factor of healthy living
- Sport in the function of recreation and health of citizens
- Sports and recreational activities as anti-stress factor
- Use of sports and recreational activities in the change of people's lifestyle
- Modern sports and recreational activities (fitness, extreme sports, etc.) and health of exercisers
- Corrective exercises and kinetic therapy in the elimination of postural disorders
- Sport for people with special needs as a function of training for life and work
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Poštovani čitaoci,

Iza nas je još jedna godina napornog rada i ponosni smo na činjenicu da naš časopis izlazi već sedam godina u kontinuitetu.

U ovom broju možete pročitati članke iz oblasti sportske rekreacije osoba treće životne dobi, trenažne tehnologije, antropomotoričkih karakteristika i sposobnosti i primjene magnetoterapije u fizikalnoj medicini i rehabilitaciji. Autori u ovom broju su iz Bosne i Hercegovine, Makedonije i Srbije.

Zahvaljujemo se svim autorima, istraživačima i čitaocima na dobronamjernim sugestijama. Očekujemo Vaše članke i u skoroj budućnosti. Budite hrabri u nauci i imajte na umu da je Albert Ajnštajn rekao: ''Nikad do otkrića nisam došao isključivo racionalnim razmišljanjem.''

UREDNIŠTVO ČASOPISA

DearReaders,

One more year of hard work is behind us and we are proud of the fact that our scientific journal has been published for seven years continuously.

In this issue you can read articles in the field of sports recreation of the third age persons, training technology, anthropometric characteristics and the abilities and application of magnet therapy in physical medicine and rehabilitation. Authors in this issue are from Bosnia and Herzegovina, Macedonia and Serbia.

We thank all authors, researchers and readers for their well-meaning suggestions. We expect your articles in the close future. Be brave in science and keep in mind that Albert Einstein said: "I never came to the discovery solely through rational thinking."

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Benefits of Strength Training for Elderly Women

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Abstract: The aging process is associated with loss of skeletal muscle mass and increase in intramuscular fat, the latter also defined as muscle attenuation. Muscle weakness, termed sarcopenia and dynapenia, is a normal age-related phenomenon, occurring at a rate of 1% to 5% annually from the age of 30. This rate means that given typical patterns of physical activity, a 70-year-old woman could have 50% to 70% less strength than she had at age 30. Contrary to long held beliefs, the muscles of elderly women (i.e. aged 65 years and older) continue to be adaptable, even into the extremes of old age, particularly if their muscles are significantly overloaded during training. Therefore, effective strengthening practices must be employed to maintain the highest level of function and achieve optimal aging in elderly women. Done regularly (2-3 times a week), strength training preserve bone density, independence and vitality with age. In addition, strength training also has the ability to reduce the risk of osteoporosis and the signs and symptoms of numerous chronic diseases such as heart disease, arthritis and type 2 diabetes, while also improving sleep and reducing depression. Finally, though muscle strength has been recognized as an important predictor for reduced functional performance, emerging evidence suggests that muscle power (the product of force time velocity or the rate of performing work) is highly effective to elicit substantial improvements in maximal mechanical muscle function (rapid force generation, muscle power and muscle strength) and in functional performance in old and very old women.
Keywords: exercise, sarcopenia, muscle power

Introduction

With a significant demographic change in the Balkans and the rest of the world, with regard to the increase in the number of third-person animals, the growing interest of the community is evident in creating effective strategies to cope with muscular atrophy that results from aging. This muscular weakness, defined by the notion of sarcopenia I by Diappenia, represents the normal physiological response of

Dobrobiti treninga snage za žene treće životne dobi

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Sažetak: Starenje je proces povezan gubitkom mišićne mase i porastom intramuskularnih masti. Mišićna slabost, definisana kao sarkopenija i dinapenija, predstavlja normalan fenomen povezan sa procesom starenja koji se ostvaruje po stopi od 1% do 5% godišnje nakon 30. godine života. Ova stopa zapravo znači da ukoliko se radi o uobičajenom nivou fizičke aktivnosti, 70-godišnja žena će se odlikovati za 50-70% manjim nivoom snage od nivoa koji je imala u 30. godini života. Nasuprot dugogodišnjim verovanjima, mišićno tkivo žena treće životne dobi (npr. starosti 65 godina) je veoma adaptabilno i nastavlja to da bude do duboke starosti, ukoliko su mišići značajno nadopterećeni tokom trenažnih epizoda. Stoga, efektivan trening snage je neophodan u cilju očuvanja visokog nivoa funkcionalnosti i dostizanja optimalne starosti. Redovno sprovođen trening snage (2-3 puta nedeljno) u stanju je da očuva gustinu kostiju, nezavisnost i značajan nivo vitalnosti sa starenjem. Takođe, trening snage je u stanju da smanji rizike za nastanak većeg broja hroničnih oboljenja poput srčanih oboljenja, artritisa i dijabetesa tipa 2, ali i da poboljša kvalitet sna i smanji simptome depresije. Konačno, iako je mišićna snaga prepoznata kao važan prediktor smanjene funkcionalnosti žena treće životne dobi, narastajući broj dokaza ukazuje na to da eksplozivna snaga (proizvod sile i brzine, ili stopa vršenja rada) predstavlja parameter koji direktno utiče na mehaničke osobine mišića (brz prirast sile) i veliki broj parametara funkcionalnih performansi na uzorku žena treće životne dobi.
Ključne reči: vežbanje, sarkopenija, eksplozivna snaga

Uvod

Sa značajnom demografskom promenom na Balkanu ali i celom svetu sa aspekta porasta broja osoba treće živone dobi, evidentan je i narastajući interes zajednice za kreiranjem efikasnih strategija koje bi se nosile sa mišićnom atrofijom koja nastaje kao posledica starenja. Ta mišićna slabost, definisana pojmom sarkopenija i odnedavno dijapenija, predstavlja normalan fiziološki odgo-

the mechanism to the aging process, and occurs at a rate of 1% to 5% per year starting from the age of 30 (Lindel et al., 1997). This practically means that the average person in 70 years of age has a 50-70% lower level of power compared to his 30s. The rate of decline in power levels depends on the level of physical activity, however, people who are less physically active have more pronounced loss of muscle than those who are physically active (Bortz, 2002).

Sarcopenia is a term originally presented by Rosenberg in 1989 (Rosenberg, 1989), and is a loss of muscle mass as a result of aging. However, the meaning of this term often extends to the loss of muscular strength and other parameters of functionality of persons of third age. Although sarcophenia also contributes significantly to the effect of loss of muscle function during the aging process, it is considered necessary to separate these two terms since the loss of muscle mass is not in direct correlation with loss of muscular strength (Clark & Manini, 2008), which is responsible for a greater number neurological peculiarities of the aging process (Clark & Manini, 2008; Duchateau & Enoka, 2002). Consequently, a new term, Diaphenia, was used recently, referring primarily to the loss of muscular strength parameters as a result of aging (Clark & Manini, 2008). Muscle mass declines at a rate between 3% and 8% for every decade of life since the age of 30 (Fleck et al., 2011), which means a loss of about 0.2 kg of muscle mass per year. This loss is increased to 5 to 10% or about 0.4 kg per year after each decade of life of 50 years (Nelson et al., 1994). Muscle metabolism is a very significant part of total basal metabolism and consequently plays a major role in the decline in basal metabolism at the rate of 2-3% per adult life span (Wolfe, 2006). Since basal metabolism makes about 65-70% of daily calorie consumption in the sedentary adult population, the reduction in muscle mass can significantly contribute to the rise in subcutaneous fat tissue in this population (Wolfe, 2006).

Loss of muscle mass and aging is a clinically significant phenomenon on the sample of women because it leads to a decrease in the level of strength and functionality, which has significant consequences for everyday activities. Moreover, loss of muscle mass is a powerful predictor of mortality in the third lifespan (Szulc et al, 2010).

After 60 years of age, the level of explosive power drops significantly more than the level of absolute power at a rate of as much as 3-5% per year, significantly affecting the ability to perform explosive or sudden movements. This loss of explosiveness in the broader sense seems to be the leading cause of a greater number of falls on a sample of people of third age, which in turn strengthens sedentary habits (Bortz, 2002). The loss of

vor mehanizma na process starenja, i javlja se stopom od 1% do 5% godišnje počevši od 30. godine života (Lindel i sar.,1997). Ovo praktično znači da prosečna osoba u 70. godini života ima za 50-70% niži nivo snage u odnosu na svoje 30. godine. Stopa opadanja nivoa snage zavisi svakako i od nivoa fizičke aktivnosti, osobe koje su manje fizički aktivne imaju izraženiju stopu gubljenja mišićne mase od osoba koje su fizički aktivne (Bortz, 2002).

Sarkopenija je termin originalno predstavljen od strane Rozenberga još 1989. godine (Rosenberg, 1989), i predstavlja gubitak mišićne mase kao posledice starenja. Ipak, značenje ovog termina se često proširuje i na gubitak mišićne snage i ostalih parmetara funkconalnosti osoba treće životne dobi. Iako sarkopenija značajno doprinosi i efektu gubitka mišićne funkcije tokom procesa starenja, smatra se da je potrebno razdvojiti ova dva termina s obzirom na to da gubitak mišićne mase nije u direktnoj korelaciji sa gubitkom mišićne snage (Clark i Manini, 2008), za šta je odgovoran veći broj neuroloških specifičnosti procesa starenja (Clark i Manini, 2008; Duchateau i Enoka, 2002). Shodno tome, nedavo je upotrebljen novi termin , dijapenija, koji se odnosi pre svega na gubitak parametara mišićne snage kao posledice starenja (Clark i Manini, 2008). Mišićna masa opada po stopi između 3% i 8% za svaku deceniju života od 30. godine (Fleck i sar., 2011), što prosečno znači gubitak oko 0,2kg mišićne mase godišnje. Ovaj gubitak se povećava na 5 do 10% ili na oko 0,4kg godišnje po svakoj deceniji života od 50. godine (Nelson et al., 1994). Mišićni metabolizam je veoma značajan deo ukupnom bazalnog metabilizma i posledično igra veliku ulogu u padu bazalnog metabolizma po stopi od 2-3% po deceniji života kod odraslih (Wolfe, 2006). S obzirom na to da bazalni metabolizam čini oko 65-70% dnevne kalorijske potrošnje kod sedentarne odrasle populacije, smanjenje mišićne mase može značajno doprineti porastu potkožnog masnog tkiva kod ove populacije (Wolfe, 2006).

Gubitak mišićne mase sa starenjem je klinički značajan fenomen na uzorku žena jer dovodi do smanjenja nivoa snage I funkcionalnosti, što ima značajne posledice po svakodnevne aktivnosti. Štaviše, gubitak mišićne mase je snažan prediktor smrtnosti u trećem životnom dobu (Szulc et al, 2010).

Nakon 60. godine života, nivo eksplozivne snage opada i značajnije od nivoa apsolutne snage, po stopi od čak 3-5% godišnje, značajno negativno utičući na sposobnost izvođenja eksplozivnih ili naglih pokreta. Ovaj gubitak eksplozivnosti u širem smislu je izgleda vodeći uzrok većem broju padova na uzorku osoba treće životne dobi, što posledično učvršćuje sedentarne navike (Bortz, 2002.). Gubitak mišićne mase je posledica smanjenog broja mišćnih vlakana i smanjenim poprečnim presekom

muscle mass is due to a decrease in the number of muscle fibers and a decreased cross-section of the remaining muscle cells, with fast muscle fibers showing a greater downward trend, especially in late life (Andersen, 2003).

Taken together, these results indicate that quantitative and qualitative changes in the muscle structure lead to a progressive decline in overall muscular performance, with the parameters of the explosive power losing faster than the parameters of absolute power. (Skelton et al, 1994; Skelton et al, 2002). From the standpoint of functionality, this leads to a significantly reduced ability to perform daily activities and to a greater subjective sense of effort for common activities (Hortobagyi et al., 2003). It is important to note, however, that while the general ability to perform movement decreases in the third life of the age, the ability to perform rapid and fast turns, such as the ability to maintain an equilibrium position in situations of disturbed balance (Pijnappels et al, 2005), is particularly affected.

Sarcopenia and diaphenia have significantly increased in the last decade or two. (Sayer et al., 2013). Today we still have a shortage of pharmacological studies that indicate effective strategies for treating sarcopenia or diaphenia. On the other hand, the growing number of evidence points to the importance of strength training for people of third age and especially women in the struggle with these two phenomena (Burton & Sumukadas, 2010), since it is established that strength training has a significant impact on all neurological and muscular mechanisms that lead to a rise in power (Duchateau & Enoka, 2002). Thus, a series of fundamental research published in the early 90's of the 20th century by Faltarone et al. (Fiatarone et al., 1990) in prestigious scientific journals (Fiatarone et al., 1994) pointed to the extremely high importance of strength training on the rise strong muscle characteristics, but also a whole set of parameaters of functionality on a sample of people of third age. Thus, the first of these studies has shown that people of third age can increase the level of strong abilities for an incredible 174%, a cross section of 9% and a speed of 48% for 8 weeks of strength training (Fiatarone et al., 1990)! Furthermore, maximum muscle activation has been shown to increase by 49% after 6 weeks of strength training (Kamen & Knight, 2004). And other muscle parameters increase as a result of strength training, such as the size of the muscle cell or stiffness of the tendon (10% and 64%, respectively) (Reeves, Maganaris, & Narici, 2003). 24 week training, supported by increased protein intake, leads to an increase in the cross section of muscle by almost 5% on the third-year female sample. (Chale et al., 2013). With the advent of the 21st century, we know that the muscle fiber has a

preostalih mišićnih ćelija, sa tim da brza mišićna vlakna pokazuju veći trend opadanja, naročito u kasnoj životnoj dobi (Andersen, 2003).

Uzeto zajedno, ovi rezultati ukazuju na to da kvantitativne i kvalitativne promene u strukturi mišića dovode do progresivnog opadanja ukupnih mišićnih performansi pri čemu se parametri eksplozivne snage gube brže od parametara apsolutne snage. (Skelton i sar, 1994; Skelton i sar., 2002). Sa stanovišta funkcionalnosti, ovo dovodi do značajno smanjene sposobnosti za izvođenjem svakodnevnih aktivnosti i do većeg subjektivnog osećaja napora za uobičajene aktivnosti (Hortobagyi i sar., 2003). Važno je ipak napomenuti da iako opšta sposobnst izvođenja kretanja opada u trećoj životnoj dobi, posebno pada sposobnost izvođenja naglih i brzih okreta poput sposobnosti zadržavanja ravnotežnog položaja u situacijama narušene ravnoteže (saplitanje) (Pijnappels i sar.,2005).

Istraživanja sarkopenije i dijapenije su značajno porasla po obimu u poslednjih deceniju ili dve. (Sayer i sar., 2013). Danas imamo još uvek manjak farmakoloških studija koje ukazuju na efikasne strategije tretiranja sarkopenije ili dijapenije. Sa druge strane, narastajući broj dokaza ukazuje na značaj treninga snage na osobama treće životne dobi a naročito žena u borbi sa ova dva fenomena (Burton i Sumukadas, 2010), s obzirom na toda je utvđeno da trening snage ima značajan uticaj na sve neurološke i mišićne mehanizme koji dovode do porasta snage (Duchateau i Enoka, 2002). Tako, serija temeljnih istraživanja publikovanih ranih 90. godina 20. veka od stane Fiataronea i saradnika (Fiatarone i sar., 1990) u prestižnim naučnim časopisima (Fiatarone i sar., 1994) su ukazali na ekstremno veliki značaj treninga snage na porast snažnih karakteristika mišića ali i čitavog seta parametara funkcionalnosti na uzorku osoba treće životne dobi. Tako, prva od ovih studija je pokazala da osobe treće životne dobi mogu da povećaju nivo snažnih sposobnosti za neverovatnih 174%, poprečni presek za 9% i brzinu hoda za 48% tokom 8 nedelja treninga snage (Fiatarone i sar., 1990)! Dalje, pokazano je da maksimalna aktivacija mišića raste za 49% nakon 6 nedelja treninga snage (Kamen i Knight, 2004). I drugi parametri mišića rastu kao posledica treninga snage, poput veličine mišićne ćelije ili krutost tetiva (10% i 64%, redom) (Reeves, Maganaris i Narici, 2003). Trening snage u trajanju od 24 nedelje, podržan porastom unosa proteina dovodi do porasta poprečnog preseka mišića od skoro 5% na uzorku žena treće životne dobi. (Chale i sar., 2013). Sa ulaskom u 21. vek znamo da mišićno vlakno ima značajnu sposobnost hipertrofije (~30% nakon 16 nedelja treninga), promene tipa mišićnog vlakna (IIX u IIA), i ima sposobnost

significant ability of hypertrophy (~ 30% after 16 weeks of training), a change in the type of muscle fiber (IIX in IIA), and has the ability to incorporate additional nuclei into the muscle fiber creating the assumption of muscular hypertrophy (Hikida et al ., 2000). Finally, these adaptations are comparable and similar levels as well as adaptations that force training produces on people younger age. Today, it is generally accepted that the effectiveness of strength training depends on a large number of parameters and that this is one of the main reasons for the variability of the positive effects in the studies. The recent meta-analysis of Peterson and associates dealt with the determination of critical apprentices of strength training in order to achieve positive effects (frequency, duration, intensity, total scope of training, etc.). (Peterson, Rhea, Sen, & Gordon, 2010; Peterson, Sen & Gordon, 2011). The authors have identified two critical parameters that influence the positive adaptations of power training. The first intensity is associated with more pronounced positive effects, and the difference between low to moderate and high intensity leads to an average difference of about 5% (Peterson et al., 2010). Second, the peak volume of strength training, defined as the total number of batches during training, is also associated with more pronounced effects (Peterson et al., 2011). These results indicate that for every 10 additional series after training, people of the third age can expect a 0.5 kg muscle mass increase. (Peterson et al., 2011). It should also be noted that with increasing age, the effect of strength training on the parameters of hypertrophy decreases (Peterson et al., 2011). Some scientists thought that there were so-called "non-responders" among third-age person lifeforce trainees (Bamman, Petrella, Kim, Mayhew, & Cross, 2007); However, recent retrospective studies have found that, although there are significant individual differences among respondents, the level of response and effects of training is directly dependent on the duration of intervention, with more positive effects in longer studies, thereby determining that there are no "non-responders" "(Churchward-Venne et al., 2015).

The benefits of strength training to the health status parameters

The strength training has positive effects on a large number of parameters of the health status of women of third age. Below the text will be listed some of which were most often the subject of quality studies.

An increase in basal metabolism

Power training stimulates protein synthesis and thus achieves a dual effect on metabolic consumption in peace

ugrađivanja dodatnih jedara u mišićno vlakno stvarajući pretpostavku mišićne hipertrofije (Hikida i sar., 2000). Konačno, ove adaptacije su uporedive i sličnog nivoa kao i adaptacije koje trening snage proizvodi na osoba mlađe životne dobi. Danas je opšteprihvaćeno da efikasnost treninga snage zavisi od velikog broja parametara i da je to jedan od osnovnih razloga varijabiliteta pozitivnih efekata u studijama. Nedavna meta analiza Petersona i saradnika bavila se utvrđivanjem kritičnih parametara treninga snage u cilju ostvarivanja pozitivnih efekata (frekvencija, trajanje, intenzitet, ukupni obim treninga i sl). (Peterson, Rhea, Sen i Gordon, 2010; Peterson, Sen i Gordon, 2011). Autori su utvrdili dva kritična parametra koji utiču na pozitivne adaptacije treninga snage. Prvoviši intenzitet je povezan sa izraženijim pozitivnim efektima i razlika između niskog ka umerenom i visokom intenzitetu dovodi do prosečne razlike od oko 5% (Peterson i sar., 2010). Drugo, povećan obim treninga snage, definisan kao ukupni broj serija tokom treninga je takođe povezan sa izraženijim efektima (Peterson i sar., 2011). Ovi rezultati ukazuju na to da za svakih 10 dodatnih serija po treningu osoba treće životne dobi može očekivati porast mišićne mase od 0,5kg. (Peterson i sar., 2011). Takođe, treba naglasiti da sa porastom starosti opada i efekat treninga snage na parametre hipertrofije (Peterson i sar 2011). Neki naučnici u smatrali da postoje i tzv "non-responderi" među osobama treće životne dobi na trenin snage (Bamman, Petrella, Kim, Mayhew i Cross, 2007); Ipak, nedavne retrospektivne studije su utvrdile da iako postoje značajne individualne razlike među ispitanicima, nivo odgovora i efekata treninga je direktno zavistan od dužine trajanja intervencije, sa pozitivnijim efektima koji nastaju u dužim studijama i time utvrđujući da ne postoje osobe koje su "non-responderi"(Churchward-Venne i sar., 2015).

