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## Articles

- 163 Block periodization - a breakthrough or a misconception  
*Vladimir Koprivica*
- 176 Comparison of nutritional knowledge and food habits of collegiate and non-collegiate athletes  
*Hamid Arazzi and Rostegar Hosseini*
- 188 Influence of motor abilities on learning of alpe ski technique  
*Vjekoslav Cigrovski, Igor Božić, and Nikola Prlenda*
- 202 Whole body vibration training improves muscular power in a recreationally active population  
*Adam Hawkey*
- 213 Descriptive profile of body structure of top greco-roman style wrestlers defined with methods of multichannel bioelectric impedance  
*Goran Kasum and Milivoj Dopsaj*
- 229 Latent structure of situational efficiency parameters at croatian top level basketball players  
*Joško Sindik, Igor Jukić, and Maja Adžija*
- 245 Differences in the explosive and repetitive strength of twelve-year old schoolchildren with different morphological characteristics  
*Nikola Stojanović, Mibajlo Mijanović, Toplica Stojanović, and Dragan Perić*
- 259 Overuse syndrom in the running  
*Milan Čob*
- 269 Validity, reliability and sensitivity of the test stroke with leg - Mae Geri  
*Žarko Kostovski, Marko Zeljković, Lužlum Ibri, Elena Skolevska, and Boško Zaborski*
- 279 Gudelines for authors

## Članci

- 163 Blok periodizacija - prekretnica ili zabluda u sportkom treningu  
*Vladimir Koprivica*
- 176 Poređenje znanja i navika o ishrani između studenata i nestudenata sportista  
*Hamid Arazzi i Rostegar Hosseini*
- 188 Doprinos razvijenosti motoričkih sposobnosti kod savladavanja skijaške tehnike  
*Vjekoslav Cigrovski, Igor Božić i Nikola Prlenda*
- 202 Vibracioni trening cijelog tijela poboljšava snagu mišića kod rekreativno aktivne populacije  
*Adam Hawkey*
- 213 Deskriptivni profil tjelesne strukture vrhunskih rvača grčko-rimskog stila definisan metodom multikanalne bioelektrične impedance  
*Goran Kasum i Milivoj Dopsaj*
- 229 Latentna struktura parametara situacione efikasnosti kod hrvatskih vrhunskih košarkaša seniora  
*Joško Sindik, Igor Jukić i Maja Adžija*
- 245 Razlike u eksplozivnoj i repetitivnoj snazi dvanaestogodišnjih učenika sa različitim morfološkim pokazateljima  
*Nikola Stojanović, Mibajlo Mijanović, Toplica Stojanović i Dragan Perić*
- 259 Sindrom prenaprezanja u trčanju  
*Milan Čob*
- 269 Valjanost, pouzdanost i osjetljivost testa udarca nogom - Mae Geri  
*Žarko Kostovski, Marko Zeljković, Lužlum Ibri, Elena Skolevska i Boško Zaborski*
- 279 Uputstvo autorima



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- 163 Block periodization - a breakthrough or a misconception  
*Vladimir Koprivica*
- 176 Comparison of nutritional knowledge and food habits of collegiate and non-collegiate athletes  
*Hamid Arazzi and Rostegar Hosseini*
- 188 Influence of motor abilities on learning of alpe ski technique  
*Vjekoslav Cigrovski, Igor Božić, and Nikola Prlenda*
- 202 Whole body vibration training improves muscular power in a recreationally active population  
*Adam Hawkey*
- 213 Descriptive profile of body structure of top greco-roman style wrestlers defined with methods of multichannel bioelectric impedance  
*Goran Kasum and Milivoj Dopsaj*
- 229 Latent structure of situational efficiency parameters at croatian top level basketball players  
*Joško Sindik, Igor Jukić, and Maja Adžija*
- 245 Differences in the explosive and repetitive strength of twelve-year old schoolchildren with different morphological characteristics  
*Nikola Stojanović, Mibajlo Mijanović, Toplica Stojanović, and Dragan Perić*
- 259 Overuse syndrom in the running  
*Milan Čob*
- 269 Validity, reliability and sensitivity of the test stroke with leg - Mae Geri  
*Žarko Kostovski, Marko Zeljković, Lužlum Ibri, Elena Skolevska, and Boško Zaborski*
- 279 Gudelines for authors

## Članci

- 163 Blok periodizacija - prekretnica ili zabluda u sportkom treningu  
*Vladimir Koprivica*
- 176 Poređenje znanja i navika o ishrani između studenata i nestudenata sportista  
*Hamid Arazzi i Rostegar Hosseini*
- 188 Doprinos razvijenosti motoričkih sposobnosti kod savladavanja skijaške tehnike  
*Vjekoslav Cigrovski, Igor Božić i Nikola Prlenda*
- 202 Vibracioni trening cijelog tijela poboljšava snagu mišića kod rekreativno aktivne populacije  
*Adam Hawkey*
- 213 Deskriptivni profil tjelesne strukture vrhunskih rvača grčko-rimskog stila definisan metodom multikanalne bioelektrične impedance  
*Goran Kasum i Milivoj Dopsaj*
- 229 Latentna struktura parametara situacione efikasnosti kod hrvatskih vrhunskih košarkaša seniora  
*Joško Sindik, Igor Jukić i Maja Adžija*
- 245 Razlike u eksplozivnoj i repetitivnoj snazi dvanaestogodišnjih učenika sa različitim morfološkim pokazateljima  
*Nikola Stojanović, Mibajlo Mijanović, Toplica Stojanović i Dragan Perić*
- 259 Sindrom prenaprezanja u trčanju  
*Milan Čob*
- 269 Valjanost, pouzdanost i osjetljivost testa udarca nogom - Mae Geri  
*Žarko Kostovski, Marko Zeljković, Lužlum Ibri, Elena Skolevska i Boško Zaborski*
- 279 Uputstvo autorima



## BLOK PERIODIZACIJA – PREKRETNICA ILI ZABLUDA U SPORTSKOM TRENINGU

### BLOCK PERIODIZATION – A BREAKTHROUGH OR A MISCONCEPTION

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### SUMMARY

Block periodization emerged as a new idea in the preparation of athletes. Based on the analysis of the traditional theory of sports training and its segments and training periodization during the competitive season, the supporters of block periodization made a number of objections. The main conclusion was that classical periodization no longer meets the requirements of modern sports because of the extended competition calendar. Classical periodization is based on the simultaneous development of multiple abilities over a longer preparation period and large volumes of work. It prevents the athletes from participating successfully in several competitions during the season. However, according to the supporters of block periodization, this applies only to top athletes.

On the other hand, there are many objections to the justification and logic of block periodization. The term "block periodization" is not adequate, and the criticism of the classical theory is methodologically incorrect because it refers to old bibliographic sources, (and) the opponents are not mentioned. It is not realistic in practice to work successively on more abilities because of short periods of preparation, there is not enough time to recover after such an effort while the risk of injury is significantly higher. Most importantly, according to the block periodization it is difficult to be fit at the right time, which is the main purpose of periodization. Therefore, one could rather say that block periodization is a misconception, rather than a breakthrough in training.

**Key words:** block periodization, the theory of sports training, top athletes, sports fitness.

### SAŽETAK

Blok periodizacija se javila kao nova ideja u pripremi sportista. Na osnovu analize tradicionalne teorije sportskog treninga i njenog segmenta, periodizacije treninga tokom takmičarske sezone, pobornici blok periodizacije su iznijeli niz primjedbi. Osnovni zaključak je da klasična periodizacija više ne odgovara zahtjevima savremenog sporta jer se raširio kalendar takmičenja. Klasična periodizacija se zasniva na istovremenom razvoju više sposobnosti u dužem pripremnom periodu i velikim obimima rada. To ometa sportiste da uspješno učestvuju na više takmičenja tokom sezone. Ipak, po mišljenju pobornika blok periodizacije, ovo se odnosi samo na vrhunske sportiste.

Sa druge strane, postoji niz primjedbi na opravdanost i logiku blok periodizacije. Termin "blok periodizacija" nije adekvatan, a kritika klasične teorije je metodološki pogrešna jer se odnosi na stare bibliografske izvore, prećutkuju se neistomišljenici. Nije realno u praksi da se radi sukcesivno na više sposobnosti jer su skraćeni periodi pripreme, nije dovoljno vremena za oporavak poslije takvih napora i znatno je veći rizik od povređivanja. Najvažnije je da je po blok periodizaciji teško biti u formi u pravo vrijeme što je osnovni smisao periodizacije. Zato bi se prije moglo reći da je blok periodizacija zabluda, a ne prekretnica u treningu.

**Ključne riječi:** blok periodizacija, teorija sportskog treninga, vrhunski sportisti, sportska forma.



The theory of sports training gradually evolved on the basis of practical experience which has rapidly accumulated since the revival of the Olympic Games. Over the years sport increasingly gained social significance, particularly after the Second World War. The achieved results were not only the measure of human capabilities, but also a means of promoting socio-economic systems, including the system of preparing athletes for the most important competitions. Initially, the preparation system was largely dependent on seasonal and climatic conditions, the season of the year and calendar events. Thereby, during the 60s people began to talk about the problem of periodization of athletic training as an important segment of the theory and practice of athletic training.

The division into periods is not new, because people have always done it in every activity, but the periodization of athletic training during the year, in order to achieve the best results at the time of a competition, was a relatively new idea. Firstly, it was thought that periodization depends on seasonal and climatic conditions, and the events calendar. However, the wider and more comprehensive analysis of the competitive reality led to serious theoretical assumptions, even to the level of the theory of periodization which Матвеев (1964, 1977) established and scientifically explained, relying on numerous predecessors. He proved that regularities of the development of sports fitness are the basis of periodization, and that periodization in fact represents the management of the process.

Matveyev became such an authority in that area that his name became synonymous with the periodization theory of athletic training. That is why in many works that deal with the problem of periodization, this theory is often referred to as the "Matveyev's theory". Since it has lasted for almost half a century as current theory, it is now referred to as the "traditional periodization theory" or "traditional Matveyev's periodization theory".

First serious criticism of this theory appeared around 1990 and exploded in the last years of the last century. The highest authorities in this field were involved in a major controversy in the most important magazine in Russia (*Теория и практика физической культуры* - Journal of Theory and Practice of Physical Culture). Some authors sharply attacked the basic assumptions of current theory, while the others vigorously defended them. Certainly the biggest critic and the biggest name among the opponents was J. V. Verhoshansky. He and several of his supporters expressed a number of critical views to the account of the Matveyev's theory. The question of periodization during the year was raised within the criticism of the entire theoretical basis of the current theory of sports training. In contrast to classical periodization, the so-called "block periodization" was suggested,

Teorija sportskog treninga je nastajala postepeno na osnovu praktičnog iskustva koje se ubrzano nagomilavalo od kada su obnovljene Olimpijske igre. Sport je sa godinama dobijao na svom društvenom značaju, naročito poslije Drugog svjetskog rata. Postignuti rezultati su bili ne samo mjerilo mogućnosti čovjeka, već i sredstvo promocije društveno-ekonomskih sistema, pa i sistema pripreme sportista za najvažnija takmičenja. Sistem pripreme je, u početku, u velikoj mjeri zavisio od sezonsko-klimatskih uslova, od godišnjeg doba i kalendara takmičenja. U vezi sa tim, 60-tih godina počelo se govoriti o problemu periodizacije sportskog treninga, kao važnom segmentu teorije i prakse sportskog treninga.

Podjela na periode nije ništa novo, jer su ljudi u svakoj aktivnosti to oduvijek činili, ali je periodizacija sportskog treninga tokom godine, sa ciljem da se postignu najbolji rezultati u vrijeme takmičenja bila relativno nova ideja. U početku se smatralo da periodizacija zavisi od sezonsko-klimatskih uslova i kalendara takmičenja. Međutim, sve obimnije i sadržajnije analize takmičarske stvarnosti dovele su do ozbiljnih teorijskih postavki, pa i do nivoa teorije periodizacije koju je, oslanjajući se na brojne prethodnike, formirao i naučno objasnio Матвеев (1964, 1977). On je dokazao da osnovu periodizacije čine zakonomjernosti procesa razvoja sportske forme i da periodizacija u suštini predstavlja upravljanje tim procesom.

Matveyev je u toj oblasti postao takav autoritet da je njegovo ime postalo sinonim za teoriju periodizacije sportskog treninga. Zato se u brojnim radovima, koji se bave problemom periodizacije, ova teorija često naziva "teorija Matvejeva". S obzirom da ona kao aktuelna teorija traje skoro pola vijeka, sve češće se označava kao "tradicionalna teorija periodizacije" ili "tradicionalna teorija periodizacije Matvejeva".

Prve ozbiljnije kritike ove teorije pojavile su se oko 1990. godine i razbuktale poslednjih godina prošlog vijeka. U najvažnijem časopisu u Rusiji (*Теория и практика физической культуры*) vođena je velika polemika između najvećih autoriteta u ovoj oblasti. Neki autori su oštro napali osnovne postavke važeće teorije, dok su ih drugi autori energično branili. Svakako najveći kritičar i najveće ime među protivnicima bio je J. V. Verhošanski. On i nekoliko njegovih istomišljenika iznijeli su niz kritičkih stavova na račun teorije Matvejeva. U okviru kritike cjelokupne teorijske osnove važeće teorije sportskog treninga postavilo se pitanje periodizacije u toku godine. Nasuprot klasičnoj periodizaciji predložena je tzv. "blok periodizacija", koja je kao ideja nastala između 1970. i 1980. godine, a kasnije

which originated as an idea between 1970 and 1980 and was later increasingly promoted in the works of Verhoshansky and his followers. "Block system - it's a non-traditional form of organization of the training process in the annual cycle, designed exclusively for top athletes, in amateur as well as in professional sports." (Верхошанский, 2005). This idea was most fully developed in the book of V. Issurin (2008) written in English under the title "BLOCK PERIODIZATION: A BREAKTHROUGH IN SPORTS TRAINING". The book has been translated into several languages, and also appeared in Serbian translation (Issurin, 2009).

What do supporters of the new block periodization object to the traditional theory of sports training and where do they see the advantage of the new approach that they propose regarding the preparation of athletes?

First, it should be noted that block periodization does not deny a traditional periodization values. Issurin (2009) points out: "The traditional approach is still suitable for standard athletes, but not for top ones", so all complaints to Matveyev's theory apply only to this segment of sport.

The opponents reduced main reasons why the traditional periodization of athletic training is unsustainable in the training of top athletes, to the following:

- the number of competitions and sports results dramatically increased during the previous decade;
- total volume of training has been significantly reduced;
- new concepts appeared that influence the planning and design of alternative periodization of training.

Classical periodization has many flaws which include (Issurin, 2009):

- limitations caused by simultaneous development of many motor and technical abilities;
- inability to provide preparation for the main competitions, and successful participation in numerous competitions;
- too long periods of basic preparation and preparation for a particular sport.

In the extensive work which explains the need to apply block periodization in practice, Верхошанский (2005) points out that the earlier analysis of the preparations of Soviet athletes revealed a number of shortcomings and negative tendencies. Everything is conditioned by "[...] low scientific, theoretical and methodological level of the used concept of training periodization." During the work with top athletes mistakes were made in the following:

- in the annual cycle the loads of different directions were used chaotically and distributed relatively evenly;

sve je više promovisana u radovima Verhošanskog i njegovih sljedbenika. "Blok sistem – to je netradicionalni oblik organizacije trenažnog procesa u godišnjem ciklusu, predviđen isključivo za vrhunske sportiste, kako u amaterskom, tako i u profesionalnom sportu" (Верхошанский, 2005). Ova ideja najcjelovitije je razrađena u knjizi V. Issurina (2008) na engleskom jeziku pod nazivom "BLOCK PERIODIZATION: BREAKTHROUGH IN SPORTS TRAINING". Knjiga je prevedena na više jezika, a pojavila se i u prevodu na srpski jezik (Issurin, 2009).

Šta pobornici nove, blok periodizacije, zamjeraju tradicionalnoj teoriji sportskog treninga i u čemu vide prednost novog pristupa koji predlažu u pripremi sportista?

Prvo treba istaći da blok periodizacija ne negira u potpunosti vrijednosti tradicionalne periodizacije. Issurin (2009) ističe: "Tradicionalni pristup je i dalje pogodan za standardne, ali ne i za vrhunske sportiste", pa se sve primjedbe upućene teoriji Matvejeva odnose samo na ovaj segment sporta.

Osnovne razloge zbog kojih je tradicionalna periodizacija sportskog treninga neodrživa u treningu vrhunskih sportista, oponenti svode na sledeće:

- poslednjih decenija dramatično je povećan broj takmičenja i povećani su sportski rezultati;
- znatno je smanjen ukupan obim trenažnog rada;
- pojavili su se novi pojmovi koji utiču na planiranje i kreiranje alternativne periodizacije treninga.

Klasična periodizacija ima niz nedostataka koji obuhvataju (Issurin, 2009):

- ograničenja nastala istovremenim razvojem brojnih motoričkih i tehničkih sposobnosti;
- nemogućnost obezbeđivanja pripreme za više glavnih takmičenja, odnosno uspešnog učešća na mnogim takmičenjima;
- preduge periode osnovne pripreme i pripreme za određeni sport.

U obimnom radu u kome detaljno obrazlaže potrebu da se u praksi primjeni blok periodizacija, Верхошанский (2005) ukazuje da su ranije analize priprema sovjetskih sportista otkrile niz nedostataka i negativnih tendencija. Sve je uslovljeno "[...] niskim naučno-teorijskim i metodičkim nivoom korišćene koncepcije periodizacije treninga". U radu sa vrhunskim sportistima griješilo se u sledećem:

- u godišnjem ciklusu haotično su se koristila i relativno ravnomjerno raspoređivala opterećenja različite usmjerenosti;

- exercises with a load were mainly used in an unspecialized way and unsystematically for the development of power and as an additional tool for solving the main tasks of training;
- in the microcycle the means with very high volume were unjustifiably used, which unsettled the synthesis of proteins that is an essential component of adaptation;
- a general tendency to increase the summary volume of loads has become a goal in itself.

"All of these tendencies had the same cause - a complex parallel form of organization of training loads [...]" and in practice coaches were led by the slogan: "If you want to beat the opponent - you should train more than him" (Верхошанский, 2005).

Issurin (2009) states that »In contrast to the traditional model, the concept of block periodization is characterized by the following advantages:

- total volume of training can be significantly reduced, thereby also reducing the risk of athletes overtraining;
- training plan that provides more maximal competition performances provides and also facilitates successful participation in numerous competitions throughout the season;
- monitoring and control of the preparedness can be effective because every drastic decrease in the ability of an athlete can be evaluated in every mesocycle;
- nutrition and recovery program of athletes can be adequately changed depending on the prevailing type of training, and
- annual plan that includes multiple phases of training provides more favourable conditions for achieving maximum results during the main competition in a season."

If we acknowledged the great writer Borges' thought that a book that does not have a counter-book is considered to be incomplete, perhaps it could be said for every theory as well. Therefore the authors who invented block periodization and critically reviewed the classical theory of periodization should be honoured. It is primarily Verhoshansky whose criticism sparked numerous authors to discuss the problem of periodization in a significant journal, *Теория и практика физической культуры* (Journal of Theory and Practice of Physical Culture - Moscow). However, everyone who criticized the classical theory of periodization may be objected for several omissions that did not escape the authors who stood in defence of the classical theory:

1. The term "blok" is very problematic when you put it in line with other terms that have long been in use: cycle, period, stage or phase. A cycle

- vježbe sa teretom su se uglavnom koristile nespecijalizovano i nesistematično za razvoj sile i kao dodatno sredstvo za rješavanje glavnih zadataka treninga;
- u mikrociklusu su neopravdano korišćena sredstva sa izrazito velikim obimom, što je narušavalo sintezu bjelančevina koja je osnovna komponenta adaptacije;
- opšta tendencija da se poveća sumarni obim opterećenja postala je sama sebi cilj.

"Sve te tendencije su imale isti uzrok – kompleksno-paralelnu formu organizacije trenažnih opterećenja [...]", a treneri su se u praksi rukovodili parolom: "Ako hoćeš da pobijediš protivnika – treba da treniraš više od njega" (Верхошанский, 2005).

Issurin (2009) navodi da "Nasuprot tradicionalnom modelu, pojam blok periodizacije karakterišu sledeće prednosti:

- ukupan obim trenažnog rada može se znatno smanjiti, čime se takođe smanjuje rizik od nastanka pretreniranosti sportiste;
- trenažni plan koji predviđa više maksimalnih takmičarskih nastupa omogućava i ujedno olakšava uspješno učešće na brojnim takmičenjima tokom čitave sezone;
- praćenje i kontrola pripremljenosti mogu biti efikasni jer se svako drastično smanjenje neke od sposobnosti sportiste može procijeniti u svakom mezociklusu;
- ishrana i program oporavka sportiste mogu se adekvatno mijenjati u zavisnosti od preovlađujućeg tipa treninga, i
- godišnji plan koji obuhvata više trenažnih faza omogućava povoljnije uslove za ostvarenje maksimalnih postignuća u vrijeme glavnog takmičenja u sezoni."

Ako bi uvažili misao velikog pisca Borhesa da knjiga koja nema protivknjigu smatra se nekompletnom, možda bi to mogli reći i za svaku teoriju. Zato autorima koji su izmislili blok periodizaciju i kritički se osvrnuli na klasičnu teoriju periodizacije, treba odati priznanje. To je prije svega Verhošanski čija je kritika izazvala brojne autore da o problemu periodizacije polemišu u značajnom časopisu, *Теория и практика физической культуры* (Moskva). Ipak, svima koji su kritikovali klasičnu teoriju periodizacije može se zamjeriti zbog više propusta koji nisu promakli autorima koji su stali u odbranu klasične teorije:

1. Termin "blok" je veoma problematičan kada se stavi u ravan sa drugim terminima koji su već duže u upotrebi: ciklus, period, etapa ili faza.

makes one designed, constructed and complete working unit with all the interrelated processes in it. A period of time is limited unit in a season in which the emphasis is on improving some process, while a stage and a phase are parts of the process. These terms reflect the essence of the competition process and of the preparation of athletes throughout the season. The term "block" is not a term related to time and it cannot mark the period in which a competition or training process takes place. Rather, it can be used to mark some small unit, a structural element of the whole. Without looking deeper into the essence of the idea, it can be concluded that in this case there is a fundamental inconsistency between the terms "block periodization" and its scientific definition – the term (Koprivica & Ćosić, 2011).

2. By criticizing classical theory of periodization, Verhoshansky and Issurin rarely quote Matveyev and analyze his theories, but they rather freely interpret them. This is evident in the book by Issurin (2009) when he gives the postulates of classical periodization in the table entitled "General characteristics of training periodization according to the traditional approach" (Матвеев, 1981), but the reference list does not contain this work. In addition, Issurin presents graphs of annual cycle, with one, two and three macrocycles which Matveyev published in distant 1977 based on the study of the sports practice of the time of a large number of athletes. In his most significant and most comprehensive article on the problem of classical and block periodization Верхошанский (2005) uses 107 bibliographic units (out of which 71 are self-citations), and neither of them is by Matveyev. A list of references for the third chapter of the book by Issurin (2009) best illustrates to what extent a subjective approach is expressed in considering the issue of periodization. While presenting problems of microcycle, mesocycle and individual trainings he does not mention Matveyev at any point, not even in the list of references. This is not only a major methodological error, because a polemics and drawing parallels between the two concepts are in question, but it is also an injustice to the author who was the first to scientifically explain the structure of training and who is quoted without exception by all authors in the field.
3. Verhoshansky and Issurin exclusively refer to the works of their like-minded authors and are silent about the works of many authors who are on opposite positions. It is unacceptable to

Ciklus čini jednu osmišljenu, izgrađenu i zaokruženu radnu cjelinu sa svim, u njoj međusobno povezanim, procesima. Period je vremenski ograničena cjelina u sezoni u kojoj je akcenat na usavršavanju nekog procesa, dok je etapa i faza dio tog procesa. Ovi termini odražavaju suštinu procesa takmičenja i pripreme sportista tokom sezone. Termin "blok" nije termin vezan za vrijeme i njime se ne može označiti vremenski period u kome se odvija neki takmičarski ili trenažni proces. On se prije može koristiti za obeležavanje neke male cjeline, nekog konstruktivnog elementa cjeline. Ne zalazeći dublje u suštinu te ideje, može se konstatovati da u ovom slučaju postoji osnovna nelogičnost između termina "blok periodizacija" i njegovog misaonog određenja – pojma (Koprivica i Ćosić, 2011).

2. Kritikujući klasičnu teoriju periodizacije, Verhošanski i Isurin, vrlo rijetko citiraju Matvejeva i ne analiziraju njegove teorijske postavke, već ih slobodno tumače. To je očigledno u knjizi Issurina (2009) kada postulate klasične periodizacije daje u tabeli pod nazivom "Opšte karakteristike periodizacije treninga prema tradicionalnom pristupu" (Матвеев, 1981), ali u literaturi nema tog rada. Pored toga, Issurin izlaže grafikone godišnjeg ciklusa sa jednim, sa dva i sa tri makrociklusa koje je Matveyev objavio daleke 1977. godine na osnovu izučavanja tadašnje sportske prakse većeg broja sportista. Верхошанский (2005) u svom najznačajnijem i najobuhvatnijem članku o problemu klasične i blok periodizacije, koristi 107 bibliografskih jedinica (od čega je 71 autocitat), a ni jedna od njih nije Matvejeva. Do koje mjere je izražen subjektivni pristup u razmatranju problematike periodizacije, najbolje ilustruje popis literature za treće poglavlje knjige Issurina (2009). Iznoseći problematiku mikrociklusa, mezociklusa i pojedinačnih treninga on ni na jednom mjestu ne pominje Matvejeva, čak ni u popisu literature. Ovo nije samo krupna metodološka greška, jer je riječ o polemici i povlačenju paralele između dva koncepta, već i nepravda prema autoru koji je prvi naučno objasnio strukturu treninga i koga u ovoj oblasti svi neizostavno citiraju.
3. Verhošanski i Isurin se isključivo pozivaju na radove svojih istomišljenika, a prećutkuju radove više autora koji su na suprotnim pozicijama. Neprihvatljivo je da u potpunosti ignorišu značajne radove vodećeg svetskog autoriteta u oblasti

- completely ignore the important works of the leading world authority in the field of sports training theories, Платонов (1998, 2008, 2009), who vigorously confronted block periodization.
4. Major omission of the proponents of block periodization is that their critique is based on older works of Matveyev, and they did not talk about everything that he later added and changed (Матвеев, 1998, 1999, 2001) in accordance with the significant changes in the world of sports.
  5. The difference between Matveyev and his opponents may best be seen in the criticism of one of the few quotations which Верхошанский (1998) states. Verhoshansky accuses Matveyev that he does not hide the negative attitude towards biological knowledge "because he claims that the macrostructure of training is not determined by biological laws, but it is determined on the whole (emphasised V. K.) by the laws which rule the sports fitness". Basically Matveyev does not deny the role of biological laws, but these laws are not the only ones, and are not independent from others, which affect the management of sport shape. Unlike Verhoshansky, Matveyev has a holistic approach in every work that is necessary every time a complex bio-psycho-social nature of man is in question.
  6. It is interesting that in practice failures are attributed to the classical theory of periodization without analysis to show the way the classical theory was actually used (Верхошанский, 2005). Great width, which, in basic principles, the Matveyev's theory has for various and not always predictable situations in practice, shows that its practical implementation has to be creative (Платонов, 2009).
  7. Matveyev was objected about mechanical sorting and linking individual training in the greater whole – microcycles which further build mesocycles and macrocycles. This objection is not justified because it is the exact opposite of the basic idea of periodization. Matveyev himself believes that training structure cannot be determined in advance. The right structure can be seen and analyzed only after the training and competition period is completed. Various structural parts must exist, because there are various influential factors. Strain and rest are regulated in microcycle, a cumulative effect of physical training is controlled in mesocycle, and sport shape is managed in macrocycle. Top sport shape, the greatest cumulative effect and rested athlete in the phase of the supercompensation of the most important skills, should all exist in the time of the most important competition.
- teorije sportskog treninga, Платонов-а (1998, 2008, 2009) koji se energično suprotstavio blok periodizaciji.
4. Veliki propust zagovornika blok periodizacije je što su svoju kritiku bazirali na starijim radovima Matvejeva, a prećutali sve ono što je on kasnije dopunio i izmjenio (Матвеев, 1998, 1999, 2001) u skladu sa značajnim promenama u svijetu sporta.
  5. Razlika između Matvejeva i njegovih oponentata najbolje se može vidjeti u kritici jednog od retkih citata koje navodi Верхошанский (1998). Verhošanski optužuje Matvejeva da ne krije negativan odnos prema biološkom znanju "jer tvrdi da biološke zakonitosti ne opredjeljuju makrostrukturu treninga, već je opredjeljuju u cjelini (podvukao V. K.) zakoni, po kojima se upravlja sportskom formom". U suštini Matvejev ne negira ulogu bioloških zakonitosti, ali te zakonitosti nisu jedine i nisu nezavisne od ostalih koje utiču na upravljanje sportskom formom. Za razliku od Verhošanskog, Matvejev u svakom svom djelu ima holistički pristup, neophodan uvijek kada se radi o složenoj bio-psiho-socijalnoj prirodi čovjeka.
  6. Interesantno je da se neuspjesi u praksi pripisuju klasičnoj teoriji periodizacije, bez analize koja bi pokazala kako je klasična teorija realno korišćena (Верхошанский, 2005). Velika širina, koju za raznovrsne i ne uvijek predvidive situacije u praksi, u osnovnim postavkama ima teorija Matvejeva, pokazuje da njena praktična primjena mora biti stvaralačka (Платонов, 2009).
  7. Matvejevu se prigovara mehaničko ređanje i povezivanje pojedinačnih treninga u veće cjeline – mikrocikluse koji dalje grade mezocikluse i makrocikluse. Ta primjedba nije opravdana jer je to potpuno suprotno osnovnoj ideji periodizacije. Upravo Matvejev smatra da strukturu treninga nije moguće unaprijed odrediti. Prava struktura se može vidjeti i analizirati tek kada se završi neki period treninga i takmičenja. Različite strukturne cjeline moraju postojati, jer su različiti i faktori koji ih uslovljavaju. U mikrociklusu se reguliše napor i odmor, u mezociklusu se upravlja kumulativnim trenažnim efektom, a u makrociklusu se upravlja sportskom formom. Vrh sportske forme, najveći kumulativni efekat i odmoran sportista u fazi superkompencacije najvažnijih sposobnosti, moraju biti u vrijeme najvažnijeg takmičenja. Osnovni smisao periodizacije je da

The main purpose of periodization is to achieve the best result in the most important competition of the season. Therefore, the classical theory of periodization seeks long-term, gradual and non forcing preparation for the important competition, which includes a series of preliminary competitions. Probability to succeed in the most important competition, if the classic periodization method is applied, is about 60-75%, while the practice has shown that the application of a block periodization lowers the probability to just 5-15% (Платонов, 2009). The commercialization of sports has a significant impact on the competition calendar and spread it to the extent that it is no longer rational (Koprivica, 2009). Selecting the most important competitions and preparing for them according to the classic periodization is more and more becoming a factor of sports longevity. Thus, block periodization does not correspond to the top sports with more sporting competitions in the season in which several of them are primary. If an athlete, according to block periodization, participates in all competitions in order to achieve maximum results, then his career cannot last long.