Dobrobiti treninga snage na parametre zdravstvenog statusa

Trening snage ostvaruje pozitivne efekte na veliki broj parametara zdravstvenog statusa žena treće životne dobi. U nastavku teksta biće navedene neke koje su najučestalije bile predmet kvalitetnih studija.

Porast bazalnog metabolizma

Trening snage stimuliše sintezu proteina i tako ostvarue dualni efekat na metaboličku potrošnju u miru (Evans, 2001). Prvo, kao hronični odgovor, porast mišićne mase zahteva i veću potrošnju energije za svakodnevno održavanje. Pokazano je da 1kg mišića dovodi do porasta energetske potrošnje za oko 20 kilokalorija dnevno

(Evans, 2001). First, as a chronic response, an increase in muscle mass requires higher energy consumption for day-to-day maintenance. It has been shown that 1kg of muscle leads to an increase in energy consumption of about 20kg per day (Strasser & Schobersberger, 2011). Furthermore, acutely, strength training leads to a larger number of microtrauma that require large amounts of energy in the process of remodeling and recovery that can last up to 72 hours after training. Studies have shown a statistically significant increase in basal metabolism (7%) several weeks after power training (Van Etten et al., 2007). However, recent studies have shown a similar increase in metabolic consumption (5% to 9%) over a period of 3 days after one session of strength training (Heden, 2011). People who performed intense training efforts increased basal metabolism by 8% (trained) or 9% (untrained respondents) (Hackney, 2002). Based on these studies, it can be noted that strength training leads to an increase in metabolic consumption in peace for about 100 kilocalories.

Reduction of subcutaneous fat tissue

The increased percentage of subcutaneous tissue is associated with a whole range of risks to the health status of third-age women such as increased cholesterol, blood sugar levels, blood pressure, which together increases the risk of type 2 diabetes and cardiovascular disease (Strasser & Schobersberger, 2011) . In their review article, Strasser and Schoberberger conclude that strength training is a recommended procedure in the management of obesity and metabolic disorders. In relation to the percentage of body fat, several studies have shown that after training, strength can increase in weight of a body weight of about 1.4 kg and a simultaneous reduction of 1.8 kg of fat deposits (Westcott et al., 2009). In relation to central obesity that seems to bear higher health risks than the total amount of subcutaneous fat, research has shown a significant loss of abdominal fat on a sample of third-age women (Hunter et al., 2002). Harley et al. (Hurley et al., 1995) have found that potential factors that can lead to the reduction of abdominal subcutaneous tissue as a consequence of strength training are the increase in metabolic consumption in peace, improved insulin sensitivity, and increased sympathetic activity. However, the increase in metabolic consumption in a peace factor that contributes most to the loss of fat tissue. Circular power training for 20 minutes can consume up to 200 kcal and an additional 25% (50 kilicals) during the recovery process during the first 4 hours (Haltom et al., 1999). Moreover, during the next 72 hours, an additional consumption of 100 kilocalories per day can be expected, which makes up about 500 kilocalories of consumption for

(Strasser i Schobersberger, 2011). Dalje, akutno, trening snage dovodi do većeg broja mikrotrauma koje zahtevaju velike količine energije u procesu remodelovanja i oporavka koje može trajati i do 72 sata nakon treninga. Istraživanja su pokazala statistički značajan porast bazalnog metabolizma (7%) nekoliko nedelja nakon treninga snage (Van Etten i sar., 2007). Ipak, skorije studije su pokazale sličan porast metaboličke potrošnje (5% do 9%) u periodu od 3 dan nakon jedne sesije treninga snage (Heden, 2011). Osobe koje su sprovodile intenzivni trening snage su povećale bazalni metabolizam za 8% (trenirani) ili 9% (netrenirani ispitanici) (Hackney, 2002). Na osnovu ovih studija može se konstatovati da trening snage dovodi do porasta metaboličke potrošnje u miru za oko 100 kilokalorija.

Smanjenje potkožnog masnog tkiva

Povećan procenat potkožnog msnog tkiva je povezan sa čitavim nizom rizika po zdravstveni status žena treće životne dobi poput povećanog holesterola, nivoa šećera u krvi, krvnog pritiska, što sve zajedno povećava rizike od nastanka dijabetesa tipa 2 kao i kardiovaskularnih oboljenja (Strasser i Schobersberger, 2011). U svom preglednom članku, Štraser i Šobersberger zaključuju kako treninga snage predstavlja preporučenu proceduru u menadžmentu gojaznosti i metaboličkih poremećaja. U odnosu na procenat masnog tkiva, nekoliko studija je pokazalo da nakon treninga snage može doći do porasta nemasne mase tela od oko 1.4 kg i istovremenog smanjenja 1,8 kg masnih naslaga (Westcott i sar.,2009). U odnosu na centralnu gojaznost koja izgleda nosi veće rizike po zdravstveni status od ukupne količine potkožnog masnog tkiva, istraživanja su pokazala značajan gubitak abdominalnih masti na uzorku žena treće životne dobi (Hunter i sar., 2002). Harli i sar. (Hurley i sar.,1995) su utvrdili da su potencijalni faktori koji mogu dovesti do smanjenja abdominalnog potkožnog tkiva kao posledice treninga snage porast metaboličke potrošnje u miru , poboljšana osetljivost na insulin i povećana simpatetička aktivnost .Ipak, izgleda da je porast metaboličke potrošnje u miru faktor koji najviše doprinosi gubitku masnog tkiva. Kružni trening snage u trajanju od 20 min može potrošiti i do 200 kilikalorija i još dodatnih 25% (50 kilikalorija) tokom procesa oporavka tokom prva 4 sata (Haltom i sar., 1999). Štaviše, tokom naredna 72 sata može se očekivati dodatni utrošak od 100 kiliklorija dnevno , što čini ukupno oko 500 kilokalorija potrošnje za jedan 20-minutni trening snage, pa je moguće potrošiti i do 5000 klokalorija mesečno samo primenjujući dva puta nedeljno ovaj tip treninga.

one 20-minute training effort, so it is possible to spend up to 5000 calories per month only by applying this type of training twice a week.

Type 2 diabetes

With the rise in obesity problems worldwide, there is a simultaneous increase in type 2 diabetes. It is estimated that by the middle of the 21st century, one in three people in the world will suffer from this disease. (Boyle, 2010). In their review work (Flack et al., 2011), the strength training can be an effective strategy for people of third age (both men and women) to counteract the normal decline in the sensitivity of the organism to insulin as a result of aging. This attitude was supported by more studies, including those that showed increased levels of insulin sensitivity and improved glycemic control. As we have already mentioned, strength training leads to a reduction in subcutaneous fat tissue, which can be particularly important in the treatment of diabetes, since it has been shown that insulin sensitivity is associated with the amount of fat in the abdomen (Coon et al., 1992). Analyzing a large number of studies, Flek et al. (20011) concluded that greater intensity and volume strength training seems to be a more effective procedure for increasing insulin sensitivity compared to strength training of intensity and intensity. These recommendations are in line with the recommendations of the American Diabetes Association which state that it is necessary to train all major muscle groups 3 times a week, with progression to three series with 8-10 high-intensity repeats (Sing et al., 2005). Furthermore, Strausser et al. Meta-analysis (Strasser et al., 2010) confirmed that strength training reduces subcutaneous fat and reduces glycosylated hemoglobin (HbA1c) in people with abnormal glucose metabolism. The authors concluded that strength training should be recommended in prevention and management of type 2 diabetes and other metabolic disorders. According to Phillips and Winett 2010, strength training is associated with homeostasis of insulin and glucose primarily through an increase in the cross section of muscle and low body mass, as well as through qualitative improvement of the metabolic functions of the muscles, including increasing the density of glucose conveyor 4 (GLUT4) and amounts of glycogen synthase. Finally, there are indications that strength training is a more desirable training strategy in order to increase insulin sensitivity compared to the long-promoted aerobic type of training (Bweir et al., 2009).

Cardiovascular health

The review work (Strasser & Schobersberger, 2011) concluded that "strength training is at least as effective as

Dijabetes tipa 2

Sa porastom problema gojaznosti na svetskom nivou dolazi i do istovremenog porasta dijabetesa tipa 2. Procene su da će do sredine 21 veka jedna od tri osobe na svetu bolovati od ove bolesti. (Boyle, 2010). U svom preglednom radu (Flack i sar., 2011) zaključuju kako trening snage može predstavljati efikasnu strategiju za osobe treće životne dobi (i muškarce i žene) da se suprotstave normalnom opadanju osetljivosti organizma na insulin kao posledice starenja. Ovaj svoj stav su potkrepili većim brojem studija uključujući i one koje su pokazale povećan nivo osetljivosti na insulin i poboljšanu glikemijsku kontrolu. Kao što smo već napomenuli, trening snage dovodi do smanjenja potkožnog masnog tkiva što može biti posebno značajno i u lečenju dijabetesa jer je pokazano da je insulinska osetljivost povezana sa količinom masnog tkiva u predelu abdomena (Coon i sar., 1992). Analizirajući veći broj studija, Flek i sar (Flack i sar., 2011) su zaključili da trening snage većeg intenziteta i obima izgleda predstavlja efikasniju proceduru za povećanje insulinske osetljivosti u poređenju sa treningom snage manjeg obima i intenziteta.Ove preporuke su u skladu sa preporukama Američke Asocijacije za Dijabetes (American Diabetes Association) koja navodi da je potrebno trenirati sve velike mišićne grupe 3 puta nedeljno , sa progresijom do tri serije sa 8-10 ponavljanja visokog intenziteta (Sing i sar., 2005). Dalje, meta analiza Straser-a i saradnika (Strasser i sar., 2010) je potvrdila da trening snage smanjuje potkožno masno tkivo i smanjuje glikozilovan hemoglobin (HbA1c) kod osoba sa abnormalnim metabolizmom glukoze. Autori su zaključili kako trening snage treba preporučiti u prevenciji i menadžmentu dijabetesa tipa 2 i ostalih metabličkih poremećaja. Prema Filipsu i Vinetu (Phillips & Winett, 2010), Trening snage je povezan sa homeostazom insulina i glukoze pre svega preko porasta poprečnog preseka mišića i nemasne mase tela, kao i preko kvalitativnog poboljšanja metaboličkih funkcija mišića, uključujući povećanje gustine glukoznog transportera 4 (GLUT4) i količine glikogen sintaze. Konačno, postoje i indicije da je trening snage poželjnija strategija treninga u cilju povećanja osetljivosti na insulin u odnosu na dugo promovisan aerobni tip treninga (Bweir i sar., 2009).

Kardiovaskularno zdravlje

Pregledni rad (Strasser i Schobersberger, 2011) je zaključio kako „je trening snage najmanje jednako efikasan kao i trening aerobnog tipa u cilju prevencije kardiovaskularnih oboljenja". Dokazani pozitivni efekti aerobnog tipa treninga na kardiovaskularno zdravlje uključuju

aerobic-type training to prevent cardiovascular disease." The proven positive effects of aerobic training on cardiovascular health include improving body composition, mobilizing visceral fat and subcutaneous fatty tissue, blood pressure reduction, improved cholesterol and triglyceride ratio in blood, and improved blood glucose control. However, an increasing number of studies indicate the same positive effects of strength training on cardiovascular health. (both diastolic and systolic) as a consequence of two or more months of strength training in a sample of third-person individuals (Hurley et al., 2000; Kelley, 1997). One study on a sample of over 16,000 third-age people showed a significant reduction blood pressure as the consequences of applying a 20-minute training session, 2-3 times a week for a period of 10 weeks. The subjects involved in this study were systolic and diastolic blood pressure of 3.2 and 1.4 mm Hg, respectively (Westcott et al, 2009). Those who trained 3 times a week achieved better improvements of 4.6 and 2.2 mm Hg, respectively. According to the American College of Sports Medicine (2009), there is evidence that training in training can increase HDL by 8% to 21%, reduce LDL cholesterol by 13% to 23%, and reduce triglycerides by 11% to 18%. In studies conducted with third-age women, strength training significantly improved the triglyceride, LDL and HDL cholesterol parameters (Fahlman, 2002). A review work from 2009 (Tambalis et al., 2009) found that while strength training itself is a potent agent for the promotion of cardiovascular health, additional positive effects are likely to be expected when this type of training is combined with aerobic training.

Osteoporosis

Research shows that loss of muscle mass is directly related to loss of bone mass (osteopenia). Third-age non-strength training subjects can expect a loss of bone loss of 1% per year (Kemler, 2005). Logically, training for improving muscle mass should produce positive effects on bone density and the vast majority of research confirms this hypothesis. Several longitudinal studies have found an increase in bone density after applying training strengths of 4-24 months. Thus, the meta analysis of Wolf and Sar (Wolfe et al., 1999) showed that strength training could increase the bone density of women of the third age by about 1% per year of training (femoral bone and lumbar spleen samples were taken). Also, the recently published review of Going and Ludermilk (2009) showed that the increase in bone density in women of the third age was in the range of 1-3%. A two-year study (Kerr et al., 2001) showed that programmed strength training resulted in an increase in bone density by 3.2%

poboljšanje telesne kompozicije, mobilizaciju visceralnih masti i potkožnog masnog tkiva, smanjenje krvnog pritiska , poboljšan odnos holesterola i triglicerida u krvi i poboljšanu kontrolu glukoze u krvi. Ipak, narastajući broj studija ukazuje na gotove jednake pozitivne efekte treninga snage na kardiovaskularno zdravlje. Nekoliko studija je autoritativno demonstrirao pozitivne efekte treninga snage na smanjenje krvnog pritiska (kako dijastolnog tako i sistolnog) kao posledice dva ili više meseci treninga snage na uzorku osoba treće životne dobi (Hurley i sar, 2000; Kelley, 1997). Jedna studija na uzorku od preko 16000 osoba i treće životne dobi je pokazala značajno smanjenje krvnog pritiska kao posledice primene treninga snage u trajanju od 20 min dnevno, 2-3 puta nedeljno u periodu od 10 nedelja. Osobe koje su angažovane u ovoj studiji spustile su sistolni i dijastolni krvni pritisak za 3.2 i 1.4 mm Hg, redom (Westcott i sar.,2009). Oni koji su trenirali 3 puta nedeljno ostvarili su i bolja poboljšanja od 4,6 i 2.2 mm Hg, redom. Prema Američkom Koledžu za Sportsku Medicinu (2009), postoje dokazi koji govore da trening snage može povećati HDL za 8% do 21%, Smanjiti LDL holesterol za 13% do 23%, i smanji trigliceride za 11% do 18%. Na stdudiji rađenoj sa ženama treće životne dobi, treninga snage je značajno poboljšao parametre triglicerida, LDL i HDL holesterola (Fahlman, 2002). Pregledni rad iz 2009 (Tambalis i sar., 2009) utvrdio je da iako trening snage sam po sebi predstavlja potentno sredstvo za unapređenje kardiovaskularnog zdravlja, izgleda da se dodatni pozitivni efekti mogu očekivati kada se ovaj tip treninga kombinuje sa aerobnim treningom.

Osteoporoza

Istraživanja pokazuju da je guubitak mišićne mase direktno povezan i sa gubljenjem koštane mase (osteopenija). Osobe treće životne dobi koje ne sprovode trening snage mogu očekivati gubitak koštane mase od 1% godišnje (Kemler, 2005). Logično, trening za poboljšnje mišićne mase trebalo bi da ostvari pozitivne efekte i na koštanu gustinu i velika većina istraživanja potvrđuje ovu hipotezu. Nekoliko longitudinalnih studija utvrdilo je porast koštane gustine nakon primene treninga snage u trajanju od 4-24 meseca. Tako, meta analiza Wolfa i sar (Wolfe i sar., 1999) pokazala je da trening snage može povećati koštanu gustinu žena treće životne dobi za oko 1% po godini treninga (uzimani su uzorci femoralne kosti i lumbalnog dela kičme). Takođe, nedavno objavljen pregledni rad Going i Ludermilka (Going i Laudermilk, 2009) pokazao je da je porast koštane gustine kod žena treće životne dobi u rasponu od 1-3%. Studija koja je tra-

on a sample of third-age women. It seems that strength training is a potent tool for causing a rise in bone density in third-generation women and therefore it is desirable to recommend and implement it. The training effects will be higher if it is done with a higher mechanical load and for a longer duration. However, it should be noted that there seems to be a tendency to lose the effects of bone density on the termination of strength training (Vouri et al., 1994).

Mental health

As far as cognitive abilities are concerned, a large number of irradiation has been conducted on people of the third age (both men and women). A large number of studies were concerned with the impact of strength training (independently or combined with training for the development of aerobic abilities) on cognitive abilities and generally determined very positive effects. In meta analysis (Colcombe and Kramer, 2003), aerobic training supplemented by strength training leads to significantly greater positive effects on the cognitive ability of applying aerobic training independently. Guided by the results of Okonor et al. (O'Connor et al., 2010), complacency, as a global concept of an individual's perception of self, shows relative stability in relation to other parameters of mental health. However, the very positive effects of strength training precisely on this ability have been established in several studies conducted on a sample of third-age individuals (both men and women) (Brown et al., 1986). Furthermore, ten weeks of combined aerobic-type training and strength training lead to a statistically significant improvement in self-esteem, total mood, reducing fatigue and depression in a third-age person group (Anessi and Westcoot, 2004). Singh et al. (Singh et al., 2005) determined the impact of strength training on depression. In this basic study, the researchers found that even after 10 weeks of strength training (three workouts per week), as many as 80% of respondents were no longer in clinical depression. Based on these studies, it seems possible to recommend the use of strength training to improve the mental health of third-age women, with very high prospects for positive effects, but in short-to-moderate studies (6-10 weeks).

Conclusion

Beginning with a progressive loss of muscle mass during the aging process, studies performed using force training consistently show improvements in muscle mass and basal metabolism as a result of strength training, with an additional effect on the loss of subcutaneous fat tissue.

jala 2 godine (Kerr i sar., 2001) pokazala je da programirani trening snage dovodi do porasta koštane gustine za 3,2% na uzorku žena treće životne dobi. Izgleda da je trening snage potentno sredstvo za izazivanje porasta koštane gustine kod žena treće životne dobi i stoga ga je poželjno preporučiti i sprovoditit. Trenažni efekti će biti veći ukoliko se radi sa većim mehaničkim opterećenjem i u dužem vremenskom trajanju. Ipak, treba znati da izgleda postoji tendencija da se sa prekidom treninga snage efekti na koštanu gustinu gube (Vouri i sar., 1994).

Mentalno zdravlje

Što se tiče kognitivnih sposobnosti, veliki broj istraživanja je sproveden na osobama treće životne dobi (i muškarcima i ženama). Veliki broj istraživanja se bavio i uticajem treninga snage (samostalno ili kombinovano sa treningom za razvoj aerobnih sposobnosti) na kognitivne sposobnosti i uglavnom utvrdilo veoma pozitivne efekte. U meta analizi (Colcombe i Kramer, 2003), aerobni trening suplementiran treningom snage dovodi do značajno većih pozitivnih efekata po kognitivne sposobnosti od primene aerobnog treninga samostalno. Vodeći se rezultatima Okonora i sar. (O'Connor i sar., 2010), samozadovoljstvo, kao globalni koncept percepcije pojedinca o sebi, pokazuje relativnu stabilnost u odnosu na ostale parametre mentalnog zdravlja. Ipak, veoma pozitivni efekti treninga snage upravo na ovu sposobnost su utvrđeni u nekoliko istraživanja rađenih na uzorku osoba treće životne dobi (i muškarci i žene) (Brown i sar., 1986). Dalje, deset nedelja kombinovanog treninga aerobnog tipa i treninga snage dovodi do statistički značajnog poboljšanja u samozadovoljstvu (self-esteem), totalnom raspoloženju, smanjuje zamor i osećaj depresije na uzorku osoba treće životne dobi (Anessi and Westcoot, 2004). Sing i sar (Singh i sar., 2005) su utvrđivali uticaj treninga snage na depresiju. U ovoj temeljnoj studiji, istraživači su utvrdili da već nakon 10 nedelja treninga snage (tri treninga nedeljno) čak 80% ispitanika više nije bilo u stanju kliničke depresije. Na osnovu ovih studija, izgleda da je moguće preporučiti primenu treninga snage u cilju poboljšanja mentalnog zdravlja žena treće životne dobi, sa veoma velikim izgledima za pozitivnim efektima već u studijama kratkog do umerenog trajanja (6-10 nedelja).