8. There is an obvious contradiction in some basic settings of block periodization. If it applies only to the top athletes and to the need to apply more training blocks in which only selected skills are developed and if it is necessary to participate successfully in a greater number of competitions throughout the year, how is that possible in a situation where competition period lasts for 10 months and the preparatory period is significantly shortened (Koprivica, 2009a, 2009b; Koprivica & Jankovic, 2010). Not only is there no time to implement block periodization, but it is impossible to develop and maintain a high level of all abilities and skills, harmonize them and bring them to such a level that it allows athletes to be successful over the long season of competition. Thus, block periodization does not create conditions for individual maximums and disturbs harmonization of more abilities and skills.
9. Block periodization mainly deals with large mesocyclic blocks that are "true embodiment of a block periodization concept" (Issurin, 2009). They have three different effects: accumulation, transformation and realization (Ibid). Compared to traditional periodization, to classical medium size structural parts (mesocycles), it is nothing new, because it is based on what is already known and scientifically explained in the training theo-

se postigne najbolji rezultat na najvažnijem takmičenju u sezoni. Zato klasična teorija periodizacije traži dugotrajnu, postepenu i neforsiranu pripremu za važno takmičenje koja obuhvata niz takmičenja pripremnog karaktera. Vjerovatnoća da se uspije na najvažnijem takmičenju, ako se primjeni ovakav način rada po klasičnoj periodizaciji je oko 60-75%, dok je praksa pokazala da primjenom blok periodizacije verovatnoća pada na svega 5-15% (Платонов, 2009). Komercijalizacija sporta je značajno uticala na kalendar takmičenja i proširila ga do mjere koja više nije racionalna (Koprivica, 2009). Odabir najvažnijih takmičenja i priprema za njih po klasičnoj periodizaciji postaje sve više faktor sportske dugovječnosti. Prema tome, blok periodizacija ne odgovara vrhunskom sportu sa više takmičenja u sezoni u kome je nekoliko njih primarno. Ako sportista po blok periodizaciji na svim takmičenjima učestvuje sa ciljem da ostvari maksimalan rezultat, onda njegova karijera ne može duže trajati.

8. Očigledna je kontradiktornost u nekim osnovnim postavkama blok periodizacije. Ako se ona odnosi isključivo na vrhunske sportiste, na potrebu da se primjeni više trenažnih blokova u kojima se razvijaju samo izabrane sposobnosti i ako je potrebno uspješno učestvovati na većem broju takmičenja tokom godine, kako je to moguće u situaciji kada takmičarski period traje i po 10 mjeseci i kada je pripremn period značajno skraćen (Koprivica, 2009a, 2009b; Koprivica & Janković, 2010). Ne samo da nema vremena za primjenu blok periodizacije, već je nemoguće razviti i održati na visokom nivou sve sposobnosti i vještine, međusobno ih uskladiti i dovesti na takav nivo koji omogućava sportisti da bude uspješan tokom duge sezone takmičenja. Prema tome, blok periodizacija ne stvara uslove za individualne maksimume i remeti međusobno usklađivanje više sposobnosti i vještina.
9. Blok periodizacija se uglavnom bavi velikim mezocikličnim blokovima koji su "pravo oличење pojma blok periodizacije" (Issurin, 2009). Oni imaju tri različita efekta: akumulaciju, transformaciju i realizaciju (Ibid). U odnosu na klasičnu periodizaciju, na klasične strukturne dijelove srednje veličine (mezocikluse), to nije novina, jer se zasniva na onome što je već poznato i naučno objašnjeno u teoriji treninga: rad sa povećanim opterećenjem u odnosu na ona na koja je sportista adaptiran

ry: working with the increased load in comparison to those on which the athlete is adapted - relativestabilization of the changes - cumulative effect of previous work.

10. A remark that classical theory recommends exercise which includes "a little bit of all" and simultaneous development of multiple skills is not substantiated. Although this remark is constantly emphasized, not a single author, supporter of a block periodization, specifies an appropriate quote neither from any of Matvejev's works nor from the works of other significant authors which relies on classical theory. It is true that classical theory recommends that all abilities must be treated in training, but with an emphasis on the particular ability in compliance with the specificities of the sport discipline, athlete's individual characteristics, climate and material and technical factors (Платонов, 2009). Especially, it should be adjusted to the position of training in the season and to major competitions. While some skills are developed, the others must be maintained at the required level. In a long competition period, a big problem is to maintain the level of competence, which means even less time for real development programs. Therefore, the preparation for the Olympic Games in the year when the Games are held is very specific (Koprivica, 2009b). Development of all abilities is practically not possible, because development means greater loads than those on which the athlete is adapted. Recovery from a great load training where athlete works on one ability lasts for at least 48 hours (Платонов, 1987, 2004). If they developed more skills (not even all of them!) simultaneously, it would mean implementation of more consecutive trainings with maximum and heavy loads. This contradicts to one of the basic principles of training, which Matvejev himself defined and explained - undulating load dynamics. Moreover it is not possible to realize such trainings because of the accumulated loads and insufficient time for athlete's recovery.
11. If, according to block periodization, a single ability development is implemented in a relatively long period of time, then the total volume of training must be reduced because the same orientation of training must leave more time for athlete's recovery. In addition, the accumulated fatigue increases the likelihood of injury, and the depletion of the same biological systems can be problematic from the standpoint of athlete's health. The solution is either to work in a complex microcycle, which the block periodization excludes, or to reduce the loads for recovery and

– relativna stabilizacija promjena – kumulativni efekat prethodnog rada.

10. Primjedba da klasična teorija preporučuje vježbanje "sve po malo" i istovremeni razvoj više sposobnosti nije argumentovana. Mada ovu primjedbu stalno potenciraju, ni jedan autor, pobornik blok periodizacije, ne navodi adekvatan citat iz bilo kod rada Matvejeva ili citat nekog drugog značajnog autora koji se oslanja na klasičnu teoriju. Istina je da klasična teorija preporučuje da se sve sposobnosti moraju tretirati u treningu, ali tako što se stavlja akcenat na određenu sposobnost u skladu sa specifičnostima sportske grane, individualnim karakteristikama sportiste, klimatskim i materijalno-tehničkim faktorima (Платонов, 2009). Posebno to treba da bude usklađeno sa mjestom treninga u sezoni i glavnim takmičenjima. Dok se neke sposobnosti razvijaju, druge se moraju održavati na potrebnom nivou. U dugom takmičarskom periodu veliki je problem da se održi nivo sposobnosti, što znači da je još manje vremena za prave razvojne programe. Zbog toga je priprema za Olimpijske igre u godini kada se igre održavaju, veoma specifična (Koprivica, 2009b). Razvoj svih sposobnosti praktično i nije moguć, jer razvoj podrazumijeva opterećenja veća od onih na koja je sportista navikao. Oporavak od treninga velikog opterećenja u kome se radi na jednoj sposobnosti traje najmanje 48 sati (Платонов, 1987, 2004). Ako bi razvijali više sposobnosti (čak ne sve!) istovremeno, to bi značilo uzastopnu primjenu više treninga sa maksimalnim i velikim opterećenjem. To protivrječi jednoj od osnovnih zakonitosti treninga koju je upravo Matvejev definisao i objasnio – valovitosti dinamike opterećenja. Osim toga i nije moguće realizovati takve treninge zbog nagomilanog opterećenja i nedovoljnog vremena za oporavak sportiste.
11. Ako se po blok periodizaciji primjeni razvoj samo jedne sposobnosti u relativno dužem periodu, onda se ukupni obim treninga mora smanjiti jer se zbog iste usmjerenosti treninga mora ostaviti više vremena za oporavak sportiste. Pored toga, zbog akumuliranog zamora, povećava se vjerovatnoća da se sportista povrijedi, a iscrpljivanje istih bioloških sistema može biti problematično sa stanovišta zdravlja sportiste. Rješenje je ili u kompleksnom radu u mikrociklusu, što blok periodizacija isključuje, ili smanjenje opterećenja radi oporavka i mirenje sa tim da se

reconcile with the fact that some tasks of training will not be done.

12. Block periodization is also based on the so-called residual effect of training (Иссурин & Шкляр, 2002). By some authors stated by Issurin (2009) abilities are maintained for a certain period of time (from 5 to 35 days) after the termination of exercise and that time is not the

neki zadaci treninga neće riješiti.

12. Blok periodizacija je zasnovana i na tzv. Rezidualnom trenažnom efektu (Иссурин и Шкляр, 2002). По неким ауторима које наводи Issurin (2009) способности се одржавају одређено вријеме (од 5 до 35 дана) након престанка вјежбања и то вријеме није исто за све моторичке способности

### FIGURE 1

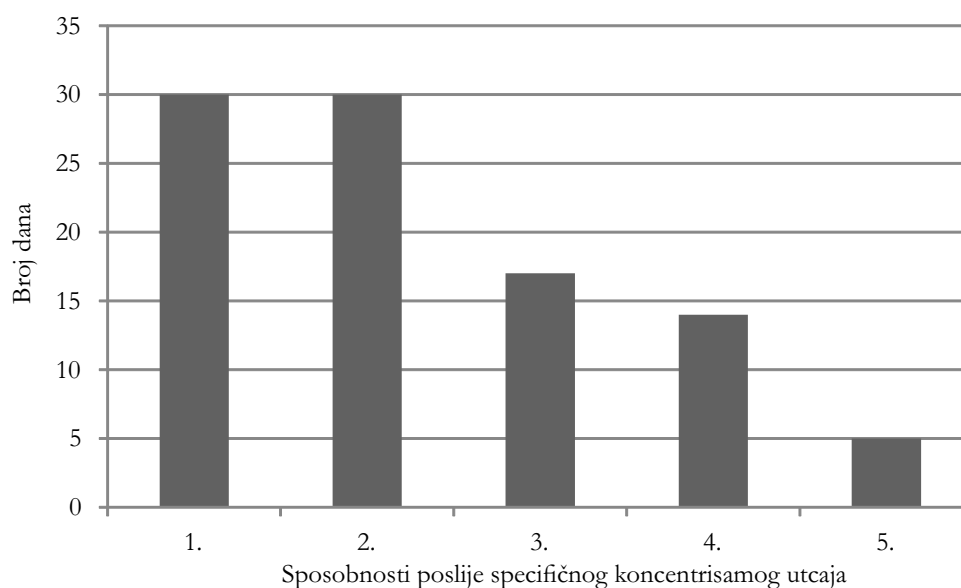
*Residual training effects of different abilities after specific concentrated impact*

*(Source: Иссурин & Шкляр, 2002)*

### SLIKA 1

*Rezidualni trenažni efekti različitih sposobnosti posle specifičnog koncentrisanog uticaja*

*(Izvor: Иссурин и Шкляр, 2002)*



Legend: **1.** - Aerobic endurance (Aerobna izdržljivost); **2.** - Maximum force (Maksimalna sila); **3.** - Anaerobic endurance (Anaerobna izdržljivost); **4.** - Strength endurance (Izdržljivost u snazi); **5.** - Alactate ability (Alaktatna sposobnost); Number of days - Broj dana; Abilities after specific concentrated impact - Sposobnosti poslije specifičnog koncentrisanog uticaja.

same for all motor abilities (Figure 1). This setting is very problematic, as some other studies (Hargreaves, 1995; Wilmore & Costill, 2004; and others, cited in Платонов, 2009) showed that after the termination of work, after 1-2 weeks, the activity of oxidative and glycolytic enzymes reduces; local muscular endurance reduces, and quickly gained abilities are quickly lost. Biological systems, previously highly adapted due to inactivity, are now subject to the process of deadaptation. Surely those abilities are not reduced at once (for example, on the twentieth day), but it is a gradual and differentiated process (Бовк, 2007, 2009). Disruption on a level of one ability (increase or decrease) changes compliance and relationships of vari-

(Slika 1). Ova postavka je veoma problematična, jer su neka druga istraživanja (Hargreaves, 1995; Wilmore i Costill, 2004; i drugi, citirano u Платонов, 2009) pokazala da se po prestanku rada već posle 1-2 nedjelje smanjuje aktivnost oksidativnih i glikolitičkih fermenata; smanjuje lokalna mišićna izdržljivost, a brzo stečene sposobnosti brzo se i gube. Biološki sistemi ranije visoko adaptirani zbog neaktivnosti su odmah podložni procesu deadaptacije. Sigurno je da se sposobnosti ne smanjuju odjednom (na primjer, dvadesetog dana), već se to odvija postepeno i diferencirano (Бовк, 2007, 2009). Poremećaj nivoa jedne sposobnosti (povećanje ili smanjenje) mijenja usklađenost i odnose različitih motoričkih sposobnosti, naročito onih



ous motor abilities, especially those that are highly correlated. This can affect, not only positively, but negatively as well, other abilities and the level of technical and tactical skills.

13. Although block periodization predicts different approaches for relatively simpler and more complex sport disciplines according to the structure of competitive activities, extensive calendar of competitions during nearly a whole year makes the practical application more difficult. While the use of some type of "blocks" is to some extent possible in cyclic sport disciplines with longer preparation period, in more complex sport disciplines (e.g. sports games, martial arts disciplines) it is not possible.

## CONCLUSION

Every theory, including the theory of sports training, must be constantly reviewed in accordance with the dynamic changes in competition and the preparation of athletes. The emergence of the so-called block periodization temporarily shook the traditional theory of training in the segment of periodization. Criticism of classical periodization is not well founded methodologically and does not match the level of scientific debate about the problem (references to old bibliographic sources, the sources in favour of block periodization, concealing everything that contradicts block periodization, deliberate misinterpretations...) and from the standpoint of science may be rejected due to subjectivism. New periodization ideas are not based on scientific facts and their application in practice is not possible if one wants to achieve a great result at the right time in the most important competition, which is the basic idea of periodization according to classical theory. Thus, block periodization is rather a misconception than a breakthrough in sports training.

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koji su velikoj međusobnoj korelaciji. To može uticati ne samo pozitivno, već i negativno na druge sposobnosti i nivo tehničko-taktičkih veština.

13. Mada se u blok periodizaciji predviđaju različiti pristupi za, po strukturi takmičarske aktivnosti, relativno jednostavnije i složenije sportske grane, primjenu u praksi otežava obiman takmičarski kalendar tokom skoro čitave godine. Dok je primjena neke vrste "blokova" donekle i moguća u cikličnim sportskim granama sa dužim pripremnim periodom, kod složenijih sportskih grana (npr. sportske igre, borilačke sportske grane) to nije moguće.

## ZAKLJUČAK

Svaka teorija, pa i teorija sportskog treninga, mora se stalno preispitivati u skladu sa dinamičnim promjenama u takmičenju i pripremi sportista. Pojava tzv. blok periodizacije privremeno je uzdrmala tradicionalnu teoriju treninga u segmentu periodizacije. Kritika klasične periodizacije nije dobro metodološki zasnovana i ne odgovara naučnom nivou rasprave o problemu (pozivanje na stare bibliografske izvore, na izvore koji idu u prilog blok periodizaciji, prećutkivanje svega što protivrjuje blok periodizaciji, namjerne pogrešne interpretacije...) i sa stanovišta nauke može se odbaciti zbog subjektivizma. Ideje nove periodizacije nisu zasnovane na naučnim činjenicama i njihova primjena u praksi nije moguća ukoliko se želi postići vrhunski rezultat u pravo vrijeme, na najvažnijem takmičenju, što je osnovna ideja periodizacije po klasičnoj teoriji. Prema tome, blok periodizacija je prije zabluda nego prekretnica u sportskom treningu.

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## БЛОКОВАЯ ПЕРИОДИЗАЦИЯ – ПЕРЕВОРОТ В ТРЕНИРОВОЧНОМ ПРОЦЕССЕ ИЛИ ЗАБЛУЖДЕНИЕ

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Опираясь на многочисленных предшественников, теорию периодизации тренировочного процесса создал и научно обосновал Л. П. Матвеев (1964, 1977). Он доказал, что в основе периодизации лежат закономерности процесса развития спортивной формы, и, что периодизация, по сути, является управлением этим процессом. Матвеев в этой области стал таким авторитетом, что его имя стало синонимом теории периодизации тренировочного процесса. Поэтому во многих публикациях, которые посвящены проблеме периодизации, эта теория часто называется "теория Матвеева", "традиционная теория периодизации" или "традиционная теория периодизации Матвеева".

Первая серьезная критика этой теории появилась примерно в 1990 году. В противовес классической периодизации была предложена так называемая "блоковая периодизация".

Классическая периодизация имеет ряд недостатков, в том числе (Иссурин, 2009):

- ограничения, возникшие в результате одновременного развития множества моторных и технических способностей;
- невозможность обеспечения подготовки ко многим главным соревнованиям, т.е., успешного участия во многих соревнованиях;
- слишком длинные периоды ОФП и подготовки по определенному виду спорта.

Иссурин (2009) считает, что "[...] в противовес традиционной модели понятие блоковой периодизации характеризуется следующими преимуществами:

1. общий объем тренировочной работы может быть существенно снижен, что также снижает риск возникновения перетренированности спортсмена;
2. план тренировок, который предусматривает больше максимальных состязательных выступлений, дает возможность и одновременно облегчает успешное выступление на многочисленных соревнованиях в течение всего сезона;
3. наблюдение и контроль формы могут быть эффективными, поскольку любое резкое

ухудшение любого навыка спортсмена можно оценить в любом мезоцикле;

4. питание и программа восстановления спортсмена могут быть адекватно изменены в зависимости от преобладающего типа тренировок и
5. годовой план, включающий в себя несколько тренировочных фаз, создает более благоприятные условия для достижения максимальных результатов в момент главного состязания сезона".

Всем, кто критиковал классическую теорию периодизации, можно указать на ряд недостатков, на которые обратили внимание авторы, защищающие классическую теорию:

1. Термин "блок" весьма проблематичен, если сравнить его с терминами, употребляющимися уже довольно давно: цикл, период, этап или фаза. Не углубляясь далее в суть этой идеи, можно констатировать, что в данном случае наблюдается базовая логическая нестыковка между термином "блоковая периодизация" и его смыслового, содержательного определения – понятия (Копривица и Чосич, 2011).
2. Критикуя классическую теорию периодизации, Верхошанский и Иссурин очень редко цитируют Матвеева и не анализируют его теоретические положения, а свободно их интерпретируют. Верхошанский и Иссурин ссылаются на работы исключительно своих единомышленников и замалчивают работы многих авторов, занимающих противоположную позицию. Неприемлемо, что они полностью игнорируют важные труды ведущего мирового авторитета в области теории спортивных тренировок Платонова (1998, 2008, 2009), который энергично воспротивился блоковой периодизации.
3. Крупная ошибка сторонников блоковой периодизации состоит в том, что они в своей критике опирались на более старые работы Матвеева, и умолчали о том, что он позже изменил и дополнил (Матвеев, 1998, 1999, 2001) в свете существенных изменений, произошедших в мире спорта.

4. Верхошанский обвиняет Матвеева в том, что тот не скрывает своего отрицательного отношения к биологической науке. По сути дела, Матвеев не отрицает роли биологических закономерностей, но закономерности – это не единственное, и они находятся в зависимости от остальных, которые управляют спортивной формой. В отличие от Верхошанского, Матвеев в каждом своем труде придерживается холистического подхода, необходимого всегда, когда речь идет о комплексной био-психо-социальной природе человека.
5. Любопытно, что неудачи на практике приписывают классической теории периодизации, без анализа, который бы продемонстрировал, как классическая теория реально использовалась (Верхошанский, 2005).
6. Матвеева упрекают в механическом чередовании и связывании отдельных тренировок в более крупное целое – микроциклы, которые далее выстраиваются в мезоциклы и макроциклы. Это замечание неоправданно, так как оно полностью противоречит идее периодизации. Основным смыслом периодизации в том, чтобы достичь наилучшего результата на самых важных состязаниях сезона. Поэтому классическая теория периодизации требует длительной, постепенной и нефорсированной подготовки к важному соревнованию, что включает в себя и ряд соревнований подготовительного характера.
7. Очевидна и противоречивость в некоторых основных постулатах блоковой периодизации. Если она распространяется исключительно на спорт высоких достижений, то есть, имеется в виду необходимость использовать большое количество тренировочных блоков, когда развиваются только определенные навыки, и если необходимо успешное участие в большом количестве состязаний в течение года, то, как это возможно в ситуации, когда соревновательный период продолжается вплоть до 10 месяцев, и когда подготовительный период существенно сокращается (Копривица, 2009а, 2009б, Копривица и Янкович, 2010).
8. По сравнению с классической периодизацией, т.е. классическими структурными блоками средней продолжительности (мезоциклы) "блоки" не являются новацией.
9. Справедливо и то, что классическая теория рекомендует развивать все способности в тренировочном процессе, но так, чтобы акцентировать определенный навык.
10. Если, следуя блоковой периодизации, развивать только один навык в течение относительно длительного периода, то общий объем тренировок следует снизить. Из-за накопившегося утомления растет вероятность получения спортсменом травмы.
11. Блоковая периодизация опирается на так называемый остаточный тренировочный эффект, но это предположение весьма спорно, так как способности не снижаются вдруг, этот процесс протекает постепенно и дифференцированно.
12. Использование "блоков" в сложных спортивных дисциплинах (например, спортивные игры, борцовские виды спорта) практически невозможно.

## ЗАКЛЮЧЕНИЕ

Критика классической периодизации методологически недостаточно обоснована и не соответствует научному уровню дискуссии по проблеме (ссылки на устаревшие библиографические источники, на источники, защищающие блоковую периодизацию, замалчивание всего, что противоречит блоковой периодизации, намеренная некорректная интерпретация...), и с научных позиций может быть отклонена как субъективная. Идеи новой периодизации не опираются на научные факты, и их использование на практике невозможно, если мы желаем достичь максимального результата своевременно, на самых важных соревнованиях, что является основной идеей периодизации по классической теории. Поэтому блоковая периодизация – это, скорее, заблуждение, чем переворот в системе спортивных тренировок.

**Ключевые слова:** блок периодизация, теория спортивной тренировки, профессиональные спортсмены, спортивная форма.

## POREĐENJE ZNANJA I NAVIKA O ISHRANI IZMEĐU STUDENATA I NESTUDENATA SPORTISTA

### A COMPARISON OF NUTRITIONAL KNOWLEDGE AND FOOD HABITS OF COLLEGIATE AND NON-COLLEGIATE ATHLETES

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#### SUMMARY

Nutrition is an important component of any physical fitness program. The main dietary goal for active individuals is to obtain adequate nutrition to optimize health fitness and to increase sports performance. The purpose of this study was to compare nutritional knowledge and food habits in collegiate and non-collegiate athletes. The target population of this study was all male and female collegiate and non-collegiate athletes in Rasht city of Iran. After translate of the standard nutrition knowledge and attitudes survey questionnaire Zawila et al., and adjust of some questions, questionnaire was evaluated by Professors of faculty of physical education and sport sciences. The reliability guided Cronbach Alpha value of .81. A researcher-built questionnaire which was developed to measure subject's nutrition knowledge and habits, distributed to 130 collegiate and non-collegiate athletes males and 120 Collegiate and non-collegiate athletes females randomly. The questionnaire contained 15 nutrition knowledge questions and 25 nutrition habits questions. The collected data was analyzed by *t*-test, one-way ANOVA and Pearson correlation coefficient ( $p < .05$ ). The correct response rate for the sport nutrition and general nutrition score were in collegiate athletes male (57.15; 52.5%) and athletes female (58.14; 54.85%); non-collegiate athlete's males (41.55; 39.86%) and athletes female (42.11; 40.66 %) respectively. Also, mean nutrition scores in collegiate athlete's males and females were significantly higher than non-collegiate athletes male and females. Furthermore, there were significant differences in the total mean score questionnaire between collegiate and non-collegiate athletes ( $p < .05$ ). Based on the result of our study the knowledge of Iranian non-collegiate athletes were lower than collegiate athletes. For this reason, nutrition knowledge and attitudes of Iranian non-collegiate athletes need to improve. So, these suggest that nutrition lectures' courses are one of the solutions to increase knowledge about nutrition.

**Key words:** nutritional knowledge, attitudes, athletes.

#### SAŽETAK

Ishrana je važan dio svakog fitnes programa. Osnovni cilj dijetetike za fizički aktivne pojedince je da jedu odgovarajuću hranu kako bi poboljšali svoje zdravlje i povećali sportske vještine. Cilj ovog rada je da uporedi znanja o ishrani i prehrambene navike sportista studenata i nestudenata. Ciljana populacija ovog istraživanja bili su svi studenti nestudenti sportisti u gradu Rasht u Iranu. Nakon prevođenja upitnika Zawila i saradnika o uopštenim znanjima i stavovima o ishrani, i prilagođavanja pojedinih pitanja, upitnik je procijenjen od strane profesora Fakulteta fizičkog vapsitanja i sportskih nauka. Pouzdanost je iznosila 0,81 vrijednosti Cronbach alfe. Izrađeni istraživački upitnik, osmišljen za mjerenje znanja i navika o ishrani, podijeljen je nasumice 130 sportista i 120 sportiskinja studenata i nestudenata. Upitnik je sadržavao od 15 pitanja o znanjima i 25 pitanja o navikama iz ishrane. Prikupljeni podaci analizirali su se *t*-testom, jednosmjernom ANOVA i Pirsonovim testom korelacije ( $p < 0,05$ ). Stepenn ispravnih odgovora za sportski ishranu i opštu ishranu bio je u sportista (57,15; 52,50%) i sportiskinja (58,14; 54,85%) studenata, a kod nestudenata sportista (41,55; 39,86%) i sportistkinja (42,11; 40,66%). Takođe, aritmetičke sredine skorova ishrane kod sportista i sportiskinja studenata značajno su više nego kod sportista i sportiskinja nestudenata. Pred toga, značajne razlika je bila u ukupnom srednjem rezultatu upitnika između sportista studenata i nestudenata ( $p < 0,05$ ). Na osnovu rezultata našeg istraživanja ustanovili smo da su znanja irnaskih sportista nestudenata niža od znanja sportista studenata. Shodno tome treba raditi na tome da se znanja i stavovi o ishrani irnaskih sportista nestudenata poboljšaju. Jedno od rješenja za poboljšanje znanja o ishrani su kursevi.

**Ključne riječi:** znanja o ishrani, stavovi, sportisti.

## INTRODUCTION

The study of nutrition dates back to over 200 years; however, sports nutrition is relatively a new discipline involving the application of nutritional principles to enhance the athletic performance. Nutrition affects a sportsman in many ways. At the basic level, it plays an important role in achieving and maintaining health. Optimal nutrition can reduce fatigue, allowing an athlete to train and compete longer or recover faster between training sessions (Lin & Lee, 2005). Nutrition plays a very important role in attaining high level of achievements in sports. Nutritional status has a direct bearing on the level of physical performance. Hence, physical fitness and training are very much dependent on nutritional status of sports personnel (Beals & Manore, 1998). Nutrition is an important complement of any physical fitness program. The main dietary goal for active supplement information from nutritionists/dietitians and individuals is to obtain adequate nutrition to optimize health and fitness or sports performance (Ozdoğan & Ozcelik, 2011). It is well recognized that optimal nutrition can enhance athletic performance. However, numerous barriers can hinder college athletes from achieving optimal dietary practices, including a lack of time and space to prepare meals (in the confines of dormitories, apartments, or shared housing), insufficient financial resources, limited meal-planning and -preparation skills, and busy travel schedules (American College of Sports Medicine, 2000; Malinauskas et al., 2007). Studies show that individuals that have basic nutrition knowledge and attitude apply these principles when selecting foods and also indicated that Food faddism is one among many influencing factors on student food choices (Read & Schlenker, 1993). Therefore, improving nutrition knowledge, attitude and dietary practices through nutritional education may help to prevent or mitigate the aforementioned diseases (Chang, 1987; Frederick & Hawkins, 1992; Lissner & Heitmann, 1995). A college athlete is an appropriate target audience for nutrition education because their lives are in transition and have the potential for positive changes (Yueching & Yi-Chia, 1999). Several studies have reported that college students frequently have misconceptions about nutrition, fail to make nutrition a priority in food selection, and are poorly informed about dietary guidelines (Abood, Black, & Birnbaum, 2004; Jacobson, Sobonya, & Ransone, 2001; Mitchell, 1990).

However, Hassapidou, Fourtounopoulos, Efstratiou, Kitsou, and Papakitsos (2003) discovered, while studying Greek basketball players, that most of the knowledge and food habits given to athletes from

## UVOD

Studije o ishrani datiraju od prije 200 godina, ali sportska ishrana je ipak relativno novija disciplina koja obuhvata primjenu nutricionih principa ishrane za poboljšanje sportskih vještina. Ishrana ima uticaja na sportiste na mnogo načina. U osnovi, ona igra važnu ulogu u postizanju i održavanju zdravlja. Optimalna ishrana može da smanji zamor, omogućava sportisti da duže trenira i takmiči se i da se brže oporavlja od treninga (Lin i Lee, 2005). Ishrana igra veoma važnu ulogu u postizanju vrhunskih postignuća u sportu. Nutritivni status ima direktan uticaj na nivo fizičkog učinka. Drugim riječima, fizička kondicija i treniranost mnog zavise od nutritivnog statusa osoba koje se bave sportom (Beals i Manore, 1998). Ishrana je važan dodatak bilo kog kondicionog programa. Glavni dietetski cilj za dobijanje prave informacije od nutricionista/dijetetičara i pojedinaca je da se postigne adekvatna ishrana za optimizaciju zdravlja i kondicije ili sportskih performansi (Ozdoğan i Ozcelik, 2011). Dobro je poznato da optimalna ishrana poboljšava sportske rezultate. Ipak, brojne barijere mogu ometati studente sportiste u postizanju optimalne dijetetske prakse, uključujući nedostatak vremena i prostora za pripremu obroka (ograničenja domova, iznajmljenih stanova ili zajednički smještaj), nedovoljna finansijska sredstva, ograničene mogućnosti planiranja obroka, nedovoljna vještina spremanja hrane i prenatrpan raspored putovanja (American College of Sports Medicine, 2000; Malinauskas i saradnici, 2007). Istraživanja pokazuju da pojedinci koji imaju osnovna znanja i navike o ishrani primjenjuju te principe pri odabiru hrane i ukazuju da je gubitak težine jedan od mnogobrojnih faktora koji utiču na izbor hrane od strane studenata (Read i Schlenker, 1993). Dakle, poboljšanje znanja i stavova o ishrani i dijetetskoj praksi kroz nutritivno obrazovanje može da pomogne u prevenciji ili ublažavanju bolesti (Chang, 1987; Frederick i Hawkins, 1992; Lissner i Heitmann, 1995). Studenti sportisti su odgovorajući ciljani auditorijum za nutritivno obrazovanje jer su njihovi životi u procesu tranzicije i imaju mogućnost za pozitivne promjene (Yueching & Yi-Chia, 1999). Nekoliko istraživanja je pokazalo da studenti često imaju zablude o ishrani, ne uspijevaju nutritivne vrijednosti učiniti prioritetom u selekciji hrane i slabo su informisani o dijetetskim upustvima (Abood, Black i Birnbaum, 2004; Jacobson, Sobonya i Ransone, 2001; Mitchell, 1990).

Hassapidou, Fourtounopoulos, Efstratiou, Kitsou i Papakitsos (2003) su otkrili, dok su istraživali grčke košarkaše, da većina znanja i navika o ishrani prenesena

their coaches was inaccurate information. Therefore, it is important for that working with athlete's to find ways to educate athletes on accurate and helpful dietary advice (Wiita, Stombaugh, & Buch, 1995). In addition, research on the effects of nutrition education reported similar findings of improving an individual's knowledge and food habits and awareness, supporting the need for and the usefulness of nutrition education in increasing nutrition knowledge, self-efficacy, and positive change in perceptions about knowledge and food habits among a student (Kunkel, Bell, & Luccia, 2001; Paschoal, & Amancio 2004). Studies show that nutrition knowledge and attitudes have an effect on eating habits (Laurie, Zawila, & Steibt, 2003; Ruka, Toyama, Amamoto, Liu, & Shinfuku, 2005). Ruka et al. (2005) described, although 85.6% of students are aware of the concept of nutritionally balanced food, only a few numbers of students (7%) apply this concept when selecting food from a menu. Moreover, only 51% of students showed a desire to learn about healthy diets (Ibid). Jacobson et al. (2001) survey results indicated that only 3, 11.7 and 29.5% correctly identified recommended percents of total calorie intake for protein, fat and carbohydrates, respectively; 37% correctly identified the role of vitamins and 54.4% for protein. Studies have indicated that males (85%) and females (87%) advised young overweight adolescents to diet to lose weight; 20% of females and 13% of male regularly skipped breakfast. The advice given showed a lack of specific nutrition education about weight control, adolescent's nutritional needs, and fat diet (O'dea, & Abraham, 2001; Sakamaki, Toyama, Amamoto, Liu, & Shinfuku, 2005). Nutrition knowledge presumably influences attitudes and eating behavior (Rosenbloom, Jonnalagadda, & Skinner, 2002). There are many reasons why nutritional advice is not followed. It may be due to the lack of knowledge or information, and interest of making a change in one's diet, or certain perceived or encountered barriers that may prevent people from eating healthier diets such as the lack of money (cost), lack of time (too busy with work) or taste (Kearney & McElhone, 1999). Athletes may often rely on coaches for nutrition guidance in certain sports. Therefore, when coaches are misinformed about nutrition, this becomes a potential problem for athletes, as well (Cotugna, Vickery, & McBee, 2005). Nutrition training can be conveyed to the individuals through regular and wide educational programs as well as the individual training himself on his own settings (Yılmaz & Özkan, 2007).

Unfortunately, many of these sources are not suitable, and at times the information imparted is unreliable and only adds to the myths surrounding nutrition that may affect athletes' diet (Barr, 1987). But, education and its relationship with nutrition

sportistima od njihovih trenera nije bila tačna. Dakle, važno je da se prilikom rada sa sportistima pronađu načini da se oni edukuju tačnim i korisnim savjetima o ishrani (Wiita, Stombaugh i Buch, 1995). Pored toga, istraživanje o efektima edukacije u ishrani došlo je do sličnih zaključaka o poboljšanju individualnih znanja, navika i razvoju svijesti o ishrani, podržavajući potrebu korisnosti nutritivne edukacije u povećanju znanja o ishrani, samoeфикаsnosti i pozitivnim promjenama percepcije znanja i navika ishrane među studentima (Kunkel, Bell i Luccia, 2001; Paschoal i Amancio 2004). Istraživanja pokazuju da znanja i stavovi utiču na navike o ishrani (Laurie, Zawila i Steibt, 2003; Ruka, Toyama, Amamoto, Liu i Shinfuku, 2005). Ruka i saradnici (2005) opisao je da iako 85,6% studenata su svjesni potrebe nutritivni izbalansirane ishrane samo nešto malo njih (7%) primjenjuju to prilikom izbora hrane iz menija. Čak šta više, samo 51% studenata pokazalo je želju da uče o zdravim dijetama (Ibid). Rezultati istraživanja Jacobson i saradnici (2001) pokazali su da samo 3, 11,7 i 29,5% su tačno prepoznali preporučeni postotak ukupnog kalorijskog unosa proteina, masti i ugljenih hidrata; 37% je ispravno prepoznalo ulogu vitamina, a 54,4% za proteine. Istraživanja su pokazala da su muškarci (85%) i žene (87%) upoučivali gojazne adolescente na dijetu za gubitak težine; 20% žena i 13% muškaraca redovno preskaču doručak. Dati savjet je pokazao nedostatak specifične nutritivne edukacije o kontroli težine, nutritivnim potrebama adolescenata i dijeti gojaznih (O'dea i Abraham, 2001; Sakamaki, Toyama, Amamoto, Liu i Shinfuku, 2005). Znanja o ishrani po svoj prilici utiču na stavove i ponašanje u ishrani (Rosenbloom, Jonnalagadda i Skinner, 2002). Postoje mnogi razlozi zašto se ne pridržavamo nutritivnih savjeta. Razlozi mogu da budu nedostatak znanja ili informacija, kao i zaiteresovanost da se prave promjene u nečijoj ishrani, kao i neke prepreke koje se uoče ili na koje se naiđe a koje mogu da spriječe ljude da jedu zdraviju hranu poput nedostatka novca (cijene hrane), nedostatak vremena (zauzetost poslom) ili ukus (Kearney i McElhone, 1999). Sportisti u određenom sportu često se oslanjaju na smjernice trenera u ishrani. Stoga, kada su treneri loše informisani o ishrani, to takođe postaje potencijalni problem za sportiste (Cotugna, Vickery i McBee, 2005). Treniranje ishrane može se prenjeti do pojedinca kroz redovne i sveobuhvatne programe edukacije kao i kroz njihov idividulani trening sa vlastitim postavkama (Yılmaz i Özkan, 2007).

Nažalost, mnogi od tih izvora nisu pogodni, a ponekad saopštena informacija je nepouzdana i samo ide na ruku mitovima o ishrani koji mogu da utiču na

knowledge and attitudes has not been well studied. Furthermore, Studies have indicated that college students appear to have positive attitudes toward nutrition (Jacobson et al., 2001; Ruka et al., 2005; Yueching & Yi-Chia, 1999). In contrast to many other countries, Iranian schoolchildren do not receive any nutrition education as part of their school's routine curriculum, so when they become college athletes, they have a very limited nutrition knowledge base (Jessri, Jessri, RashidKhani, & Zinn, 2010). This suggests that if the areas of knowledge deficits or reasons for nutritional choices can be identified, the college student will be receptive to nutrition education; and moreover, due to lack of enough information about nutritional knowledge and food habits of Athletes in Iran. The purpose of this study was to compare nutritional knowledge and food habits in collegiate and non-collegiate athletes (athletes who were competitive at national and regional levels).

## METHODS

We used standard questionnaire (Zawila, Steib, & Hoogenboom, 2003) which was used by Barr (1987) and Chapman and Toma (1997) before. This questionnaire in order to study the nutritional knowledge and food habits of students is provided. First part of the questionnaire included personal information, and the second part contained 40 True and False questions. Questions related to nutritional knowledge's was contained: CHO, Fat and Protein (five questions), fiber (two questions), general nutrition (nine questions), Vitamins (seven questions), Calcium and ferrous (nine questions), sport nutrition (six questions) and weight lose (two questions). The Reliability of the questionnaire was provided by using Cronbach Alpha value of .81 (In statistics, Cronbach's (alpha) is a coefficient of internal consistency. It is commonly used as an estimate of the reliability of a psychometric test for a sample of examinees). 300 questionnaires randomly were distributed between male and female athletes. Out of these, 130 questionnaires for males and 120 questionnaires for females were completely filled out and returned. The collected data was analyzed by descriptive and deductive statistics, Pearson correlation coefficient, t-student and one-way ANOVA.

## RESULTS

Mean and standard deviation of age, height and weight were reported in Table 1 and mean percentage of correct response to subgroups nutrition questions were presented in Table 2. Figure 1 show correct response rate to general and sport nutrition questions. In all collected answers of general nutrition and sport nutrition, maximum mean of correct

ishranu sportista (Barr, 1987). Ali, edukacija i njena veza sa znanjem i stavovima o ishrani nije dobro proučena. Osim toga, istraživanja su pokazala da studenti imaju pozitivne stavove o ishrani (Jacobson i saradnici, 2001; Ruka i saradnici, 2005; Yueching i Yi-Chia, 1999). Za razliku od mnogih drugih zemalja, učenici u Iranu ne dobijaju nikakvo obrazovanje o ishrani u okviru njihovog školskog programa, tako da kada oni postanu studenti sportisti imaju ograničena znanja o osnovama ishrane (Jessri, Jessri, RashidKhani i Zinn, 2010). Ovo upućuje na to da ako se ustanovi prostor nutritivnog znanja koji nedostaje ili razlozi izbora ishrane studenti će biti otvoreni za nutritivnu edukaciju, čak i pored nedostatka dovoljno informacija o znanjima i navikama iranskih sportista o ishrani. Cilj ovog rada je upoređivanje znanja i navika o ishrani sportista studenata i nestudenata (sportisti koji se takmiče na nacionalnom i regionalnom nivou).

## METODE

Koristili smo standardni upitnik (Zawila, Steib i Hoogenboom, 2003) koji je prije toga bio korišten od Barr (1987) i Chapman i Toma (1997). Ovaj upitnik omogućava proučavanje znanja i navike studenata o ishrani. Prvi dio upitnika sadrži personalne podatke a drugi se sastoji od 40 pitanja "tačno - netačno". Pitanja su se odnosila na znanja o ishrani i sadržavala su: ugljene hidrate, masti i proteine (pet pitanja), vlakna (dva pitanja), opštu ishranu (devet pitanja), vitamine (sedam pitanja), kalcijum i željezo (devet pitanja), sportsku ishranu (šest pitanja) i gubitak težine (dva pitanja). Cronbach Alpha vrijednost od 0,81 obezbjedila je pouzdanost upitnika (U statistici, Cronbach Alpha je koeficijent interne konzistentije. Obično se koristi za procjenu psihometrijskih testova u uzorku ispitanika). Tristo upitnika je nasumično podjeljeno sportistima muškog i ženskog pola. Od toga, 130 sportista i 120 sportistkinja je popunilo upitnike i vratilo ih. Prikupljeni podaci su analizirani pomoću deskriptivne i deduktivne statistike, Pirsonovog koeficijenta korelacije, t-Studentovog testa i jednosmjerne ANOVA.

## REZULTATI

Aritmetička sredina i standardna devijacija godina, visine i težine prikazani su u Tabeli 1, a aritmetička sredina procenta ispravnih odgovora na pitanja iz podgrupe o ishrani u Tabeli 2. Slika 1 pokazuje stopu tačnih odgovora na pitanja uopšte o ishrani i o sportskoj ishrani. U svim prikupljenim odgovorima o opštoj i



response percentage to general nutrition questions was related to collegiate athlete's females. The results show that collegiate athlete's females had highest score for question related to CHO, Fat, Protein and weight lose and collegiate athlete's males had highest score for questions related to calcium, and ferrous subdivisions. The results of present research also indicate that correct response percentages of collegiate athlete's females were significantly higher than non-collegiate athlete's females ( $p = .02$ ) and collegiate athlete's males were significant higher than non-collegiate athlete's females ( $p = .03$ ), while this dif-

sportskoj ishrani, najvišu srenju vrijednost imao je procenat ispravnih odgovora o opštoj ishrani studentica sportistkinja. Rezultati pokazuju da su sportistkinje studentice imale najbolje rezultate kod pitanja koja su se odnosila na ugljene hidrate, masti, proteine i redukciju težine, a studenti sportisti najbolje rezultate pokazali su na podgrupu pitanja koja su se odnosila na klacij i željezo. Rezultati ovog istraživanja takođe pokazuju da postotak ispravnih odgovora sportistkinja studenata statistički značajno je viši od sportistkinja nestudenata ( $p = 0,02$ ), a sportista studenata statistički značajno

**TABLE 1**

*Mean and standard deviation of age, height and weight of respondents.*

**TABELA 1**

*Aritmetička sredina i standardna devijacija godina, visine i težine ispitanika.*

Respondent	N	Age		Height (cm)		Weight (kg)	
		M	SD	M	SD	M	SD
Collegiate athlete males	63	24.71	2.30	173.10	5.20	71.19	2.08
Non-collegiate athlete males	67	23.42	1.80	170.18	3.44	74.59	4.80
Collegiate athlete females	58	23.61	2.10	163.61	6.02	58.87	4.71
Non-collegiate athlete females	62	21.49	2.80	159.98	5.60	56.78	7.22

Legend: **N** - Number od respondent (Broj ispitanika); **M** - Mean (Aritmetička sredina); **SD** - Standard deviation (Standardna devijacija); Respondent - Ispitanik; Age - Godine; Height - Visina; Weight - Težina; Collegiate athlete males - Sportisti studenti muškarc; Non-collegiate athletes males - Sportisti nestudenti muškarc; Collegiate athlete females - Studenti sportisti žene; Non-collegiate athlete females - Studenti nesportisti žene.

ference was not significant between collegiate athlete's females and collegiate athlete's males ( $p = .64$ ). Also, the results show, was no significant diference between non-collegiate athlete's females and non-collegiate athlete's males. In addition, the results show that there is significant and positive correlation between general nutrition and sport nutrition of male and female collegiate athletes (Figure 2), while there was no significant correlation between general nutrition and sport nutrition of male and female non-collegiate athletes (Figure 3).

## DISCUSSION

Recent research suggests that the adolescent athlete's is neither aware of nor prepared for the dual demands of sound nutritional practices in general, nor those demands by his or her chosen sport activities (Chapman & Toma, 1997; Laurieet et al., 2003). College athletes have misconception about nutrition, and have poor nutrition knowledge and attitude (Nancy, Connie, Vickery, & Mcbee, 2005; Schmalz, 1993). Also Studies show that athletes not

viši od sportistkinja studenata ( $p = 0,03$ ) dok razlika nije statistički značajna između sportistkinja i sportista studenata ( $p = 0,64$ ). Takođe, rezultati pokazuju da nije bilo statistički zanačajne razlike između sportistkinja i sportista nestudenata. Osim toga, rezultati ukazuju da postoji statistički značajna i pozitivna korelacija između opšte sportske ishrane spotista i sportistkinja studenara (Slika 2), dok između sportista i sportistkinja nestudenata između opšte i sportske ishrane nije bilo značajne statističke korelacije (Slika 3).

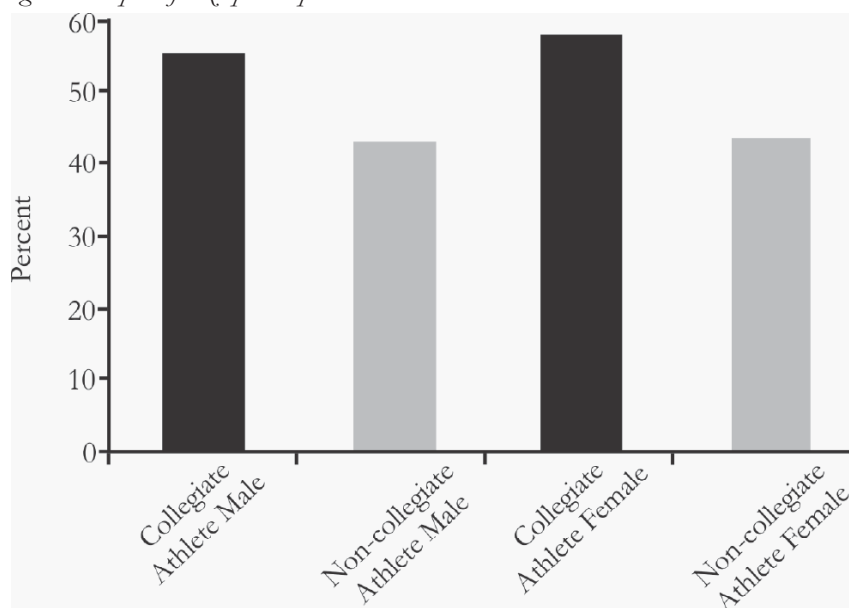
## DISKUSIJA

Nedavna istraživanja ukazala su da sportisti adoloscenti niti su svjesni niti pripremljeni za paralelne zahtijeve ni opšte prakse ishrane niti zahtijeve koje traži sportska aktivnost koju su izabrali (Chapman i Toma, 1997; Laurieet i saradnici, 2003). Studenti sportisti imaju pogrešno shvatanje ishrane i pogrešno znanje i navike u ishrani (Nancy, Connie, Vickery i Mcbee, 2005; Schmalz, 1993). Takođe, istraživanja pokazuju da sportisti nisu dovoljno obavješteni o

**TABLE 2***Mean percentage of correct response to subgroups nutrition questions.***TABELA 2***Srednji procenat ispravnih odgovora na pitanja podgrupe ishrana.*

	Male		Female	
	Collegiate	Non-collegiate	Collegiate	Non-collegiate
CHO, Fat and Protein	59.60	38.40	61.60	43.20
Fiber	53.30	45.10	59.00	52.00
Vitamin	60.70	64.41	62.57	57.10
Calcium and Iron	57.00	51.54	60.22	57.15
Weight Lose	61.90	51.40	62.50	56.00

Legend: Male - Muškarci; Female - Žene; Collegiate - Studenti; Non-collegiate - Nestudenti; CHO, Fat and Protein - Ugljeni hidrati, masti i proteini; Fiber - Vlakna; Vitamin - Vitamini; Calcium and Iron - Kalcijum i željezo; Weight Loss - Gubitak težine.

**FIGURE 1***Correct response rate to general and sport nutrition questions.***SLIKA 1***Stopa tačnih odgovora na pitanja iz opšte i sportske ishrane.*

Legend: Collegiate athlete males - Sportisti studenti muškarcu; Non-collegiate athletes males - Sportisti nestudenti muškarcu; Collegiate athlete females - Studenti sportisti žene; Non-collegiate athlete females - Studenti nespportisti žene.

knowledgeable enough about nutritional issues and their knowledge and attitude are in average level (Chang, 1987; Sakamaki et al., 2005).

The present study found that sport nutrition and general nutrition questions scores of male and female athletes studying in college was significantly higher than male and female non-college athletes. These data are similar to the study done by Chang, Georgia and Yoeching, which indicating that student's nutrition knowledge is related to their majors (Georgia et

pitanjima ishrane a da su njihova znanja i stavovi o ishrani na prosječnom nivou (Chang, 1987; Sakamaki i saradnici, 2005).

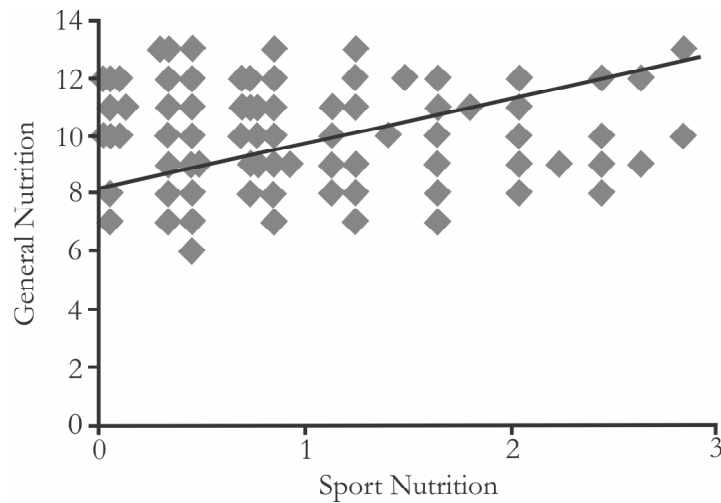
Ovo istraživanje pokazalo je da su rezultati na pitanja o sportskoj i opštoj shrani sportista studenata bila statistički više značajna nego kod sportista i sportistkinja nestudenata. Dobijeni podaci su slični podacima dobijenim u istraživanju Chang, Georgia i Yoeching, koja su pokazala da su studentka znanja o ishrani povezana sa njihovim značajem (Georgia i

**FIGURE 2**

*Correlation between general nutrition and sport nutrition of college athlete males.*

**SLIKA 2**

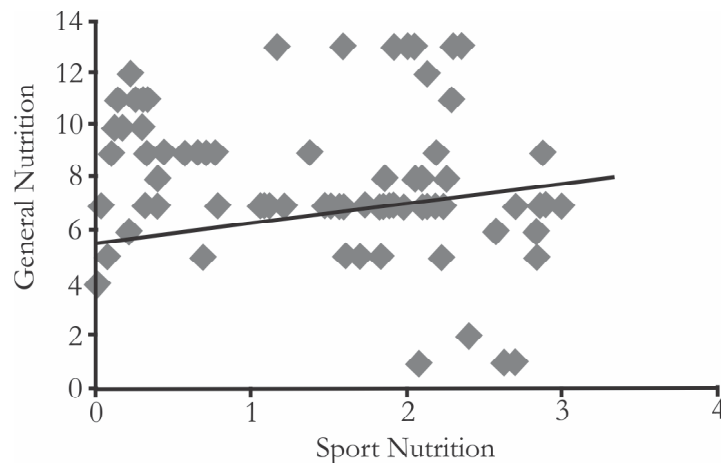
*Povezanost opšte i sportske ishrane studenata sportista muškaraca.*

**FIGURE 3**

*Correlation between general nutrition and sport nutrition of non-college athlete females.*

**SLIKA 3**

*Povezanost opšte i sportske ishrane studenata sportista žena.*



al., 1993; Yueching & Yi-Chia, 1999). Azizi, Rahmani-Nia, Malae, Malae, and Khosravi (2010) and Georgia et al. (1993) indicated that nutritional knowledge is related to the individual field of study. The result shows that athletes varied in their nutrition knowledge depending on their college majors. The combination of two variable s- gender and Education type, influenced the total knowledge score in this study. The present study found that nutrition attitude scores of female collegiate athletes were significantly higher than female non-collegiate athletes. Also nutrition attitude scores of male collegiate athletes were higher than male non-collegiate athletes, but this difference was just between male and female collegiate athletes and male and female non-collegi-

saradnici, 1993; Yueching i Yi-Chia, 1999). Azizi, Rahmani-Nia, Malae, Malae i Khosravi (2010) i Georgia i saradnici (1993) ustanovili su da su nutritivna znanja u vezi sa pojedinačnim dijelovima istraživanja. Rezultati pokazuju da sportisti se razlikuju u svojim znanjima o ishrani u zavisnosti od smjera na studiju. Kombinacija dvije varijable, pola i vrste obrazovanja, uticala je na ukupnu ocijenu znanja u ovom istraživanju. Ovim istraživanjem je utvrđeno da su rezultati stavova o hrani sportistkinja studentica bila statistički značajnija od sportiskinja nestudentica. Takođe, rezultati stavova o ishrani studenata sportista bili su viši od sportista nestudenata, ali je ta razlika samo između sportista i sportiskinja studenata i sportista i sportiskinja nestudenata bila statistički značajna. Georgia i saradnici (1993)

ate athletes was significant. Georgia et al. (1993) reported that nutrition knowledge was not related to gender. In contrast, we found that female athletes had a significantly higher knowledge and attitude score than male athletes. This is similar to Azizi et al. (2010) and Yoeching and Yi-Chia (1999) study, which indicated female students, had higher nutrition knowledge scores, and better nutrition attitude than male students. Dunn, Turner, and Denny (2007) found that female athletes scored slightly higher than their male counterparts on their nutritional knowledge questionnaire. As well as each recommendation section. In contrast, knowledge was reported to be the same in both genders in two other studies (Jessri et al., 2010; Rosenbloom et al., 2002). It suggests that females in general are more concerned about their nutrition and health than males.

The results of present study also indicate that correct response percentages of collegiate athletes were significant higher than non-collegiate athlete, while this difference was not significant between collegiate athlete's males and females. Previous studies demonstrated that athlete student who had completed a nutrition course in college scored higher on nutritional knowledge tests than those who had not (Barr, 1987; Laurie et al., 2003). However, related courses such as exercise physiology, sport nutrition and exercise science are required for collegiate athlete. A background in exercise physiology, sport nutrition and exercise science may be one of the reasons for better performances on the knowledge test, but possible relationship between nutrition knowledge, and these courses needs further investigation. Providing a nutrition or nutrition-related course to non-collegiate athletes may be one way to increase their nutrition knowledge and therefore, positively influence dietary behaviors. Previous studies found that collegiate athletes, who completed a nutrition course in college, demonstrated greater nutritional knowledge than those who did not complete a nutrition course (Barr, 1987; Laurie et al., 2003; Sakamaki et al., 2005). Our study's data support this finding, suggesting that student may benefit from taking a nutrition course or from receiving additional information for optimal health and performance.

Results also indicated correct response percentage in the CHO, Fat, Protein, Fiber, Vitamin, Calcium and iron group for collegiate athletes was higher than non-collegiate athletes. Since most athletes collegiate who attend a college degree in physical education; so sport nutrition, sport physiology or exercise science are some of the collegiate athlete's courses, we can consider passing these courses by collegiate athlete's as the reason of increasing their knowledge in comparison with a student of other fields. Achievements

objavili su da nutritivna znanja nisu povezana sa polom. Nasuprot tome, mi smo utvrdili da sportistkinje imaju statistički značajnije rezultate znanja i stavova od sportista. Ovo je slično istraživanjima Azizi i saradnika (2010) i Yoeching i Yi-Chia (1999) koja su pokazala da studentice su imale bolje rezultate znanja i stavova o ishrani od studenata. Dunn, Turner i Denny (2007) su utvrdili da su sportistkinje postigle neznatno bolje rezultate u odnosu na svoje muške kolege u njihovom upitniku o nutritivnim znanjima. Kao i u svakom od pojedinačnih dijelova. Za razliku od toga, u dva druga istraživanja ustanovljeno je isto znanje kod oba pola (Jessri i saradnici, 2010; Rosenbloom i saradnici, 2002). Ovo nam sugerše da su žene, generalno, zainteresovanije o svojoj ishrani i zdravlju od muškaraca.

Rezultati ovog istraživanja takođe ukazuje da procenat pravilnih odgovora sportista studenata je statistički značajniji od odgovora sportista nestudenata, dok ta razlika nije bila značajna između studenata sportista i sportistkinja. Prethodna istraživanja pokazala su da student sportista koji je imao predmet ishrane na fakultetu postigao je bolji rezultat na testovima o poznavanju ishrane od onih koji to nisu imali (Barr, 1987; Laurie i saradnici, 2003). Ipak, studentu sportisti potrebni su srodni predmeti poput vježbi iz fiziologije, sportske ishrane i naučne vježbe. Prisustvo vježbama iz fiziologije, sportske ishrane i naučne vježbe može da bude jedan od razloga za bolje rezultate u testu znanja ali moguća veza između nutritivnih znanja i ovih predmeta trebaju buduća istraživanja. Organizovanje nutritivnih kurseva ili kurseva koji se odnose na ishranu sportistima nestudentima može da bude jedan od načina da se uvećaju njihova znanja o ishrani i, na osnovu toga, da se pozitivno utiče na ponašanje u ishrani. Prethodna istraživanja su ustanovila da sportisti na fakultetima, koji su imali predmet ishrane, su pokazala veća nutritivna znanja od onih koji to nisu imali (Barr, 1987; Laurie i saradnici, 2003; Sakamaki i saradnici, 2005). Podaci iz našeg istraživanja podržavaju prethodno, ukazujući da student može da ima koristi od prisustvovanja predavnjima iz ishrane ili od dobijanja dodatnih informacija za optimalno zdravlje i performase.