Zaključak

Počevši od progresivnog gubljenja mišićne mase tokom procesa starenja, studije rađene primenom treninga snage konzistentno pokazuju poboljšanja u mišićnoj masi i bazalnom metabolizmu kao posledice treninga snage , sa dodatnim efektom na gubitak potkožnog masnog tki-

The strength training has proven effective in treating a whole set of functional parameters of third-age people (walking speed, degree of independence, reduced number of falls ...) but also of health status, from improving insulin sensitivity and consequently to treatment of type 2 diabetes, by improving cardiovascular status, bone density and mental health. Finally, although muscle strength has been recognized as an important predictor of reduced functionality, an increasing number of evidence indicates that an explosive force (product of force and velocity, or rate of operation) is a parameter that directly affects the mechanical properties of the muscle (rapid power increment) and a large number of parameters of functional performance on the sample of women of the third age.

va. Trening snage je dokazano efikasan u tretiranju čitavog niza funkcionalnih parametara osoba treće životne dobi (brzine hoda, stepena nezavisnosti, smanjenom broju padova…), ali i zdravstvenog stanja, od poboljšanja osetljivosti na insulin i posledično tretiranju dijabetesa tipa 2, preko poboljšanja kardiovaskularnog statusa, koštane gustine i mentalnog zdravlja. Konačno, iako je mišićna snaga prepoznata kao važan prediktor smanjene funkcionalnosti, narastajući broj dokaza ukazuje da eksplozivna snaga (proizvod sile i brzine, ili stopa vršenja rada) predstavlja parameter koji direktno utiče na mehaničke osobine mišića (brz prirast sile) i veliki broj parametara funkcionalnih performansi na uzorku žena treće životne dobi.

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Contemporary Principles of Magnetotherapy Application in Physical Medicine and Rehabilitation

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Abstract: Magnetotherapy is one of the oldest methods of treatment and throughout the history of medicine it passed the path from alternative to official method. In the 21st century a large number of scientific researches broadened the indication areas based on magnetotherapy. The objective of the paper is to demonstrate: historical development, types of magnetotherapy, its biological effects, clinical application and mechanisms of effects. Available world reference from the fields of basic and clinical researches on magnetotherapy was used. Basic studies indicate that leucocytes, thrombocytes, osteoblasts, chondrocytes, fibrinogen, fibrin, cytokine, the factors of growth, collagen, elastin and free radicals show the alteration in its effects when exposed to magnetic field. Magnetic fields impact the proliferation of cells, epithelization, phagocytosis, vasodilation which certainly improves the physiological surrounding that contributes to the regeneration and healing. Therapeutic effects depend upon all characteristics of electromagnetic field and patient's condition. The widest application of PEMP has in stimulation of osteogenesis (badly coalesced fractures, pseudarthrosis, spinal fusions coalescence), osteoarthritis, osteoporosis and other painful conditions. Transcranial magnetic stimulation has an increasing application in neuro-rehabilitation. Precise mechanisms of electromagnetic therapy effects are not known yet which is certainly one of the reasons of various approach and sufficient and on evidence based clinical application of this physical modality. A precise dosimetry, well-defined laboratory conditions, designed clinical studies, defined treatment protocols contribute to clearer clinical application as well as actuality of magnetotherapy in the future.
Key words: magnetotherapy, clinical application, PEMF (pulsed electromagnetic field), TMS (transcranial magnetic stimulation)

History

Data on biological effects of magnets date back from the time of magnetism discovery in an ancient Greece. Magnetotherapy is a physical therapy which has the lon-

Savremeni principi primjene magnetoterapije u fizikalnoj medicini i rehabilitaciji

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Sažetak: Magnetoterapija je jedna od najstarijih metoda liječenja i kroz istoriju medicine prolazi put od alternativne do zvanične metode. U XXI vijeku veliki broj naučnih istraživanja proširuje indikaciona područja zasnovana na magnetoterapiji. Cilj rada je da se prikažu: istorijski razvoj, vrste magnetoterapije, njihovi biološke efekti, klinička primjena i mehanizmi djelovanja. Korištena je dostupna svjetska literatura iz oblasti bazičnih i kliničkih istraživanja o magnetoterapiji. Bazične studije ukazuju da leukociti, trombociti, osteoblasti, hondrociti, fibrinogen, fibrin, citokini, faktori rasta, kolagen, elastin i slobodni radikali pokazuju alteraciju u svom djelovanju kad su izloženi magnetnom polju. Magnetna polja utiču na proliferaciju ćelija, epitelizaciju, fagocitozu, vazodilataciju što svakako poboljšava fiziološku sredinu koja doprinosi regeneraciji i izlječenju. Terapijski efekti zavise od svih karakteristika elektromagnetnog polja i od stanja pacijenta. Najširu primjenu pulsno elektromagnetno polje (PEMP) ima u stimulaciji osteogeneze (loše srasli prelomi, pseudoartroza, zarastanje spinalnih fuzija), osteoartritisa, osteoporoze i kod bolnih stanja. Transkranijalna magnetna stimulacija ima sve veću primjenu u neurorehabilitaciji. Precizni mehanizmi djelovanja elektromagnetne terapije još uvijek nisu poznati, što je svakako jedan od razloga različitih pristupa i nedovoljne i na dokazima utemeljene kliničke primjene ovog fizikalnog modaliteta. Precizna dozimetrija, dobro definisani laboratorijski uslovi, dizajnirane kliničke studije, definisani protokoli liječenja doprinose jasnijom kliničkoj primjeni, kao i aktuelnosti magnetoterapije i u budućnosti.
Ključne riječi: magnetoterapija, klinička primjena, pulsno elektromagnetno polje, transkranijalna magnetna stimulacija

Istorijat

Podaci o biološkim efektima magneta datiraju još iz vremena otkrića magnetizma u staroj Grčkoj. Magnetoterapija je fizikalna terapija koja se najduže primijenjuje

gest application in the history of medicine. Old Greeks before Homer discovered magnetite in Magnesia, a province in Asia Minor where the term magnet is originally from. It was then considered for magnet to have a medical value and there are data they have used it for treatment of various diseases. In Egypt, in 3600 BC they used the magnets in treatment of head injuries and sunstroke. In India in Ayurveda mantras in some chapters was described the use of magnet. Greek physician Galen used the magnet as a purgative agent in 200 BC, and Avicenna, Arab physician for liver treatment in 1000 BC. During Renaissance in the 15th century a Swiss physician Paracelsus used the magnets for treating toothache and inflammation (Basford, 2001). The first scientific depiction about the use of magnet in treatment is found in the book "De magnete", which was written in 1600 by William Gilbert, Physician to the Queen Elizabeth I (Gilbert, 1991). This brilliant physician and philosopher recommended magnets to treat various diseases. He pointed that planet Earth is a large magnet and that geomagnetic field of Earth as part of biosphere significantly impacts the formation and survival of all living systems. In the 18th century, the Austrian psychiatrist Mesmer explained that disturbing magnetic forces in the body cause disease so that he used magnets to treat different diseases. In time of Empress Maria Theresa he was expelled to France. French Academy of Sciences discredited Mesmer a fraud after four years and banned his work and his learning about magnets was called "mesmerism" (Lažetić, 2004). In history of magnetic therapy Mesmer compromised this method for a long time. In the beginning of the 19th century there came to the increase of number of researchers in the field of magnetism and electricity that saw the relationship between electric and magnetic appearances. Physicists Oersted, Arago and Ampere contributed to define electrical magnetic fields. In 1831 Faradey discovered an electromagnetic induction, and in the end of the 19th century a research of Nikola Tesla completed a scientific depiction about electromagnetic appearances. In the second half of the 20th century there began a more intensive production of magnetotherapy devices with artificial sources of EMP of various characteristics. A discovery of piezoelectricity in bone (Fukada & Yasuda, 1957) of Japanese scientists Yasuda and Fukada in 1957 marked the beginning of modern and scientific era of magnetotherapy. In 1966 Brighton described the bioelectric potential of osteocytes which appear in bones in absence of load (Friedenberg, 1966). Bioelectric potentials are solely negative and they appear in the fields of active growth and bone repair. During the seventies, a team led by American orthopaedist Bassed applied a pulsed electromagnetic field for stimulation of osteogenesis in treatment of slow fracture healing

u istoriji medicine. Stari Grci prije Homera su otkrili magnetit u Magneziji, provinciji u Maloj Aziji, odakle potiče i naziv magnet. Još tada se smatralo da magnet ima medicinsku vrijednost i postoje podaci da su ih koristili za liječenje različitih oboljenja. U Egiptu su 3600 godina p.n.e koristili magnete u liječenju povreda glave i sunčanice. U Indiji u Ajurvedskim mantrama u nekim poglavljima je opisana upotreba magneta. Grčki ljekar Galen je 200. godine p.n.e. koristio magnet kao purgativno sredstvo, 1000. godine arapski ljekar Avicena za liječenje jetre. U renesansnom periodu u XVI vijeku švajcarski ljekar Paracelzus je koristio magnete za liječenje zubobolje i upalnih stanja (Basford, 2001). Prvi naučni prikaz o upotrebi magneta u liječenju nalazi se u knjizi „De magnete", koju je 1600. godine napisao Wiliam Gilbert, lični ljekar engleske kraljice Elizabete I (Gilbert, 1991). Ovaj briljantni ljekar i filozof je preporučivao magnete za liječenje različitih oboljenja. Ukazao je na to da je planeta Zemlja veliki magnet i da geomagnetno polje Zemlje kao dio biosfere značajno utiče na formiranje i opstanak svih živih sistema. U XVIII vijeku austrijski psihijatar Mesmer objašnjava da remećenje magnetnih sila u organizmu izaziva bolest, tako da je koristio magnete u liječenju različitih oboljenja. U doba kraljice Marije Terezije je protjeran u Francusku. Francuska akademija nauka je nakon četiri godine Mesmera proglasila varalicom i zabranila rad, a njegovo učenje o magnetima je nazvano „mesmerizam" (Lažetić, 2004). U istoriji magnetoterapije Mesmer je za duži vremenski period iskompromitovao ovu metodu. Početkom XIX vijeka je značajno porastao broj istraživača u oblasti magnetizma i elektriciteta i veliki broj naučnika je uočio povezanost električnih i magnetnih pojava. Fizičari Oersted, Arago i Ampere su dali doprinos u definisanju elektromagnetnih polja. Faradey je 1831. godine otkrio elektromagnetnu indukciju, a krajem XlX vijeka istraživanja Nikole Tesle su upotpunila naučnu sliku o elektromagnetnim pojavama. U drugoj polovini XX vijeka se počelo intenzivno sa proizvodnjom aparata za magnetoterapiju sa vještačkim izvorima elektromagnetnih polja (EMP) različitih karakteristika. Otkrićem piezoelektriciteta kosti (Fukada i Yasuda, 1957) japanskih naučnika Yasude i Fukade 1957. godine počinje moderna i naučna era magnetoterapije. Brighton je 1966. godine opisao bioelektrični potencijal osteocita koji se u kostima javljaju u odsustvu opterećenja (Friedenberg, 1966). Biolelektrični potencijali su isključivo negativni, a javljaju se u oblastima aktivnog rasta i reparacije kosti. Tokom 70-tih godina, tim na čijem je čelu bio američki ortoped Bassett je primjenjivao pulsno elektromagnetno polje za stimulaciju osteogeneze u liječenju

(Bassett, Pawluk & Pilla, 1974). The clinical application was based on results of numerous animal and human studies, based on which Food and Drugs Agency (FDA) in the USA in 1979 recommended the stimulation of osteogenesis with EMP biphasic low frequency field in bad coalescences of bone fractures, pseudarthrosis and postponed coalescence of spinal fusions (Linovitz et al., 2002). Magnetotherapy has an analgesic effect in patients with rheumatoid arthritis and it contributes to improvement of functionality of these patients (Leśniewicz, Pieszyński, Zboralski et al., 2014). Pulsed electric field has a large clinical use after arthroplasty of the hip joint (Kocić, Lazarević, Kojović et al., 2006). Pulsed electromagnetic field and transcranial magnetic stimulation have a neromodulatory effect and they have a wide clinical use in Parkinson's disease (Vadala, Vallelunga et al., 2015), rehabilitation after stroke (Hsu, Cheng, Liao et al., 2012) and multiple sclerosis (Vijaysheree, Bever, Bowen et al., 2014).

In the 21st century an interest in applying the magnetic and electromagnetic fields in clinical practice has increased so that this physical modality passes the transition from alternative to official method. Over the last six decades of development of contemporary magnetotherapy, a successful treatment of a wide spectrum of musculoskeletal diseases, pain and neurological diseases has become possible.

Types of electromagnetic fields applied in clinical practice

Magnetotherapy is just one segment of magneto biology, a large interdisciplinary field which is nowadays intensively developed and researched. Undoubtedly, specialists in physical medicine and rehabilitation play an important role in development of magnetotherapy being those who use most this physical modality in their clinical practice.

Magnetotherapy involves seven groups of electromagnetic fields, developed and used in various countries of the world over the last 50 years (Markov, 2015):

Static/permanent magnetic fields created by different permanent magnets as well as the passage of direct current through the coil

Low-frequency sine wave electromagnetic fields mostly use 60 Hz (in the USA and Canada) and 50 Hz in Europe and Asia frequency in power distribution networks

Pulsed electromagnetic field (PEMP)(5-300Hz) are low-frequency fields with different shapes and amplitudes

Pulsed radio frequency electromagnetic fields (PRF) uses the selected frequencies in range of radio frequency: 13.56, 27.12, and 40.68 MHz.

usporenog zarastanja preloma (Bassett, Pawluk i Pilla, 1974). Klinička primjena zasnovana je na rezultatima brojnih animalnih i humanih studija, na osnovu kojih je 1979.godine Agencija za hranu i lijekove u SAD (FDA) preporučila stimulaciju osteogeneze EMP-om dvofaznim poljem niske frekvencije kod loše sraslih preloma kosti, pseudoartroza i odloženih srastanja spinalnih fuzija (Linovitz i sar., 2002). Magnetoterapija ima analgetski efekat kod pacijenata sa reumatoidnim artritisom i doprinosi poboljšanju funkcionalnosti oboljelih (Leśniewicz, Pieszyński, Zboralski i sar., 2014). Pulsno elektromagnetno polje ima veliku kliničku upotrebu nakon artroplastike zgloba kuka (Kocić, Lazarević, Kojović i sar., 2006). Pulsno elektromagnetno polje i transkranijalna magnetna stimulacija imaju neuromodulatorni efekat i našli su široku kliničku upotrebu kod Parkinsonove bolesti (Vadala, Vallelunga i sar., 2015), rehabilitaciji nakon moždanog udara (Hsu, Cheng, Liao i sar., 2012) i multiple skleroze (Vijaysheree, Bever, Bowen i sar., 2014).

U XXI vijeku je povećan interes za aplikaciju magnetnih i elektromagnetnih polja u kliničkoj praksi, tako da ovaj fizikalni modalitet prolazi tranziciju od alternativne do zvanične metode. Tokom zadnjih šest decenija razvoja savremene magnetoterapije, omogućeno je uspješno liječenje širokog dijapazona muskuloskeletnih oboljenja, bolnih stanja i neuroloških oboljenja.

Vrste elektromagnetnih polja koja se primijenjuju u kliničkoj praksi

Magnetoterapija je samo jedan segment magnetobiologije, velikog interdisciplinarnog područja koje se danas intenzivno razvija i istražuje. Svakako da važnu ulogu u razvoju magnetoterapije imaju specijalisti fizikalne medicine i rehabilitacije koji ovaj fizikalni modalitet najviše primijenjuju u svojoj kliničkoj praksi.

Magnetoterapija uključuje sedam grupa elektromagnetnih polja, razvijenih i korišćenih u različitim zemljama svijeta tokom proteklih 50 godina (Markov, 2015):

Statična/permanentna magnetna polja koja stvaraju razni permanentni magneti kao i prolazak jednosmjerne struje kroz kalem.

Niskofrekventna sine talas elektromagnetna polja većinom koriste 60 Hz (u SAD i Kanadi) i 50 Hz u Evropi i Aziji frekvencija u elektrodistributivnim mrežama

Pulsno elektromagnetno polje (PEMP)(5-300Hz) su niskofrekventna polja sa različitim oblicima i amplitudama

Pulsna radio frekvencijska elektromagnetna polja (PRF) koristi izabrane frekvencije u rasponu radio frekvencije*:* 13.56, 27.12, i 40.68 MHz.

Transcranial magnetic/electric stimulation (1-200Hz) is a treatment method of selected brain areas with short but intensive magnetic pulses.

Millimeter waves have a very high frequency 30–100 GHz. Over the last 10 years this modality has been tested and used for treatment of large number of diseases;

Ultra-short pulses have been developed and researched in the last decade.

Permanent magnets are made of special ferrous alloys (so-called hard ferromagnetic materials) and they permanently retain magnetic properties. They are put directly on to the body as a magnetofore or fitted in jewelry (bracelets, necklaces, ring) as well as in chairs and mattresses.

Pulsed electromagnetic field has found a very wide clinical application.

It is a specific electromagnetic field which contains of impulse train of low-frequency impulses or "packages" of high-frequency impulses. The basic frequency is divided into packages of impulses (burst/sec), which last for 60 microseconds (μs), with a changeable pause 1 000-10 000 μs, which repeats 5-640 times. From a therapeutic point of view, PEMP combines useful effects of low-frequency and high-frequency EMP. Low-frequency components create transmembrane potentials which normalize the changed membrane potential of the cell. High-frequency component enable more effective entry of electromagnetic energy into the organism and quicker movement of the particles.

PRF field of pulsed radio frequency was originally suggested by Ginsburg in 1934 and later FDA permitted the treatment of pain and edema in surface soft tissue (Diapulse) to use 27.12 MHz . In that manner, a short 65 ms burst and 1600 ms pause between the pulsed bursts do not create the heat during a 30-minute-long use.

Transcranial magnetic stimulation (TMS*)* (1-200Hz) is a method of treatment of selected brain areas with short but intensive, low-frequency or high-frequency magnetic pulses. It is applied via calvarium because a magnetic wave penetrates well through bone tissue. In clinical practice we have a repetitive transcranial magnetic stimulation (rTMS). TMS is a safe and non-invasive method of electric stimulation of neurons in brain tissue modifying the neuron activity locally and in remote areas. TMS is also useful to research various aspects of human neurophysiology in healthy and patients with neurological diseases.

There are three types of devices for magnetotherapy: (a) solenoid, (b) two coils and (c) flat mattresses. Each of these devices has its advantages and faults connected to the benefit of use, standardization of param-

Transkranijalna magnetna/električna stimulacija (1-200Hz) je metod liječenja izabranih područja mozga sa kratkim ali intenzivnim magnetnim pulsevima.

Millimetarski talasi imaju veoma visoku frekvenciju 30–100 GHz. U posljednjih 10 godina ovaj modalitet se ispituje i koristi za liječenja velikog broja bolesti;

Ultra kratki pulsevi su razvijeni i istražuju se u posljednjoj deceniji

Stalni ili permanentni magneti izrađuju se od posebnih željeznih legura (tzv. tvrdih feromagnetskih materijala) i trajno zadržavaju magnetska svojstva. Oni su kao magnetofore stavljaju direktno na tijelo ili se ugrađuju u nakit (narukvice, ogrlice, prsten), kao i u stolice i madrace.Pulsno elektromagnetno polje je našlo vrlo široku kliničku primjenu. To je specifično elektromagnetno polje, koje se sastoji od povorki niskofrekventnih impulsa ili "paketa" visokofrekventnih impulsa. Osnovna frekvencija je podijeljena u pakete impulsa (burst/s), koji traju 60 mikrosekundi (μs), sa promjenljivom pauzom 1 000-10 000 μs, što se ponavlja 5-640 puta. Sa terapijskog stanovišta, PEMP objedinjuje korisne efekte niskofrekventnog i visokofrekventnog EMP. Niskofrekventne komponente stvaraju transmembranske potencijale, koji normalizuju izmijenjen membranski potencijal ćelije. Visokofrekventne komponente omogućavaju efikasnije unošenje elektromagnetne energije u organizam i življe kretanje čestica.