Rezultati, takođe, ukazuju da procenat tačnih dogovora o ugljenim hidratima, mastima, proteinima, vlaknima, vitaminima, kalcijum i železu je bio bolji kod sportista studenata nego kod nestudenata. Kako većina sportista studenata koji pohađaju akademski studij fizičkog vaspitanja pa sportsku ishranu, fiziologiju sporta ili naučne vježbe su neki od akademskih predmeta sportista možemo da razmotrimo doprinos ovih predmeta na uvećanje znanja studenata sportista u odnosu na studente iz drugih akademskih oblasti. Uspjesi u ovim istraživanjima pokazala su da se putem

of these studies show that educational interferences will cause a growth of knowledge important for individual's attitude toward nutrition (Jessri et al., 2010; Rosenbloom et al., 2002). The results of present study also indicate that superiority of knowledge and attitude of collegiate athlete's in comparison with collegiate athletes will emphasize this idea too. Appropriate nutrition is very significant in important for social health. Main objective of nutrition schemes and programs is to achieve appropriate and sufficient nutrition in order to increase the health level. Since the advancement in level of knowledge, attitude and nutritional style of this majority of society can help to improve individual's nutritional knowledge and information to have a healthy society and is effective in decreasing the rate of problems related to health and diseases. Although sport nutrition education may benefit athletes, Iranian college and club entities are lacking in the sport-science and nutrition services needed to provide best-practice nutrition information to their athletes. Although most Iranian coaches are misinformed about nutrition science, they play the central role in training and educating athletes. Our results suggest that college athletes could benefit from nutrition courses at university as a cost-effective and accessible way of obtaining reputable nutritional information. These results also suggest that management personnel of sport teams could attempt to secure funding to contract with dietitians and nutritionists to provide best-practice current and relevant sport nutrition information to the team. Nutrition knowledge was found low for the collegiate and non-collegiate athlete; but, had lower nutrition knowledge in non-college athletes enrolled in sport campuses to become prospective teachers and coaches and they were not aware of the importance of the nutrition for performance. Enough and balanced nutrition should be a perfect life style and an eating habit for a sportsman. The number of courses related to nutrition should be increased in universities and sport campuses. The main objective in these courses should be to make the theoretical knowledge applicable in daily life. Experienced sportsmen and trainers should pursue ways to educate young people on how to select nutritious foods that will promote a lifetime of good health.

## CONCLUSIONS

This study represents a first step in identifying the current nutrition knowledge and attitudes of collegiate and non-collegiate male and female athletes in Iran. Based on the result of our study the knowledge of Iranian non-college athletes is lower in comparison to college athletes, and these suggest that nutrition

obrazovanja može doći do uvećanja znanja od velike važnosti za odnos pojedinca prema ishrani (Jessri i saradnici, 2010; Rosenbloom i saradnici, 2002). Rezultati ovog istraživanja pokazala su da superiornost studenata sporta u znanjima i stavovima o ishrani u odnosu na ostale studente sportiste takođe potvrđuje prethodnu teoriju. Odgovarajuća ishrana je značajna u važnosti socijalnog zdravlja. Glavni cilj planova i programa ishrane je postizanje odgovarajuće i dovoljne ishrane u svrhu povećanja nivoa zdravlja. Budući napredak u nivou znanja, stavova i stila ishrane većeg dijela društva može pomoći u unapređenju individualnih nutritivnih znanja i informaciji da imamo zdravo društvo i da smo efikasni u smanjenu stope problema koji su vezani za zdravlje i bolest. Iako edukacija o sportskoj ishrani može da koristi sportistima, iranskim fakultetima i klubovima nedostaju sportsko-naučne i nutritivne usluge potrebne da obezbijede najbolje praktične informacije o ishrani svojim sportistima. Premda je većina iranskih trenera pogrešno informisana o ishrani na naučnoj osnovi oni igraju centralnu ulogu u edukaciji i obuci sportista. Rezultati našeg istraživanja pokazali su da bi studenti sportisti imali koristi od predmeta ishrane na univerzitetu kao ekonomičnog i pristupačnog načina dobijanja ispravnih nutritivnih informacija. Ovi rezultati takođe ukazuju da rukovodstva klubova trebaju da pokušaju obezbejediti sredstva za sklapanje ugovora sa dijetetičarima i nutricionistima kako bi obezbjedili najbolje aktelne i odgovorajuće praktične nutritivne informacije timu. Utvrđeno je da su znanja o ishrani niska i kod studenata i nestudenata sportista ali i niža nutritivna znanja kod sportista nestudenata upisanih u sportske kampuse da postanu budući učitelji i treneri i oni nisu bili svjesni važnosti ishrane u razvoju sportskih vještina. Dovoljna i uravnotežena ishrana treba biti savršen stil života i prehrambrena navika za sportiste. Broj predmeta koji se odnose na ishranu treba povećati na univerzitetima i sportskim kampusima. Glavni cilj ovih predmeta trebao bi biti da teoretsko znanje primjeni u svakodnevnom životu. Iskusni sportisti i treneri trebaju da nastave iznalaziti načine da edukuju mlade ljude kako da izaberu hranjive namjernice koje će promovisati život u dobrom zdravlju.

## ZAKLJUČAK

Ovo istraživanje predstavlja prvi korak u identifikovanju trenutnih znanja i stavova o ishrani sportista i sportistkinja studenata i nestudenata u Iranu. Na osnovu rezultata našeg istraživanja znanja iranskih sportista nestudenata su manja u odnosu na sportsite studente i to upućuje da znanja i stavove o ishrani iranskih sportista

knowledge and attitudes of Iranian non-college athletes need to improve. So, improving a nutrition education program for non-college athlete could be an effective way to promote their nutrition knowledge and attitudes. The importance of nutrition and improvement of the learning environment, relate to nutrition need to be emphasized on sport campuses.

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nestudenata treba poboljšavati. Dakle, unapređenje edukativnih programa za sportsite nestudente može da bude efikasan način da se unaprijede njihova znanja i stavovi. Značaj ishrane i unapređenje obrazovnog ambijenta koji se odnosi na ishranu treba naglasiti u sportskim kampusima.

## ZAHVALNOST

Autori bi željeli da izraze zahvalnost istraživačkom komitetu i univerzitetskim fakultetskim članovima koji su pregledali prevedeni uputnik, posebno za njihovu pomoć u koncipiranju ovog istraživačkog projekta. Posebno smo zahvalni učesnicima istraživanja za vrijeme koje su utrošili za popunjavanje upitnika.

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## مقایسه دانش تغذیه‌ای و عادات غذایی در بین ورزشکاران دانشگاهی و غیر دانشگاهی

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### خلاصه

تغذیه یکی از مولفه‌های مهم در برنامه‌های آمادگی جسمانی می‌باشد. هدف اصلی رژیم غذایی برای افراد فعال تغذیه مناسب برای دستیابی به آمادگی جسمانی ایده‌آل و افزایش عملکرد ورزشی است. لذا هدف پژوهش حاضر، مقایسه دانش تغذیه‌ای و عادات غذایی ورزشکاران دانشگاهی و غیر دانشگاهی بود. جامعه آماری این تحقیق را کلیه ورزشکاران پسر و دختر دانشگاهی و غیر دانشگاهی تشکیل می‌دادند. پس از ترجمه پرسشنامه استاندارد دانش و نگرش تغذیه‌ای زاویلا و همکارانش؛ و تعدیل برخی از سوال‌ها، با نظر خواهی از متخصصین روائی صورتی، پایایی آن توسط آزمون آلفای کرونباخ (۰/۸۱) بدست آمد. سپس، بر اساس جدول اودینسکی ۱۳۰ پرسشنامه بین ورزشکاران پسر دانشگاهی و غیر دانشگاهی و ۱۲۰ پرسشنامه بین ورزشکاران دختر دانشگاهی و غیر دانشگاهی توزیع و جمع‌آوری گردید. این پرسشنامه شامل ۱۵ سوال در مورد دانش تغذیه و ۲۵ سوال در مورد عادات غذایی بود. برای تجزیه و تحلیل داده‌ها از آمار توصیفی و استنباطی ضریب همبستگی پیرسون، t- student و ANOVA استفاده شد ( $p \leq 0.05$ ). درصد پاسخ صحیح به سوالات تغذیه ورزشی و تغذیه عمومی ورزشکاران دانشگاهی، به ترتیب شامل تربیت بدنی پسر (۵۲/۵؛۵۷/۱۵ درصد) و دختر (۵۴/۱۴؛۵۸/۱۴ درصد)؛ ورزشکاران غیر دانشگاهی پسر (۴۱/۵۵؛ ۳۹/۸۶ درصد) و دختر (۴۴/۶۶؛ ۶۲/۱۱ درصد) بود. همچنین، اختلاف میانگین نمرات کل پرسشنامه در ورزشکاران پسر و دختر دانشگاهی به طور معناداری بالاتر از ورزشکاران پسر و دختر غیر دانشگاهی بود ( $p \leq 0.05$ ). علاوه بر این، تفاوت معناداری در نمرات کل پرسشنامه ورزشکاران دانشگاهی و غیر دانشگاهی مشاهده شد ( $p \leq 0.05$ ). براساس نتایج این مطالعه دانش تغذیه‌ای ورزشکاران غیر دانشگاهی پایین‌تر از ورزشکاران دانشگاهی بود. به سبب لزوم افزایش دانش و نگرش غذایی ورزشکاران غیر دانشگاهی، برگزاری دوره‌های آموزشی تغذیه برای ورزشکاران غیر دانشگاهی به عنوان یکی از راهکارهای افزایش دانش و آگاهی آنها درباره تغذیه پیشنهاد می‌شود.

**کلید واژه:** دانش تغذیه‌ای، نگرش، ورزشکاران.



## DOPRINOS RAZVIJENOSTI MOTORIČKIH SPOSOBNOSTI KOD SAVLADAVANJA SKIJAŠKE TEHNIKE

### INFLUENCE OF MOTOR ABILITIES ON LEARNING OF ALPINE SKI TECHNIQUE

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#### SUMMARY

The research determined influence of motor abilities on alpine ski learning. Moreover, the aim was also to estimate the contribution of some morphological characteristics to acquisition of ski knowledge. At the beginning of the study, participants were tested by tests evaluating balance, agility, explosive and static strength, movement frequency and flexibility. After evaluation of motor abilities, basic morphological characteristics were noted and then participants entered a seven days alpine ski course. Acquired alpine ski knowledge was assessed through demonstration of seven elements of alpine ski technique, by five independent judges. Data analysis showed positive influence of agility on all tested elements of alpine ski technique (traversing,  $\beta = .38$ ;  $\beta = .26$ ; uphill turn,  $\beta = .33$ ;  $\beta = .23$ ; basic turn,  $\beta = .18$ ; parallel turn,  $\beta = .32$ ; short turn,  $\beta = .34$ ). Subjects' results in squat endurance test assessing the static leg strength contribute to learning uphill turn ( $\beta = .19$ ), basic turn ( $\beta = .35$ ) and parallel turn ( $\beta = .27$ ). Test used to measure balance (single leg balance test) significantly influences learning of basic elements of alpine ski technique (traversing right,  $\beta = .23$ ; traversing left,  $\beta = .28$ ; uphill turn to the left,  $\beta = .24$ ). Body height has a negative effect on alpine ski learning ( $\beta = -0.5$ ), indicating that taller ski beginners tend to have more difficulties during alpine ski learning than shorter alpine ski beginners. According to our results, agility, static leg strength and balance are the motor abilities with the greatest influence on beginners' alpine ski learning.

**Key words:** alpine skiing, learning, motor abilities, morphological characteristics.

#### SAŽETAK

Ovim istraživanjem utvrđen je uticaj motoričkih sposobnosti na proces učenja alpskog skijanja. Takođe, cilj ovog istraživanja bio je utvrditi uticaj određenih morfoloških karakteristika na savladavanje skijaških znanja. Na početku istraživanja ispitanici su bili testirani pomoću testova za procjenu: ravnoteže, agilnosti, eksplozivne i statičke snage, frekvencije pokreta, te fleksibilnosti. Nakon procjene motoričkih sposobnosti, ispitanicima su utvrđene osnovne morfološke karakteristike, te su pristupili školi alpskog skijanja u trajanju od sedam dana. Po završetku učenja alpskog skijanja svi ispitanici demonstrirali su sedam elemenata skijaške tehnike ispred pet nezavisnih ispitivača. Analiza rezultata pokazala je kako agilnost pozitivno utiče pri učenju svih ispitanih elemenata skijaške tehnike (kosi spust,  $\beta = 0,38$ ;  $\beta = 0,26$ ; zavoje ka padini,  $\beta = 0,33$ ;  $\beta = 0,23$ ; osnovni zavoje,  $\beta = 0,18$ ; paralelni zavoje,  $\beta = 0,32$ ; vijuganje,  $\beta = 0,34$ ). Rezultati ispitanika u testu izdržaj u čučnju kojim se procjenjuje statička snaga nogu pozitivno utiče kod učenja zavoja ka padini ( $\beta = 0,19$ ), osnovnog zavoja ( $\beta = 0,35$ ), te paralelnog zavoja ( $\beta = 0,27$ ). Test za procjenu ravnoteže (ravnotežni položaj lijeve noge uzdužno) značajno utiče pri učenju osnovnih elemenata skijaške tehnike (kosi spust u desnu stranu,  $\beta = 0,23$ ; kosi spust u lijevu stranu,  $\beta = 0,28$ ; zavoje ka padini u lijevu stranu,  $\beta = 0,24$ ). Tjelesna visina skijaša početnika negativno utiče na efikasnost usvajanja skijaških znanja ( $\beta = -0,5$ ), što znači da će višim skijašima biti teže usvajati skijaška znanja u odnosu na niže skijaše. S obzirom na rezultate ovog istraživanja moguće je istaknuti agilnost, statičku snagu, te ravnotežu kao one motoričke sposobnosti koje najviše doprinose skijaškim početnicima prilikom učenja skijaške tehnike.

**Ključne riječi:** alpsko skijanje, učenje, motoričke sposobnosti, morfološke karakteristike

## INTRODUCTION

Children and young people less frequently spend their free time doing some physical activity in a natural environment, so it is recorded that the number of obese people among this population was increasing during the past years (Benson, Torode, & Fiatarone Singh, 2008; Grung, Krause, Siewers, Rieckert, & Muller, 2000; Laguna, Ruiz, Lara, & Aznar, 2012). Obvious lack of physical activity influences the whole body composition, and reflects negatively on growth and development (Högström, Pietilä, Nordström, & Nordström, 2012). Motor abilities are often neglected or developed poorly in children, and their level influences significantly better or worse technical performance in each sport, so as in skiing. Therefore, there is an increasing social necessity for taking care of young people's physical activity, which will influence the development of motor abilities (Cleland et al., 2008). Alpine skiing is extremely mass sport at recreation level (Horterer, 2005) and a large number of families go skiing during the winter. Aim of this study is to try to answer the question on helping ski beginners to learn skiing easily. Fear of injury, caused by skiing speed contributes to loss of proportion of ski beginners in further alpine ski learning, often loss of the balance or high ski lifts contribute additionally. Moreover, some skiers give up further ski learning because of the previous inadequate fitness motor preparation. In alpine skiing a person moves in a specific way which occurs rarely in an everyday life, so that is the reason why proper fitness preparation of a beginner skier is harder. It is known that in alpine skiing some motor abilities are used more than the other (Dolenec & Žvan, 2001; Emeterio & Gonzales-Badillo, 2010; Neumayr et al., 2003). The studies also showed that the same motor abilities in the same ratio do not influence equally the competitor skiers' sports results and skiing learning efficiency in recreational skiers (Cigrovski, Matković, & Matković, 2008a, 2008b; Cigrovski, Bilić, Prlenda, & Martinčević, 2010; Gross et al., 2010; Maffioletti, Jordan, Spring, Impellizzeri, & Bizzini, 2009; Oreb, Vlašić, Cigrovski, Prlenda, & Radman, 2011). Having in mind the proof that certain motor abilities are differently employed in competitive skiers and recreational skiers, this study's aim is to determine which motor abilities contribute to learning of elements of alpine ski technique in ski beginners. The study will also try to determine the influence of some morphological characteristics on efficiency of learning alpine skiing.

## UVOD

Djeca i mladi ljudi svoje slobodno vrijeme sve rjeđe provedu fizički aktivno u prirodnom okruženju, pa je u toj populaciji posljednjih godina zabilježen porast gojaznosti (Benson, Torode i Fiatarone Singh, 2008; Grung, Krause, Siewers, Rieckert i Muller, 2000; Laguna, Ruiz, Lara i Aznar, 2012). Evidentni nedostatak fizičke aktivnosti utiče na cjelokupni sastav tijela, negativno se odražavajući na rast i razvoj (Högström, Pietilä, Nordström i Nordström, 2012). Kod djece su vrlo često zapostavljene ili slabije razvijene motoričke sposobnosti čiji nivo bitno utiče na bolju ili lošiju tehničku uspješnost u svakom sportu, pa tako i u skijanju. Zbog toga je sve naglašenija potreba društva za brigom o fizičkoj aktivnosti mladih, putem koje će se djelovati i na razvoj motoričkih sposobnosti (Cleland i saradnici, 2008). Alpsko skijanje na rekreativnom nivou izrazito je masovan sport (Horterer, 2005) kojim se tokom zimskog perioda aktivno bavi veliki broj porodica. Kako pomoći skijaškim početnicima da lakše nauče skijati pokušaću se odgovoriti u ovom radu. Dio skijaških početnika odustane od daljeg učenja skijanja zbog straha od povrede, koji, između ostalog, može biti izazvan brzinom kretanja na skijama, čestim narušavanjem ravnoteže ili visinom skijaških žičara. Međutim, svakako dio skijaša odustaje od daljeg učenja zbog prethodne neadekvatne kondiciono-motoričke pripremljenosti. Prilikom alpskog skijanja čovjek se kreće na specifičan način, koji se vrlo rijetko pojavljuje u svakodnevnom kretanju, te je zbog toga i pravilna kondiciona priprema skijaša početnika teža. Poznato je da neke motoričke sposobnosti u većoj mjeri od drugih učestvuju prilikom alpskog skijanja (Dolenec i Žvan, 2001; Emeterio i González-Badillo, 2010; Neumayr i saradnici, 2003). Isto tako istraživanja su pokazala da iste motoričke sposobnosti u istom odnosu ne utiču jednako na sportski rezultat kod skijaša takmičara kao i na efikasnost učenja skijanja kod skijaša rekreativnog nivoa (Cigrovski, Matković i Matković, 2008a, 2008b; Cigrovski, Bilić, Prlenda i Martinčević, 2010; Gross i saradnici, 2010; Maffioletti, Jordan, Spring, Impellizzeri i Bizzini, 2009; Oreb, Vlašić, Cigrovski, Prlenda i Radman, 2011). S obzirom na dokazani različiti udio pojedinih motoričkih sposobnosti kod skijaša takmičara i kod skijaša rekreacijskog nivoa, ovim istraživanjem želja je utvrditi koje motoričke sposobnosti doprinose usvajanju elemenata skijaške tehnike kod skijaških početnika. Isto tako ovim radom pokušaću se utvrditi uticaj nekih morfoloških karakteristika na efikasnost sticanja skijaških znanja.

## METHODS

86 subjects participated in this study and their age was  $22.76 \pm 1.15$ . All the subjects were male and beginners without any previous experience in alpine skiing. For this study 17 tests were chosen in order to assess subjects' motor abilities. All the applied tests for motor abilities assessment were carried out according to standard procedure for measurement and they were chosen because of their good metric characteristics (Bosco, 1997; Reid, Johnson, Kipp, Albert, & White, 1997). The following tests were used: side agility with step and close (MAGKUS), frontal agility (MAG9NN), vertical squat jump (MESSJ), vertical jump with preparation (MESCM), standing long jump (MESSDM), throwing the medicine ball from supine position (MESBML3), leg taping – 15 seconds (MFR-TAN), "cating" – 15 seconds (MFRCAT), "sit and reach" (MFLSAR), longitudinal left leg balance (MRU10L), longitudinal right leg balance (MRU10D), diagonal left leg balance (MRP10L), diagonal right leg balance (MRP10D), 20m running (MES20M), and "hexagon" (MAGHEX). Morphological characteristics followed in this study are measured according to instructions and regulations of International Biological Program (IBP). This program consists of 39 measures (Mišigoj-Duraković, 2008), and the ones used in this study are: body height (HEIGHT), body mass (MASS), body fat percentage (% FAT), right thigh girth (OPSNATD). Alpine skiing learning process has lasted for 7 days for all the subjects. During these 7 days, the subjects had the same conditions related to a number of subjects in each skiing group (10), a number of hours spent on learning every day (4), amount of exercising every day (2), quality and adequacy of ski equipment, ski instructor and skiing ground adequacy. After learning process was completed, all the subjects were joined in one group, and in alphabetical order they presented 7 previously learned skiing technique elements to independent judges. On the basis of marks given for the demonstrations of traversing left (KSL), traversing right (KSD), left uphill turn (ZKBL), right uphill turn (ZKBD), basic turn (OZ), parallel turn (PZ), and short turn (V), acquired skiing knowledge of every subject was evaluated. Marks for subjects' knowledge ranged from 1 to 5, where 1 represents the poor and 5 represents the superb skiing knowledge. Since the study's results depend significantly on skiing instructors and judges, they were very carefully chosen. Every single instructor and judge included in this study got detailed in-

## METODE

U ovom istraživanju učestvovalo je 86 ispitanika, životne dobi od  $22,76 \pm 1,15$  godina. Svi ispitanici bili su muškoga pola i skijaški početnici, što znači bez prethodnog iskustva u alpskom skijanju. Za potrebe ovoga istraživanja odabrano je sedamnaest testova za procjenu motoričkih sposobnosti ispitanika. Svi primijenjeni testovi za procjenu motoričkih sposobnosti provedeni su prema standardizovanom postupku mjerenja, a izabrani su zbog svojih dobrih metrijskih karakteristika (Bosco, 1997; Reid, Johnson, Kipp, Albert i White, 1997). Korišćeni testovi su: bočna agilnost dokorakom (MAGKUS), čeona agilnost (MAG9NN), vertikalni skok iz čučnja (MESSJ), vertikalni skok s pripremom (MESCM), skok u dalj iz mjesta (MESSDM), bacanje medicine od 3 kg iz ležanja (MESBML3), taping nogom - 15 sekundi (MFR-TAN), "cating" - 15 sekundi (MFRCAT), podizanje trupa u 60 sekundi (MRSPT6), izdržaj u čučnju (MSSIC), "sit and reach" (MFLSAR), ravnotežni položaj lijeve noge uzdužno (MRU10L), ravnotežni položaj desne noge uzdužno (MRU10D), ravnotežni položaj lijeve noge poprečno (MRP10L), ravnotežni položaj desne noge poprečno (MRP10D), trčanje 20 m (MES20M) te "hexagon" (MAGHEX). Morfološke karakteristike koje su praćene u ovom istraživanju mjerene su prema uputstvima i propisima Međunarodnog biološkog programa (IBP-International Biological Program). Taj program sastoji se od 39 mjera (Mišigoj-Duraković, 2008), od kojih su za potrebe ovoga istraživanja korištene: visina tijela (VISINA), masa tijela (MASA), procenat tjelesne masti (% MASTI) te obim desne natkoljenice (OPSNATD). Proces učenja alpskog skijanja trajao je sedam dana za sve ispitanike. Tokom perioda od sedam dana ispitanici su imali jednake uslove vezano uz: broj ispitanika u pojedinoj skijaškoj grupi (10), broj časova učenja tokom svakoga dana (4), broj časova vježbanja tokom svakoga dana (2), kvalitet i adekvatnost skijaške opreme, kvalitet učitelja skijanja, te adekvatnost skijaških terena. Nakon procesa učenja svi ispitanici spojeni su u jednu grupu, te su prema abecednom redu ispred nezavisnih ispitivača demonstrirali 7 elemenata skijaške tehnike koje su prethodno usvajali tokom procesa učenja. Na osnovu dobijenih ocjena za demonstraciju: spusta koso u lijevu stranu (KSL), spusta koso u desnu stranu (KSD), zavoja ka padini u lijevu stranu (ZKBL), zavoja ka padini u desnu stranu (ZKBD), osnovnih zavoja (OZ), paralelnih zavoja (PZ), te vijuganja (V), utvrđen je usvojeni nivo skijaškog znanja za svakog ispitanika. Ocjenjivanje ispitanika vršeno je ocjenama od jedan do pet, gdje jedan predstavlja najmanji, a pet najveći nivo usvojenog skijaškog znanja. Budući da rezultati ovog istraživanja značajno zavise od učitelja skijanja, te ocjenjivača, posebna pažnja usmjerena je prilikom

structions on a method of beginner skiers teaching and a method and criteria for evaluation. Standard procedure for measurement for evaluation of skiing knowledge was carried out while collecting data (Cigrovski et al., 2008a, 2008b). Data in this study were processed by regression analysis with the aim to determine the influence of the predictor set of tests for assessment of motor abilities and determined morphological abilities on the level of skiing knowledge. Factor analysis was used for the entire skiing knowledge determination. Collected data were analyzed by statistics package "Statistica 8.0". The obtained results were considered statistically significant with  $p < .05$ .

njihovog izbora. Svaki pojedini učitelj i ispitivač uključen u ovo istraživanje dobio je detaljna uputstva o načinu podučavanja skijaških početnika, te načinu i kriterijumima ocjenjivanja. Prilikom prikupljanja podataka korišćen je standardizovani postupak ocjenjivanja skijaških znanja (Cigrovski i saradnici, 2008a, 2008b). Podaci u ovom istraživanju obrađeni su regresijskom analizom s ciljem utvrđivanja uticaja prediktorskog skupa testova za procjenu motoričkih sposobnosti i utvrđenih morfoloških karakteristika na nivo usvojenog skijaškog znanja. Za utvrđivanje ukupnog skijaškog znanja korišćena je faktorska analiza. Prikupljeni podaci obrađeni su pomoću statističkoga paketa "Statistica 8.0". Dobijeni rezultati smatrani su statistički značajnima pri  $p < 0,05$ .

## RESULTS AND DISCUSSION

In Tables from 1 to 7 is shown the contribution of test results obtained during assessment of developed motor abilities and determined morphological characteristics of the subjects to learning of alpine skiing technique elements: traversing right and left, right and left uphill turn, basic turn, parallel turn and short turn.

Four tests for motor abilities assessment selected by regression analysis statistically significantly contribute to learning of traversing. These four selected tests explain 23%, i.e. 20% of common variability

## REZULTATI I DISKUSIJA

U Tabelama 1 do 7 prikazan je doprinos rezultata u testovima za procjenu razvijenosti motoričkih sposobnosti i utvrđenih morfoloških karakteristika ispitanika na učenje elemenata skijaške tehnike: kosi spust u desnu i lijevu stranu, zavoj ka padini u desnu i lijevu stranu, osnovni zavoj, paralelni zavoj i vijuganje.

Regresijskom analizom izdvojena su četiri testa za procjenu motoričkih sposobnosti, koji statistički značajno doprinose učenju spusta koso. Četiri izdvojena testa objašnjavaju 23%, odnosno 20% zajedničkog varijabiliteta pri učenju spusta koso ( $R^2 = 0,23$ ;  $R^2 =$

**TABLE 1**

*Regression analysis results ( $R = .48$ ;  $R^2 = .23$ ;  $p = .00$ ) between tests for assessment of subjects' motor abilities and determined morphological characteristics, and success in demonstration of skiing technique elements for traversing right.*

**TABELA 1**

*Rezultati regresione analize ( $R = 0,48$ ;  $R^2 = 0,23$ ;  $p = 0,00$ ) između testova za procjenu motoričkih sposobnosti ispitanika, te utvrđenih morfoloških karakteristika i uspjeha pri demonstraciji elementa skijaške tehnike kosi spust u desnu stranu.*

	B	SE	$\beta$	p
MFRCAT	-.08	.03	-.31	<b>.01</b>
MRSPT6	.02	.01	.20	.07
MRU10L	.01	.00	.23	<b>.03</b>
MAGHEX	.22	.06	.38	<b>.00</b>

Legend: **MFRCAT** - "Cating" - 15 seconds ("Cating" - 15 sekundi); **MRSPT6** - Body raising in 60 seconds (Podizanje trupa u 60 sekundi); **MRU10L** - Longitudinal left leg balance (Ravnotežni položaj lijeve noge uzdužno); **MAGHEX** - "Hexagon" ("Hexagon"); **B** - Partial regression non-standardized coefficient (Nestandardizovani koeficijent parcijalne regresije); **SE** - Standard error in B coefficient assessment (Standardna greška procjene B koeficijenta);  **$\beta$**  - Standardized, partial regression coefficient (Standardizovani, parcijalni, regresioni koeficijent); **p** - Probability (Vjerovatnoća).