PRF polje pulsne radiofrekvencije je prvobitno predložio Ginsburg 1934. a kasnije Agencija za lijekove i hranu dozvolila za liječenja bola i edema u površinskim mekim tkivima (Diapulse) koristi 27.12 MHz u pulsnom hodu. Na taj način, kratki 65 ms prasak i 1600 ms pauza između pulsnih prasaka, ne stvara toplotu tokom 30 minuta korišćenja.

Transkranijalna magnetna stimulacija (TMS) (1-200Hz) je metod liječenja izabranih područja mozga sa kratkim ali intenzivnim, niskofrekventnim ili visokofrekventnih magnetnim pulsevima. Aplikuje se preko kalvarije jer kroz koštano tkivo dobro penetrira magnetni talas. U kliničkoj praksi imamo i repetitivnu transkranijalnu magnetnu stimulaciju (rTMS). TMS je bezbjedan i neinvazivan metod električnog stimulisanja neurona u moždanom tkivu, modifikujući neuronsku aktivnost lokalno i na udaljenim mjestima. TMS je takođe korisna za istraživanje različitih aspekata humane neurofiziologije kod zdravih i pacijenata sa neurološkim oboljenjima.

Postoje tri vrste uređaja za magnetoterapiju:(a) solenoid, (b) dva kalema i (c) ravni dušek. Svaki od ovih aparata ima prednosti i nedostatke povezane sa pogodnošću korišćenja, standardizacijom parametara i kontrolom uslova

eters and control of condition use. Magnetotherapy is a non-invasive, a cost-effective way and comfortable for application.

In clinical use the devices for magnetotherapy do not provide complete data on physical and biophysical dosimetry. Producers and distributors of magnetotherapy devices usually do not provide enough information on devices properties. In most cases it happens due to the lack of knowledge in sense what information is necessary to physicians to make an adequate choice of devices and treatment protocol.

Parameters characterizing the electromagnetic field are frequency, intensity, a shape of impulse and duration of exposure. Frequencies are divided into extremely low frequencies from 3 Hz to 3 KHz, very low frequencies from 3 Hz to 30 KHz and ultra-low frequencies below 3 Hz. Intensity of EMP was prescribed by the World Health Organization in tutorial where a certain intensity does not harm tissues and is from 5-50 mT (WHO, 1989). Time of exposure duration is from 20 minutes to 8-10 hours a day which varies from pathological state and biotropic characteristics of the fields. Both the shape and the form are important. We have a sinusoidal and non-sinusoidal form of the field.

With his research team Markov gave recommendations for conducting correctly designed studies and clinical researches. Parameters needed for characterization of devices are (Markov, 2015): the type of field, frequency, a shape of pulse, intensity or induction, gradient (dB/dt), vector (dB/dx), component (electric or magnetic), the depth of penetration, localization and time of exposure (duration of session). Biotropic characteristics of electromagnetic field are just one component impacting the regular dosimetry. The other components are the cells, tissues, living systems, i.e. characteristics of the patient. The following characteristics are important for clinical studies: age of patient, sex, general condition, stage of disease, types of pathological process on a tissue, organ, disease duration and/or injuries and hypersensitivity to magnetotherapy.

Biological effects and mechanisms of EMP activity on living systems

Electromagnetic field as part of biosphere is a natural and constant surrounding not only for the humans but for all living systems. There can be stressed the assumption that in living organisms representing the complex hierarchy of cells, tissues, organs and systems there are endogenous magnetic fields and electromagnetic homeostasis. A principle of magnetotherapy is to impact with activity of exterior EMP on pathological process and put interior sur-

korišćenja. Magnetoterapija je neinvazivna, ekonomična i komforna za primjenu.

U kliničkoj upotrebi su aparati za magnetoterapiju koji ne daju kompletne podatke o fizičkoj i biofizičkoj dozimetriji. Proizvođači i distributeri magnetoterapijskih uređaja u pravilu ne pružaju dovoljno informaciju o karakteristikama uređaja. U većini slučajeva se to dešava zbog nedostatka znanja u smislu koja informacija je potrebna kliničarima da bi napravili odgovarajući izbor uređaja i protokola za liječenje.

Parametri koji karakterišu elektromagnetno polje su frekvencija, intenzitet, oblik impulsa i trajanje ekspozicije. Frekvencije su podijeljene u ekstremno niske frekvencije od 3 Hz do 3KHz, veoma niske frekvencije od 3Hz do 30 KHz i ultra niske frekvencije ispod 3Hz. Intenzitet EMP-a je propisala Svjetska zdravstvena organizacija u vodiču gdje je određen intenzitet koji ne šteti tkivima i iznosi od 5-50 mT (WHO, 1989). Vrijeme trajanja ekspozicije je od 20 minuta do 8-10 sati dnevno što varira od patološkog stanja i biotropnih karakteristika polja. Bitni su i oblik i forma signala. Postoji sinusoidalni i nesinusoidni oblik polja.

Markov sa svojim istraživačkim timom je dao preporuke za izvođenje korektno dizajniranih studija i kliničkih istraživanja. Parametari koji su potrebni za karakterizaciju uređaja su (Markov, 2015): tip polja, frekvencija, oblik pulsa, intenzitet ili indukcija, gradijent (dB/dt), vektor (dB/dx), komponenta (električna ili magnetna), dubina prodiranja, lokalizacija i vrijeme izlaganja (trajanje sesije). Biotropne karakteristike elektromagnetnog polja su samo jedna komponenta koja utiče na pravilnu dozimetriju. Druga komponenta su ćelije, tkiva, živi sistemi, odnosno karakteristike bolesnika. Za kliničke studije su bitne sljedeće karakteristike: starost pacijenta, pol, opšte stanje, stadijum bolesti, vrste patološkog procesa na tkivu/organu, dužina trajanja bolesti i/ili povrede i preosjetljivost na magnetoterapiju.

Biološki efekti i mehanizmi djelovanja EMP-a na žive sisteme

Elektromagnetno polje je kao dio biosfere prirodno i stalno okruženje ne samo čovjeka već svih živih sistema. Može se istaći pretpostavka da u živim organizmima koji predstavljaju složenu hijerarhiju ćelija, tkiva, organa i sistema postoje endogena magnetna polja i elektromagnetna homeostaza. Princip magnetoterapije je da djelovanjem spoljnjih EMP-a utičemo na patološki proces i vraćamo unutrašnju sredinu organizma u ekvilibrijum (Lažetić, 2004). Većina istraživača koja ispituje interak-

rounding of the organism into equilibrium (Lažetić, 2004). Most of researchers exploring the interaction of EMP and living systems accept that cellular membrane and transmembrane proteins are the primary place of interaction with EMP (Adey, 2004). This finding is important because intramembrane proteins play the role of ionic channels, enzymes or receptors so that the change of functional status of one or several of these proteins would undoubtedly cause consequences for intracellular processes. Oscillations caused by impulsed magnetic field lead to movement of cell membrane, hyperpolarization on the north pole and hypopolarization on the southern pole which leads to periodic increase of permeability of membrane with no energy consumption for ions of sodium, potassium and other molecules (Kirilov, Uhov, Lastučkin et al., 1995).

Under influence of PEMP there comes to the increase of the partial pressure of oxygen in tissues and usage of adenosine triphosphate (ATP) in mitochondria of the cells (Barnothy, 1969). Magnetic field acts on biochemical processes as well as physical-chemical characteristic of water (surface voltage, viscosity, electrical conductivity and dielectric permeability (Markov, Todorov & Ratcheva, 1975). An important factor of EMP and the cell are the type of cell, cellular cycle, a shape of cell, existence of specific growth/mitosis, cellular density as well as temperature during exposure (Liburdy, 1995).

Calcium is nowadays accepted as the main cation with the role of mediator between the activity of EMP and effects creating on biological systems (Pilla, 2015). In vitro researches showed that under the influence of EMP there comes to significant increase of intracellular concentration of calcium ions after a 30-minute long exposure and this increase is completely dependent on influx of these ions from an extracellular medium (Cho, Thatte, Silvia & Golan, 1999), whilst the liberation of calcium's ions from intracellular depots is inhibited (Ikehara, Park, Yamaguchi et al., 2002). In a series of studies calcium calmodulin a depending myosin of phosphorylation (24) it has showed that special magnetic fields as well as 27.12 MHz PRF can modulate the binding of calcium with CAM and increase its kinetic.

A biomagnetic researching group has developed a few methods of biophysical dosimetry including the miosine phosphorylation (Markov, 2004) which is able to predict what electromagnetic fields may be bio-effective and it monitors this efficiency. Therefore, theoretic models and biophysical dosimetry could be effective in selecting appropriate signals and in applying new electromagnetic therapeutic devices in engineering and clinical application. Magnetic fields impact the vasodilation, decrease the viscije EMP-a i živih sistema prihvata da je ćelijska membrana i transmembranski proteini primarno mjesto interakcije sa EMP-om (Adey, 2004). Ovaj nalaz je značajan jer intramembranski proteini imaju ulogu jonskih kanala, enzima ili receptora, tako da bi promjena funkcionalnog statusa jednog ili više ovih proteina nesumljivo imala posljedice po intraćelijske procese. Oscilacije izazvane impulsnim magnetnim poljem dovode do kretanja ćelijske membrane, hiperpolarizacija na sjevernom polu i hipopolarizacija na južnom polu što dovodi do periodičnog povećanja propustljivosti membrane bez utroška energije za jone natrijuma, kalijuma i druge molekule (Kirilov, Uhov, Lastučkin i sar., 1995).

Pod uticajem PEMP-a povećava se parcijalni pritisak kiseonika u tkivima i iskorišćavanje adenozintrifosfata (ATP) u mitohondrijama ćelija (Barnothy, 1969). Magnetno polje djeluje na biohemijske procese kao i fizičko-hemijska svojstva vode (površinski napon, viskoznost, električnu provodljivost i dielektričnu propustljivost) (Markov, Todorov i Ratcheva, 1975). Važan faktor interakcije EMP-a i ćelije su tip ćelije, ćelijski ciklus, aktivacija ćelije, oblik ćelije, postojanje specifičnih rast/mitoza faktora, ćelijska gustina kao i temperatura u toku ekspozicije (Liburdy, 1995).

Kalcijum je danas prihvaćen kao glavni katjon sa ulogom medijatora između djelovanja EMP-a i efekata koje ostvaruje na biološke sisteme (Pilla, 2015). In vitro istraživanja su pokazala da pod uticajem EMP-a dolazi do značajnog povećanja intracelularne koncentracije jona kalcijuma već nakon 30 minuta izlaganja i da je ovo povećanje u potpunosti zavisno od influksa ovih jona iz ekstracelularnog medijuma (Cho, Thatte, Silvia i Golan, 1999), dok je oslobađanje jona kalcijuma iz intracelularnih depoa inhibirano (Ikehara, Park, Yamaguchi i sar., 2002). U seriji studija kalcijum-kalmodulin zavisni miozin fosforilizacije je pokazano da posebna magnetna polja i PEMP kao i 27.12 MHz PRF mogu modulirati vezivanje kalcijuma sa CAM i povećavaju njegovu kinetiku. Bioelektromagnetna istraživačka grupa je razvila nekoliko metoda biofizičke dozimetrije uključujući analizu miozin-fosforilizacije (Markov, 2004) koja je u stanju da predvidi koja bi elektromagnetna polja mogla biti bio-efektivna i nadgleda ovu efikasnost. Zato bi teoretski modeli i biofizička dozimetrija mogli da budu djelotvorni u izboru odgovarajućih signala i u inženjeringu i kliničkoj primjeni novih elektromagnetnih terapijskih uređaja. Magnetna polja utiču na vazodilataciju, smanjenje viskoznosti krvi, stimulaciju osteogeneze, proliferaciju ćelija, formiranje mreže ćelija, epitelizaciju, na imunitet, a imaju i sedacijski, biostimulativni i analgetski efekat. EMP-e

cosity of blood, stimulate the osteogenesis, the proliferation of cells, form the networks of cells, epithelization, the immunity and have a sedation, biostimulative and analgesic effect. EMP can have a various efficiency depending upon target tissues and medical problem to be treated. A term of "biological window" (Berg, 1995) has been actual for a while. "Biological windows" are preferable combinations of amplitude and frequencies of exogenous EMP which can be recognized by the cell and respond to it. A research in that direction requires the estimation of replies in a range of amplitudes and frequencies. A question of "dosage" of electromagnetic field is much more complicated than dosing the pharmacological substances. Therapeutic dosage of EMP has been designed to induce in treated tissues the potentials similar to those physiologically being created. By bringing the exogenous EMP to the place of a fracture is possible by applying energy from exterior surrounding to change the polarization of cellular membrane and by effecting the fibroblasts, chondroblasts and osteoblasts to stimulate osteogenesis. Numerous in vitro, in vivo studies on animals as well as clinical experience suggest that initial conditions of sensible way of electromagnetic field determine whether physiological bio-effects can be achieved. Gap junction connections directly impact the electric conductibility which comes from the exogenous stimulus of EMP inside the cellular membrane (Sreedharan & Yhang, 2003). Researchers show that increasing the proliferation stimulated by PEMP is independent from gap junction communication, whilst the increasing of the enzyme activity (alkaline phosphatase) is depending on electrical communication being accomplished through gap junction (Vander, Donahue, Rubin & McLeod , 2000). PEMP stimulation of osteogenesis is an impetus to the general biological laws, it does not speed up osteoporosis but it optimizes its physiological course, supplements and strengthens their effect (Zečević-Luković et al., 2007). For instance, when the broken bone is treated with electromagnetic field, a surrounding tissue receives the same dosage as the fractured one, but physiologically important response happens only in an injured tissue of the bone while the changes in the soft tissue have not been detected. This is crucially important effect indicating that magnetic fields are more effective when the tissue is out of balance. Certainly, basic researches confirm that healthy tissues do not have the same sensitivity to EMP effect. The most sensitive is the neuroendocrine system (Lukač, Matavulj A., Matavulj M. et al., 2006), whilst the bone tissue is the least sensitive to EMP stimulation. Also, healthy tissues have the capability of better compensation and adaptation to EMP effect (Lažetić, 2004).

može imati različitu efikasnost u zavisnosti od target tkiva i medicinskog problema koji treba tretirati. Već dugo je aktuelan koncept "biološkog prozora" (Berg, 1995). "Biološki prozori" su poželjne kombinacije amplitude i frekvencije egzogenih EMP-a koje ćelija može prepoznati i na njih odreagovati. Istraživanje u ovom pravcu zahtijeva procjenu odgovora u rasponu amplituda i frekvencija. Pitanje "doze" elektromagnetnog polja je mnogo komplikovanije nego doziranje farmakoloških supstanci. Terapijske doze EMP-a dizajnirane su tako da indukuju u tretiranim tkivima potencijale slične onima koji se fiziološki stvaraju. Dovođenjem egzogenog EMP-a na mjesto preloma moguće je primjenom energije iz spoljašnje sredine mijenjati polarizaciju ćelijske membrane, a dejstvom na fibroblaste, hondroblaste i osteoblaste stimulisati osteogenezu. Brojne in vitro, in vivo studije na životinjama kao i klinička iskustva sugerišu da inicijalni uslovi senzitivnog puta elektromagnetnog polja određuju da li fiziološki značajni bioefekti mogu da se postignu. Gap junction veze direktno utiču na električnu provodljivost koja dolazi od egzogenog stimulusa EMP-a unutar ćelijske membrane (Sreedharan i Yhang, 2003). Istraživanja pokazuju da je povećanje proliferacije stimulisano PEMP-om nezavisno od gap junction komunikacije, dok je povećanje enzimske aktivnosti (alkalna fosfataza) zavisno od električne komunikacije koja se ostvaruje kroz gap junction (Vander, Donahue, Rubin i McLeod, 2000). Stimulacija PEMP-om osteogeneze je poticaj opštim biološkim zakonima, ne ubrzava osteogenezu, već optimizira njen fiziološki tok, dopunjava i pojačava njihov efekat (Zečević-Luković i sar., 2007). Na primjer, kad se na slomljenoj kosti uradi tretman elektromagnetnim poljem, okolno meko tkivo prima istu dozu kao i prelomljeno, ali fiziološki važan odgovor događa se samo u povrijeđenom tkivu kosti, dok promjene u mekom tkivu nisu primjećene. Ovo je suštinski važno dejstvo, ukazujući da su magnetna polja djelotvornija kad je tkivo van ravnoteže. Svakako da bazična istraživanja potvrđuju da zdrava tkiva nemaju istu senzitivnost na djelovanje EMP-a. Najsenzitivniji je neuroendokrini sistem (Lukač, Matavulj A., Matavulj M. i sar., 2006), dok je koštano tkivo najmanje osjetljivo na stimulaciju EMP-om. Isto tako zdrava tkiva posjeduju mogućnost bolje kompenzacije i adaptacije na djelovanje EMP-a (Lažetić, 2004).

Jedno od osnovih pitanja interakcije NF-EMP-a i bioloških sistema je mehanizam kojim ova polja ostvaruju zapažene efekte. Za razliku od drugih vrsta nejonizirajućih zračenja (mikrotalasa i raditalasa) koji ostvaruju termalne efekte odnosno generisanje unutrašnjeg temperaturnog gradijenta EMP-a ne ostvaruju ovo djelovanje

One of the essential questions of interaction of NF-EMP and biological system is the mechanism by which these fields accomplish remarkable results. Unlike other types of non-ionizing radiation (a microwave and radio wave) which achieve the thermal effects, i.e. generating the interior temperature gradient of EMP not achieving this effect (Glaser, 1992). A group of scientists produced the overview of as-yet assumed mechanisms of EMP interaction and biological systems (Markov, 2015):

The first mechanism includes the transmission of energy by accelerating the ions and electrified proteins that modify the cellular membrane and protein receptors; however, this mechanism is not accepted because the energy carried by EMP is far smaller than energy characteristic for bio-molecules in the cell.

The second mechanism refers that electrical fields induced in the body act by force to the electrified particles and electrical moment; but these forces are far weaker than biological forces.

The third mechanism includes the magnetic moments of ferromagnetic particles and molecules of free radicals which interact with magnetic fields, but so far the existence of sensitive cells to the magnetic moment in the humans has not been established, whilst the modification of speed of radical re-combinations by EMP in the biological systems has been very problematic.

The fourth mechanism relates to the resonant interactions which involve by the EMP caused vibrations or orbital pass in complexes ion-biomolecule, however, this mechanism is not acceptable too because it is opposed to the knowledge of as-yet physics and numerous experimental tests having been conducted have not confirmed these assumptions.

To clarify the mechanisms of EMP effect it is crucial to have a multidisciplinary approach and a team work of experts from physics, engineering, biological sciences and clinical medicine (Markov, 2015).

Animal studies on magnetotherapy effect

The most basic studies have been conducted in vitro on cultures of various cells and in vivo on animal models. Human lymphoide cells exposed to EMP (in 50 Hz, 2mT, 72h) modify the cytoskeletal organization, with increase of activity of protein kinase, without the cellular proliferation (Santono, Lisi, Pozzi et al., 1997). Selvam and associates showed that rats with induced arthritis exposed to the field of 5Hz, 4μT, 90 minutes during 52 days there comes to the anti-inflammatory effect through a change of activity of lymphocyte calcium ATP (Selvam et al., 2007). Reported was the decrease of level of inflammatory mediator

(Glaser, 1992). Grupa naučnika je dala pregled do sada pretpostavljenih mehanizama interakcije EMP-a i bioloških sistema (Markov, 2015):

Prvi mehanizam uključuje prenos energije akceleracijom jona i naelektrisanih proteina koji modifikuju ćelijsku membranu i proteinske receptore, međutim ovaj mehanizam nije prihvatljiv jer energija koju nosi EMP-e je daleko manje od energije svojstvene biomolekulima u ćeliji.

Drugi mehanizam upućuje da električna polja indukovana u tijelu djeluju silom na naelektrisane čestice i električni momenat; ali ove sile su znatno slabije u odnosu na biološke sile.

Trećim mehanizmom obuhvaćeni su magnetni momenti feromagnetnih čestica i molekula slobodnih radikala koji stupaju u interakciju sa magnetnim poljima, ali do sada nije ustanovljeno postojanje senzitivnih ćelija na magnetni momenat u ljudi, dok je modifikacija brzine radikalskih rekombinacija od strane EMP-a u biološkim sistemima veoma problematično.

Četvrti mehanizam odnosi se na rezonatne interakcije koje uključuju EMP-em izazvane vibracije ili orbitalne prelaze u kompleksima jon-biomolekul, međutim ovaj mehanizam takođe nije prihvatljiv jer je u suprotnosti sa saznanjima današnje fizike i brojni eksperimentalni testovi koji su sprovedeni nisu potvrdili ove pretpostavke.

Za razjašnjavanje mehanizama djelovanja EMP-a je bitan multidisciplinarni pristup i timski rad stručnjaka iz fizike, inženjeringa, bioloških nauka i kliničke medicine (Markov, 2015).

Animalne studije o efektima magnetoterapije

Najviše bazičnih studija je izvedeno in vitro na kulturama različitih ćelija i in vivo na animalnim modelima. Humane limfoidne ćelije izložene EMP-u (50 Hz, 2mT, 72h) modifikuju citoskeletnu organizaciju, sa povećanjem aktivnosti protein kinaze, bez ćelijske proliferacije (Santono, Lisi, Pozzi i sar., 1997). Selvam i saradnici su prikazali da u pacova sa indukovanim artritisom koji su izloženi polju od 5Hz, 4μT, 90 minuta tokom 52 dana dolazi do antiinflamatornog efekta kroz promjenu aktivnosti limfocitne kalcijum ATP-ase (Selvam i sar., 2007). Saopšteno je i smanjenje nivoa upalnog medijatora PGE_2 i antioksidativni efekat. U grupi zdravih pacova koji su izlagani PEMP-u nemamo statistički značajne promjene ovih parametara.

U studiji iz 2016. godine (Anbarasan, Baraneedharan, Paul i sar., 2016) grupa istraživača je ustanovila da kratkotrajno (60 min / dan), frekvencije 0,1 Hz, intenzite-

PGE_2 and anti-oxidative effect. In the group of healthy rats exposed to PEMP we do not have statistically important changes of these parameters.

In a study from 2016 (Anbarasan, Baraneedharan, Paul et al., 2016) a group of researchers established that short-term (60 min / day), frequencies 0,1 Hz, intensity 1.95 mT PEMP has a positive effect on chondrocytes, production of extracellular matrix, its differentiation and cytoskeleton. A recommendation from this study is that a short-term exposure of patients with osteoarthritis to EMP in duration of 3 days can produce a beneficial clinical effect. Results of research must be confirmed with methodology involving the estimation of quality and quantity of chondrocytes exposed to PEMP. In most of the researches on animal models it was showed that PEMP effects the re-modelling the bones. In our research on a rat estrogen-deficient osteoporotic model showed that PEMP 40 Hz,10 mT, 45 minutes, a five-day long exposure in the course of five weeks statistically significantly improved the quality of bones. A statistically significant decrease of alkaline phosphatase and osteocalcin have correlated with improvement of bone quality and improvement of bone quality was proved in biomechanical measurements (Popović, 2007).

PEMP has a stimulative effect on an osteoblast proliferation and differentiation. In a study Yuan- Li and his associates stimulated with PEMP of 0,6 mT, 50 Hz the proliferation and osteogen differentiation of osteoblast of rats'calvarium. They showed that primary cilia of osteoblast are the sensors for electromagnetic field and important for osteogene effect of PEMP(Juan-Li, Jian at al., 2015). The effect of PEMP of 7,5 Hz on cultures of osteoblast impact its growth, stimulation of TGF-β and increase of activity of alkaline phosphatase (Li, Lin, Liu & Chang, 2007). In 2004 Chang and associates have tested on the culture of cells of bone marrow of ovariectomised rats the effects of 7,5 Hz EMP, exposure of 60 minutes a day during nine days on the process of osteoclastogenesis via effects on cytokine such as factor of tumor necrosis TNF-α, interleukin 1β (IL-1 β) and IL-6. It has been showed in their results that exposure to PEMP stimulation can inhibit the liberation of TNF-α, IL-1β and IL-6 and forming the osteoclast (Chang K, Chang WH, Yu, & Shih, 2004).

Clinical studies on the effect of pulsed electromagnetic field

Bassett's group, after positive effects of PEMP on osteogenesis on animal model, confirmed it in a clinical study (Bassett, Mitchell, Norton et al., 1979). A study was conducted on patients who had tibia pseudarthrosis and who had been unsuccessfully

ta 1.95 mT PEMP-e ima pozitivno dejstvo na hondrocite, proizvodnju ekstracelularnog matriksa, njihovu diferencijaciju i citoskelet. Iz ove studije su preporučili da kratkotrajna izloženost pacijenata sa osteoartritisom EMP-u u trajanju od 3 dana može da proizvede povoljan klinički efekat. Rezultati istraživanja moraju biti potvrđeni sa metodologijom koja uključuje procjenu kvaliteta i kvantiteta hondrocita izloženih PEMP-u. U većini istraživanja na animalnim modelima pokazano je da PEMP djeluje na remodeliranje kosti. U našem istraživanju na pacovskom estrogen-deficijentnom osteoporotskom modelu je prikazano da PEMP 40 Hz,10 mT, 45 minuta, petodnevne ekspozicije u toku pet sedmica statistički značajno poboljšala kvalitet kosti. Statistički značajno sniženje alkalna fosfataze i osteokalcina su korelirali sa poboljšanjem kvaliteta kosti, a poboljšanje kvaliteta kosti je dokazano i biomehaničkim mjerenjima (Popović, 2007).

PEMP djeluje stimulativno na osteoblastnu proliferaciju i diferencijaciju. U studiji Juan-Li i saradnici su sa PEMP-om od 0,6 mT, 50 Hz stimulisali i proliferaciju i osteogenu diferencijaciju osteoblasta kalvarije pacova. Pokazali su da su primarne cilije osteoblasta senzori za elektromagnetno polje i značajni za osteogeni efekat PEMP-a (Juan-Li, Jian i sar., 2015). Djelovanje PEMP-a od 7,5 Hz na kulture osteoblasta utiče na njihov rast, stimulaciju TGF-β i povećanje aktivnosti alkalne fosfataze (Li, Lin, Liu i Chang, 2007).). Chang i saradnici 2004. godine su na kulturi ćelija koštane srži ovarijektomiranih pacova ispitivali efekte 7,5 Hz EMP-a, ekspozicije 6o minuta dnevno u toku devet dana na proces osteoklastogeneze preko efekata na citokine kao što su faktor tumorske nekroze TNF-α, interleukin 1β (IL-1 β) i IL-6. U njihovim rezultatima je pokazano da izloženost PEMP stimulaciji može inhibirati oslobađanje TNF-α, IL-1β i IL-6 i formiranje osteoklasta (Chang K, Chang WH, Yu i Shih, 2004).).

Kliničke studije o dejstvu pulsnog elektromagnetnog polja

Bassettova grupa je nakon pozitivnih efekata PEMP-a na osteogenezu na animalnom modelu to potvrdila i u kliničkoj studiji (Bassett, Mitchell, Norton i sar., 1979). Studija je provedena na bolesnicima koji su imali pseudoartrozu tibije i koji su bezuspješno hirurški liječeni. Izlagani su PEMP-u ugrađenom u gips sa frekvencijom od 75Hz i gustinom struje od 10μA. Postignuto je poboljšanje zarastanja kod 87% pacijenata, što je sličan rezultat kao kod hirurški liječenih pacijenata. Bassettov tim je zaključio da je povećana vaskularizacija i da ima

treated. They were exposed to PEMP fitted in a cast with frequency of 75 Hz and density of electricity of 10μA. Improvement of healing in 87% of patients was reported which is a similar result to surgically treated patients. Bassett's team concluded that vascularization was increased with a synergic effect on osteogenesis. In a review study of clinical researches from 2013 (Seo,Yun, Kwang & Hyungsun, 2013) it was shown that even PEMP was not as efficient as placebo in treating the pain in osteoarthritis of the knee, but it was efficient in improving the function of the knee 8 weeks after the beginning of the therapy. However, results of this research used the methodology of high quality, give a proof supporting the efficiency of PEMP in reducing the pain. In conclusion there is a need for well-controlled randomized studies with adequate methodology to estimate at last the efficiency of PEMP in treating osteoarthritis. In clinical treatment of post-menopause women with PEMP of 72 Hz, 10 hours a day in period of 12 weeks led to improvement of bone density (Tabrah, Ross, Hoffmeier & Gilbert, 1998). Trock and associates tested the effects of PEMP in patients with osteoarthritis of the knee and osteoarthritis of cervical spine. Patients were exposed to the field of various parameters from 5Hz, 10-16Gausa, 10 minutes, then 10Hz, 15-25 Gausa 10 minutes and 12 Hz, 15-25 Hz 10 minutes. Exposure lasted 30 minutes 3-5 sessions a week, with 18 sessions in total during the month. This treatment reduced the pain for 37% (Trock, Bollet & Markoll, 1994). In a research conducted by Kocić and associates (Kocić, Lazarević, Kojović et al., 2006) the effects of various protocols in post-operative rehabilitation after total hip replacement in prevention of heterotopic ossification were tested. In group C there were 66 patients/ 79 endoprosthesis who had only kinesitherapy in post-operative rehabilitation. In group B there were 117 patients / 131 hips who had the PEMP involved and interferent electricity on the 14th day after surgery with standard kinesitherapy programme. In group A there were 117 patients / 131 hips who were involved in PEMP on the third day after surgery and after two weeks of standard kinesitherapy. In group A there was only 16,67% heterotopic ossifications whilst in the two others we had 50,63% and 43,51%. An early PEMP treatment significantly statistically prevents the occurrence of heterotopic ossifications. In 2008 the FDA recommended the application of PEMP in treating heavy depression in patients with Parkinson's diseases to decrease antidepressants intake. A

sinergički efekat na osteogenezu. U preglednoj studiji kliničkih istraživanja iz 2013 (Seo,Yun, Kwang i Hyungsun, 2013). je pokazano da iako PEMP nije bio efikasniji od placeba u liječenju bola kod osteoartritisa koljena, ali je efikasniji u poboljšanju funkcije koljena 8 nedelja nakon početka terapije. Međutim, rezultati ovog istraživanja su koristili metodologiju visokog kvaliteta, pružaju dokaz koji podržava efikasnost PEMP-a u smanjenju bola. U zaključku postoji potreba za dobro kontrolisanim randomiziranim studijama sa adekvatnom metodologijom da konačno procijeni efikasnost PEMP-a u tretmanu osteoartritisa. U kliničkoj tretmanu postmenopauzalnih žena sa PEMP-om od 72Hz, 10 sati dnevno u periodu od 12 nedelja je doveo do poboljšanja koštane gustine (Tabrah, Ross, Hoffmeier i Gilbert, 1998). Trock i saradnici su ispitivali efekte PEMP-a kod pacijenata sa osteoartritisom koljena i osteoartritisom vratne kičme. Pacijenti su izlagani polju različitih parametara od 5Hz, 10-16Gausa, 10 minuta, potom 10Hz, 15-25 Gausa 10 minuta i 12 Hz, 15-25 Hz 10 minuta. Ekspozicija je trajala 30 minuta 3-5 sesija sedmično, sa ukupno 18 sesija u toku mjeseca. Ovaj tretman je smanjio bol za 37% (Trock, Bollet i Markoll, 1994). U istraživanju Kocić i saradnika (Kocić, Lazarević, Kojović i sar., 2006) ispitani su efekti različitih protokola u postoperativnoj rehabilitaciji nakon ugradnje totalne endoproteze kuka u prevenciji heterotopičnih osifikacija. U grupi C je bilo 66 pacijenata/79 endoproteza koji su u postoperativnoj rehabilitaciji imali samo kineziterapiju. U grupi B 117 pacijenata/131 kuk kojima je uključen PEMP i interferentna struja 14-og dana nakon hirurške intervencije sa standardnim kineziterapijskim programom. U grupi A je bilo 117 pacijenata/131 kuk kojima je uključen PEMP treći postoperativni dan i nakon dvije nedelje standardna kineziterapija. U grupi A je bilo samo 16,67 % heterotopičnih osifikacija dok smo u ostale dvije imali 50,63% i 43, 51 %. Rani tretman PEMP-om statistički značajno prevenira nastanak heterotopičnih osifikacija. Agencija za hranu i lekove (Food and Drug Administration – FDA) je 2008. godine preporučila primjenu PEMP-a u tretmanu teške depresije kod pacijenata sa Parkinsonovom bolešću, kako bi se smanjilo uzimanje antidepresiva. U preglednom radu se navode i efekti PEMP-a na kognitivne i motorne smetnje kod ovih pacijenata (Vijaysheree, Bever, Bowen et al., 2014). U studiji Leśniewicz i saradnika evaluiran je efekat fizikalnih tretmana na pokretljivost pacijentica sa reumatoidnim artritisom. Smanjenje bola u zglobovima je ustanovljeno nakon primjene jo-

review study quoted effects of PEMP on cognitive and motor disorders in these patients (Vijaysheree, Bever, Bowen et al., 2014). In a study by Leśniewicz and associates it was evaluated the effect of physical treatments on mobility of female patients with rheumatoid arthritis. Decreasing the pain in joints was established after applying ionophoresis and magnetotherapy. There is no statistically important difference between the group that had just ionophoresis and the other one that used magnetotherapy except ionophoresis (Leśniewicz , Pieszyński , Zboralski et al., 2014). In a tutorial for multiple sclerosis treatment it was indicated that magnetotherapy impacts the decrease of weakness and fatigue (level B) and it is inefficient for treating depression in these patients (level B) (Vijaysheree, Bever, Bowen et al., 2014).

Clinical application of transcranial magnetic stimulation (TMS)

Transcranial magnetic stimulation affects the neuroplasticity of cerebral neural tissue and contributes to broadening potentials to the periphery.

In a randomized study of post-stroke chronic phase patients showed the clinically positive effect of rTMS on motor recovery in the upper limb. Low frequency rTMS via unaffected hemisphere is more effective than high frequency rTMS via affected hemisphere which is compatible with a concept of interhemispheric inhibition. In comparison with patients who had cortical stroke, patients with sub-cortical stroke may have more benefit from rTMS. Further and well-designed studies are needed to determine the duration of effect and plastic change of cortical irritation after rTMS protocols (Hsu, Cheng, Liao et al., 2012). Meta-analysis from 2016 confirmed that repetitive transcranial magnetic stimulation has positive effect on disphagia in patients after stroke. In comparison with low-frequency rTMS, high-frequency TMS can be useful for patients. This meta-analysis also supports that rTMS on normal or bilateral hemisphere has a significant therapeutic effect on disphagia (Wagle, Shuster, Chung et al., 2016). Repetitive transcranial magnetic stimulation in patients with Parkinson's disease leads to mild and moderate improvement of motor functions and it has a potential to be used as an additional therapy to treat Parkinson's disease. Future large studies should be projected to isolate specific clinical characteristics of Parkinson's disease that respond well to therapy rTMS (Mark, George et al., 2013). Since 2011 the FDA has been recommending TMS for treating depression. References recommend the stimulation of the left prefrontal with TMS in the course of 3 to 6 weeks which has statistically important anti-depressive

noforeze i magnetoterapije. Nema statistički značajne ralike između grupe koja je imala samo jonoforezu i druge grupe koja je uz jonoforezu koristila i magnetoterapiju (Leśniewicz , Pieszyński , Zboralski i sar., 2014). U vodiču za liječenje multiple skleroze navedeno je da magnetoterapija djeluje za smanjenje slabosti i malaksalosti (nivo B) i da je neefikasna za tretman depresije kod ovih pacijenata(nivo B) (Vijaysheree, Bever, Bowen i sar., 2014).

Klinička primjena transkranijalne magnetne stimulacije (TMS)

Transkranijalna magnetna stimulacija djeluje na neuroplastičnost moždanog nervnog tkiva i doprinosi širenju potencijala ka periferiji.

U randomiziranoj studiji kod pacijenata u hroničnoj fazi nakon moždanog udara pokazani klinički pozitivan učinak rTMS na motorni oporavak u gornjem ekstremitetu. Niska frekvencija rTMS preko nepogođene hemisfere je efektivnija od visoke frekvencije rTMS preko zahvaćene hemisfere što je kompatibilno sa konceptom interhemisferične inhibicije. U poređenju sa pacijentima koji su imali kortikalni udar, pacijenti sa subkortikalnim udarom možda mogu imati više koristi od rTMS. Potrebne su daljnje dobro osmišljene studije da se odredi trajanje efekta i plastična promjena kortikalne nadraženosti nakon individualnih rTMS protokola (Hsu, Cheng, Liao et al., 2012). Meta-a analiza iz 2016. godine potvrđuje da ponavljajuća transkranijalna magnetna stimulacija ima pozitivan efekat na disfagije kod pacijenata nakon moždanog udara. U poređenju sa niskofrekventnom rTMS, visokofrekventne TMS mogu biti korisne za pacijente. Ova meta - analiza takođe podržava da rTMS na normalnoj ili bilateralnoj hemisferi ima značajan terapijski efekat na disfagije (Wagle, Shuster, Chung i sar., 2016). Repetitivna transkranijalna magnetna stimulacija kod pacijenata sa Parkinsonovom bolešću dovodi do blagog i umjerenog poboljšanja motornih funkcija i ima potencijal da se koristi kao dodatna terapija za liječenje Parkinsonove bolesti. Buduće velike studije trebaju biti projektovane tako da izoluju specifične kliničke karakteristike Parkinsonove bolesti koje dobro reaguju na terapiju rTMS (Mark S. George i sar., 2013). FDA od 2011. godine preporučuje TMS za tretman depresije. U literaturi se preporučuje stimulacija lijevo prefrontalno sa TMS u toku 3-6 sedmica koja ima statistički značajan antidepresivni efekat u odnosu na placebo grupu sa minimalnim neželjenim efektima. TMS ima mogućnost i za liječenje drugih psihijatrijskih oboljenja, kao i u liječenju akutnog i hroničnog bola (Vrbanić i Ćurković, 2012).

effect in relation to placebo group with minimum adverse effects. TMS has a possibility for treating other psychiatric diseases as well as treating acute and chronic pain (Vrbanić & Ćurković, 2012).

Contraindications

Contraindications in applying physical agents are divided into absolute and relative as well as on special precautions in applying certain procedures. Also, for each modality vulnerable and sensitive tissues and organs are indicated whose understanding is also necessary in everyday clinical practice. Actual contraindications for magnetotherapy are: malignant diseases, acute infective diseases, bleeding, coagulation disorder, thrombosis, occlusive diseases of aortas, coronal decompensation, coronal pacemaker, the presence of ferromagnetic metal implants and pregnancy (Batavia, 2006). Precautions are in carrying hearing aid and insulin pump and it is recommended to remove devices during magnetotherapy (Klein, 2015). Additional contraindications for transcranial magnetic stimulation are the presence of high intracranial pressure, epilepsy and carrying various stimulators with microprocessors in the area of the neck.

Conclusion

Magnetotherapy has been successfully applied for more than 60 years in physical medicine and rehabilitation in treatment of a wide range of diseases. As in vitro, in vivo and clinical studies proved, magnetotherapy has osteogenetic, anti-inflammatory, chondroprotective and analgesic effect and potential to regenerate the damaged tissue. Despite reports on useful effects of magnetic fields in treating bone fractures, osteoporosis, rheumatoid arthritis, osteoarthritis, neurological damages, adenosine triphosphates, we are only half way to explain the mechanism by which magnet therapy strengthens regenerative capabilities of pathological and damaged tissue. It is up to future researchers to clarify the mechanisms of activity which would contribute to the clearer clinical application and actuality of magnet therapy in the future.