**TABLE 2**

*Regression analysis results ( $R = .45$ ;  $R^2 = .25$ ;  $p = .00$ ) between tests for assessment of subjects' motor abilities and determined morphological characteristics, and success in demonstration of skiing technique elements for traversing left.*

**TABELA 2**

*Rezultati regresione analize ( $R = 0,45$ ;  $R^2 = 0,25$ ;  $p = 0,00$ ) između testova za procjenu motoričkih sposobnosti ispitanika, te utvrđenih morfoloških karakteristika i uspjeha pri demonstraciji elementa skijaške tehnike kosi spust u lijevu stranu.*

	B	SE	$\beta$	p
MFRCAT	-.07	.03	-.25	<b>.03</b>
MRSPT6	.03	.01	.30	<b>.01</b>
MRU10L	.01	.00	.28	<b>.01</b>
MAGHEX	.16	.07	.26	<b>.02</b>

Legend: **MFRCAT** - "Cating" - 15 seconds ("Cating" - 15 sekundi); **MRSPT6** - Body raising in 60 seconds (Podizanje trupa u 60 sekundi); **MRU10L** - Longitudinal left leg balance (Ravnotežni položaj lijeve noge uzdužno); **MAGHEX** - "Hexagon" ("Hexagon"); **B** - Partial regression non-standardized coefficient (Nestandardizovani koeficijent parcijalne regresije); **SE** - Standard error in B coefficient assessment (Standardna greška procjene B koeficijenta);  **$\beta$**  - Standardized, partial, regression coefficient (Standardizovani, parcijalni, regresioni koeficijent); **p** - Probability (Vjerovatnoća).

while learning traversing ( $R^2 = .23$ ;  $R^2 = .20$ ), and the greatest single influence on traversing learning has the subject's result in hexagon ( $\beta = .38$ ;  $\beta = .26$ ). Since the traversing left and right elements are performed statically, without additional movement of a skier during the performance, one can expect that subject's results in tests for static balance assessment influence significantly the learning process ( $\beta = .23$ ;  $\beta = .28$ ). Correlation of balance with success during ski beginners' learning of basic elements of alpine ski technique was also noted in studies carried out by Malliou et al. (2004), whose experimental group had balance improvement trainings besides learning of basic alpine skiing technique. In his study, Kostelić (2005) also emphasizes that balance can probably make an important difference between those who will learn to ski faster than the ones who will acquire the skiing technique somewhat slower.

Of all the used tests for assessment of motor abilities, the biggest influence on acquiring of traversing elements had tests for agility assessment (side agility with step and close  $\beta = .26$  and hexagon  $\beta = .33$ ;  $\beta = .23$ ). Except the tests for assessment of motor abilities in right uphill turn, body height and mass are selected as morphological measures which influence significantly the level of acquired knowledge related to this element. Having in mind that the obtained body height result has a minus sign, we can

0,20), a najveći zasebni uticaj na usvajanje spusta koso ima rezultat ispitanika u testu hexagon ( $\beta = 0,38$ ;  $\beta = 0,26$ ). Kako se elementi spust koso u lijevu i desnu stranu izvode statički, bez dodatnih kretanja skijaša tokom njegovog izvođenja, za očekivati je da rezultati ispitanika u testovima za procjenu statičke ravnoteže značajno utiču na njihovo usvajanje ( $\beta = 0,23$ ;  $\beta = 0,28$ ). Povezanost ravnoteže s uspjehom pri učenju osnovnih elemenata skijaške tehnike kod skijaških početnika utvrđena je i u istraživanja Mallioua i saradnika (2004), čija eksperimentalna grupa je osim učenja osnove skijaške tehnike imala i treninge za razvoj ravnoteže. Kostelić (2005) u svom radu takođe naglašava kako ravnoteža vjerovatno najviše razlikuje one koji će brže naučiti skijati od onih koji će skijašku tehniku usvojiti nešto sporije.

Od svih korišćenih testova za procjenu motoričkih sposobnosti najveći uticaj na usvajanje elementa zavoj ka padini imaju testovi za procjenu agilnosti (bočna agilnost dokorakom  $\beta = 0,26$  te hexagon  $\beta = 0,33$ ;  $\beta = 0,23$ ). Osim testova za procjenu motoričkih sposobnosti kod zavoja ka padini u desnu stranu izdvojena je tjelesna visina i masa, kao morfološke mjere koje značajno utiču na nivo usvojenog znanja ovog elementa. S obzirom da je dobijeni rezultat kod tjelesne visine negativnog predznaka, za pretpostaviti je kako ona obrnuto proporcionalno utiče na brzinu

**TABLE 3**

*Regression analysis results ( $R = .57$ ;  $R^2 = .32$ ;  $p = .00$ ) of tests for assessment of subjects' motor abilities and determined morphological characteristics, and success in demonstration of skiing technique elements for right uphill turn.*

**TABELA 3**

*Rezultati regresione analize ( $R = 0,57$ ;  $R^2 = 0,32$ ;  $p = 0,00$ ) testova za procjenu motoričkih sposobnosti ispitanika, te utvrđenih morfoloških karakteristika i uspjeha pri demonstraciji elementa skijaške tehnike zavoja ka padini u desnu stranu.*

	B	SE	$\beta$	p
MAGKUS	.36	.13	.26	<b>.01</b>
MFRTAN	-.09	.04	-.24	<b>.03</b>
MRSPT6	.02	.01	.18	.07
MES20M	.63	.37	.16	<b>.01</b>
MAGHEX	.19	.06	.33	<b>.00</b>
HEIGHT	-.05	.02	-.50	<b>.00</b>
MASS	.03	.01	.34	<b>.02</b>

Legend: **MAGKUS** - Side agility with step and close (Bočna agilnost dokorakom); **MFR-TAN** - Leg taping - 15 seconds (Taping nogom-15 sekundi); **MRSPT6** - Body raising in 60 seconds (Podizanje trupa u 60 sekundi); **MES20M** - Running 20 m (Trčanje 20 m); **MAGHEX** - "Hexagon" ("Hexagon"); **HEIGHT** - Body height (Visina tijela); **MASS** - Body mass (Težina tijela); **B** - Partial regression non-standardized coefficient (Nestandardizovani koeficijent parcijalne regresije); **SE** - Standard error in B coefficient assessment (Standardna greška procjene B koeficijenta);  **$\beta$**  - Standardized, partial, regression coefficient (Standardizovani, parcijalni, regresioni koeficijent); **p** - Probability (Vjerovatnoća).

**TABLE 4**

*Regression analysis results ( $R = .43$ ;  $R^2 = .19$ ;  $p = .00$ ) of tests for assessment of subjects' motor abilities and determined morphological characteristics, and success in demonstration of skiing technique elements for left uphill turn.*

**TABELA 4**

*Rezultati regresione analize ( $R = 0,43$ ;  $R^2 = 0,19$ ;  $p = 0,00$ ) testova za procjenu motoričkih sposobnosti ispitanika, te utvrđenih morfoloških karakteristika i uspjeha pri demonstraciji elementa skijaške tehnike zavoja ka padini u lijevu stranu.*

	B	SE	$\beta$	p
MRSPT6	.02	.01	.21	.06
MSSIC	.00	.00	.19	<b>.05</b>
MRU10L	.01	.00	.24	<b>.03</b>
MAGHEX	.13	.06	.23	<b>.03</b>

Legend: **MRSPT6** - Body raising in 60 seconds (Podizanje trupa u 60 sekundi); **MSSIC** - Squat endurance (Izdržaj u čučnju); **MRU10L** - Longitudinal left leg balance (Ravno-težni položaj lijeve noge uzdužno); **MAGHEX** - "Hexagon" ("Hexagon"); **B** - Partial regression non-standardized coefficient (Nestandardizovani koeficijent parcijalne regresije); **SE** - Standard error in B coefficient assessment (Standardna greška procjene B koeficijenta);  **$\beta$**  - Standardized, partial, regression coefficient (Standardizovani, parcijalni, regresioni koeficijent); **p** - Probability (Vjerovatnoća).

**TABLE 5**

Regression analysis results ( $R = .47$ ;  $R^2 = .22$ ;  $p = .00$ ) of tests for assessment of subjects' motor abilities and success in demonstration of skiing technique elements for basic turn.

**TABELA 5**

Rezultati regresione analize ( $R = 0,47$ ;  $R^2 = 0,22$ ;  $p = 0,00$ ) testova za procjenu motoričkih sposobnosti ispitanika i uspjeha pri demonstraciji elementa skijaške tehnike osnovni zavoji.

	B	SE	$\beta$	p
MSSIC	.01	.00	.35	<b>.00</b>
MES20M	-.88	.48	-.18	.07
MAGHEX	.12	.07	.18	.09

Legend: **MSSIC** - Squat endurance (Izdržaj u čučnju); **MES20M** - Running 20 m (Trčanje 20 m); **MAGHEX** - "Hexagon" ("Hexagon"); **B** - Partial regression non-standardized coefficient (Nestandardizovani koeficijent parcijalne regresije); **SE** - Standard error in B coefficient assessment (Standardna greška procjene B koeficijenta);  **$\beta$**  - Standardized, partial, regression coefficient (Standardizovani, parcijalni, regresioni koeficijent); **p** - Probability (Vjerovatnoća).

**TABLE 6**

Regression analysis results ( $R = .47$ ;  $R^2 = .22$ ;  $p = 0,00$ ) of tests for assessment of subjects' motor abilities and success in demonstration of skiing technique elements for parallel turn.

**TABELA 6**

Rezultati regresione analize ( $R = 0,47$ ;  $R^2 = 0,22$ ;  $p = 0,00$ ) testova za procjenu motoričkih sposobnosti ispitanika i uspjeha pri demonstraciji elementa skijaške tehnike paralelni zavoji.

	B	SE	$\beta$	p
MAG9NN	.34	.16	.22	<b>.03</b>
MSSIC	.00	.00	.27	<b>.01</b>
MAGHEX	.20	.07	.32	<b>.00</b>

Legend: **MAG9NN** - Frontal agility (Čeona agilnost); **MSSIC** - Squat endurance (Izdržaj u čučnju); **MAGHEX** - "Hexagon" ("Hexagon"); **B** - Partial regression non-standardized coefficient (Nestandardizovani koeficijent parcijalne regresije); **SE** - Standard error in B coefficient assessment (Standardna greška procjene B koeficijenta);  **$\beta$**  - Standardized, partial, regression coefficient (Standardizovani, parcijalni, regresioni koeficijent); **p** - Probability (Vjerovatnoća).

assume it reversely influences the speed of skiing technique acquiring. The obtained results can be explained by the fact that in higher skiers the body's centre of gravity is further from snow field than in shorter skiers, therefore it is easier for them to disrupt the balance and harder to get it back while moving downhill. Except the negative influence of skier's body height on balance, it also influences coordination negatively, so it means that higher skiers learn alpine skiing harder than the shorter ones (Dolenc & Žvan, 2001). Unlike the body height, skier's body mass has a positive influence on level of acquired knowledge related to uphill turn. Proved positive

usvajanja skijaške tehnike. Dobijene podatke moguće je objasniti činjenicom kako je kod visokih skijaša težište tijela udaljenije od snježne podloge u odnosu na niže skijaše, pa zbog toga lakše narušavaju ravnotežni položaj, te ga nakon narušavanja ponovno teže uspostavljaju prilikom kretanja niz skijašku padinu. Osim negativnog uticaja visine tijela skijaša na ravnotežu, ona negativno utiče i na koordinaciju što znači da će višim skijašima biti teže usvajati skijaška znanja u odnosu na niže skijaše (Dolenc i Žvan, 2001). Za razliku od visine tijela, masa skijaša pozitivno utiče na nivo usvojenog znanja zavoja ka padini. Utvrđen pozitivan doprinos mase tijela moguće je objasniti

contribution of body mass can be explained by necessary continuous body pressure of a skier on outer ski while performing uphill turn. We can expect that the skiers with greater body mass will make the necessary body pressure over the skis to the snow field more easily. An important rule of properly performed turn is that a skier must transfer his body mass mostly or completely to the outer ski (Matković, Ferenčak, & Žvan, 2004), and uphill turn is one of the first turns which a ski beginner learns. Therefore, it is logical to have a positive contribution of test results for longitudinal left leg balance on a balance bench while learning uphill turn.

Basic turn, parallel turn and short turn are skiing technique elements in which a skier associates more turns continuously, so in their performance leg muscles are much more engaged in comparison to traversing and uphill turn which are only performed to the left or right side. Three selected tests for subjects' motor abilities assessment explain 22% of common variability while learning basic turn ( $R^2 = .22$ ), and the greatest single influence on learning basic turn has the subject's result in test for assessment of static strength of leg muscles ( $\beta = .35$ ). Obtained results confirm that in learning and improving of skiing technique elements, where many turns are linked continuously, thigh and lower leg muscles' strength is necessary.

Parallel turn is the best representative of skiing technique in a wider corridor, which is mostly done by skiers while acquiring downhill skiing. Taking into account obtained results, it is possible to emphasize agility (frontal agility,  $\beta = .22$ ; hexagon,  $\beta = .32$ ) and static strength (squat endurance,  $\beta = .27$ ) to contribute the most to parallel turn learning.

According to a definition, short turn is continuous association of short, incomplete parallel turns (Matković et al., 2004), and a skier will learn this element if he has developed agility. Subjects' ability to change direction of moving swiftly is assessed by three tests (side agility with step and close ( $\beta = .26$ ), frontal agility ( $\beta = .26$ ), hexagon ( $\beta = .34$ )) which influence significantly short turn learning.

According to regression analysis results it is possible to note that hexagon test for agility assessment occurs systematically in learning all skiing technique elements, since the previous studies proved that, of all the motor abilities, explosive leg strength has the greatest influence on success of alpine ski competitors (Bocco, 1997; Reid et al., 1997). So we can assume that agility is a motor ability which particularly contributes to skiing technique basics learning.

The previous studies arranged motor abilities according to their importance for competitor and

neophodnim kontinuiranim pritiskom tijela skijaša na vanjsku skiju tokom izvođenja zavoja ka padini. Za očekivati je kako će oni skijaši koji imaju veću tjelesnu masu lakše učiniti potreban pritisak tijela preko skija na snježnu podlogu. Važno pravilo korektno izvedenog zavoja je da skijaš težinu tijela većinom ili u potpunosti mora prebaciti na vanjsku skiju (Matković, Ferenčak i Žvan, 2004), a zavoj ka padini jedan je od prvih zavoja koji skijaški početnik usvaja. Stoga je logičan pozitivan doprinos rezultata u testu ravnotežni položaj lijeve noge uzdužno na klupici za ravnotežu kod učenja zavoja ka padini.

Osnovni zavoj, paralelni zavoj, te vijuganje su elementi skijaške tehnike u kojima skijaš u kontinuitetu povezuje više zavoja, pa se kod njihovog izvođenja znatno više angažuju mišići nogu, u odnosu na spust koso i zavoj ka padini, koji se izvode samo u lijevu ili desnu stranu. Tri izdvojena testa za procjenu motoričkih sposobnosti ispitanika objašnjavaju 22% zajedničkog varijabiliteta pri učenju osnovnog zavoja ( $R^2 = 0,22$ ), a najveći pojedinačni uticaj na usvajanje osnovnog zavoja ima rezultat ispitanika u testu za procjenu statičke snage mišića nogu ( $\beta = 0,35$ ). Dobijeni rezultati potvrđuju kako je kod učenja i usavršavanja elemenata skijaške tehnike, gdje se povezuje više zavoja u kontinuitetu neophodna snaga mišića natkoljenice i potkoljenice.

Paralelni zavoj je najbolji predstavnik skijaške tehnike u širem koridoru, koji skijaši najčešće koriste prilikom savladavanja padine. Uvidom u dobijene rezultate moguće je istaknuti agilnost (čeoona agilnost,  $\beta = 0,22$ ; hexagon,  $\beta = 0,32$ ), te statičku snagu (izdržaj u čučnju,  $\beta = 0,27$ ), koje od svih motoričkih sposobnosti najviše doprinose učenju paralelnog zavoja.

Vijuganje po definiciji predstavlja kontinuirano povezivanje kratkih, nedovršenih, paralelnih zavoja (Matković i saradnici, 2004), te će opisani element skijaš brže usvojiti ako ima razvijenu agilnost. Sposobnost brze promjene pravca kretanja kod ispitanika procijenjena s tri testa (bočna agilnost dokorakom ( $\beta = 0,26$ ), čeoona agilnost ( $\beta = 0,26$ ) i hexagon ( $\beta = 0,34$ ), koji značajno utiču na usvajanje vijuganja.

Uvidom u rezultate regresione analize moguće je uočiti kako se test hexagon za procjenu agilnosti sistematski pojavljuje kod učenja svih elemenata skijaške tehnike. Kako su dosadašnja istraživanja dokazala da eksplozivna snaga nogu od svih motoričkih sposobnosti ima najveći uticaj na uspjeh takmičara u alpskom skijanju (Bocco, 1997; Reid i saradnici, 1997), tako je moguće pretpostaviti kako je agilnost motorička sposobnost koja izrazito doprinosi učenju osnova skijaške tehnike.



recreational alpine skiers (Neumayr et al., 2003). The biggest influence on single motor ability development is possible to achieve by a proper training, doing specific focused exercises which will stimulate the rising of certain motor ability level. However, systematic skiing can also influence the motor abilities which are particularly important for skiing. But, since the recreational level skiers ski continuously for 6, or

Dosadašnja istraživanja definisala su poredak motoričkih sposobnosti po važnosti za alpske skijaše bilo takmičarskog, bilo rekreacijskog nivoa (Neumayr i saradnici, 2003). Najveći uticaj na razvoj pojedine motoričke sposobnosti moguće je ostvariti adekvatnim treningom, korišćenjem specifičnih, usmjerenih vježbi koje će podstaći podizanje nivoa određene motoričke sposobnosti. Međutim, na one motoričke sposobnosti

**TABLE 7**

*Regression analysis results ( $R = .52$ ;  $R^2 = .27$ ;  $p = .00$ ) of tests for assessment of subjects' motor abilities and determined morphological characteristics, and success in demonstration of skiing technique elements for short turn.*

**TABELA 7**

*Rezultati regresione analize ( $R = 0,52$ ;  $R^2 = 0,27$ ;  $p = 0,00$ ) testova za procjenu motoričkih sposobnosti ispitanika te utvrđenih morfoloških karakteristika i uspjeha pri demonstraciji elementa skijaške tehnike vijuganje.*

	B	SE	$\beta$	p
MAGKUS	.43	.17	.26	<b>.02</b>
MAG9NN	.44	.18	.26	<b>.02</b>
MAGHEX	.24	.07	.34	<b>.00</b>
HEIGHT	-.03	.01	-.24	<b>.04</b>
%FAT	-.08	.04	-.34	<b>.03</b>
OPSNATD	.07	.04	.33	<b>.05</b>

Legend: **MAGKUS** - Side agility with step and close (Bočna agilnost dokorakom); **MAG9NN** - Frontal agility (Čeona agilnost); **MAGHEX** - "Hexagon" ("Hexagon"); **HEIGHT** - Body height (Visina tijela); **%FAT** - Body fat percentage (Postotak tjelesne masti); **OPSNATD** - Right thigh scope (Obim desne nadkoljenice); **B** - Partial regression non-standardized coefficient (Nestandardizovani koeficijent parcijalne regresije); **SE** - Standard error in B coefficient assessment (Standardna greška procjene B koeficijenta);  **$\beta$**  - Standardized, partial, regression coefficient (Standardizovani, parcijalni, regresioni koeficijent); **p** - Probability (Vjerovatnoća).

**TABLE 8**

*Factor analysis results.*

**TABELA 8**

*Rezultati faktorske analize.*

Components (Factors)	Characteristic value	% variance	Cumulative %
1	4.36	62.26	62.26
2	.91	13.00	75.26
3	.63	8.96	84.22
4	.47	6.67	90.89
5	.26	3.71	94.60
6	.21	2.95	97.55
7	.17	2.45	100.00

Legend: Components (Factors) - Komponente (faktori); Characteristic value - Karakteristična vrijednost; % variance - % varijanse; Cumulative % - Kumulativni %.

**TABLE 9**

*Regression analysis results ( $R = .48$ ;  $R^2 = .23$ ;  $p = .00$ ) of tests for assessment of subjects' motor abilities and acquired alpine ski knowledge.*

**TABELA 9**

*Rezultati regresione analize ( $R = 0,48$ ;  $R^2 = 0,23$ ;  $p = 0,00$ ) testova za procjenu motoričkih sposobnosti ispitanika i usvojenog skijaškog znanjaj.*

	B	SE	$\beta$	p
MSSIC	.00	.00	.21	<b>.04</b>
MRU10L	.01	.00	.21	<b>.04</b>
MAGHEX	.29	.08	.35	<b>.00</b>

Legend: **MSSIC** - Squat endurance (Izdržaj u čučnju); **MRU10L** - Longitudinal left leg balance (Ravnotežni položaj lijeve noge uzdužno); **MAGHEX** - "Hexagon" ("Hexagon"); **B** - Partial regression non-standardized coefficient (Nestandardizovani koeficijent parcijalne regresije); **SE** - Standard error in B coefficient assessment (Standardna greška procjene B koeficijenta);  **$\beta$**  - Standardized, partial, regression coefficient (Standardizovani, parcijalni, regresioni koeficijent); **p** - Probability (Vjerovatnoća).

7 days, yearly we can assume that in such a short period of time it is not possible to significantly influence the development of the motor abilities important for skiing. For that reason, it is logical to recommend to skiers and those who will start skiing to have proper body preparation prior to skiing course. In order to have quality fitness preparation, skiers must definitely develop agility, static leg muscles strength and balance, because they have a great influence on efficacy of skiing learning. Underdevelopment of motor abilities undoubtedly has a certain negative influence on success while acquiring skiing technique elements. Focused exercises not done in ski field can influence development of the motor abilities which are particularly employed while skiing. Moreover, it is possible to influence the significant motor abilities important for skiing by doing specific body activities like rollerblading, besides preparation in specialized fitness centers. During rollerblading, a person performs almost the same movements as in performing short turn, and that is the reason why rollerblading is recommended while preparing for skiing (Roman, Miranda, Martinez, & Viciano, 2009; Takahashi & Yoneyama, 2001). Good fitness preparation influences the speed of skiing technique acquiring and minimizes the risk of possible injuries while skiing (Koehle, Loyd-Smith, & Taunton, 2002).

Main components matrix was calculated by factor analysis based on subjects' marks for seven skiing technique elements.

One important factor is isolated ( $\lambda = 4.36$ ) on the basis of calculated characteristic values using GK criteria. It is possible to assume that obtained factor

koje su izrazito važne za skijanje moguće je uticati i sistemskim skijanjem. Ali, kako skijaši rekreacionog nivoa u pravilu kontinuirano skijaju 6, odnosno 7 dana pretpostavka je da u tako kratkom periodu nije moguće znatnije uticati na razvoj onih motoričkih sposobnosti koje su važne za skijanje. Stoga je logična preporuka skijašima i onima koji će to tek postati da se prije početka škole skijanja adekvatno za nju fizički pripreme. Kako bi se mogli kvalitetno kondiciono pripremiti, skijaši definitivno moraju razvijati agilnost, statičku snagu mišića nogu i ravnotežu, jer one izrazito utiču na efikasnost učenja skijanja. Nerazvijenost motoričkih sposobnosti definitivno ima određeni negativan uticaj na uspješnost usvajanja elemenata skijaške tehnike. Na razvoj motoričkih sposobnosti koje su izrazito zastupljene prilikom skijanja moguće je uticati pomoću usmjerenih vježbi koje se najčešće ne izvode na skijaškom terenu. Ali, uticati na bitne motoričke sposobnosti za skijanje moguće je, osim pripreme u specijalizovanim fitness centrima, baveći se specifičnim fizičkim aktivnostima poput rolanja. Naime, tokom rolanja čovjek čini gotovo identična kretanja kao i prilikom izvođenja vijuganja (Roman, Miranda, Martinez i Viciano, 2009; Takahashi i Yoneyama, 2001), te se zbog toga rolanje preporučuje u periodu pripreme za odlazak na skijanje. Kvalitetnom kondicionom pripremom, osim što će se uticati na brzinu usvajanja skijaške tehnike, uticaće se i na smanjenje mogućih povreda prilikom skijanja (Koehle, Loyd-Smith, & Taunton, 2002, 2002).

Faktorskom analizom izračunata je matrica glavnih komponenti na osnovu ostvarenih ocjena ispitanika na sedam elemenata skijaške tehnike.

Na osnovu izračunatih svojstvenih vrijednosti uz pomoću GK kriterija izolovan je jedan značajni faktor

represents skiing knowledge because it best explains the complete variance of seven elements of skiing technique (62.26%).

Three tests for motor abilities assessment which influence a beginner's acquiring of skiing knowledge were selected in a variable obtained by factor analysis. As in skiing technique analyzed elements, contribution of test hexagon ( $\beta = .35$ ) is emphasized, and according to it subject's agility was estimated. Obtained results confirm the influence of agility on acquired skiing knowledge level.

## CONCLUSION

Since the configuration of each ski field is different and snow conditions there are unique, at every moment a skier, while going down the slope, uses all motor abilities which together with acquired skiing knowledge take part in directing of skis. Of all the assessed motor abilities, agility has the greatest influence on ski beginners' acquiring of ski knowledge. Static leg strength also influences skiing technique learning, and balance is significantly important at the beginning of learning process while learning basic elements. Pedagogues, teachers and instructors should know ways and methods for teaching skiing. But when they teach specific ski movements they should respect motor abilities influence on that process. Therefore, recreational skiers or the future ones are recommended to have proper fitness motor preparation before going in ski fields.

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( $\lambda = 4,36$ ). Moguće je pretpostaviti da dobijeni faktor predstavlja skijaško znanje, jer najviše objašnjava ukupnu varijansu sedam elemenata skijaške tehnike (62,26%).

Na varijabli dobijenoj faktorskom analizom izdvojila su se tri testa za procjenu motoričkih sposobnosti koja utiču na usvajanje skijaškog znanja kod početnika. Kao i kod analiziranih elemenata skijaške tehnike ističe se doprinos ( $\beta = 0,35$ ) testa hexagon, na osnovu čega je procijenjena agilnost ispitanika. Dobijeni rezultati samo potvrđuju uticaj agilnosti na nivo usvojenog skijaškog znanja.

## ZAKLJUČAK

Kako je konfiguracija svakog skijaškog terena drugačija, te kako su trenutni snježni uslovi na njima jedinstveni, skijaš u svakom trenutku savladavanja padine koristi svoje motoričke sposobnosti koje zajedno sa stečenim skijaškim znanjem učestvuju u upravljanju skijama. Od procijenjenih motoričkih sposobnosti najveći uticaj prilikom usvajanja skijaških znanja kod skijaških početnika ima agilnost. Statička snaga nogu takođe utiče na proces učenja skijaške tehnike, dok ravnoteža ima značajan uticaj u samom početku učenja, prilikom usvajanja osnovnih elemenata. Pedagoški radnici, učitelji i treneri su sigurno ti koji bi trebali poznavati načine i metode prenošenja skijaškog znanja. Međutim, kada podučavaju specifična skijaška kretanja trebalo bi poštovati uticaj motoričkih sposobnosti na taj proces. Stoga je preporuka skijašima rekreativnog nivoa ili budućim skijašima da se adekvatno kondiciono-motorički pripreme prije odlaska na skijaške terene.

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## DER EINFLUSS DER MOTORISCHEN FÄHIGKEITEN BEZÜGLICH DER TECHNIK DES ALPINEN SKIFAHRENS

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Alpines Skifahren auf Erholungsebene ist ein deutlich populärer Sport, dem während der Winterzeit viele Interessenten aktiv nachgehen.

Allerdings gibt es einige Anfänger, die bereits am ersten Lerntag das Skifahren, aufgrund Angst vor Verletzungsgefahr, aufgeben.

Einer der Faktoren, welcher das Aufgeben der weiteren Aneignung der Kenntnisse des Skifahrens beeinflusst, ist auch die vorrangig adäquate, leistungsfähige und motorische Vorbereitung zukünftiger Skifahrer.

Anlässlich dem Alpine Skifahren bewegt man sich auf eine spezielle Art und Weise, die sehr selten in der alltäglichen Bewegung vorkommt. Daher ist eine adäquate Vorbereitung der eigenen Fähigkeiten bereits vor dem Erlernen des Skifahrens notwendig.

Es ist bekannt, dass einige motorische Fähigkeiten im größeren Ausmaß als andere motorische Fähigkeiten das Erlernen des Skifahrens auf Erholungsebene beeinflussen.

Durch diese Forschung sind diese motorischen Fähigkeiten, welche die Aneignung der Kenntnisse des Skifahrens beeinflussen, belegt.

Außerdem war das Ziel der Forschung die Belegung der Auswirkung bestimmter morphologischer Charakteristiken auf das Erlernen der Kenntnisse des Skifahrens.

Bei der Forschung waren 86 Befragte im Alter von  $22.76 \pm 1.15$  beteiligt.

Alle Befragten waren männlich und Skineulinge, was bedeutet, sie hatten keine vorhergehende Erfahrung bezüglich Alpine Skifahren.

Für den Bedarf dieser Forschung wurden 17 Tests für die Beurteilung ausgewählt:

Balance, Agilität, explosive und statistische Kraft, Frequenz der Bewegung sowie Flexibilität des Befragten.

Morphologische Charakteristika welche bei diesen Forschungen beachtet wurden:

Körpergröße, Körpergewicht, Prozentanteil des Körperfettes sowie der Umfang des rechten Oberschenkels. Der Prozess des Erlernens des Alpines Skifahrens dauerte für alle Befragten sieben Tage. Während der Lernperiode hatten alle Befragten dieselben Bedingungen bezüglich: Anzahl der Befragten in den einzelnen Skigruppen (10), Anzahl der täglichen Lernstunden (4), Anzahl der täglichen Übungsstunden (2), Qualität und Adäquatheit der Skiausrüstung, Qualität des Skilehrers sowie Adäquatheit des Skigebietes.

Nach dem Lernprozess wurden alle Befragten in einer Gruppe alphabetisch zusammengestellt und demonstrierten vor den unabhängigen Prüfern die sieben Elemente der Techniken, die sie sich während der Lernphase angeeignet haben. Durch die Demonstration von: Abfahrt schräg links, Abfahrt schräg rechts, Abbiegung zum Berg links, Abbiegung zum Berg rechts, grundlegende Abbiegungen, parallele Abbiegungen sowie Windungen ist die erlernte Menge der Kenntnisse des Skifahrens für jeden Befragten durch eine Benotung belegt.

Die Benotung der Prüflinge erfolgte mittels Noten von 1 bis 5, wobei 1 das niedrigste und 5 das höchste Niveau des Erlernen darstellt. Die Ergebnisanalyse

zeigte, wie sich Agilität auf das Lernen aller erfragten Elemente der Skifahrertechnik positiv auswirkt. (schräge Abfahrt,  $\text{Beta}=0,38$ ;  $\text{Beta}=0,26$ ; Abbiegung zum Berg,  $\text{Beta}=0,33$ ;  $\text{Beta}=0,23$ ; grundlegende Abbiegung,  $\text{Beta}=0,18$ ; parallele Abbiegung,  $\text{Beta}=0,32$ ; Windung,  $\text{Beta}=0,34$ ). Die Ergebnisse der Befragten im Test bezüglich Ausdauer in der Hocke, bei dem die statische Kraft der Beine bewertet wird, haben gezeigt, dass sich die statische Kraft der Beine positiv auf das Erlernen der Abbiegung zum Berg ( $\text{Beta}=0,19$ ), grundlegende Abbiegung ( $\text{Beta}=0,35$ ), parallele Abbiegung ( $\text{Beta}=0,27$ ) auswirkt. Der Test für die Beurteilung des Gleichgewichtes (gleichgewichtige Lage der linken Beine waagrecht) hat gezeigt, dass sich das Gleichgewicht wesentlich auf das Erlernen der Grundelemente des Skifahrens (schräge Abfahrt rechts,  $\text{Beta}=0,23$ , schräge Abfahrt links,  $\text{Beta}=0,28$ , Abbiegung zum Berg links,  $\text{Beta}=0,24$ ) auswirkt. Die Körpergröße der Anfänger wirkt sich negativ auf die Leistung der Aneignung der Skifahrer-Kenntnisse aus,

( $\text{Beta}=-0,5$ ) was bedeutet, dass es den größeren Skifahrern im Vergleich zu den kleineren Skifahrern schwerer fällt, sich die Kenntnisse des Skifahrens anzueignen. Von den bewerteten motorischen Fähigkeiten bei Anfängern hat Agilität die größte Auswirkung beim Erlernen der Techniken des Skifahrens. Die statische Kraft der Beine hat ebenfalls einen Einfluss auf das Erlernen des Skifahrens, wobei das Gleichgewicht, anlässlich des Erlernens der Basiselemente, eine große Auswirkung am Anfang des Lernprozesses hat. Deshalb empfiehlt man angehenden Skifahrern eine adäquate leistungsfähige Vorbereitung vor dem Gang zur Skipiste, weil die Ergebnisse der Forschung auf die Wichtigkeit der Agilität, der statischen Kraft und des Gleichgewichtes beim Erlernen des Skifahrens deutet.

**Schlüsselwörter:** Alpiner Skilauf, Lernen, motorische Fähigkeiten, morphologische Merkmale.

# VIBRACIONI TRENING CIJELOG TIJELA POBOLJŠAVA SNAGU MIŠIĆA KOD REKREATIVNO AKTIVNE POPULACIJE

## WHOLE BODY VIBRATION TRAINING IMPROVES MUSCULAR POWER IN A RECREATIONALLY ACTIVE POPULATION

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### SUMMARY

Whole body vibration training has been shown to improve athletic performance. However, the majority of studies have utilised relatively intensive training programmes. The current study assessed the effect of a 6-week vibration training programme on a recreationally active population. Following institutional ethics approval, 22 healthy, recreationally active male individuals were recruited and randomly assigned into either a vibration group ( $n = 11$ ) or a control group ( $n = 11$ ). The vibration group undertook 6-weeks training, conducted once-a-week, utilising 3 different squatting exercises (120° and 90° static squats, and 120° - 90° dynamic squat) on a NEMES Bosco vibration platform: Week 1 (3 x 60 s, 35 Hz/2 mm); Week 2 (3 x 70 s, 35 Hz/2 mm); Week 3 (3 x 60 s, 40 Hz/2 mm); Week 4 (3 x 70 s, 40 Hz/2 mm); Week 5 (3 x 60 s, 45 Hz/2 mm); Week 6 (3 x 70 s, 45 Hz/2 mm). The control group followed the same training programme with sham (0 Hz/0 mm) vibration. Prior to, and on completion of, the study all participants performed 3 maximal countermovement jumps to assess muscular power. A 2-way ANOVA with repeated measures, with one between-subject factor "group" (experimental vs. control) and one within-subject factor "time" (pre vs. post intervention), indicated that there was a significant time x group interaction ( $p < .0001$ ) for countermovement jump performance between the intervention (pre- .43 ± .08m to post- .49m ± .08) and control group (pre- .43 ± .07m to post- .41 ± .08m). Results suggest that 6-week vibration training conducted once-a-week is sufficient to elicit significant increases in jumping performance in a recreationally active population.

**Key words:** jumping, performance, squatting,  
recreationally active, strength, power.

### SAŽETAK

Vibracioni trening cijelog tijela pokazao je poboljšanje sportskih sposobnosti. Međutim, većina istraživanja relativno su koristila intenzivne programe treninga. Ovo istraživanje procijenilo je efekat šestonedelnog programa vibracionog treninga na rekreativno aktivnom stanovništvu. Nakon što je dobijeno etičko institucionalno odobrenje, 22-oje rekreativno zdravih muškaraca nasumično je regrutovano i podijeljeno na vibracionu grupu ( $n = 11$ ) i kontrolnu grupu ( $n = 11$ ). Sa vibracionom grupom odrađen je šestonedeljni trening jednom sedmično koristeći tri različite vježbe čučnja (120° i 90° statički čučanj i 120° - 90° dinamički čučanj) na NEMES Bosco vibracionoj platformi: prva sedmica (3 x 60 s, 35 Hz/2 mm), druga sedmica (3 x 70 s, 35 Hz/2 mm), treća sedmica (3 x 60 s, 40 Hz/2 mm), četvrta sedmica (3 x 70 s, 40 Hz/2 mm), peta sedmica (3 x 60 s, 45 Hz/2 mm) i šesta sedmica (3 x 70 s, 45 Hz/2 mm). Kontrolna grupa koristila je isti program treninga sa lažnom vibracijom (0 Hz/0 mm). Prije i po završetku istraživanja svi učesnici izvodili su tri maksimalna skoka za procjenu mišićne snage (countermovement skoka). Dvostruka ANOVA s ponovljenim mjerenjem, s jednim među-faktorom "grupa" (eksperimentalna nasuprot kontrolna) i jednim unutrašnjim faktorom "vrijeme" (prije i poslije istraživanja) pokazala su da postoji statistički značajna vrijeme x grupa interakcija ( $p < 0,0001$ ) kod izvođenja countermovement skoka između eksperimentalne (prije - 0,43 ± 0,08m i poslije - 0,49m ± 0,08) i kontrolne grupe (prije - 0,43 ± 0,07m i poslije - 0,41 ± 0,08m). Rezultati pokazuju da šestonedeljni vibracioni trening proveden jedan puta nedeljno je dovoljan da izazove značajno povećanje performansi skoka kod rekreativno aktivnog stanovništva.

**Ključne riječi:** skokovi, performanse, čučnjevi,  
rekreativno aktivni, snaga, sila.

## INTRODUCTION

Vibration can be described as a mechanical stimulus characterised by a recurring oscillatory motion back and forth over the same pattern. We experience vibration throughout our daily lives when driving a car or operating machinery with motorised parts and exposure is traditionally associated with negative effects on the human body. However, whole body vibration (WBV) training also referred to as vibration training (VT) or vibration exercise (VE) has been developed as a relatively recent advance in health and fitness. The most common method of receiving vibration, as a specific training modality, is through the use of a vibration platform, also known as a vibration plate (Figure 1). These platforms operate in movements, which can be classified as either linear (vertically only), oscillating (moving vertically on alternate sides in a seesaw-like manner) or tri-planar (moving through all three axis), with the intensity of the training being manipulated by altering the frequency and/or amplitude of oscillations (Hawkey, 2012). The frequency of the vibration stimulus simply quantifies the number of impulses or oscillations (Hz) delivered every second (the repetition rate of the cycles), while the amplitude corresponds to the extent of the vertical displacement from the centre point of movement or its equilibrium position (Riley & Sturges, 1996). The acceleration of the movement is measured in g's, or magnitudes of gravity (where 1g is the acceleration due to the earth's gravitational field or  $9.81 \text{ ms}^{-2}$ ). The acceleration that a body experiences while on a vibration platform can be estimated using the equation shown in Figure 2 (Where  $a$  is the acceleration experienced expressed as the equivalent of the acceleration of earth's gravity [ $9.81 \text{ ms}^{-2}$ ];  $A$  is the amplitude of the vibration; and  $f$  is the frequency of the vibration). For this formula to work effectively it is vital to reduce each component to mass, length and time, so that  $\text{force} = \text{mass} \times \text{length} \times \text{time}^{-2}$  (Hawkey, 2012).

Although the exact mechanisms are not yet fully understood, it is thought that WBV elicits changes through physiological adaptations to accommodate vibratory waves (Cardinale & Bosco, 2003), via a process termed the tonic vibration reflex (TVR; Nordlund & Thorstensson, 2007); originally proposed by Eklund and Hagbarth (1966) following research directly exposing tendons to vibration. It is believed that stimulation of neuromuscular pathways and muscle spindles (Ia. afferent) excites the motor-neurons, causing contraction of homonymous motor units (Luo, McNamara, & Moran, 2005), which, according to Mester, Kleinoder, and Yue (2006), means that TVR can improve maximum voluntary contrac-

## UVOD

Vibracija se može opisati kao mehanički stimulans koji karakteriše ponavljanje oscilatornog kretanja naprijed nazad po istom obrazcu. Mi doživljavamo vibracije u svakodnevnom životu kada se vozimo automobilom ili na industrijskim mašinama sa motorizovanim dijelovima. Izloženost vibracijama je tradicionalno povezana sa negativnim efektima na ljudsko tijelo. Međutim trening vibracije cijelog tijela (WBV) koji se takođe naziva i vibracioni tening (VT) ili vibraciono vježbanje (VE), je relativno nedavno razvijen u svrhu unapređenja zdravlja i kondicije. Najčešći način primjene vibracija, kao specifičan vid treninga, je korišćenjem vibracione platforme, takođe poznate kao vibraciona ploča (Slika 1). Ove platforme rade pokretima koji mogu da budu klasifikovani kao linerani (samo vertikalno), oscilatorni (vertikalno kretanje sa svakim sledećim na drugoj strani po sistemu klackalice) i triplanarni (kretanje kroz sve tri ose), a intenzitetom treninga se rukovodi promjenom frekvencije i/ili amplitude oscilacija (Hawkey, 2012). Frekvencija vibracionih podsticaja jednostavno kvantifikuje broj impulsa ili oscilacija (Hz) isporučenih svake sekunde (ponavljanje stope ciklusa) dok amplituda odgovara obimu vertikalnog pomaka iz centralne tačke kretanja ili njenog ravnotežnog položaja (Riley i Sturges, 1996). Ubrzanje kretanja mjeri se u g-ovima, ili magnitudi gravitacije (gdje je 1g ubrzanje zbog gravitacionog zemljinog polja ili  $9,81 \text{ ms}^{-2}$ ). Ubrzanje koje tijelo doživljava dok je na vibracionoj platformi može se procijeniti korišćenjem formule prikazane na Slici 2 (Gdje je iskustveno ubrzanje izraženo kao ekvivalent ubrzanja zemljine gravitacije [ $9.81 \text{ ms}^{-2}$ ];  $A$  je amplituda vibracije;  $a$   $f$  je frekvencija vibracije). Za ovu formulu, da bi efikasno djelovala, od presudnog značaja je da se smanje sve komponente mase, dužine i vremena, tako da  $\text{sil} = \text{masa} \times \text{dužina} \times \text{vrijeme}^{-2}$  (Hawkey, 2012).

Iako tačni mehanizmi još nisu u potpunosti razumljivi, smatra se da WBV izaziva promjene kroz fiziološke adaptacije prilagođavanja vibracionim talasima (Cardinale i Bosco, 2003), putem procesa nazvanog tonik vibracioni refleks (TVR; Nordlund i Thorstensson, 2007), koji su prvobitno predložili Eklund i Hagbarth (1966) nakon istraživanja direktnog izlaganja tetiva na vibracije. Vjeruje se da stimulacija neuromišićnih puteva i mišićnog vretena (Ia. afferent) pobuđuje motorne neurone što izaziva kontrakcije istoimenih motornih jedinica (Luo, McNamara i Moran, 2005), što, prema Mester, Kleinoder i Yue



tion of muscles. However, the connection between WBV and the TVR has not been fully accepted, with others proposing alternative mechanisms of increased muscle temperature and blood flow (Issurin & Tenenbaum, 1999), change of perception by vibration (Liebermann & Issurin, 1997), increased hormone secretion (Cardinale & Bosco, 2003), and motor-unit synchronization and the recruitment of previously inactive motor-units (Issurin & Tenenbaum, 1999). Research has shown that performing traditional weight training on a vibration platform produces significantly greater improvements in maximal strength and explosive power compared to traditional weight training (Rønnestad, 2004), while increases in the rate of force development and a reduction in electro-mechanical delay, both beneficial for explosive muscular activation, have also been observed (Hong, Kipp, Maddalozzo, & Hoffman, 2010).

Vibration training has therefore been utilised for a variety of purposes in both the medical and sporting arenas. Improvements in bone health of post-menopausal women (Rubin et al., 2004), balance, gait, and quality of life ratings of elderly patients (Bruyere et al., 2005), and the reduction of joint swelling in rheumatoid arthritis patients (Kumari, Wyon, Hawkey, & Metsios, 2011) have all been observed, while the jumping performance of semi-professional football players (Hawkey, Evans, & Nevill, 2012), professional football goalkeepers (Hawkey, Morrison, Williams, & Nevill, 2009a), and athletes' sprinting, jump height and explosive strength endurance (Paradisis & Zacharogiannis, 2007) have all been enhanced by WBV programmes. However, not all research has reported such improvements; one study conducted on basketball players reported no changes in jumping performance following WBV exposure (Hawkey, Lau, & Nevill, 2009b). The reasons for this disparity in findings could be multi-factorial: differing protocols, testing equipment, and the performance level or experience of the participants. While the majority of previous research has reported improvements in jumping performance in these trained populations, those conducted on sedentary or recreationally active individuals are limited. Torvinen, Kannu, and Sievanen (2002) found an 8.5% improvement following a 4-month intervention in untrained individuals. However, no placebo group was utilised making it difficult to ascertain if the improvements resulted from the exercises that were performed on the platform or from the WBV intervention. Delecluse, Roelants, and Verschueren (2003), did include a control group and reported a nearly 17% improvement in knee extensor strength and an almost 8% increase in the jumping performance of sedentary individuals who adhered to a WBV training programme 3-times-a-week over

(2006), znači da TVR može poboljšati makasimlanu voljnu kontrakciju mišića. Ipak, veza između WBV i TVR nije u potpunosti prihvaćena, s drugim prijedlozima alternativnih mehanizama povećanja mišićne temperature i protoka krvi (Issurin i Tenenbaum, 1999), promjene percepcije vibracijom (Liebermann i Issurin, 1997), povećanja sekrecije hormona (Cardinale i Bosco, 2003) i sinhronizaciju motornih jedinica i upošljavanje prethodno neaktivnih motornih jedinica (Issurin i Tenenbaum, 1999). Istraživanja su pokazala da izvođenje tradicionalnog treninga sa tegovima na vibracionoj platformi daje značajno veća poboljšanja maksimalne i eksplozivne snage u odnosu na tradicionalne treninge sa tegovima (Rønnestad, 2004), dok je povećanje stope sile razvoja i smanjenje elektromehaničkih kašnjenja i djelotvornost eksplozivne mišićne aktivacije takođe uočen (Hong, Kipp, Maddalozzo i Hoffman, 2010).

Stoga se vibracioni trening koristi u različite namjene i u medicinskom i u sportskom polju. Uočena su poboljšanja zdravlja kostiju kod žena u postmenopauzi (Rubin i saradnici, 2004), ravnoteže, hoda i procjena kvaliteta života starijih osoba (Bruyere i saradnici, 2005) i smanjenje otoka zglobova kod pacijenata sa reumatoidnim artritismom (Kumari, Wyon, Hawkey i Metsios, 2011), dok je skočnost kod poluprofesionalnih fudbalera (Hawkey, Evans i Nevill, 2012), profesionalnih fudbalskih golmana (Hawkey, Morrison, Williams i Nevill, 2009a) i brzina, skok u vis i izdržljivost u eksplozivnoj snazi sptista (Paradisis i Zacharogiannis, 2007) sve bilo poboljšano WBV programima. Ipak, u svim istraživanjima nije došlo do takvih poboljšanja. Jedna studija, sprovedena na košarašima, nije prijavila nikava poboljšanja u preformansama skoka nakon izlaganja WBV (Hawkey, Lau i Nevill, 2009b). Razlozi za ove razlike mogu da budu multifaktorijalne: različiti protokoli, oprema za testiranje i nivo vještine i iskustva učesnika. Dok su većina prethodnih istraživanja govorila o poboljšanju skakačkih kvaliteta kod populacije u treningu, ona sprovedena na fizički neaktivnim ili rekreativno aktivnim pojedincima su ograničena. Torvinen, Kannu i Sievanen (2002) našli su poboljšanje od 8,5% nakon četiri mjeseca treninga kod netreniranih osoba. Nažalost, nije koiščena placebo grupa što otežava da se utvrdi da li su poboljšanja rezultat vježbi koje su rađene na platformi ili od WBV djelovanja. Delecluse, Roelants i Verschueren (2003) uključili su kontrolnu grupu i prijavili su skoro 17% poboljšanja u snazi ekstenzora koljena i skoro 8% povećanja u skakačkim performansama kod osoba sa smanjenom fitzičkom aktivnošću koji su uključeni u WBV trening program obuke tri puta sedmično u trajanju tokom

a 12-week period. With the popularity and availability of vibration platforms in fitness centres and gyms around the world reported to be increasing (Fischbach, 2007), there is a need to add further research to the limited amount of data available on the effects of WBV on untrained and recreationally active populations. Therefore, the aim of the current study was to examine the effects of a relatively short duration, low intensity, WBV training programme, on the jumping performance of a recreationally active population.

## METHODS

Following institutional ethics approval, and the completion of informed consent forms and medical questionnaires, 22 healthy, recreationally active, male undergraduate sports students (age mean 28,  $s = 10$  years; height mean 1.77,  $s = .09$  m; mass mean 77,  $s = 13$  kg) were randomised into either a WBV or control group. The vibration intervention consisted of 6-week WBV training, utilising three different squatting exercises (static half squat at 120°, static deep squat at 90° and a dynamic squat ranging from 120° to 90°; monitored using a goniometer), conducted once a week, on a NEMES Bosco vibration platform (Figure 1). Prior to training and testing, both vibration and control groups completed a warm up, which consisted of 5 minutes on a Monark Cycle Ergometer with heart rate between 120-140 BPM in accordance with the American College of Sports Medicine (ACSM) who recommend a minimum of five to ten minutes of low- to moderate-level activity in order to increase muscle temperature (ACSM, 2012). Training followed the overload principle: 3 x 60 s (1 x 60 s for each exercise, with 30 s rest between each) at a frequency of 35 Hz and amplitude of 2 mm (acceleration =  $\sim 9.86$  g) in week one; 3 x 70 s at 35 Hz/2 mm ( $\sim 9.86$  g) in week two; 3 x 60 s at 40 Hz/2 mm ( $\sim 12.9$  g) in week three; 3 x 70 s at 40 Hz/2 mm ( $\sim 12.9$  g) in week four; 3 x 60 s at 45 Hz/2 mm ( $\sim 16.3$  g) in week five; and 3 x 70 s at 45 Hz/2 mm ( $\sim 16.3$  g) in week six. The protocol was selected to reflect previous research suggesting that frequencies between 35 Hz and 50 Hz can improve vertical jumping performance in untrained (Bazett-Jones, Finch, & Dugan, 2008; Delecluse et al., 2003) and trained individuals (Hawkey et al., 2009a). The acceleration of vibration was calculated in accordance with Hawkey (2012) (Figure 2).

Prior to, and on completion of, the study all participants performed three maximal countermovement jumps (CMJ); reported to be an accurate and reliable method of assessing body size-independent muscular

dvanaest nedjelja. Istraživanja pokazuju povećanje popularnosti i dostupnosti vibracionih platformi u fitness centrima i dvoranama širom svijeta (Fischbach, 2007) takao da postoji potreba daljih dodatnih istraživanja na ograničen broj raspoloživih podataka o efektima WBV treninga na rekreativno aktivnu populaciju. Dakle, cilj ovog istraživanja bio je da se ispita uticaj relativno kratkog trajanja, niskog intenziteta WBV trening programa na skakčke performance rekreativno aktivne populacije.

## METODE

Nakon etičkog institucionalnog odobrenja i popunjavanja informativnog pristanka i medicinskog upitnika, 22-oje zdravih, rekreativno aktivnih, redovnih studenata sportista muškog pola (prosječna starost 28,  $s = 10$  godina; prosječna visina 1,77,  $s = 0,10$  m; prosječna težina 77,  $s = 13$  kg) su nasumično izabrani za WBV i kontrolnu grupu. Vibraciono djelovanje sastojalo se u šetonedjeljnom WBV treningu koristeći tri različite vježbe čučnja (120° i 90° statički čučanj i 120° - 90° dinamički čučanj, praćen pomoću goniometra) sprovedenom jednom nedjeljno na NEMES Bosco vibracionoj platformi (Slika 1). Prije treninga i testiranja i vibraciona i kontrolna grupa izvodili su petominutno zagrijavanje na Monark Cycle Ergometer sa otkucajima srca 120-140 BPM u skladu sa American College of Sports Medicine (ACSM) koji preporučuje minimalno pet do deset minuta niskog do umjerenog nivoa aktivnosti u cilju povećanja temperature mišića (ACSM, 2012). Trening se pridržavao sledećih principa opterećenja: 3 x 60 s (1 x 60 s za svaku vježbu, sa 30 s odmora između njih) sa frekvencijom od 35Hz i amplitudom 2 mm (ubrzanje = 9,86 g) u prvoj sedmici; 3 x 70 s sa 35 Hz/2 mm u drugoj sedmici; 3 x 60 s sa 40 Hz/2 mm ( $\sim 12.9$  g) u trećoj sedmici; 3 x 70s sa 40Hz/2mm ( $\sim 12.9$  g) u četvrtoj sedmici; 3 x 60 s sa 45 Hz/2 mm ( $\sim 16.3$  g) u petoj sedmici; i 3 x 70 s sa 45 Hz/2 mm ( $\sim 16.3$  g) u šestoj sedmici. Protokol je tako izabran da podržava prethodna istraživanja koja su pokazala da frekvencije između 35 Hz i 50 Hz mogu da unaprijede skakačke preformanse kod netreniranih (Bazett-Jones, Finch i Dugan, 2008; Delecluse i saradnici, 2003) i treniranih osoba (Hawkey i saradnici, 2009a). Vibraciono ubrzanje izračunato je shodno Hawkey (2012) (Slika 2).

Prije i po završetku istraživanja svi učesnici izvodili su tri maksimalna countermovement skoka (CMJ) koji su se pokazali tačnom i pouzdanom metodom procjene tjelesne veličine nezavisne mišićne snage (Marković i Jarić, 2007). Svi skokovi vršeni su na kontakt prostirci (Just Jump: Probotics Inc. USA) koristeći brojne

power (Marković & Jarić, 2007). All jumps were performed on a contact mat (Just Jump: Probotics Inc. USA); utilised in a number of previous studies (Christensen and Nordstrom, 2008; Delecluse et al., 2003; Hawkey et al., 2012) and shown to be a reliable method of assessing jump performance (Isaacs, 1998), with high criterion validity (Leard et al., 2007). During the jump testing, hands were required to remain on the hips in accordance with previous research (Hawkey et al., 2012; Linthorne, 2001) in an attempt to standardise jumping technique and because arm use has a significant impact on jumping performance (Linthorne, 2001). Knee angles for the jumps were initially measured using a goniometer, and were then controlled visually to ensure consistency. All CMJ data was analysed using a 2-way ANOVA with repeated measures, with one between-subject factor "group" (experimental vs. control) and one within-subject factor "time" (pre vs. post intervention).

prethodne studije (Christensen i Nordstrom, 2008; Delecluse i saradnici, 2003; Hawkey i saradnici, 2012) koji se pokazao kao pouzdan metod za procjenjivanje skakačkih performansi (Isaacs, 1998) sa visokim kriterijumom valjanosti (Leard i saradnici, 2007). Tokom testiranja skoka ruke su morale da ostanu na kukovima u skladu sa prethodnim istraživanjima (Hawkey i saradnici, 2012; Linthorne, 2001) u pokušaju standardizacije skokova pošto upotreba ruku ima značajan uticaj na skakačke performanse (Linthorne, 2001). Koljeni uglovi pri skokovima u početku su mjereni goniometrom, a potom su vizuelno kontrolisani da bi se obezbjedila doslijednost. Svi CMJ podaci su analizirani korišćenjem dvostruke ANOVA sa ponovljenim mjerenjima, s jednim među-faktorom "grupa" (eksperimentalna nasuprot kontrolna) i jednim unutrašnjim faktorom "vrijeme" (prije i poslije istraživanja).

#### FIGURE 1

*An athlete trains on the NEMES Bosco Vibration Platform (© Adam Hawkey).*

#### SLIKA 1

*Trening sportiste na NEMES Bosco vibracionoj platformi (© Adam Hawkey).*



**FIGURE 2**

Formula used to calculate acceleration of vibration (adapted from Hawkey, 2012).

**SLIKA 2**

Formula koja se koristi za izračunavanje ubrzanja vibracije (prilagodeno od Hawkey, 2012).

$$a = \frac{A \times (2\pi f)^2}{g}$$

**RESULTS**

A 2-way ANOVA with repeated measures indicated that there was a significant time x group interaction ( $p < .0001$ ) for CMJ performance between the intervention (pre-  $.43 \pm .08m$  to post-  $.49m \pm .08$ ) and the control group (pre-  $.43 \pm .07m$  to post-  $.41 \pm .08m$ ) (Figure 3).

**REZULTATI**

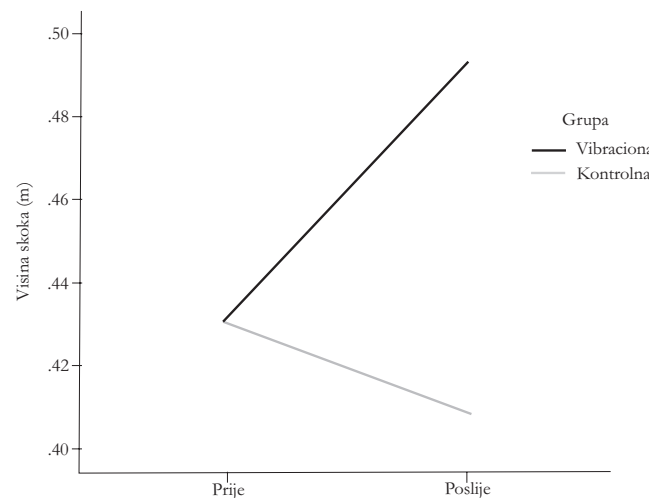
Dvostruka ANOVA sa ponovljenim mjerenjem pokazala je da postoji statistički značajna vrijeme x grupa interakcija ( $p < 0,0001$ ) za CMJ preformance tokom istraživanja (prije  $0,43 \pm 0,08m$  do poslije  $0,49m \pm 0,08$ ) i kontrolne grupe (prije  $0,43 \pm 0,07m$  do poslije  $0,41 \pm 0,08m$ ) (Slika 3).

**FIGURE 3**

Plot from the 2-way ANOVA showing pre- and post- jump performance in the vibration and control groups.

**SLIKA 3**

Grafikon dvosmjerne ANOVA koji pokazuje sposobnost skoka prije i poslije vibracionog treninga eksperimentalne i kontrolne grupe.



Legend: Jumping height - Visina skoka; Pre - Prije; Post - Poslije; Group - Grupa; Vibration - Eksperimentalna; Control - Kontrolna.

**DISCUSSION**

Previous research into the effects of WBV has shown improvements in a variety of performance measures in a range of populations. Studies conducted on footballers and athletes (Hawkey et al., 2009a, 2009b; Hawkey et al., 2012; Paradisis & Zachardiogiorgis, 2007) and sedentary individuals (Delecluse et al., 2003; Torvinen et al., 2002) have all highlighted that WBV has the potential to improve activity specific performance. Results of the current study show that 6-weeks WBV training is sufficient to elicit signi-

**DISKUSIJA**

Prethodna istraživanja o efektima WBV pokazala su poboljšanja u različitim mjerama uticaja u različitim populacijama. Istraživanja sprovedena na fudbalerima i atletičarima (Hawkey i saradnici, 2009a, 2009b; Hawkey i saradnici, 2012; Paradisis i Zachardiogiorgis, 2007) i pojedincima koji se ne bave fizičkom aktivnošću (Delecluse i saradnici, 2003; Torvinen i saradnici, 2002) su istakla da WBV ima mogućnost da unaprijedi specifične performanse. Rezultati ovog istraživanja su pokazala da šestomedjeljni WBV trening je dovoljan

ficant improvements in vertical jumping performance in a recreationally active male population. The difference between the pre- and post- jumping performance of the WBV group equates to a > 14% improvement, while the control group experienced a 3% reduction in pre- to post- measures; resulting in a significant time x group interaction ( $p < .0001$ ). Despite the current study only being conducted over a period of 6-weeks the findings show similarities with the studies of Delecluse et al. (2003) and Torvinen et al. (2002), which were conducted over 12-week and 4-month periods, respectively. However, it is difficult to directly compare these studies due to differences in experimental protocols, the different equipment used for both testing and training, and the variation of performance level and training experience of the participants. This is highlighted by Moras, Tous, Muñoz, Padullés, and Vallejo (2006) who state that differences in their results when compared against other similar studies could have been due to different equipment (NEMES versus PowerPlate), or different samples employed in the respective trials. One difference in protocol is that Delecluse et al. (2003) used only female participants, while the current study utilised a male only population. This is potentially significant because, according to Bazett-Jones et al. (2008), men and women respond differently to vibratory stimuli. There is also an obvious disparity in the frequency and amplitude of the platform utilised in the current study compared to some previous research. While it has been widely reported that a frequency of 30 Hz is conducive to improvements in muscular power (Paradisis & Zachardiogiorgis, 2007), it is currently unclear why this is the case and there is currently confusion regarding how certain variables used in vibration training (frequency, amplitude and acceleration) are reported and quantified (Hawkey, 2012; Lorenzen, Maschette, Koh, & Wilson, 2009). The justification for using a frequency range of 35-45 Hz and amplitude of 2 mm was in accordance with previous research (Delecluse et al., 2003; Hawkey et al., 2009a, 2009b; Hawkey et al., 2012), which had reported improvements in jumping performance within these ranges. The squatting exercises ( $90^\circ - 120^\circ$ ) used for the current study were also used in accordance with previous research showing favourable outcomes in jumping performance (Hawkey et al., 2012; Paradisis & Zachardiogiorgis, 2007).