Kontraindikacije

Kontraindikacije u primjeni fizikalnih agensa su podijeljenje na apsolutne i relativne, kao i na posebne mjere opreza kod primjene pojedinih procedura. Isto tako za svaki modalitet se navode i koja su vulnerabilna i osjetljiva tkiva i organi čije poznavanje je takođe nužno u svakodnevnoj kliničkoj praksi. Aktuelne kontraindikacije za magnetoterapiju su: maligna oboljenja, akutna infektivna oboljenja, krvarenje, poremećaj koagulacije, tromboza, okluzivne bolesti arterija, srčana dekompenzacija, srčani pejsmejker, prisustvo feromagnetnih metalnih implantata i trudnoća (Batavia, 2006). Mjere opreza su kod nošenja slušnog aparata i inzulinske pumpe i preporučuje se skidanje aparata tokom magnetoterapije (Klein, 2015). Za transkranijalnu magnetnu stimulaciju su dodatne kontraindikacije prisustvo povišenog intrakranijalnog pritiska, epilepsija i nošenje različitih stimulatora sa mikroprocesorima u području vrata.

Zaključak

Magnetoterapija se više od 60 godina uspješno primjenjuje u fizikalnoj medicini i rehabilitacije u liječenju širokog dijapazona oboljenja. Kao što su pokazale in vitro, in vivo i kliničke studije magnetoterapija ima osteogenetski, antiupalni, hondroprotektivni , analgetski efekat i potencijal da obnovi oštećeno tkivo. Uprkos izvještajima o korisnom učinku magnetnog polja u tretmanu koštanih preloma, osteoporoze, reumatoidnog artritisa, osteoartritisa, neuroloških oštećenja, tek smo na pola puta u razjašnjavanju mehanizma putem kojeg magnetoterapija ojačava regenerativne sposobnosti patološkog i oštećenog tkiva. Na budućim istraživanjima je da se razjasne mehanizmi djelovanja koji bi doprinijeli jasnijoj kliničkoj primjeni i aktuelnost magnetoterapije i u budućnosti.

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A Review of Research of Strenght Development Using Complex Training

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Abstract: Using complex training for developing strength is a method which is becoming more frequently used with athletes and one which is simply defined as a combination of heavier and lighter (pliometric) load within one series. The scientific study is is based upon the assumption that complex training has given positive results in the development of explosive strength of professional athletes. The methodical procedure included an overview of research on the affects of complex training done in the last twenty years and up to now, using Google Scholar, PubMed, Scopus and Web of Science. The results of the reviewed studies mostly show that complex training has given positive effects with professional athletes, which were physically prepared.
Keywords: strength training, complex strengtht raining, methods of strength development

Introduction

The basic criterion of evaluation in sports is the result, or success at the sports event, which requires permanent improvement of the content of sports training as a tool for achieving the goal, especially in the training of strength. Optimal training techniques designed to maximize power/force are of particular interest to fitness and sports trainers, as well as to sports scientists and researchers (Macdonald et al., 2013). Particularly interesting is the application and effects of complex strength training (CT), dealt also by a series of conducted studies (Eben, 1997; Backer, 2003; Chatzopoulos et al, 2007; Dobbs, Gill, Smart, McGuigan, 2015; Adams et al, 1992). Complex training is defined as changed classical training under load (higher loads) to which plyometric exercises (lower loads) are added within one series of exercises

Pregled istraživanja razvoja snage kompleksnim treningom

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Sažetak: Kompleksni trening u razvoju snage je jedan od metoda koji se sve češće primenjuje kod sportista, a jednostavno se definiše kao kombinacija težih opterećenja i lakših (pliometrijskih) vežbi unutar jedne serije. U naučnu studiju se pošlo sa pretpostavkom da je kompleksni trening dao pozitivne rezultate na razvoj eksplozivne snage kod vrhunskih sportista. Metodski postupak je podrazumevao pregled dosadašnjih istraživanja preko pretraživača Google Scholar, PubMed, Scopus i Web of Science u proteklih dvadeset godina na temu uticaja kompleksnog treninga. Rezultati ukazuju na to da je u većini pregledanih naučnih radova kompleksni trening (KT) dao pozitivne efekte i to kod vrhunskih sportista koji su dobro fizički pripremljeni.
Ključne reči: trening snage, kompleksni trening snage, metode razvoja snage.

Uvod

Osnovni kriterijum vrednovanja u sportu predstavlja rezultat, odnosno uspeh na sportskom takmičenju, što iziskuje permanentno unapređenje sadržaja sportskog treninga kao sredstava za ostvarivanje cilja, posebno u treningu snage. Optimalne trenažne tehnike dizajnirane da maksimalno povećaju karakteristike snage/sile su od posebnog interesa za kondicione i sportske trenere, kao i za sportske naučnike i istraživače (Macdonald et al., 2013). Posebno interesovanje se javlja za primenu i efekte kompleksnog treninga snage (KT) o čemu govori i niz sprovedenih istraživanja (Eben, 1997; Backer, 2003; Chatzopoulos i sar., 2007; Dobbs, Gill, Smart, McGuigan, 2015; Adams i sar., 1992). Kompleksni trening je definisan izmenom klasičnog treninga sa opterećenjem (teža opterećenja) kome su dodate pliometrijske vežbe (lakša opterećenja) unutar jedne serije vežbi (Eben,

(Eben, 1997; 2002; Sale, 2002). These two methods of performing strength exercises together form a complex pair and are considered to be the optimal strategy for increasing the strength through increased neuromuscular activity (Docherty et al., 2004, Adams et al., 1992), which is the result of an post-activation potentiation (PAP). PAP is a common technique used to induce short-term strength increase and generation of force during training and competition (Hodgson, Docherty, Robbins, 2005; Robbins, 2005), where previous intense muscular contractions increase subsequent force and strength level relative to the initial level. Mechanisms that cause PAP are associated with metabolic changes within the muscle (e.g., phosphorylation of light chain myosin; (Grange et al., 1993), as well as corrections of motoneurons and their irritability reflecting changes in H-reflex (Zucker and Regehr 2002; Misiaszek, 2003). The essence of PAP (post-activation potentiation) is in the action of high loads that cause a high degree of nerve stimulation. There are two basic ways of applying complex training from the aspect of load. One way refers to a combination of high and low loads which are performed between the series while the other way refers to the "super series" which is made up of high and low loads within one series. As complex training in modern training technology is increasingly applied, scientific questions arise which create a series of open questions for athletes, trainers and pedagogues of physical culture. One of the essential concerns of using CT relates to its objective effects on explosive strength, as well as on the profile of athletes who apply it, that is, whether they are top athletes or recreational athletes. The goal of the paper will therefore be to review and analyze the current studies on the subject of CT, where authors will try to answer the above questions.

Method

In order to make a more relevant overview of the previous research from the field of complex strength training, the authors have primarily opted for scientific papers which, on their own subject, deal with different effects of complex strength training in order to gain insight into the training effects. Scientific literature is available through *GoogleScholar, PubMed, Scopus* and *Web of Science*, while key words included "strength training", "complex strength training", "strength development methods". Search was limited to studies that have been conducted in the last 20 years. The study began with the assumption that complex training gave positive results on the development of explosive strength in athletes who are well-prepared.

1997; 2002; Sale, 2002). Ova dva načina izvođenja vežbi snage zajedno daju kompleksan par i smatraju se optimalnom strategijom u povećanju snage preko povećane neuromuskularne aktivnosti (Docherty i sar., 2004, Adams i sar., 1992) koja predstavlja rezultat post aktivacione potencijacije (PAP). **PAP** predstavlja uobičajenu tehniku koja se koristi za izazivanje kratkoročnog povećanja snage i razvoj sile tokom treninga i takmičenja (Hodgson, Docherty, Robbins, 2005; Robbins, 2005), gde prethodne intenzivne mišićne kontrakcije povećavaju naknadnu silu i manifestaciju snage u odnosu na početni nivo. Mehanizmi koje uzrokuju PAP povezani su sa metaboličkim promenama unutar mišića (npr. fosforilacija miozinskog lakog lanca; (Grange i sar., 1993), kao i korekcije motoneurona i njihova razdražljivost što se odražava promene H-refleksa (Zucker i Regehr 2002; Misiaszek, 2003). Suština PAP-a (postaktivacijske potencijacije) je u dejstvu velikih opterećenja koja uzrokuju visok stepen nervne stimulacije. Postoje dva osnovna načina primene kompleksnog treninga sa aspekta opterećenja. Prvi se odnosi na kombinaciju velikih i malih opterećenja koja se izvode između serija, dok se drugi način odnosi na tzv. "super serije", odnosno kombinacije većih i manjih opterećenja unutar jedne serije. Kako se kompleksni trening u savremnoj trenažnoj tehnologiji sve češće primenjuje, otvara se niz naučnih pitanja na koja treba dati odgovor kako bi treneri, pedagozi fizičke kulture i sportisti bili efikasniji prilikom primene kompleksnog metoda razvoja snage. Jedna od suštinskih nedoumica primene KT se odnosi na njegove objektivne efekte na eksplozivnu snagu, kao i na profil sportista koji ga primenjuju, odnosno da li se radi o vrhunskim sportistima ili o rekreativcima. Cilj rada će dakle biti usmeren na pregled i analizu dosadašnjih studija na temu kompleksnog treninga, gde će autori pokušati da odgovore na gore navedena pitanja.

Metod

U cilju pravljenja što relevantnijeg pregleda dosadašnjih istraživanja iz prostora kompleksnog treninga snage, autori su se prvenstveno opredelili za naučne radove koji po svojoj tematici istražuju različite efekte kompleksnog treninga snage, u cilju lakšeg uvida u trenažne efekte. Korištena je dostupna naučna literatura preko pretraživača Google Scholar, PubMed, Scopus i Web of Science, dok su ključne reči uključivale „trening snage", „kompleksni trening snage", „metode razvoja snage". Pretraga je ograničena na studije koje su sprovedene u poslednjih 20 godina. U studiju se pošlo sa pretpostavkom da je kompleksni trening dao pozitivne rezultate na razvoj eksplozivne snage kod sportista koji su dobro pripremljeni.

Results with discussion

Table 1. *An overview of previous research related to complex training*

Rezultati sa diskusijom

Tabela 1. *Pregled dosadašnjih istraživanja koja se odnose na kompleksni trening*

Studija	N	Sport	Rezultati studije
Gossen & Sale (2000)	13 M 10 F	Mačevaoci	Kod muškaraca koji su u vrhunskom treningu može se očekivati povećanje vertikalne skočnosti i snage nogu metodom PAP.
Hamada, Sale, McDougall, & Tarnopolsky (2000)	20	Aktivni sportisti	Mišići sa kraćim vremenom trzaja imaju veću šansu da brže i efikasnije iskoriste PAP efekat u kompleksnom treningu.
Duthie, Young, Aitken (2002)	11	Žene različitog sporta	Kompleksni trening daje očekivano povećanje snage kod vrhunskih i fizički dobro pripremljnih sportiskinja.
Backer (2003a)	16	Ragbi igrači	U drugom setu vežbi sa opterećenjm nastaju najveći efekti kompleksnog treninga
Backer (2003b)	27	Ragbi igrači	Veliki broj ponavljanja u malom vremenskom periodu može da dovede do smanjenja efekata kompleksnog treninga.
Backer & Newton (2005)	24	Ragbi igrača	Snaga mišića nogu nakon primene kompleksnog treninga se povećala za 4,7% .
French, Kraemer, Cooke (2003)	14	Atletičari	Podaci ukazuju da izvođenje serije ponavljanja maksimalne izometrijske ekstenzije kolena (3 ponavljanja po 3 sekunde) pre izabrane dinamičke vežbe (# 0.25 sekunde) može imati povoljnije efekte na performanse u odnosu na standarde postignute bez prethodnog velikog opterećenja
Hamada et al. (2003)	20	Različiti sportisti	Mišićno vlakno koje je opterećeno trenigom ima uticaj na ispoljavanje PAP kao i na pojavu zamora od momenta trzaja do pojave PAP nakon primene kompleksnog treninga
Jensen & Ebben (2003)	21	NCAA lige - košarkaši	Kompleksni trening ne daje očekivane rezultate u poboljšanju visine vertikalnog skoka ako se skok ne izvede odmah nakon opeterećenja većom težinom u prvoj fazi (ne sme biti veća pauza)
Smith & Fry (2007)		Rekreativni vežbači	Rekreativci neće imati koristi od efekata postaktivacijske potencijacije tokom izvođenja vežbi sa različitim opterećenjem ako je oporavak između serija 7 minuta
Ingle, Sleap, Tolfrey (2006)	26	Nesportisti	Kompleksni trening daje malo povećanje snage eksplozivnog karaktera mišića ruku, ramenog pojasa i nogu u dinamičkim radnjama
Kukrić et al. (2009)	33	Košarkaši	Nema statistički značajne razlike između primene pliometrijskog i kompleksnog treninga
Chatzopoulos et al. (2007)	15	Košarkaši, fudbaleri, odbojkaši	Kompleksni trening može da poboljša brzinu trčanja ako se istrčavanja kratkih deonica primenjuju nakon 5 minuta od momenta vežbi sa opterećenjem
Folland, Wakamatsu, Fimland (2008)	8	Rekreativni vežbači	Nema uticaja na povećanje snage m. quadriceps-a
Dobbs, Gill, Smart, McGuigan (2015)	20	Atletičari	Kompleksni trening kroz dinamičke pokrete izaziva poboljšanje snage i veličine vertikalnog odraza

Study	N	Sport	Study results
Gossen& Sale (2000)	13 M 10 F	Swordsmen	In men who are in top training, it is possible to expect an increase in vertical jump and leg strength by using the PAP method.
Hamada, Sale, McDougall, &Tarnopolsky (2000)	20	Active athletes	Muscles with faster muscle twitches have a greater chance to use the PAP effect more quickly and effectively in complex training.
Duthie, Young, Aitken (2002)	11	Women engaged in different sports	Complex training gives the expected increase in strength in top-level and physically well-prepared sportswomen.
Backer (2003a)	16	Rugby players	The greatest effects of complex training are generated in the second set of exercises under load
Backer (2003b)	27	Rugby players	A high number of repetitions over a short period of time can lead to a reduction in the effects of complex training.
Backer&Newton (2005)	24	Rugby players	The strength of the leg muscles after the application of complex training increased by 4.7%.
French, Kraemer, Cooke (2003)	14	Athletes (athletics)	The data indicate that performing a series of repetitions of the maximum isometric knee extension (3 reps of 3 seconds) prior to the selected dynamic exercise (# 0.25 seconds) may have more favorable performance effects compared to the standards achieved without the previous high load.
Hamada et al. (2003)	20	Various athletes	The muscular fibers under load during training have an effect on the expression of PAP as well as on the appearance of fatigue from the moment of twitch to the onset of PAP after the application of complex training
Jensen&Ebben (2003)	21	NCAA Leagues – basketball players	Complex training does not give the expected results in improving the vertical jump if the jump is not performed immediately after the application of load with higher weight in the first stage (there must be no longer breaks)
Smith&Fry (2007)		Recreational athletes	Recreational athletes will not benefit from the effects of post-activation potentiation during exercises under different loads if the recovery between the series is 7 minutes
Ingle, Sleap,Tolfrey (2006)	26	Non-athletes	Complex training gives a slight increase in the explosive strength of the arms, shoulders and legs muscles in dynamic actions.

Kukrić et al. (2009)	33	Basketball players	There is no statistically significant difference between the application of plyometric and complex training.
Chatzopoulos et al. (2007)	15	Basketball, football and volleyball players	Complex training can improve running speeds if the running of short sections takes place after 5 minutes of the exercise under load.
Folland,Wakamatsu,Fimland (2008)	8	Recreational exsercisers	No effect on increase of strength of quadriceps
Dobbs, Gill, Smart, McGuigan (2015)	20	Athletes (athletics)	Complex training through dynamic movements causes an increase in strength and size of the vertical jump.

In recent years, science has confirmed the trainer's assumptions and in research laboratories it has come to the conclusion that alternate use of high-load and low-load exercises can result in great training effects and increase in strength (Blakey, 1987; Ebben, Blackard, 1998; Duthie, Young, Aitken, 2002) . Dynamic (Chatzopoulos et al, 2007, Kilduff et al, 2007), isometric (French, Kraemer, Cooke, 2003); Gossen and Sale, 2000; Hamada et al, 2000) and ballistic or plyometric (Hilfiker et al., 2007, Masamoto et al., 2003, Till & Kuk, 2009) contractions at maximum or sub-maximal load give positive results. According to the results of the research so far, it can be noticed that almost all research deal with active professional athletes, which can be justified by specific requirements and the construction of complex training.

Hamada, Sale, McDougall & Tarnopolsky (2000) found that faster-twitch muscles have a greater chance of using the PAP effect in complex training more quickly and efficiently. This fact explains why complex training is most commonly used in sports where explosive strength plays a dominant role. The question arises whether the use of CT is justified in sports where strength does not have a dominant role, which opens up space for further research on CT. The results of the Kukrić et al (2009) show that there is no statistically significant difference between the use of pure plyometric training and CT. This result confirms the effect of CT if we have in mind that it is conceived from a plyometric exercises.

The application of higher training loads, such as preloading with plyometric exercises, will lead to improvement in explosive motions. Previous performance of high-load exercises enables the next action to be temporarily enhanced due to increased excitation of the central nervous system (Jense et al, 1999; Fatouros et al, 2000). Consequently, the greatest effects of complex training are achieved in the second set of exercises, which is shown in the research by Backer (2003). Excitation of the central nervous system is the result of acute physiological adaptation, which lasts from 8 to 10 min and is called post-activation potentiation - PAP (Sale, 2002).

If PAP is performed in people who are physically fit, an increase of the explosive strength of the leg muscles may be expected, and hence the performance of the jump. However, the conditioned contraction leads to fatigue, so

Nauka je poslednjih godina potvrdila pretpostavke trenera i u istraživačkim laboratorijama došla do saznanja da se menjanjem vežbi velikog i malog opterećenja može doći do velikih trenažnih efekata i napretka u snazi (Blakey, 1987; Ebben, Blackard, 1998; Duthie, Young, Aitken, 2002). Dinamičke (Chatzopoulos i sar., 2007, Kilduff i sar.,2007), izometrijske (French, Kraemer, Cooke, 2003); Gossen i Sale, 2000; Hamada i sar., 2000) i balističke ili pliometrijske (Hilfiker i sar., 2007, Masamoto i sar., 2003, Till i Kuk, 2009) kontrakcije pri maksimalnom ili submaksimalnim opterećenju daju pozitivne rezultate. Sagledano kroz rezultate dosadašnjih istraživanja može se uočiti da se u gotovo svim istraživanjima radi o aktivnim-profesionalnim sportistima, što se može objasniti specifičnim zahtevima i konstrukcijom kompleksnog treninga.

Hamada, Sale, McDougall i Tarnopolsky (2000), su ustanovili da mišići sa kraćim vremenom trzaja imaju veću šansu da brže i efikasnije iskoriste PAP efekat u kompleksnom treningu. Upravo ova činjenica objašnjava iz kog razloga se kompleksni trening primenjuje najčešće u sportovima gde eksplozivna snaga igra dominantnu ulogu. Postavlja se pitanje, da li je primena KT opravdana u sportovima u kojima snaga nema dominantnu ulogu i time se otvara prostor za dalja istraživanja na temu kompleksnog treninga. Rezultati studije Kukrić i sar. (2009), ukazuje na nepostojanje statistički značajne razlike u primeni čistog pliometrijskog treninga i KT. Ovim rezultatom se potvrđuje efekat kompleksnog treninga ako se uzme u obzir da je koncipiran od vežbi pliometrijskog karaktera.

Primena većih trenažnih opterećenja, kao predopterećenje pliometrijskim vežbama dovešće do poboljšanja eksplozivnih kretnji. Izvođenjem vežbi velikog opterećenja omogućuje se da naredna akcija bude privremeno poboljšana zbog povećanog nadražaja centralnog nervnog sistema (Jense i sar., 1999; Fatouros i sar., 2000). Samim tim se ostvaruju najveći efekti kompleksnog treninga u drugom setu vežbi, što pokazuje istraživanje Backer (2003). Ekscitacija centralnog nervnog sistema rezultat je akutne fiziološke adaptacije, koja traje od 8 do 10 minuta i naziva se postaktivacijska potencijacija-PAP (Sale, 2002).

Ukoliko se PAP izvodi kod ljudi koji su fizički spremni, može se očekivati povećanje eksplozivne sna-

the time of generation of fatigue and the effect of post-activation potentiation will greatly affect the manifestation of strength.