It is also difficult to quantify the mechanisms involved in the reported performance improvements. Enhancements in muscular performance following WBV are similar to those seen after explosive power training (Bosco, Colli, & Introvini, 1999). As the first mechanism involved in skeletal muscle adaptation is

da dovede do značajnih poboljšanja performansi vertikalne skočnosti kod rekreativno aktivne muške populacije. Razlika između prije i poslije istraživanja skakačkih performansi WBV grupe jednaka je a > 14% poboljšanja, dok je kontrolna grupa doživjela 3% smanjenje u prije i poslije mjerenju što je rezultiralo statistiki značajnom interakcijom vrijeme x grupa ( $p < 0,0001$ ). Uprkos činjenici što je ovo istraživanje sprovedeno u periodu od šest nedjelja rezultati pokazuju sličnost sa istraživanjima Delecluse i saradnika (2003) and Torvinen i saradnika (2002) koji su provedena u periodu od 12 sedmica odnosno 4 mjeseca. Ipak je teško porediti ova istraživanja zbog razlike u eksperimentalnim protokolima, korištenja različite opreme i za trening i za testiranje i nivoa vještine i iskustva učesnika. To su naglasili Moras, Tous, Muñoz, Padullés i Vallejo (2006) koji navode da razlike njihovih rezultata kada se uporede sa drugim sličnim istraživanjima su zbog različite opreme (NEMES versus PowerPlate) ili različitog uzorka uključenih u odgovarajuće istraživanje. Jedna od razlika u protokolu je da Delecluse i saradnici (2003) koriste samo ženske učesnike dok ovo istraživanje koristi isključivo mušku populaciju. Ovo je potencijalno značajno zato što, prema Bazett-Jones i saradnici (2008), muškarci i žene različito reaguju na vibracione nadražaje. Ovdje je i očigledna razlika u frekvenciji i amplitudi platforme koja se koristila u ovom istraživanju u odnosu na neka prethodna istraživanja. Iako je opširno objašnjeno da frekvencija od 30 Hz je pogodna za poboljšanje mišićne snage (Paradisis & Zachardiogiorgis, 2007) nejasno je zašto je to tako i trenutno postoji konfuzija o tome kako su koje varijable korišćene u vibracionom treningu (frekvencija, amplituda i ubrzanje) i izvještavanju i kvantifikovanju (Hawkey, 2012; Lorenzen, Maschette, Koh i Wilson, 2009). Opravdanje za korištenje frekvencije u rasponu 35-45 Hz i amplitude 2 mm je u skladu sa prethodnim istraživanjima (Delecluse i saradnici, 2003; Hawkey i saradnici, 2009a, 2009b; Hawkey i saradnici, 2012) koji su prijavili poboljšanje u skakačkim performansama unutar ovog raspona. Vježbe čučnjeva ( $90^\circ - 120^\circ$ ) korišćene u ovom istraživanju su u skladu sa prethodnim istraživanjima i pokazale su dobre rezultate u skakačkim performansama (Hawkey i saradnici, 2012; Paradisis i Zachardiogiorgis, 2007).

Takođe je teško kvantifikovati mehanizme uključene u prijavljenim poboljšanjima performansi. Poboljšanja u mišićnom učinku koja su proizašla nakon WBV treninga slična su onim koja se mogu vidjeti nakon treninga eksplozivne snage (Bosco, Colli i Introvini, 1999). Neuronski mehanizam je prvi koji je uključen u adaptaciju skeletnih mišića (Delecluse i saradnici, 2003) stoga je vjerovatno da poboljšanja u performansama, o kojima se govori nakon WBV treninga, takođe

neural (Delecluse et al., 2003), it is therefore likely that the improvements in performance, reported following WBV, are also likely to originate from neural adaptations. The mechanisms of these improvements are likely to be through stimulation of the primary endings of the muscle spindle, resulting in a tonic contraction of the muscle, known as the tonic vibration reflex (Mester et al., 2006), increases in motor unit synchronisation, co-contraction of the synergist muscles, and increased inhibition of the antagonist muscles (Hawkey, 2012). It is feasible to suggest that improvement in muscular power in the 12-week (Delecluse et al., 2003) and 4-month (Torvinen et al., 2002) studies were not only influenced by neural adaptations (as mentioned above), but also through intramuscular factors such as enlargement of slow- and fast-twitch fibres; as has been reported in studies using vibration exposed rats (Necking, Lundstrom, Lundborg, Thornell, & Friden, 2006).

The results from this current study add to the growing evidence about the benefits of vibration training on a range of performance measures in a variety of populations. Combined with the findings of Delecluse et al. (2003) and Torvinen et al. (2002) in particular, this current study's findings are encouraging for those individuals, who are sedentary or inactive, wanting to improve their muscular strength following a relatively low impact, low intensity exercise intervention. However, there are some limitations with the current research. Although the study was very well controlled regarding the standardisation of training protocols, and performance level of the participants, there was no regulation of participants' activity outside of the confines of the study. It is therefore feasible that participants, in either the control or the WBV group, undertook additional training during the intervention; this could have contributed to the improved jumping performance of the WBV group or jeopardised the control group due to muscle fatigue. That the acceleration rate was not quantified or verified using accelerometers, as was the case during the Delecluse et al. (2003) study is also a negative aspect of the current research.

## CONCLUSION

Results from the current study appear to suggest that a 6-week WBV training programme, conducted once-a-week, has the potential to significantly improve the jumping performance, and therefore muscular power, of a recreationally active male population. While results from this current and other previous studies would lend support to the inclusion of vibration interventions for a range of health, fitness, and performance improvements it is currently unclear as

vjerovatno dolaze od neuronskih adaptacija. Mehanizmi ovih prilagođavanja su vjerovatno su u stimulisanju primarnih završetaka mišićnog vretena što rezultira toničkim kontrakcijama mišića poznat kao tonički vibracioni refleksi (Mester i saradnici, 2006), povećava sinhronizaciju motornih jedinica, kontrakcije mišića sinergista i povećava inhibiciju mišića antagonistata (Hawkey, 2012). Moguće je ukazati da poboljšanja mišićne snage u dvanaestonedjeljnim (Delecluse i saradnici, 2003) i četvoromjesečnim (Torvinen i saradnici, 2002) istraživanjima nisu samo pod uticajem nervnih adaptacija (kao što je prethodno naglašeno) već i kroz intramuskularne faktore kao što su proširenja sporih i brzo trzajnih vlakana, kao što je ustanovljeno u istraživanjima u kojima su vibraciji bili izloženi štakori (Necking, Lundstrom, Lundborg, Thornell i Friden, 2006).

Rezultati ovog istraživanja idu u prilog sve većem broju dokaza o prednosti vibracijskog treninga na niz izmjerenih performansi na različite populacije. U kombinaciji sa nalazima istraživanja Delecluse i saradnika (2003) i Torvinen i saradnika (2002) i, naročito, ovog istraživanja rezultati su ohrabrujući za sedentarne ili fizički neaktivne pojedince koji žele da poboljšaju svoju mišićnu snagu sa relativno malim angažovanjem, uticajem vježbi niskog intenziteta. Međutim, postoje i neka ograničenja u aktuelnom istraživanju. Iako je istraživanje veoma dobro kontrolisano što se tiče standardizacije protokola treninga kao i nivoa sposobnosti pojedinaca nije bilo regulisanja aktivnosti učesnika izvan okvira istraživanja. Zato je moguće je da su učesnici i kontrolne i WBV grupe radili dodatne treninge tokom istraživanja, a to je moglo da utiče na bolje skakačke performanse WBV grupe ili da dovede u pitanje rezultate kontrolne grupe zbog umora mišića. Step en ubrzanja koje nije kvantifikovano ili procijenjeno korišćenjem akcelerometra, kao što je to bio slučaj u istraživanju Delecluse i saradnika (2003) takođe je negativan aspekt ovog istraživanja.

## ZAKLJUČAK

Rezultati ovog istraživanja pokazuju da šestonedjeljni WBV program treninga, koji se izvodi jedan put sedmično, ima potencijal da statistički značajno poboljša skakačke performanse, a samim tim i mišićnu snagu, rekreativno aktivnih muškaraca. Iako rezultati ovog i drugih prethodnih istraživanja govore u prilog uključivanja vibracionog treninga za čitav niz zdravstvenih, kondicionih i poboljšanja performansi trenutno su nejasni precizni mehanizmi koji utiču na te pogodnosti

to the exact mechanisms influencing these benefits and the potential impact, if any, of any external training performed outside the realms, and control, of the current study. Future research should now focus on ascertaining the optimum frequencies and amplitudes conducive to maximising performance improvements. The effect of activity/performance level, the duration and specific exercises performed on the vibration platform, and also any age and sex differences would also be useful variables to investigate further.

i potencijalni uticaj, ako postoji, svakog dodatnog treninga koji se izvodi izvan djelokruga i kontrole ovog istraživanja. Buduća istraživanja trebala bi da se fokusiraju na utvrđivanje optimalnih frekvencija i amplituda pogodnih za maksimalno poboljšanje preformansi. Bilo bi korisno u daljim istraživanjima usmjeriti se na uticaj nivoa aktivnost/činak, trajanje i specifičnost vježbi koje se izvode na vibracionoj platformi kao i na razlike u polu i godinama starosti.

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## GANZE KÖRPERVIBRATIONSAUSBILDUNG VERBESSERT MUSKULÖSE KRAFT IN EINER FREIZEIT TÄTIGEN BEVÖLKERUNG

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Obwohl die genauen Mechanismen nicht noch völlig verstanden sind, wird es gedacht, dass ganze Körpervibration (WBV) Änderungen durch physiologische Anpassungen herausbekommt, vibratory Wellen (Cardinale und Bosco, 2003) anzupassen, über ein Verfahren hat der tonische Vibrationsreflex (TVR; Nordlund und Thorstensson, 2007) genannt. Springenleistung von halbprofessionellen Fußballspielern (Hawkey et Al., 2012), berufliche Fußballtorwarte (Hawkey et Al., 2009a), und Sportler sprintend, Sprunghöhe und explosive Kraftausdauer (Paradis und Zacharogiannis, 2007) alle sind erhöht worden von WBV Programmen. Während die Mehrheit der vorheriger Forschung hat Verbesserungen in Springenleistung in ausgebildeten Bevölkerungen berichtet, ist die geleitetes auf sitzenden oder freizeit tätigen Individuen begrenzt. Daher war das Ziel des jetzigen Studiums, die Wirkungen von einem verhältnismäßig kurze Zeitdauer zu untersuchen, programmieren niedrige Intensität, WBV Ausbildung, auf der springenden Leistung einer freizeit tätigen Bevölkerung.

Die institutioneller Ethikgenehmigung Folgen, tragen 22 gesunde, freizeit tätige, männliche Studenten stolz Studenten (Alter bedeuten Sie 28, s = 10 Jahre; Höhengmittel 1,77, s = 0,09 m; sammelt sich bedeutet 77, s = 13 Kg, an) wurden randomisiert in entweder ein WBV oder kontrollieren Sie gruppiert. Die Vibrationseinmischung hat aus 6 bestanden-Woche die WBV Ausbildung, verwendet die drei verschiedene hockende Übungen (atmosphärische Aufladung halb an 120o hocken, atmosphärische Aufladung hockt tief an 90o und ein dynamisches hockt Verlaufen von 120o zu 90o), geleitet einmal pro Woche, auf einer NEMES Bosco Vibration Plattform. Ausbildung ist dem Überlastungsprinzip gefolgt: 3 X 60s (1 X 60s für jede Übung, mit 30s Rest zwischen jedem) an einer Frequenz der 35Hz und Amplitude von 2 Mm in Woche einer; 3 X 70s an 35Hz/2mm in Woche zwei; 3 X 60s an 40Hz/2mm in Woche drei; 3 X 70s an 40Hz/2mm in Woche vier; 3 X 60s an 45Hz/2mm in Woche fünf; und 3 X 70s an 45Hz/2mm in Woche sechs. Vor, und auf Vollendung von, das Studium, das alle Teilnehmer drei maximale Gegenbewegungssprünge (CMJ) auf einer Kontaktmatte durchgeführt haben (Nur Sprung: Probotics Inc. Vereinigten Staaten). Alle CMJ Daten wurden Benutzen eines 2 weg ANOVA mit wiederholten Maßnahme, mit einem Zwischen-Themafaktor „gruppe“ (experimentell gegen

Steuerung) und einer Innerhalb-Thema Faktor „Zeit“ (vor Gegen Posteneinmischung) analysiert.

Ein 2 weg ANOVA mit wiederholten Maßnahme haben angezeigt, dass es eine bedeutsame Zeit X Gruppenwechselwirkung ( $P < 0,0001$ ) für CMJ Leistung zwischen der Einmischung (vor-  $0,43 \pm 0,08$ m gab, aufzustellen-  $0,49 \pm 0,08$ ) und zu kontrollieren, gruppiert (vor-  $0,43 \pm 0,07$ m aufzustellen-  $0,41 \pm 0,08$ m). Ergebnisse der jetzigen Studiumsschau, die 6-Wochen WBV Ausbildung genügend herauszubekommen bedeutsame Verbesserungen in senkrechter Springenleistung in einer freizeit tätigen männlichen Bevölkerung ist, stimmend mit vorherigen Studien (Hawkey et Al., 2012; Hawkey et Al., 2009; Paradis und Zachardiogiorgis, 2007; Delecluse et Al., 2003; Torvinen et Al., 2002) überein. Anreicherungen in muskulösem Leistung Folgendem WBV sind ähnlich zu den gesehenen nach explosiver Kraft ausbildend (Bosco et Al., 1999). Als der erste Mechanismus, der in skelettartiger Muskelanpassung verwickelt wird, neural (Delecluse et Al., 2003) ist, ist es daher wahrscheinlich, dass die Verbesserungen in Leistung, wird berichtet die WBV folgend, auch wahrscheinlich hervorzubringen von neuronalen Anpassungen sind. Die Mechanismen dieser Verbesserungen sind wahrscheinlich, durch Anregung der primären Enden der Muskelspindel zu sein, resultierend in einer tonischen Zusammenziehung des Muskels, bekannt als der tonische Vibrationsreflex (Mester et Al., 2006), Zunahmen in Motoreinheitssynchronisierung, Co-zusammenziehung des synergist Muskeln, und vermehrte Hemmung der Gegnersmuskeln (Hawkey, 2012).

Resultiert vom jetzigen Studium erscheint vorzuschlagen, dass eine 6 wochenlange WBV die Ausbildung programmiert, geleitet einmal-einen-Woche, hat das Potential zu bedeutend verbessert die springende Leistung, und daher muskulöse Kraft, einer freizeit tätigen männlichen Bevölkerung. Zukünftige Forschung sollte sich jetzt auf Feststellen der günstigsten Frequenzen und der Amplituden konzentrieren, die dienlich sind zu Maximierenleistungsverbesserungen. Die Wirkung der Tätigkeit/Leistungshöhe, die Zeitdauer und spezifische Übungen haben auf der Vibrationsplattform durchgeführt, und auch irgendein Alter und Geschlechtsunterschiede wären auch nützliche Variablen, weiter zu untersuchen.

**Schlüsselwörter:** springend; Leistung; hockend; freizeit tätig; Kraft

# DESKRIPTIVNI PROFIL TJELESNE STRUKTURE VRHUNSKIH RVAČA GRČKO-RIMSKOG STILA DEFINISAN METODOM MULTIKANALNE BIOELEKTRIČNE IMPEDANCE

## DESCRIPTIVE PROFILE OF BODY STRUCTURE OF TOP GRECO-ROMAN STYLE WRESTLERS DEFINED WITH METHOD OF MULTICHANNEL BIOELECTRIC IMPEDANCE

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### SUMMARY

Because of the specificity of given sport and weight categories wrestlers are characterized by specific morphologic characteristics. With the development of new measurement technologies there are some new opportunities for the development of new ways of obtaining information relevant to the sports system. One of the new technologies, which are used in area of measurement of body composition structure, is a method of bioimpedance, and the latest generations use a variant of the multichannel bioelectrical bioimpedance. The goal of this study is to define morphological model of top senior wrestlers by using the latest technological methods that will revalidate the existing knowledge about the given area. The sample of respondents is made of 22 male wrestlers, Greco-Roman style, top senior level athletes from four different countries: Serbia ( $n = 10$ ), Croatia ( $n = 9$ ), Montenegro ( $n = 2$ ) and Greece ( $n = 1$ ). Measurement of body composition is made with method of multichannel bioelectric impedance with professional apparatus of latest generation - InBody 720 Tetrapolar 8-Point Tactile Electrode System (Biospace, Co., Ltd). The most important result of this research is definition of generic (general) four-dimensional model (4D model) of body composition with quality international level wrestlers with following characteristics (in regards to average body mass of sample wrestlers – 81.95 kg): the amount of water is 55.08 L or 67.24 %, the amount of proteins is 15.00 kg or 18.33%, minerals 4.98 kg or 5.97% and fat mass 6.99 kg or 8.49 %.

**Key words:** Greco-Roman style wrestlers, bioimpedance, body composition, model.

### SAŽETAK

Zbog specifičnosti sporta i težinskih kategorija rvači se odlikuju i specifičnim morfološkim karakteristikama. Sa razvojem novih tehnologija mjerenja stvaraju se i nove mogućnosti za usavršavanje načina dobijanja novih informacija značajnih za sistem sporta. Jedna od novih tehnologija, koja se primenjuje u prostoru mjerenja strukture tjelesnog sastava je metod bioimpedance, a najnovije generacije koriste varijantu multikanalne bioelektrične bioimpedance. Cilj ovog rada je da definiše morfološki model vrhunskih rvača seniorskog uzrasta, primjenom tehnološki najnovije metode, čime će se izvršiti revalidacija postojećih saznanja o datom prostoru. Uzorak ispitanika je bio sastavljen od 22 ispitanika muškog pola, rvača iz discipline grčko-rimski, takmičara vrhunskog seniorskog nivoa iz četiri zemlje: Srbija ( $n = 10$ ), Hrvatska ( $n = 9$ ), Crna Gora ( $n = 2$ ) i Grčka ( $n = 1$ ). Mjerenje tjelesnog sastava je izvršeno metodom multikanalne bioelektrične impedance pomoću profesionalnog aparata najnovije generacije - InBody 720 Tetrapolar 8-Point Tactile Electrode System (Biospace, Co., Ltd). Najvažniji rezultat ovog istraživanja je definisanje generičkog (opšteg) četvorodimenzionalnog modela (4D model) sastava tijela u funkciji kvalitetnih rvača međunarodne klase koji ima sljedeće karakteristike (u odnosu na prosječnu tjelesnu masu rvača iz uzorka – 81,95 kg): sadržaj vode iznosi 55,08 L ili 67,24%, količina proteina iznosi 15,00 kg ili 18,33 %, masa minerala iznosi 4,98 kg ili 5,97% i masa masti iznosi 6,99 kg ili 8,49%.

**Ključne riječi:** rvači grčko-rimskog stila, bioimpedanca, tjelesni sastav, mod.

## INTRODUCTION

The majority of experts and scientists dealing with morphology of athletes consider that there is a dialectic connection between particular sports and morphological characteristics of the one athlete. Namely, in majority of cases, young athletes choose sports adequate to their morphology, because that morphology is the fact that in certain amount determines his body advantage. On the other hand, by practicing the chosen sport, and considering the phenomena of adaptation to certain sports exertion, the athlete gains characteristics typical for given sports. It was shown that as higher the sports achievements are, the tighter is their connection to athlete's body composition (Bajić, Ponorac, Rašeta, & Bajić, 2010; Obradović et al., 2011; Yoon, 2002). That is why the significant attention in majority of sports is given to research of anthropological status of active athletes, as also to those who have the intention of doing some of the sports (Khani, Farokhi, Shalchi, Angoori, & Ansari, 2011; Rupčić, Matković, Knjaz, Baščevan, & Rodić, 2011; Schmidt, Piencikowski, & Vandervest, 2005). Knowing of individual characteristics of active wrestlers is necessary precondition for successful planning of quality programs for management of training process (Станков, Климин, & Письмеский, 1984). Among many characteristics owned by every athlete, the morphological ones are, for sure, one of those that significantly influence the achievement of significant sports results. That is why they are recorded and analysed with special attention, as a base or morphological status at the very beginning of training process, but also as a goal, e.g. morphological status that needs to be achieved (Kasum & Obradović, 2008).

Wrestlers are characterized by specific morphological characteristics, which basic features are: accentuated width and girth of the body, proportionally long arms and short legs, a large percentage of active muscular body weight (Борисов и Туманян, 1973). By classification of Bunaka (Станков et al., 1984), there are three basic constitutional types of fighters (chest, muscular and abdominal), and four transition (breastbone - muscular, muscular - thorax, muscular - belly and belly - muscular). Chest type fighters are characterized by well-developed chest and powerful shoulder belt. Muscular type is characterized by cylindrical shape of the chest, flat stomach and a strong, well-developed muscles and moderate fat deposits. Abdominal type is characterized by a conical shape of the chest, bulging stomach, his back bent, significant amount of fat and medium musculature. There are a number of morphological parameters that are monitored and analyzed which can significantly affect the choice of technique that is most often used in combat (Kasum & Radovic, 2009). This primarily refers to the longitudinal and transverse dimensions of the skeleton and the diameters of the joints, whi-

## UVOD

Većina stručnjaka i naučnika koji se bave morfoloijom sportista, smatra da između sporta kojim se on bavi i njegovih morfoloških karakteristika, postoji dijalektička veza. Naime, u većini slučajeva, mladi sportista se opredjeljuje baš za sport koji najviše odgovara njegovoj morfoloiji, jer upravo morfoloija i predstavlja u određenoj mjeri njegovu tjelesnu prednost. Sa druge strane, baveći se odabranim sportom, usljed fenomena adaptacije na sportske napore, sportista vremenom dobija sve izraženije karakteristike tipične za taj sport. Pokazalo se da, što su sportska dostignuća veća, to su ona u tjesnijoj vezi sa sastavom i građom tijela sportista (Bajić, Ponorac, Rašeta i Bajić, 2010; Obradović i saradnici, 2011; Yoon, 2002). Zato se u većini sportova značajna pažnja poklanja posmatranju i izučavanju antropološkog statusa aktivnih sportista, ali i onih koji tek namjeravaju da se bave nekim od sportova (Khani, Farokhi, Shalchi, Angoori i Ansari, 2011; Rupčić, Matković, Knjaz, Baščevan i Rodić, 2011; Schmidt, Piencikowski i Vandervest, 2005). Poznavanje individualnih osobnosti sportista koji se aktivno bave rvanjem, neophodan je preduslov za uspješnu izradu kvalitetnih programa po kojima će se raditi i upravljanje trenažnim procesom (Станков, Климин и Письмеский, 1984). Među mnogim osobnostima koje svaki sportista posjeduje, morfološke karakteristike su, sasvim sigurno, jedna od onih koje veoma značajno utiču na ostvarivanje značajnih sportskih rezultata. Zato se one sa posebnom pažnjom prate i analiziraju, kao polazište, odnosno morfološki status na početku trenažnog procesa, ali i kao cilj, odnosno morfološki status kakvom treba težiti (Kasum i Obradović, 2008).

Rvači se odlikuju specifičnim morfološkim karakteristikama, čija su osnovna obilježja: naglašene širine i obimi tijela, proporcionalno dugačke ruke i kraće noge, velik procenat aktivne mišićne tjelesne mase (Борисов и Туманян, 1973). По класификацији Bunaka (Станков и saradnici, 1984), postoje tri osnovna konstitucionalna tipa boraca (grudni, muskularni i trbušni), i četiri prelazna (grudno – muskularni, muskularno – grudni, muskularno – trbušni i trbušno – muskularni). Grudni tip boraca karakteriše dobro razvijen grudni koš i snažan rameni pojas. Muskularni tip karakterišu cilindrični oblik grudnog koša, jak i ravan stomak, dobro razvijeni mišići i umjerene naslage sala. Trbušni tip karakterišu konični oblik grudnog koša, ispupčen stomak, povijena leđa, značajne masne naslage i srednja muskulatura. Postoji čitav niz morfoloških pokazatelja koji se prate i analiziraju, a mogu značajno uticati na izbor tehnika koje takmičar najčešće koristi u borbi (Kasum i Radović, 2009). Tu se prije svega misli na longitudinalne i transverzne

ch are to a large extent determined by hereditary factors. However, it was observed that the biggest wrestling competition winners, compared to other competitors of the same weight category, often have more accentuated longitudinal dimensions (Kasum, 2001).

Influence of long term training process on some morphological parameters can be significant, but they cannot significantly be influenced by planning. This is the case with osseous system, where the wrestlers, under the influence of stress, obtained higher specific gravity, and volume (Аньшп, 1999). It was observed that the champions of Europe, World and Olympic games differ from other wrestlers from the team by the fact that they have greater absolute and relative size of the bone and muscle tissue, and the smaller size of subcutaneous and total internal fat. Similar results were obtained by Туманян and Мартиросов (1974), and they believe that such a relationship of components of the body weight predisposes appropriate specific body weight of wrestlers, which is the largest in representatives of smallest weight classes, and the lowest with representatives of heavyweights.

There are several different formulas to calculate body composition. All of them use data obtained by anthropometric measurements. In this way are obtained values of muscle, bone and fat tissue in absolute and relative values. Thus Моргунова, Патратия, and Старков (1985), based on a sample of 138 free-style wrestlers from the structure of the SSSR national team, using the formula I. Matiegka, made a table of basic parameters of body composition of wrestlers in preparation and competition period. They found that the absolute values of muscle, bone and fat tissue growth from the lowest to highest weight categories, while the mean relative values of muscle tissue in wrestlers range from 48.37 to 52.5% (minimum 43.67, maximum 56.46%), the mean relative values of bone tissue from 14.2% to 16.92 (12:39 minimum, maximum 23.88%), and the mean relative values of fat from 8.44 to 17.43% (minimum 5.57, maximum 27.44%). The same authors found that the percentage of body fat increases from the lowest to the highest weight categories, the percentage of bone tissue decreases with weight of tested wrestlers, while the percentage of muscle tissue did not reveal any clear principle. Comparing the 12 parameters of body composition of wrestlers, of which 7 are indicators of absolute and 5 indicators of varying values, it was found that in all 12 indicators of the morphological status there are some differences between the values obtained during the preparation and competition period. However, statistically significant differences were found only for values of absolute and relative amounts of body fat, for the values for total amount of fat in the body, as well as for the relative values of muscle tissue.

dimenzije skeleta i dijambre zglobova, koji su u značajnoj mjeri određeni nasljednim faktorima. Ipak, uočeno je da se pobjednici najvećih rvačkih takmičenja, u poređenju sa ostalim takmičarima iste težinske kategorije, često imaju izraženije longitudinalne dimenzije (Kasum, 2001).

Uticaj dugotrajnog treninga na neke morfološke pokazatelje može biti značajan, ali na njih nije moguće značajnije uticati planski. Ovo je slučaj sa koštanim sistemom, koji kod rvača, pod uticajem naprežanja, dobija veću specifičnu težinu, ali i zapreminu (Аньшп, 1999). Uočeno je da se šampioni Evrope, svijeta i Olimpijskih igara razlikuju od ostalih rvača iz reprezentacije po tome, što imaju veće apsolutne i relativne veličine koštanog i mišićnog tkiva, i manje veličine potkožnog, unutrašnjeg i ukupnog masnog tkiva. Slične rezultate dobili su Туманян и Мартиросов (1974), a oni smatraju da takav odnos komponenata težine tijela predodređuje odgovarajuću specifičnu težinu tijela rvača, koja je najveća kod predstavnika najmanjih težinskih kategorija, a najmanja kod predstavnika teške kategorije.

Za izračunavanje sastava tijela postoji više različitih formula. Sve one koriste podatke koji su dobijeni antropometrijskim mjerenjima. Na taj način se dobijaju vrijednosti mišićnog, koštanog i masnog tkiva, u apsolutnim i relativnim vrijednostima. Tako su Моргунова, Патратия и Старков (1985), na osnovu uzorka od 138 rvača slobodnim stilom iz sastava reprezentacije SSSR, koristeći formulu I. Matiegka, napravili tablice osnovnih parametara sastava tijela rvača, u pripremnom i takmičarskom periodu. Oni su ustanovili da apsolutne vrijednosti mišićnog, koštanog i masnog tkiva rastu od najnižih ka najvišim težinskim kategorijama, dok se srednje relativne vrijednosti mišićnog tkiva kod rvača kreću od 48,37 do 52,50% (minimum 43,67, maksimum 56,46%), srednje relativne vrijednosti koštanog tkiva od 14,20 do 16,92 % (minimum 12,39, maksimum 23,88 %), a srednje relativne vrijednosti masnog tkiva od 8,44 do 17,43% (minimum 5,57, maksimum 27,44%). Isti autori su ustanovili da procenat masnog tkiva raste od najnižih ka najvišim težinskim kategorijama, procenat koštanog tkiva opada sa težinom ispitivanih rvača, dok kod procenta mišićnog tkiva nije uočena neka jasna zakonitost. Poređenjem 12 parametara sastava tijela rvača, od čega su 7 pokazatelji apsolutnih, a 5 pokazatelji relativizovanih vrijednosti, konstatovno je da se kod svih 12 pokazatelja morfološkog statusa javljaju razlike između vrijednosti dobijenih tokom pripremnog i takmičarskog perioda. Ipak, statistički značajne razlike konstatovane su samo za vrijednosti apsolutne i relativne količine potkožnog masnog tkiva, za vrijednosti ukupne količine masti u telu, kao i za relativne vrijednosti mišićnog tkiva.