Post-activation potentiation depends on the volume and intensity of contractions caused by higher loading in the first part of the exercise (activity) and its duration (Tillin & Bishop, 2009). Therefore, in further research, it is necessary to see which performances of complex training and the time of its application (breaks between two loads) lead to the best results regarding the manifestation of strength.

In order to encourage further adaptation to specific training objectives, the progressive strength training protocols must be observed. Optimal characteristics of specific strength increase programs, including complex training, include the use of concentric, eccentric and isometric muscular contractions and the performance of bilateral and unilateral exercises. In addition, it is recommended that strength increase programs contain a series of exercises to optimize and preserve the intensity of the exercises (high load before a low load, large muscle groups must be affected before small muscle groups, stronger and higher intensity before low intensity).

Conclusion

Based on the literature reviewed, it can be concluded that the effect of complex training is greater if it is an active and top-level athletes. The effects of complex training depend on the progressiveness of the load, the overload, the ratio of the higher and the lower load, and the duration of the PAP effect. The effect of acute nerve excitation or PAP effect is a physiological response to high loads that favor a more efficient and explosive exercise of movements under lower load. The PAP effect is directly related to the intensity and duration of the pause between the series, otherwise the fatigue may occur which does not favor the execution of the "second phase" movement. The application of complex training in almost all of the examined studies has led to an increase in the manifestation of the explosive strength. Complex training gives the best results if applied to top athletes, or athletes who are well prepared, by properly dosing pauses between the series as one of the conditions on which the effect of CT depends, which can be seen as the general finding. What also may be seen from the literature reviewed is that the effect of complex training depends on the type of muscle fiber, that is, the fast-twitch muscle fibers efficiently use the PAP effect, which can be an "open field" for further scientific studies.

ge mišića nogu, a time i performansi skoka. Međutim, uslovljena kontrakcija dovodi do zamora, pa će vreme nastajanja zamora i dejstvo postaktivacijskog potencijala u velikoj meri uticati na ispoljavanje snage.

Postaktivacijska potencijacija zavisi od obima i intenziteta kontrakcija izazivanih većim opterećenjem u prvom delu vežbe (aktivnosti) i vremena njegovog trajanja (Tillin, & Bishop, 2009). Zato je potrebno u daljim istraživanjima sagledati od kojih sve performansi kompleksnog treninga i vremena njegove primene (pauze između dva opterećenja) se ostvaruju najbolji rezultati na ispoljavanje snage.

U cilju podsticanja daljeg prilagođavanja ka određenim ciljevima treninga, moraju se poštovati protokoli progresivnog treninga snage. Optimalne karakteristike specifičnih programa snage, pa i kompleksnog treninga uključuju upotrebu koncentričnih, ekscentričnih, i izometrijskih mišićnih kontrakcija i performansi bilateralnih i unilateralnih vežbi. Pored toga, preporučuje se da programi snage sadrže niz vežbi za optimizaciju i očuvanje intenziteta vežbi (veliko opterećenje pre malog opterećenja, velike mišićne grupe moraju biti zahvaćene pre malih mišićnih grupa, jači i veći intenzitet pre manjeg intenziteta).

Zaključak

Na osnovu pregledane literature, može se izvesti zaključak da je efekat kompleksnog treninga veći ukoliko se radi o aktivnim i vrhunskim sportistima. Efekti kompleksnog treninga zavise od progresivnosti opterećenja, predopterećenja, odnosa većeg i manjeg opterećenja kao i dužine PAP efekta. Efekat akutne nervne nadraženosti ili PAP efekat, je fiziološki odgovor na velika opterećenja koja pogoduju efikasnijem i eksplozivnijem izvršavanju pokreta pod manjim opterećenjem. PAP efekat je i direktnoj vezi sa intenzitetom i vremenom trajanja pauze između serije, jer u suprotnom može doći do zamora koji ne pogoduje izvršavanu pokreta" druge faze". Primena kompleksnog treninga je u gotovo svim sagledanim istraživanjima dovela do povećanja ispoljavanja eksplozivne snage. Kompleksni treninga daje najbolje rezultate ukoliko se primenjuje kod vrhunskih sportista, odnosno kod sportista koji su dobro pripremljeni, i to pravilnim doziranjem pauza između serija kao jedan od uslova od kojih zavisi efekat kompleksnog treninga, što se može posmatrati i kao generalni zaljučak. Ono što se još može uočiti na osnovu pregledane literature je da efekat kompleksnog treninga zavisi od tipa mišićnog vlakna, odnosno da mišićna vlakna brzog trzaja efikasnije koriste PAP efekat, što može da bude"otvoren ulaz" za dalje naučne studije.

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Differences in Anthropometrics Characteristics, Somatotype and Motor Skill in Karate and Non-Athletes

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Abstract: Anthropometric characteristics aim to improve the performance in many sports. Morphological status of top athletes is relatively homogeneous, depending on the sport, and can be defined as a pattern for the achievements of athletes (Misigoj-Duraković, Matković, &Medved, 1995). Somatotype reflects the overall appearance of the human body and gives meaning to the total morphological status of the human body (Ross, Ward, Leahy, & Day 1982). Our research was conducted with the main objective to identify the differences in anthropometric characteristics somatotype and some basic motor skills in karate and non-athletes. The research was conducted on 100 male subjects 17-18 years, karate (50) and non-athletes (50). The purpose of this study is to define the differences in anthropometric characteristics, somatotypes and basic motor skills in karate and non-athletes. The pattern of the anthropometric measures is defined by ISAK (International Society for the Advancement of Kinanthropmetry), except the variables: body mass index (BMI), body fat percentage (BF %) and lean body mass (ALBM), which are calculated according to the methodology During Womerslay, while the variable (HWR) derives from the software program somatotype 1.2, the pattern of motor skill is defined by battery of Eurofit testing. For determining the differences between the two groups of respondents, a t-test for independent samples is applied, while the evaluation of the somatotypes was done according to the methodology by Heath-Carter with 10 anthropometric measurements. Based on the obtained results of measurements from both groups respondents, was proved that there are no statistically significant differences in anthropometric measures. Based on our study, while in karate we found balanced mesomorph somatotype 3.07-4.28-2.85 in non-athletes we find endomorphic mesomorph somatotype 3.47-4.96-2.67. Statistically significant differences on the components of somatotypes exist at mesomorph component. Differences in the motor skill were found in favor of karate athletes.
Key Words: somatotype, anthropometrics characteristics, motor skills, karate, non-athletes

Introduction

Anthropometric characteristics aim to improve the performance in many sports. Morphological status of top athletes is relatively homogeneous, depending on the sport, and can be defined as a pattern for the achievements of athletes (Misigoj-Duraković, Matković, & Medved, 1995). Somatotype reflects the overall appearance of the human body and gives meaning to the total morphological status of the human body (Ross, Ward, Leahy, & Day 1982). Many studies show that the somatotypes have a strong genetic basis (Harrison, Weiner, & Tanner, 1976). Somatotype measurements are applied based on external features of body structure and it is accepted as one of the indicators of physical body structure (Zorba, 2005). The researches of Amus and Onievadume (2001) in karate representatives from Botswana, as a part of the preparations for the African Games in 1999, concluded that the main somatotype in men was 2.5+1.1- 3.9+0.9-3.0+1.2 and in women 4.4+0.8-4.7+1.2-1.3+1.1 (endomorph, mesomorph and ectomorph). Katić, Blazević, Krstulović, and Mulić (2005) found that adult elite karate in Croatia is predominantly characterized by mesomorph somatotype, which was confirmed by Fritzsche and Raschka (2007) in the German elite adult karate determined by Heath-Carter methodology and found medium somatotype in elite male karate 2.0-3.7-2.7. Meanwhile in female elite karate 3.4-2.4-2.4. Gualdo and Graziani (1993) made an analysis and description of the somatotypes in 1593 young Italian athletes (717 male and 876 female subjects) from different sports. The average of somatotypes was 2.7-4.7-2.7 in male subjects and 3.6-3.7- 2.8 in female subjects. Sandeep Roy Sarkari and Samir Sil (2014) in their research "Somatotype of Non-athlete Tribal School Boys of West Tripura, District of Tripura (Aged 8+ to 16+ Years)", has concluded that the mean somatotypes fell in the mesomorph-ectomorph sectors with a rating of 1.78-4.22-3.78. The somatotype categories ectomorphic mesomorph and mesomorph-ectomorph included the greatest proportion of these tribal boys. Thus the non-athlete tribal school boys of West Tripura district were predominantly mesomorphic. Kostovski et. al (2017) in

the research "Morphological Characteristics with Students – Karate Athletes and Non-athletes the Age of 16-18 Years old" in a battery of 5tests for assessment of the body composition was applied to the respondents, he found that differences in the components of the body composition were found in favor of karate athletes. The main objective of our research was to identify the differences in anthropometric characteristics, somatotypes and some basic motor skills in karate and non-athletes.

Methods

The research was conducted on 100 male subjects 17-18 years ± 6 month, 50 karate junior competitors in kata and kumite of different categories and 50 non-athlete students in high school. In this research we applied 26 variable, 17 anthropometric and 9 motor variables, of which 13 variables were measured by-ISAK (International Society for the Advancement of Kinanthropometry), body height (AVT), bodymass (AMT), triceps skinfold (AKNT), biceps skinfold (AKNB), abdomen skinfold (AKNA), supraspinale skinfold (AKNS), subscapular skinfold (AKNG), femur skinfold (AKNN), calf skinfold (AKNP), upper arm girth (AON), calf girth (AOP), breadth of the humerus (ADL), breadth of the femur (ADK), except the variables: body massindex (BMI), body fat percentage (BF%) and lean body mass (ALBM), which were calculated according to the methodology of DuringWomerslay, while the variable Height-Weight ratio calculation (HWR) derives from the software program somatotype 1.2., while the evaluation of the somatotypes was done according to the methodology by Heath-Carter with 10 anthropometric measurements. Variables for evaluation motor skill are defined by battery of *EuroFIT* testing: Flamingo balance test (MFT), Plate tapping (MTR), Sit and reach (MDPS), Standing broad jump (MSDM), Hand grip (MDSH), Sit-ups (MPTL), Bent arm hang (MVZN), Shuttle run: 10 x 5 m (MSHR10x5) and Endurance shuttle run test (MFBT20m). For the data processing we used the software program SPSS20 for Windows. To determine the significant differences between arithmetic averages of each group, we used a student *t*-test, while the determination of somatotypes and their difference was made by the software program somatotype1.2. This procedure determines somatotypes for each subject individually, according to the methodology of Heath-Carter.

Results and discussion

Table no. 1 presents the differences of the anthropometric characteristics of the two groups taken in the study, karate and non-athletes. Based on the values of the table, we can conclude that significant differences do not appear in any of the variables, although based on the arithmetic average values, we can see that all variables with which the fat tissue is determined, karate exhibit smaller values than in the group of non- athletes, which means that karatists have less fat tissue than non- athletes.

Table 1. *T-test in anthropometric characteristics between karate and non-athletes*

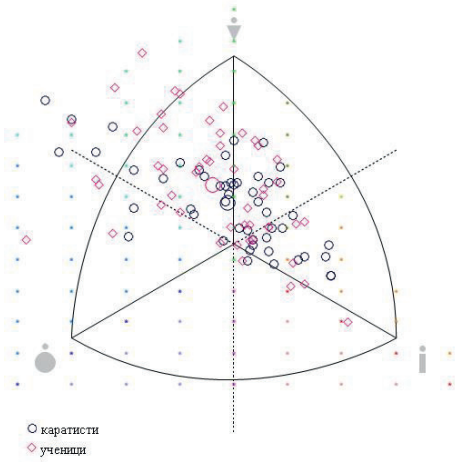
Variable	Karate (N=50)		Non-athlets(N=50)		F	t	Sig.
	Mean	SD	Mean	SD			
AVT	173.86	5.13	173.77	6.94	6.28	0.07	0.94
AMT	67.25	8.34	68.50	10.92	3.86	-0.64	0.52
BMI	22.21	2.60	22.54	2.96	1.78	-0.58	0.56
BF%	14.63	6.40	16.19	6.02	0.00	-1.26	0.21
ALBM	57.04	5.06	56.75	6.91	3.66	0.24	0.81
AKNT	11.08	6.72	12.90	6.37	0.02	-1.39	0.17
AKNB	5.86	3.88	5.78	2.89	0.73	0.12	0.91
AKNA	12.68	9.29	15.72	7.90	0.01	-1.76	0.08
AKNG	10.22	4.55	11.36	4.84	0.17	-1.21	0.23
AKNS	10.90	7.03	11.78	6.57	0.02	-0.65	0.52
AKNN	13.22	6.25	15.30	6.79	1.29	-1.59	0.11
AKNP	11.14	5.50	11.80	5.85	0.06	-0.58	0.56
AON	26.00	3.60	27.10	3.08	0.26	-1.64	0.10
AOP	35.08	2.83	36.09	2.90	1.21	-1.76	0.08
ADL	7.52	0.52	7.73	0.85	7.35	-1.48	0.14
ADK	9.90	0.74	10.18	0.78	0.75	-1.83	0.07
HWR	42.88	1.77	42.65	1.82	0.17	0.63	0.53

If we compare the values of BF% 14.63 with the study of Kostovski et. al (2017) 11.09, we can conclude that the percentages of the fat tissue in our study show higher values in karate, whereas the same situation appears to non-athletes. If we analyze BMI 22.21 variables in karatists and 22.54 in non-athletes with the same study Kostovski et. al (2017), karatists 22.62 and non-athletes in rural areas 20.64, we can conclude that the values of our BMI study are lower in karatists while non-athletes are of higher values.

Table 2. *T-test in somatotype between karate and non-athletes*

Variable	Karate (N=50)		Non-athlets (N=50)				
	Mean	SD	Mean	SD	F	t	Sig.
ENDO	3.07	1.57	3.47	1.50	0.04	-1.30	0.20
MESO	4.28	1.38	4.96	1.58	0.81	-2.29	0.02
ECTO	2.85	1.22	2.67	1.25	0.23	0.70	0.48

To better reflect the differences, we are presenting the distribution of somatotype components through the somatochart below:



Based on the data in table no. 2 where the values of the somatotype components are presented, we can conclude that the values of the somatotype components in karatists are 3.07-4.28-2.85 and they belong to the balanced mesomorphic component whereas non-athletes present the values of 3.47-4.96-2.67 which belong to the endomorphic mesomorph component. Significant statistical differences appear in the mesomorphe component P = 0.02 in which we can say that the highest values in this component are presented in the group of non-athletes who are not involved in the training process.

Figure 1. *Distribution of the somatotype categories in karate and non-athletes*

Taking into account the characteristics of the mesomorphic component and by analyzing and observing the situation on the ground, we can conclude that although students are not involved in the training process, they come from rural areas where many physical activities are present, therefore we can conclude that the mesomorphic component represents the most emphasized values and to remind that many studies show that the somatotypes have a strong genetic basis (Harrison, Weiner, & Tanner, 1976). If we compare our study with the studies of Sandeep Roy Sarkari and Samir Sil (2014) in their research "Somatotype of Non-athlete Tribal School Boys of West Tripura, District of Tripura (Aged 8+ to 16+ Years)", where the mean somatotypes fell in the mesomorph-ectomorph sectors with a rating of 1.78-4.22-3.78, Amus and Onievadume (2001) in karate representatives from Botswana, as a part of the preparations for the African Games in 1999, where the main somatotype in men was 2.5- 3.9-3.0, Gualdo and Graziani (1993) in their analysis and description of the somatotypes in 1593 young Italian athletes from different sports, where the average of somatotypes was 2.7-4.7-2.7 in male subjects, we can conclude as the common conclusion of all studies that the values of the mesomorph component are higher compared to the endomorph and ectomorph component.

Based on the values of variables we presented in table no. 3, we can conclude that out of 9 variables, significant statistical differences are presented in 5 variables which are: Flamingo balance test (MFTp = 0.01), Standing broad jump (MSDMp=0.02), Sit-ups (MPTL p = 0.00), Bent arm hang (MVZN p = 0.01) and Shuttle run: 10 x 5 m (MSHR10x5)p = 0.00. In all the variables of the motor space in which there are significant statistical differences, we can see that the best values appear in favor of the karate group.

Table 3. *T-test in motor skills between karate and non-athletes*

Variable	Karate (N=50)		Non-athlets(N=50)				
	Mean	SD	Mean	SD	F	t	Sig.
MFT	11.96	7.26	16.02	6.92	0.03	-2.86	0.01
MTR	11.74	1.14	11.85	2.03	15.08	-0.32	0.75
MDPS	30.28	6.85	28.05	8.06	1.97	1.49	0.14
MSDM	197.30	20.96	185.64	26.64	5.10	2.43	0.02
MDSH	33.64	4.71	32.68	7.23	10.57	0.79	0.43
MPTL	26.70	3.36	20.94	3.41	0.89	8.51	0.00
MVZN	33.17	17.77	23.83	19.54	0.01	2.50	0.01
MSHR10x5	20.21	1.27	21.95	2.22	20.32	-4.82	0.00
MFBT20m	37.28	4.99	35.49	5.74	1.98	1.66	0.10

Generally we can conclude that although in the anthropometric characteristics there were no significant differences between the two study groups, in the motor space where there are significant differences in the 5 variables which are in favor of the group of karateists, we can say that the training process that the karateists follow significantly affects the rise of motor performance in them.

Conclusion

Based on the obtained results of measurements from both groups respondents, it was proven that there are no statistically significant differences in anthropometric measures. Based on our study, while in karate we found balanced mesomorph somatotype 3.07-4.28-2.85, in non-athletes we found endomorphic mesomorph somatotype 3.47-4.96-2.67. Statistically significant differences on the components of somatotypes exist at the mesomorph component, where the highest values appear in the non-athletic group compared to karateists. The result is mainly explained by the genetic aspect and the physical activity of non-athletes coming from rural areas. Based on the differences in the motor space where there are significant differences in the 5 variables which are in favor of the group of karateists, we can say that the training process that follow karateists follow significantly affects the rise of motor performance in them.

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Short notice

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Kinesiological Analysis of Difference in Application of the Body Building and Crossfit Training Method

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Abstract: The main aim of this research is to identify the kinesiological differences in approaches and methods of training in the field of Crossfit and Bodybuilding, based on the kinesiological, anthropological and technical characteristics, as well as to determine the difference between recreationists and athletes in engagement programs such as Crossfit and Bodybuilding. The survey was conducted on a sample of 84 subjects, namely: 48 recreationists and 36 athletes. Research results show that a far greater number of recreationists are engaged in Bodybuilding compared to athletes. What is the main characteristic of this study is that the recreationists or athletes are not sufficiently informed about the Crossfit program and that it is rarely used in recreational and training activities.
Keywords: bodybuilding, crossfit, training, athletes, recreational athletes, differences.

Introduction

Our greatest strength is not to never fall,
but every time we fall - we lift up.
Confucius

Bodybuilding can be described as a sport in which a worker raising the weights and training on the machines builds and transforms his body - in order to gain a higher muscular weight, strength and fitness. Muscles strengthen in time and take on a new - visually more beautiful form. Bodybuilding is somehow a way of life, for many it is only a pleasant recreation, and for some it serves as an irreplaceable supplemental exercise and help in achieving top results in another sport (Mikić et al., 2000).

Lately, it is becoming more and more popular among the recreationists working as a crossfit as one of

Kineziološka analiza razlika u primjeni metoda treninga body buildinga i crossfita

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Sažetak: Osnovni cilj ovog istraživanja je utvrđivanje kineziloških razlika u pristupu i načinu treniranja u oblasti Crossfita i Bodybuildinga, sa stanovišta njegovih kineziloških, antropoloških i tehničkih obilježja, kao i utvrđivanje razlike između rekreativaca i sportaša u angažiranosti u programima Crossfita i Bodybuildinga. Istraživanje je sprovedeno na uzorku od 84 ispitanika, i to: 48 rekreativaca i 36 sportaša. Rezultati istraživanja pokazuju da se daleko veći broj rekreativaca bavi Bodybuildingom u odnosu na sportaše. Ono što je osnovna karakteristika ovog istraživanja jeste to, da ni rekreativci, a ni sportaši nisu dovoljno informirani o programu Crossfita i da ga nedovoljno primjenjuju u rekreativnim i trenažnim aktivnostima.
Ključne riječi: bodybuilding, crossfit, trening, sportaši, rekreativci, razlike.

Uvod

Naša najveća snaga nije u tome da nikad ne padnemo,
već da se svaki put kada padnemo – podignemo.
Konfučije

Bodybuilding možemo opisati kao sport u kojem vježbač dižući utege i treniranjem na spravama izgrađuje i preoblikuje svoje tijelo – kako bi dobio kvalitetniju mišićnu masu, snagu i kondiciju. Mišići tako vremenom jačaju i poprimaju jedan novi – vizualno ljepši oblik.

Bodybuilding je nekima i način života, mnogima je samo ugodna rekreacija, a nekima služi kao nezamjenjivo dopunsko vježbanje i pomoć u postizanju vrhunskih rezultata u nekom drugom sportu (Mikić i sur., 2000).

U zadnje vrijeme je sve više popularnije među rekreativcima bavljenje crossfitom kao jednim od najboljih

the best training systems. Certain methods of training, exercises and training protocols from crossfit are also used successfully in the fitness preparation of athletes, especially in martial arts.

Preparing an organism for everyday activities and acting on a versatile development of the trainer is the main goal of crossfit. Crossfit training is conceived as the basis for other sports disciplines. Crossfit is a "core" that represents the center of conditioning. It focuses on the main and central axis of the human body, through running, throwing, and striking. Conceptually, it wants to act from inside to outside. Considering the elements of gymnastics, weight lifting, cardio training, weight training, plyometry, functional movements, crossfit causes a wider adaptation stimulus, with everyday learning of skills. The crossfit movement also found its place in competitive disciplines. The concept is subordinate to the development of 10 motor and functional abilities (cardiovascular and respiratory endurance, general durability, strength, flexibility, strength, speed, coordination, agility, balance, precision).

Crossfit is primarily a training system. Crossfit is defined as continuously variable functional movements performed at high intensity (Mikić et al.,., 2016).

Crossfit is strength training and fitness - a program designed to challenge the broader adaptation response of an organism. It is based on short, intensive and varied trainings. It prepares the body to be good in several things, not just one.

Crossfit's goal is to prepare us for everyday activities. The idea is to constantly change the training so that the body never adapts to what we are preparing. By combining gymnastics, lifting, cardio training, exercise with your own body, plyometry, functional movements, etc. it also causes the body to learn new skills.

In all exercises, the more muscles work at the same time, and in most exercises, most of the exercises affect the stomach and lower part of the back, which are most common in most people as the weakest of the links (Đurašković, 2011).

Even if we add this to the minimum interval between exercises, we get a very powerful tool for burning fat and building muscles.

Functional crossfit training is based on a large selection of complex exercises that simulate movements from everyday life and sports, and as a rule involve multiple muscle groups. They use a variety of trainers and aids. This way of training was recognized by many Hollywood actors, models, athletes.

Requirements for training are: kettlebells, medical balls, gymnastics, plyometric boxes of various sizes, ropes,

sustava vježbanja. Određena metodika treninga, vježbe i protokoli vježbanja iz crossfita se uspješno koriste i u kondicijskoj pripremi sportaša, pogotovo u borilačkim sportovima.

Pripremanje organizma za svakodnevne aktivnosti i djelovanje na svestran razvoj vježbača je osnovni cilj crossfita. Crossfit vježbanje je zamišljeno kao temelj ostalim sportskim disciplinama. Crossfit je „jezgra" što predstavlja središte kondiciranja. U njemu se fokusira na glavnu i središnju osu ljudskoga tijela, kroz trčanje, bacanja i udaranja. Konceptualno se želi djelovati od unutrašnjosti prema vani. Obzirom da sadrži elemente gimnastike, dizanja tegova, kardio treninga, treninga sa vlastitom težinom, pliometriju, funkcionalne pokrete, crossfit izaziva širi adaptacijski podražaj, uz svakodnevno učenje vještina. Pokret crossfita je našao svoje mjesto i u takmičarskim disciplinama. Koncept je podređen razvoju 10 motoričkih i funkcionalnih sposobnosti (kardiovaskularna i respiratorna izdržljivost, opća izdržljivost, snaga, gipkost, jakost, brzina, koordinacija, agilnost, ravnoteža, preciznost).

Crossfit je prije svega sustav treninga. Crossfit definiramo kao stalno promijenjive funkcionalne pokrete koje izvodimo pri visokom intenzitetu (Mikić i sur., 2016).

Crossfit je trening snage i kondicije - program dizajniran sa namjerom da izazove što širi adaptacijski odgovor organizma. Bazira se na kratkim, intenzivnim i raznolikim treninzima. On priprema tijelo da bude dobro u više stvari, a ne samo u jednoj.

Cilj crossfit-a je da nas pripremi za svakodnevne aktivnosti. Ideja je stalno mjenjati treninge, tako da se tijelo nikada ne adaptira na ono što mu spremimo. Kombinirajući gimnastiku, dizanja, kardio trening, vježbe sa vlastitim tijelom, pliometriju, funkcionalne pokrete itd. ujedno izaziva tijelo i uči novim vještinama.

Bit kod svih vježbi je da što više mišića radi istovremeno, a u principu većina vježbi najviše pogađa trbuh i donji dio leđa, što su kod većine ljudi i najslabije karike (Đurašković, 2011).

Još ako tome pridodamo i minimalne odmore između vježbi, dobijamo vrlo moćno oruđe za sagorijevanje masti i izgradnju mišića.

Funkcionalni crossfit trening temelji se na velikom izboru složenih vježbi koje simuliraju pokrete iz svakodnevnog života i sporta, te u pravilu uključuju više mišićnih skupina. U njima se koriste najrazličitiji trenažeri i pomagala. Ovaj način treniranja prepoznali su i mnogi hollywoodski glumci, modeli, sportaši.

Rekviziti koji se koriste za treninge su: girje (kettlebells), medicinske lopte, gimnastičke karike, pliometrij-

screws, elastic tape, bulk bag, slosh pipe, weights of various sizes and weights (Freeman, 2007, Bašić et al, 2008, Đurković, 2011, Mikić and sur., 2016), and there is of course a great repertoire of exercises that are performed only with the weight of one›s own body. So there are no isolation exercises like bodybuilding type biceps, triceps, etc.

The main aim of this paper is to determine the kinesiological differences in approach and method of training in the fields of crossfit and bodybuilding, from the point of view of their basic kinesiological, anthropological characteristics of the art, as well as the establishment of differences between athletes and recreationists in engagement in crossfit and bodybuilding programs.

Methods

Sample respondents

The sample of respondents is made up of 84 entities of athletes and recreational athletes. The sample of the respondents was differentiated into two subgroups, 48 of them and 36 athletes.

Sample variables

Variables are defined on the basis of a questionnaire designed for this research:

1. Sex
2. Age
3. Do you do bodybuilding?
4. Do you engage in crossfit activities?
5. Are you familiar with the bodybuilding program?
6. Are you familiar with the crossfit program?
7. Do you know the difference between bodybuilding and crossfit?
8. What is the basic difference between bodybuilding and crossfit?

The data were processed by the basic descriptive statistical survey through frequency and percentage.

Results and Discussion

The basic descriptive parameters of the sent variables in both groups

The research included two groups of patients: 48 amateurs and 36 athletes.

Table 1. *Sex and age*

Skupina / *group*	M / *M*	Ž / *F*	Uzrast / *Age*
Rekreativci / *Amateurs*	30	18	19-46
Sportaši / *Athletes*	28	8	18-27

ske kutije različitih dimenzija, konopi, vijače, elastične trake, bugarska vreća, vodena cijev (slosh pipe), tegovi raznih veličina i težina (Freeman, 2007; Bašić i sur. 2008; Đurković, 2011; Mikić i sur., 2016), a tu je i naravno veliki repertoar vježbi koje se izvode samo sa težinom vlastitog tijela. Znači nema nikakvih izolacijskih vježbi kao u bodybuildingu tipa biceps, triceps, itd.

Osnovni cilj ovog rada je utvrđivanje kineziološkihrazlika u pristupanju i načinu treniranja u oblastima krossfita i bodybuildinga, sa stanovišta njihovih osnovnih kineziološkihantropoloških i tehničkih obilježja, kao i utvđivanje razlika između sportaša i rekreativaca u angažiranosti u programima crossfita i bodybuildinga.

Metod Rada

Uzorak ispitanika

Uzorak ispitanika je sastavljen od 84 entiteta sportaša i rekreativaca. Uzorak ispitanika je diferenciran na dva subuzorka i to 48 rekreativaca i 36 sportaša.

Uzorak varijabli

Varijable su definirane na osnovu upitnika koji je konstruiran za ovo istraživanje:

1. Pol
2. Uzrast
3. Da li se bavite bodybuildingom?
4. Da li se bavite aktivnostima crossfita?
5. Da li ste upoznati sa programom bodybuildinga?
6. Da li ste upoznati sa programom crossfita?
7. Da li znate razliku između bodybuildinga i crossfita?
8. Koja je osnovna razlika između bodybuildinga i crossfita?

Metode obrade podataka

Podaci su obrađeni osnovnom deskriptivnom statistikom izraženom kroz frekvencije i procenat.

Rezultati i diskusija

Osnovni deskriptivni parametri praćenih varijabli u objema skupinama

Istraživanjem su obuhvaćene dvije skupine ispitanika i to: 48 rekreativaca i 36 sportaša.

Tabela 1. *Pripadnost po polu i uzrastu*

The results presented (Table 2 and 3) represent the opinion of recreationalists about bodybuilding and crossfit programs.

Table 2. *Descriptive parameters monitored variables with amateurs*

Varijable – rekreativci / *Variables - Recreational*	**DA / *YES* %**	**NE / *NO* %**	**Djelimično povremeno / *Partly occasionally* %**
1. Da li se bavite Bodybuildingom? / *Do you do bodybuilding?*	23 47,9	12 25,0	13 27,0
2. Da li se bavite aktivnostima Crossfita? / *Do you engage in Crossfit activities?*	6 12,5	34 70,0	8 16,6
3. Da li ste upoznati sa programom Crossfita? / *Are you familiar with the Crossfit program?*	6 12,5	32 66,0	10 20,0
4. Da li ste upoznati sa programom Bodybuildinga? / *Are you familiar with the Bodybuilding program?*	29 60,0	7 14,5	12 25,0
5. Da li znate razliku između Bodybuildinga i Crossfita? / *Do you know the difference between Bodybuilding and Crossfit?*	10 20,0	30 62,5	8 16,6
6. Navedite koja je osnovna razlika između Bodybuildinga i Crossfita Bodybuilding - 27 Crossfit – 7 / *State what the basic difference between Bodybuilding and Crossfit is* *Bodybuilding - 27* *Crossfit - 7*	Bodybuilding – razvoj mišićne mase, jačanje muskulature Crossfit – razvoj svih motoričkih sposobnosti, kondicija i izdržljivost / *Bodybuilding - development of muscle mass, strengthening of musculature* *Crossfit - development of all motor skills, fitness and endurance*		

Table 3. *Descriptive parameters of the observed variables with athletes*

Varijable – sportaši / *Variables - athletes*	**DA / *YES* %**	**NE / *NO* %**	**Djelimično povremeno / *Partly occasionally* %**
1. Da li se bavite Bodybuildingom? / *Do you do bodybuilding?*	11 30,5	7 19,4	18 50,0
2. Da li se bavite aktivnostima Crossfita? / *Do you engage in Crossfit activities?*	10 27,7	11 31,3	15 41,0
3. Da li ste upoznati sa programom Crossfita? / *Are you familiar with the Crossfit program?*	12 33,3	13 36,4	11 30,3
4. Da li ste upoznati sa programom Bodybuildinga? / *Are you familiar with the Bodybuilding program?*	24 66,0	5 14,5	7 19,4
5. Da li znate razliku između Bodybuildinga i Crossfita? / *Do you know the difference between Bodybuilding and Crossfit?*	8 22,2	10 27,7	18 50,0
6. Navedite koja je osnovna razlika između Bodybuildinga i Crossfita Bodybuilding - 30 Crossfit – 18 / *State what the basic difference between Bodybuilding and Crossfit is* *Bodybuilding - 30* *Crossfit - 18*	Bodybuilding – oblikovanje mišićne mase, razvoj snage Crossfit – kondicija, raznovrsnost treninga / *Bodybuilding - muscle mass design, power development* *Crossfit - fitness, diversity of training*		

Table 2 shows the descriptive parameters of the tracked variables for recreational athletes. Based on the results presented, it is obvious that a significant number of recreational athletes regularly or occasionally do Bodybuilding (36 or 75%), most of them are familiar with the bodybuilding program (41 or 85%) and most of them do not know the difference between Bodybuilding and Crossfit (62.5%).

As for Crossfit, most respondents do not do Crossfit (34 or 70.00%), they are not familiar with the Crossfit program (32 or 66.0%), and do not know the difference between Bodybuilding and Crossfit. 27 of them listed what the Bodybuilding program offered, and only 7 or 14.5% of what Crossfit's activities are.

Prikazani rezultati (tabela 2 i 3) predstavljaju mišljenje rekreativaca o programima bodybuildinga i crossfita.

Tabela 2. *Deskriptivni parametri praćenih varijabli kod rekreativaca*

U tabeli 2. prikazani su deskriptivni parametri praćenih varijabli kod rekreativaca. Na osnovu prezentiranih rezultata očigledno je da se značajan broj rekreativaca redovno ili povremeno bavi Bodybuildingom (36 ili 75%), da je većina njih upoznata sa programom Bodybuildinga (41 ili 85%) i da većina njih ne zna razlike između Bodybuildinga i Crossfita (30 ili 62,5%).

Što se tiče Crossfita većina ispitanika se ne bavi aktivnostima Crossfita (34 ili 70,00%), nisu upoznati sa programom Crossfita (32 ili 66,0%), i ne znaju razlike između Bodybuildinga i Crossfita. Njih 27 je navelo šta pruža program Bodybuildinga, a samo 7 ili 14,5% šta pružaju aktivnosti Crossfita.

Tabela 3. *Deskriptivni parametri praćenih varijabli kod sportaša*

Table 3 shows the descriptive parameters of the observed variables in athletes. We can say that 29 or 80.5% of athletes are regularly or occasionally involved in bodybuilding, that most of them are familiar with the bodybuilding program (31 or 85.5%) and that 26 or 72% of them are familiar with the difference between Bodybuilding and Crossfit. When it comes to Crossfit activities, a significant number of athletes are dealing with Crossfit activities regularly or occasionally (25 or 78.7%), with 23 or 63.3% familiar with Crossfit, with a difference between Bodybuilding and Crossfit 70.3 %. 30% or 83% of them stated what the Bodybuilding program provides, and 18% or 50% of what Crossfit offers.

When comparing these two groups of respondents, we can say that recreational athletes and athletes are familiar with the bodybuilding program, while crossfit activities are more familiar to athletes than recreational athletes.

As for knowing the differences between Bodybuilding and Crossfit, it's obvious that athletes know better about those differences than recreationalists.

When it comes to engaging in the programs of Bodybuilding and Crossfit, it is obvious that there is a significant difference between athletes and recreational athletes. Recreative athletes are more engaged in Bodybuilding programs, and athletes in Crossfit activities.

Conclusion

The main aim of this paper is to determine the kinesiological differences in approach and method of training in the field of Crossfit and Bodybuilding, from the point of view of its kinesiological, anthropological and technical characteristics, as well as to determine the differences between recreationists and athletes in the engagement in Crossfit and Bodybuilding programs. The survey was conducted on a sample of 84 respondents: 48 recreative athletes and 36 athletes.

On the basis of the presented results, we can say that the recreative athletes are more engaged in the programs of Bodybuilding and are less familiar with the activities of Crossfit. On the other hand, athletes are more engaged in Crossfit activities, they are more familiar with Crossfit activities but are to some extent involved in the Bodybuilding program. It is obvious that Crossfit programs are still not well known to athletes, especially recreational athletes, and that additional training of trainers, athletes, recreational managers and recreational athletes is needed to achieve the efficiency and effectiveness of these programs.

It is certain that the benefits of Crossfit are reflected in:

U tabeli 3. su prikazani deskriptivni parametri praćenih varijabli kod sportaša. Možemo konstatovati da se redovito ili povremeno bavi Bodybuildingom 29 ili 80,5% sportaša, da je većina njih upoznata sa programom Bodybuildinga (31 ili 85,5%) i da je njih 26 ili 72% upoznato sa razlikom između Bodybuildinga i Crossfita. Kada su u pitanju aktivnosti Crossfita značajan broj sportaša se bavi aktivnostima Crossfita redovito ili povremeno (25 ili 78,7%), sa programom Crossfita je upoznato njih 23 ili 63,3%, sa razlikom između Bodybuildinga i Crossfita je upoznato njih 70,3%. Njih 30 ili 83% je navelo šta pruža program Bodybuildinga, a 18 ili 50,00% šta pruža program Crossfita.

Komparacijom rezultata ove dvije skupine ispitanika možemo konstatovati da su rekreativci i sportaši upoznati sa programom Bodybuildinga, dok su sa aktivnostima Crossfita više upoznati sportaši u odnosu na rekreativce.

Što se tiče poznavanja razlika između programa Bodybuildinga i Crossfita očigledno je da sportaši nešto bolje poznaju te razlike u odnosu na rekreativce.

Kada je u pitanju angažiranost u programima Bodybuildinga i Crossfita očigledno je da tu postoji značajna razlika između sportaša i rekreativaca. Rekreativci su više angažirani u programima Bodybuildinga, a sportaši u aktivnostima Crossfita.

Zaključak

Osnovni cilj ovog rada bio je utvrđivanje kinezioloških razlika u pristupanju i načinu treniranja u oblasti Crossfita i Bodybuildinga, sa stanovišta njegovih kinezioloških, antropoloških i tehničkih obilježja, kao i utvrđivanje razlika između rekreativaca i sportaša u angažiranosti u programima Crossfita i Bodybuildinga. Istraživanje je provedeno na uzorku od 84 ispitanika, i to: 48 rekreativaca i 36 sportaša.

Na osnovu prezentiranih rezultata možemo konstatirati da su rekreativci više angažirani u programima Bodybuildinga i da su manje upoznati sa aktivnostima Crossfita. Za razliku od rekreativaca sportaši su više angažirani u aktivnostima Crossfita, više su upoznati sa aktivnostima Crossfita, ali su u određenoj mjeri uključeni u program Bodybuildinga. Očigledno je da programi Crossfita još uvjek nisu dovoljno poznati ni sportašima, a posebno rekreativcima i da je potrebno izvršiti dodatnu edukaciju trenera, sportaša, rukovodilaca rekreativnih aktivnosti i rekreativaca sa efikasnošću i učinkovitošću ovih programa.

Sigurno je da se prednosti programa Crossfita ogledaju u:

- increase and efficiency of energy systems
- improving the composition of the body
- increase the work capacity of the exercise
- variety of training sequences
- increase in strength and muscle mass
- the universal applicability of Crossfit

Crossfit's aim is to prepare trainees for the unknown and non-stereotyped. The specificity of Crossfit is in non-specialization, which relates to a constantly changing and highly intensive functional movement. It can be said that crossfit training takes what is most effective and complex in all sports, thus achieving a very diverse concept of training.

Crossfit and our life paths coincide in the fact that the greatest struggle is the one we lead with ourselves, but when we manage to overcome it, the steps we make are easier and we manage to see it further than others.

- povećanju i efikasnosti energijskih sustava
- poboljšanju kompozicije tijela
- povećanju radnog kapaciteta vježbanja
- raznolikosti trenažnih sekvenci
- povećanju snage i mišićne mase
- univerzalnoj primjenjivosti Crossfita

Cilj Crossfita je pripremiti vježbače za nepoznato i nestereotipno. Specifičnost Crossfita je u nespecijalizaciji, koja se odnosi na stalno promjenjiv i visoko intenzivan funkcionalan pokret. Moglo bi se reći da je u Crossfit treningu uzeto iz svih sportova ono što je najučinkovitije, te složeno u jedan veoma raznolik koncept vježbanja.

Crossfit i naša životna putanja podudaraju se u tome da je najveća borba ona koju vodimo sa nama samima, ali kada je savladamo, koraci koje pravimo su laganiji i uspijevamo da vidimo dalje od drugih.

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