The development of new measurement technologies opens new possibilities for the development of new ways of obtaining information relevant to the sport system. One of the new technologies used in space measurement of body composition structure is a method bioimpedance and the latest generation use multichannel bioelectrical bioimpedance variation, as a method that is becoming the gold standard in studies of human morphology (InBody 720 Biospace, 2008).

The aim of this research is to define morphological model of senior age wrestlers, using the latest technological methods that will make revalidation of existing knowledge about the given area.

## METHODS

### Sample of respondents

The sample was composed of 22 male respondents competing in the discipline of Greco-Roman style of wrestling at the elite senior level. Respondents were members of representations of following countries: Serbia ( $n = 10$ ), Croatia ( $n = 9$ ), Montenegro ( $n = 2$ ) and Greece ( $n = 1$ ). All were familiar with the testing conditions and they voluntarily participated in the study. Basic descriptive characteristics of the sample were: Age =  $23.1 \pm 2.4$  yrs., BH =  $175.7 \pm 8.96$  cm, BM =  $81.95 \pm 14.75$  kg, BMI =  $26.33 \pm 2.43$  kg/m<sup>2</sup>., Training Experience =  $12.5 \pm 2.7$  yrs., weekly training frequency =  $9.5 \pm .9$  training session / week., the summary volume of weekly training mode =  $842.4 \pm 139.2$  min workouts / week. The research was carried out in accordance with the conditions of "Declaration of Helsinki for recommendations guiding physicians in Biomedical Research Involving Human Subjects" - (<http://www.cirp.org/library/ethics/helsinki/>), and with the approval and consent of the Ethics Committee of the Faculty sport and Physical education, University of Belgrade.

### Testing procedures

Measurement of body composition was performed using bioelectrical impedance (Bioelectrical Impedance Analysis - BIA), using the latest generation of professional appliances - InBody 720 Tetrapolar 8-Point Tactile Electrode System (Biospace, Co., Ltd.). InBody 720 apparatus uses the latest technology of measuring body composition using DSM-BIA method (Direct Segmental Multi-frequency Bioelectrical Impedance Analysis), where the use of a different frequency range from 1kHz to 1MHz using methods reactivity measures quantity / weight of all four major body components - water, proteins, minerals and fats with accuracy of: 92.2% for Visceral fat Area (VFA) to 98.0% for the Fat Free Mass (FFM) (720 InBody Biospace, 2008).

Sa razvojem novih tehnologija mjerenja, otvaraju se i nove mogućnosti za usavršavanje načina dobijanja novih informacija značajnih za sistem sporta. Jedna od novih tehnologija, koja se primjenjuje u prostoru mjerenja strukture tjelesnog sastava je metod bioimpedance, a najnovije generacije koriste varijantu multikanalne bioelektrične bioimpedance, koja kao metod postaje zlatni standard u istraživanjima morfologije ljudi (InBody 720 Biospace, 2008).

Cilj ovog rada je da definiše morfološki model vrhunskih rvača seniorskog uzrasta, primjenom tehnološki najnovije metode, čime će se izvršiti revalidacija postojećih saznanja o datom prostoru.

## METODE

### Uzorak

Uzorak ispitanika je bio sastavljen od 22 ispitanika muškog pola, koji su se takmičili u rvačkom sportu u disciplini grčko-rimski stil na vrhunskom seniorskom nivou. Ispitanici su pripadali reprezentacijama sljedećih zemalja: Srbija ( $n = 10$ ), Hrvatska ( $n = 9$ ), Crna Gora ( $n = 2$ ) i Grčka ( $n = 1$ ). Svi su bili upoznati sa uslovima testiranja i dobrovoljno su učestvovali u istraživanju. Osnovni deskriptivni karakteristike uzorka su bili: uzrast =  $23,1 \pm 2,4$  god., BH =  $175,7 \pm 8,96$  cm, BM =  $81,95 \pm 14,75$  kg, BMI =  $26,33 \pm 2,43$  kg/m<sup>2</sup>, bavljenje rvanjem =  $12,5 \pm 2,7$  god., nedjeljna učestalost treninga =  $9,5 \pm 0,9$  treninga/sedmično, sumarni obim nedjeljnog trenažnog rada =  $842,4 \pm 139,2$  min treninga/sedmično. Istraživanje je realizovano u skladu sa uslovima "Deklaracija iz Helsinkija sa prijedlozima smjernica ljekarima u biomedicinskim istraživanjima koji uključuju čovjeka" - (<http://www.cirp.org/library/ethics/helsinki/>), a uz odobrenje i saglasnost Etičke komisije Fakulteta sporta i fizičkog vaspitanja Univerziteta u Beogradu.

### Procedure testiranja

Mjerenje tjelesnog sastava je izvršeno metodom bioelektrične impedance (Bioelectrical Impedance Analysis – BIA), pomoću profesionalnog aparata najnovije generacije - InBody 720 Tetrapolar 8-Point Tactile Electrode System (Biospace, Co., Ltd). Aparat InBody 720 koristi najnoviju tehnologiju mjerenja tjelesnog sastava primjenom DSM-BIA metode (Direct Segmental Multi-frequency Bioelectrical Impedance Analysis), gde se upotrebom različitog raspona frekvencije od 1KHZ do 1MHz pomoću metode reaktivnosti mjeri količina/masa sve četiri glavne tjelesne komponente – voda, proteini, minerali i masti

All measurements were carried out in the period March - April 2010, during the final stages of preparation for the European Championship in wrestling, and the respondents were familiar with all preconditions of measurement procedures (ACSM, 2005; Heyward, 2006; InBody 720 Biospace, 2008):

- measurements were carried out in the morning (between 9:00 and 10:00 a.m.); evening before measurements respondents were not taking any food after 9:00 p.m., and on the day of measurement they were not eating breakfast or drinking liquids before the end of the measurement procedure;
- 12 hours before measurements respondents did not have great physical strain, i.e. practice strains; before measurements respondents performed all basic physiological needs;
- 48 hours before the measurement the respondents were not consuming alcohol; before the measurement the respondents were standing at least 5 minutes to redistribute the body fluids in the tissues;
- the measurement was performed in the standing position by the procedure recommended by the manufacturer (hands aside 150 from the body).

## Variables

This study comprises a total of 23 variables, of which 13 are primary and 10 are derived (index) variables which define the morphology and composition of the body:

Basic variables to define the morphological structure and body composition were:

- TM – body mass, expressed in kg;
- BMI – body mass index, expressed in  $\text{kg}/\text{m}^2$ ;
- ICW – intra cellular water, expressed in L;
- ECW – extra cellular water, expressed in L;
- TBW – total body water, expressed in L;
- Proteins, expressed in kg;
- Minerals, expressed in kg;
- BMC – bone mineral content, expressed in kg;
- BFM – body fat mass, expressed in kg;
- SMM – skeletal muscle mass, expressed in kg;
- BCM – body cell mass, expressed in kg;
- VFA – visceral fat area, expressed in  $\text{cm}^2$ ;
- Fitness\_SCORE, body composition score – expressed as numerical equivalent.

Derived (index) variables to define morphological structure and body composition were:

- TBW% – percent of total body water, calculated as:  $\text{TBW} / \text{BM}$ , expressed in %;
- Proteini%, percent of proteins, calculated as:  $\text{Proteini} / \text{BM}$ , expressed in %;
- BMC% – percent of BMC, calculated as:  $\text{BMC} / \text{BM}$ , expressed in %;

i to tačnošću od: 92,2% za područje viscelarne masti (VFA) do 98,0% za slobodne masne mase (FFM) (InBody 720 Biospace, 2008).

Sva mjerenja su izvršena u periodu Mart – April 2010, tokom finalnih faza priprema za EP u rvanju, a ispitanici su bili upoznati sa svim preduslovima mjerne procedure (Ibid):

- mjerenja su realizovana u jutarnjim časovima (između 9:00 i 10:00 časova); večer prije mjerenja ispitanici nisu uzimali hranu poslije 21:00 časova, a na dan mjerenja nisu doručkovali niti pili tečnost prije završetka mjernog postupka;
- 12 sati prije mjerenja ispitanici nisu imali velika fizička tj. trenažna naprezanja; ispitanici su prije mjerenja obavili sve osnovne fiziološke potrebe;
- 48 sati prije mjerenja ispitanici nisu konzumirali alkohol; prije samog mjerenja ispitanici su stajali najmanje 5 minuta, radi preraspodjele tjelesnih tečnosti u tkivima;
- mjerenje je izvršeno u stojećoj poziciji po proceduri koju je preporučio proizvođač (ruke odmaknute 150 od tela).

## Varijable

Ovim istraživanjem je obuhvaćeno ukupno 23 varijabli, i to 13 osnovnih i 10 izvedenih (indeksnih) varijabli kojima je definisana morfološka struktura i sastav tijela.

Osnovne varijable za definisanje morfološke strukture i sastava tijela bile su:

- TM – tjelesna masa, izražena u kg;
- BMI – indeks tjelesne mase, izražen u  $\text{kg}/\text{m}^2$ ;
- ICW – unutarćelijska tečnost, izražena u L;
- ECW – vanćelijska tečnost, izražena u L;
- TBW – ukupna tjelesna tečnost, izražena u L;
- Protein, izraženi u kg;
- Minerali, izraženi u kg;
- BMC – mineralni sadržaj kostiju, izražen u kg;
- BFM – masna masa tijela, izražena u kg;
- SMM – masa skeletnih mišića, izražena u kg;
- BCM – ćelijska masa tijel, izražen u kg;
- VFA – područje viscelarne masti, izražen u  $\text{cm}^2$ ;
- Fitness\_SCORE, skor tjelesnog sastava – izražen kao numerički ekvivalent;

Izvedene (indeksne) varijable za definisanje morfološke strukture i sastava tijela bile su:

- TBW% – procenat ukupne tjelesne tečnosti, izračunata kao:  $\text{TBW} / \text{BM}$  – izražen u %;
- Proteini%, procenat proteina, izračunato kao:  $\text{Proteini} / \text{BM}$ , izraženo u %;
- BMC% – procenta BMC, izračunat kao: BMC

- PBF – percent of body fat, calculated as:  $\text{BFM} / \text{BM}$ , expressed in %;
- SMM% – percent of smooth muscle mass index, calculated as:  $\text{SMM} / \text{BM}$ , expressed in %;
- BCM% – percent of body cell mass, calculated as:  $\text{BCM} / \text{BM}$ , expressed in %;
- PFI – protein fat index, calculated as relation between Protein and Body Fat Mass, expressed in kg;
- BSI – bone strength index, calculated as relation between BMC and BM, expressed in g/kg;
- BMI/PBF index – calculated as relation between BMI and PBF, expressed in  $\text{kg}/\text{m}^2$  per 1% of fat;
- Fat Distribution Index (VFA/BF) as relation between VFA and BF, expressed in  $\text{cm}^2$  of visceral fat per 1 kg of body mass fat.

## Statistical analysis of data

All results were first subjected to descriptive statistical analysis to define the basic measures of central tendency and dispersion of data (M, SD, cV%, SE, 95% confidence interval - lower and upper bound). For the form of distribution were used measures of flatness and curvature (skewnis and kurtosis), while for calculating the regularity of distribution was used a non-parametric Kolmogorov-Smirnov test. All statistical analyzes were implemented using software SPSS Statistics 17.0. (SPSS Statistics, Inc.).

## RESULTS

### Results of basic morphological variables

Results of basic descriptive statistics and comparative analysis of partial morphological variables measured by sample respondents (Wrestlers /  $n = 22$ ), are shown in Table 1.

### The results of derived (index) morphological variables

Results of basic descriptive statistics of derived (index) morphological variables measured on samples of respondents ( $W/n = 22$ ) are shown in Table 2.

## DISCUSSION

On a general level, adequate body composition is one of the factors that have a significant degree of influence in terms of selection of preferential techniques and the formation of a specific wrestling style (Kasum & Radovic, 2009), and achieving competitive success at major competitions (Jagiello & Krusze-

- / BM, izražen u %;
- PBF, procenat tjelesne masti, izračunat kao:  $\text{BFM} / \text{BM}$  – izražen u %;
- SMM% – procenat od indeksa glatke mišićne mase, izračunat kao:  $\text{SMM} / \text{BM}$ , izražen u %;
- BCM% – procenat od ćelijske mase tijela, izračunat kao:  $\text{BCM} / \text{BM}$ , izražen u %;
- PFI – indeks proteina i masti, izračunat kao odnos između proteina i masne mase tijela, izražen u kg;
- BSI – indeks čvrstoće kostiju, izračunat kao odnos između BMC i BM, izražen u g/kg;
- BMI/PBF index – izračunat kao odnos između BMI i PBF, izražen u  $\text{kg}/\text{m}^2$  po 1% masti;
- Indeks raspodjele masti (VFA/BF), kao relacija između VFA i BF, izražen u  $\text{cm}^2$  visceralne masti po 1 kg masne mase tijela.

## Statistička obrada podataka

Svi rezultati su prvo podvrgnuti deskriptivnoj statističkoj analizi radi definisanja osnovnih mjera centralne tendencije i disperzije podataka (M, SD, cV%, SE, 95% intervala pouzdanosti – donja i gornja granica). Za oblik distribucije su korišćene mjere spljoštenosti i zakrivljenosti (skjunis i kurtosis), dok je izračunavanje pravilnosti distribucije korišćenih varijabli upotrebljen neparametrijski test Kolmogorov-Smirnov. Sve statističke analize su realizovane primjenom softvera SPSS Statistics 17.0. (SPSS Statistics, Inc.).

## REZULTATI

### Rezultati osnovnih morfoloških varijabli

Rezultati osnovne deskriptivne statistike, kao i parcijalne komparativne analize osnovnih morfoloških varijabli mjenog uzoraka ispitanika (Wrestlers /  $n = 22$ ), prikazani su u Tabeli 1.

### Rezultati izvedenih (indeksnih) morfoloških varijabli

Rezultati osnovne deskriptivne statistike izvedenih (indeksnih) morfoloških varijabli mjenih uzoraka ispitanika ( $W/n = 22$ ) prikazani su u Tabeli 2.

## DISKUSIJA

Na generalnom nivou, adekvatan tjelesni sastav jedan je od faktora koji u značajnoj mjeri ima uticaja u smislu izbora preferentnih tehnika i formiranja specifičnog stila rvanja (Kasum i Radović, 2009), kao i postizanja takmičarske uspješnosti na najvećim

wski, 2005; Jagiello, Tkaczuk, & Kruszewski, 2004). Given effect in certain sports is even more important, especially in those sports where there are weight classes, i.e. martial arts and strength sports such as lifting weights (Jagiello & Kruszewski, 2009).

Advancement of technology itself evolves development of new measurement instruments, which has resulted in the establishment of such new instruments and measurement procedures, which all together establishes the basis for a new understanding potential with the possibility to improve the existing level of knowledge. The aim of this study was to use this new technology - multi-channel electrical bioimpedance, and by that define a generic /general/ de-

takmičenjima (Jagiello i Kruszewski, 2005; Jagiello, Tkaczuk i Kruszewski, 2004). Dati uticaj je u određenim sportovima još značajniji, a naročito je to slučaj u sportovima gdje postoje težinske kategorije, odnosno u borilačkim sportovima i sportovima snage kao što je npr. dizanje tegova (Jagiello i Kruszewski, 2009).

Usavršavanjem tehnologije samo po sebi, usavršava se i izrada novih mjernih instrumenata, što kao posledicu ima uspostavljanje novih instrumenata i procedura mjerenja, što sve zajedno obezbjeđuje uslove za novi saznanji potencijal kojim se postojeći nivo znanja poboljšava. Cilj ovog rada je bio da primjenom nove tehnologije – multikanalne električne bioimpedance definiše generički /opšti/ deskriptivni

**TABLE 1**

*Indicators descriptive statistics basic morphological variables measured by sample respondents.*

**TABELA 1**

*Pokazatelji deskriptivne statistike osnovnih morfoloških varijabli mjenjenog uzoraka ispitanika.*

Varibales	<i>M</i>	<i>SD</i>	<i>cV%</i>	Min	Max	Skew	Kurt	<i>SE</i>	95% Confidence Interval		<i>K-S p</i>
									Lower Bound	Upper Bound	
TM (kg)	81.95	14.39	17.56	61.50	118.20	.66	.42	3.07	76.60	87.30	.852
BMI (kg/m <sup>2</sup> )	26.33	2.37	9.00	21.78	31.25	.33	.34	.51	25.34	27.33	.850
ICW (L)	34.71	6.10	17.57	26.10	52.80	1.12	2.46	1.30	32.58	36.84	.728
ECW (L)	20.37	3.83	18.80	15.50	31.20	.99	1.68	.82	19.04	21.70	.552
TBW (L)	55.08	9.91	17.99	41.80	84.00	1.08	2.17	2.11	51.63	58.53	.816
Proteins (kg)	15.00	2.62	17.47	11.30	22.80	1.13	2.52	.56	14.06	15.91	.731
Minerals (kg)	4.89	.99	20.25	3.60	7.77	.99	2.03	.21	4.55	5.24	.927
BMC (kg)	4.00	.83	20.75	2.87	6.39	.98	1.87	.18	3.71	4.29	.986
BFM (kg)	6.99	3.28	46.92	2.30	17.00	1.18	2.89	.70	4.74	9.23	.942
SMM (kg)	43.26	7.96	18.40	32.00	66.90	1.12	2.48	1.70	40.50	46.02	.722
BCM (kg)	49.71	8.73	17.56	37.40	75.60	1.11	2.44	1.86	46.67	52.76	.723
VFA (cm <sup>2</sup> )	46.60	20.11	43.15	20.20	95.40	.76	.12	4.29	36.57	56.64	.935
Fitness_SCORE	96.90	8.11	8.37	85.00	120.00	1.06	2.06	1.73	93.05	100.00	.545

Legend: **M** - Mean (Aritmetička sredina); **SD** - Standard deviation (Standardna devijacija); **cV%** - Coefficient of variation in percent (Koefficijent varijacije u procentima); **Min** - Minimum (Minimum); **Max** - Maximum (Maksimum); **Skew** - Skewness (Skjunis); **Kurt** - Kurtosis (Kurtozis); **SE** - Standard error (Standardna greška); 95% Confidence Interval - 95% intervala pouzdanosti; Lower Bound - Donja granica; Upper Bound - Gornja granica; **K-S p** - Kolmogorov–Smirnov probability (Kolmogorov-Smirnov vjerovatnoća); **TM** - Body weight (Tjelesna težina); **BMI** - Body mass index (Indeks tjelesne mase); **ICW** - Intracellular water (Unutarćelijska tečnost); **ECW** - Extracellular water (Vanćelijska tečnost); **TBW** - Total body water (Ukupna tjelesna tečnost); Proteins - Proteini; Minerals - Minerali; **BMC** - Bone mineral content (Mineralni sadržaj kostiju); **BFM** - Body fat mass (Masa masnog tkiva); **SMM** - Skeletal muscle mass (Masa skeletnih mišića); **BCM** - Body cell mass (Ćelijska masa tijela); **VFA** - Visceral fat area (Područje vicelarne masti); **Fitness\_SCORE** - Skor tjelesnog sastava.



**TABLE 2***Basic descriptive statistics derived (index) morphological variables measured by samples respondents.***TABELA 2***Osnovna deskriptivna statistika izvedenih (indeksnih) morfoloških varijabli mjerenih uzoraka ispitanika.*

Varibales	<i>M</i>	<i>SD</i>	<i>cV</i> %	Min	Max	Skew	Kurt	<i>SE</i>	95% Confidence Interval		K-S <i>p</i>
									Lower Bound	Upper Bound	
TBW% (%)	67.24	2.51	3.73	60.91	71.41	-.42	.76	.54	65.61	68.88	.658
Proteins% (%)	18.33	.70	3.84	16.46	19.62	-.46	1.25	.15	17.86	18.79	.779
BMC% (%)	4.86	.24	4.96	4.45	5.41	.41	.10	.51	4.73	4.98	.965
PBF% (%)	8.49	3.36	39.58	2.95	17.17	.42	1.03	.72	6.28	10.70	.579
SMM% (%)	52.79	2.06	3.90	47.78	56.79	.44	-.03	.96	51.45	54.13	.658
BCM% (%)	60.74	2.32	3.82	54.75	65.13	-.34	1.02	.50	59.19	62.30	.884
PFI (%)	2.69	1.54	57.30	.96	6.65	1.60	1.82	.33	2.18	3.21	.051
BSI (%)	.0486	.0024	4.94	.0445	.0541	.41	.10	.0005	.047	.05	.965
BMI/PBF index (%)	3.79	2.11	55.68	1.82	9.70	1.89	2.90	.45	3.11	4.47	.056
VFA/BF (%)	7.267	2.959	40.73	2.802	17.000	2.02	5.44	.631	6.30	8.23	.174

Legend: **M** - Mean (Aritmetička sredina); **SD** - Standard deviation (Standardna devijacija); **cV%** - Coefficient of variation in percent (Koefficient varijacije u procentima); **Min** - Minimum (Minimum); **Max** - Maximum (Maksimum); **Skew** - Skewness (Skjunis); **Kurt** - Kurtosis (Kurtosis); **SE** - Standard error (Standardna greška); 95% Confidence Interval - 95% intervala pouzdanosti; Lower Bound - Donja granica; Upper Bound - Gornja granica; **K-S p** - Kolmogorov–Smirnov probability (Kolmogorov-Smirnov vjerovatnoća); **TBW%** - Percent of total body water (Procenat ukupne tjelesne vode); **Proteins%** - Percent of proteins (Procenat proteina); **BMC%** - Percent bone mineral content (Procenat mineralnog koštanog sadržaja); **PBF%** - Percent of body fat (Procenat tjelesne masti); **SMM%** - Percent of smooth muscle mass index (Procenat od indeksa glatke mišićne mase); **BCM%** - Percent of body cell mass (Procenat od ćelijske mase tijela); **PFI** - Protein fat index (Indeks proteina i masti); **BSI** - Bone strength index (Indeks čvrstoće kostiju); **VFA/BF** - Fat distribution index (Indeks raspodjele masti).

scriptive profile of body composition of elite Greco-Roman style wrestlers, as well as to establish new indicators defined as index values for the evaluation of the same.

The results showed that distribution of all analysed variables is not different from the hypothetical correct one, and therefore it can be argued that the results can be interpreted as valid and reliable, regardless of whether it is original or derivative (index) variables (Table 1 and 2, from K-S  $p = .986$  for Osseous to  $p = .051$  for PFI).

In relation to body mass (TM) measured average value of tested sample was  $14.39 \pm 81.95$  kg with a range of scores from 61.5 to 118.2 kg. As the test sample was made up of wrestlers from all weight categories, data on the average weight is only informative.

profil tjelesnog sastava vrhunskih rvača grčko-rimskog stila, kao i da etablira nove indikatore definisane kao indeksne vrijednosti za procjenu istog.

Rezultati su pokazali da distribucija svih analiziranih varijabli nije različita od hipotetski pravilne, ta se može tvrditi da se rezultati mogu interpretirati kao validni i pouzdani, bez obzira da li se radi o originalnim ili izvedenim (indeksnim) varijablama (Tabela 1 i 2, od K-S  $p = 0,986$  za BMC do  $p = 0,051$  za PFI).

U odnosu na tjelesnu masu (TM) izmjerena prosječna vrijednost testiranog uzorka je bila  $81,95 \pm 14,39$  kg sa rasponom rezultata od 61,5 do 118,2 kg. Kako je testirani uzorak rvača bio sastavljen od svih težinskih kategorija, podatak o prosječnoj masi ima informativni karakter.

U odnosu na indeks tjelesne mase (BMI) izmjerena

In relation to body mass index (BMI) measured average value of tested sample was  $26.33 \pm 2.37$  kg/m<sup>2</sup> with limit values from 21.78 to 31.25 kg/m<sup>2</sup>. On the basis of the reliability interval (95% probability) it can be argued that elite wrestler's optimal BMI values are in the range of 25.34 to 27.33 kg/m<sup>2</sup>. Bearing in mind the fact that the tested sample is comprised of top level wrestlers from four regional countries (Serbia, Croatia, Montenegro and Greece) it can be accepted as a fact that the given range of BMI is competitive optimum in relation to quantitative characteristics of body mass for Balkan region population of wrestlers.

Data about the amount of fluid inside the body (Tables 1 and 2) showed that the average hydration measures of tested wrestlers were at a level of  $34.71 \pm 6.10$  liters of liquid content in the cells (ICW),  $20.37 \pm 3.83$  liters of liquid contents in the extracellular space (ECW), that the total amount of water in the body was at the level of  $55.08 \pm 9.91$  liters of total fluid in the body (TBW). Measured amount of TBW represented  $67.24 \pm 2.51\%$  of total body weight (TBW%). Given variable had the characteristics of a very homogeneous size with minimal variation of only 3.73%, a very small error in measurement methods of only 0.54% and a reliability interval of 65.61 to 68.88%.

In any case, the amount of water is very important information for wrestlers. Excessive loss of fluids leads to dehydration of the body, and each dehydration leads to the loss of electrolytes. Electrolytes that are actually dissolved ions in the liquid, have the function of nerve impulse delivery and shortening of muscles, i.e. all physiological functions. As the fluid enters the body through the gastrointestinal tract, and eliminates through the sweat glands and kidneys, the body (especially the kidneys) makes an effort to preserve the proper concentration of electrolytes. However, if the dehydration process is too fast, violent or too long, the concentration of the electrolyte is more disrupting. Even a little disruption of electrolyte balance is manifested by general weakness, impaired mental function and loss of muscular coordination. The excessive dehydration of organism disrupts the function of the kidney, and therefore leads so reduction in the volume of blood and the loss of intracellular liquids.

In relation to the variable status of contractile tissue (protein and skeletal muscles), the results showed that the measured average protein value is  $15.00 \pm 2.62$  kg, with a range from minimum of 11.30 to a maximum of 22.80 kg, and a reliability interval of 14.06 to 15.9 kg of proteins weight. In relation to the established skeletal muscle mass (SMM) the average value of the sample was  $43.26 \pm 7.96$  kg with a range from a minimum of 32.00 and a maximum of 66.90 kg, and a reliability interval of 40.50 to 46.02 kg of

prosječna vrijednost testiranog uzorka je bila  $26,33 \pm 2,37$  kg/m<sup>2</sup> sa graničnim vrijednostima od 21,78 do 31,25 kg/m<sup>2</sup>. Na osnovu intervala pouzdanosti (95% vjerovatnoće) može se tvrditi da se kod vrhunskih rvača optimalne vrijednosti BMI nalaze u rasponu od 25,34 do 27,33 kg/m<sup>2</sup>. Imajući u vidu činjenicu da su testirani uzorak činili vrhunski rvači uz čak 4 zemlje regiona (Srbija, Hrvatska, Crna Gora i Grčka) može se prihvatiti kao činjenica da je dati raspon BMI takmičarski optimalan u odnosu na kvantitativno obilježje indeksa mase tijela populacije rvača balkanskog regiona.

Podaci o količini tečnosti u organizmu (Tabele 1 i 2) su pokazali da je prosječna mjera hidriranosti testiranih rvača bila na nivou od  $34,71 \pm 6,10$  litara sadržaja tečnosti u ćelijama (ICW),  $20,37 \pm 3,83$  litara sadržaja tečnosti u vanćelijskom prostoru (ECW), da je ukupna količina vode u tijelu bila na nivou od  $55,08 \pm 9,91$  litara ukupne tečnosti u organizmu (TBW). Izmjerena količina TBW je predstavljala  $67,24 \pm 2,51\%$  ukupne mase tijela (TBW%). Data varijabla je imala karakteristike veoma homogene veličine sa minimalnom varijacijom od samo 3,73%, veoma malom greškom mjerenja metode od samo 0,54%, i intervalom pouzdanosti od 65,61 do 68,88%.

U svakom slučaju i količina vode je podatak koji ima veliki značaj za rvače. Prekomjerno gubljenje tečnosti dovodi do dehidracije organizma, a svaka dehidracija dovodi i do gubljenja elektrolita. Elektroliti koji su ustvari joni rastvoreni u tečnosti, imaju funkciju kod predaje nervnih impulsa i skraćivanja mišića, odnosno svih fizioloških funkcija. Pošto se tečnost u organizam unosi preko želudačno crijevnog trakta, a eliminiše preko znojnih žlijezda i bubrega, organizam (posebno bubrezi) čini napor da sačuva odgovarajuću koncentraciju elektrolita. Međutim, ako je proces dehidracije suviše brz, nasilan ili suviše dugotrajan, koncentracija elektrolita se sve više narušava. Čak i malo narušavanje elektrolitnog balansa, manifestuje se opštom slabošću, slabljenjem umnih funkcija i gubljenjem mišićne koordinacije. Pri pretjeranoj dehidraciji organizma, narušava se funkcija bubrega, dolazi do smanjenja obima krvi i do gubljenja unutarćelijske tečnosti.

U odnosu na varijable statusa kontraktilnog tkiva (proteini i skeletni mišići) rezultati su pokazali da je izmjerena prosječna vrijednost proteina od  $15,00 \pm 2,62$  kg, sa rasponom od minimalnih 11,30 do maksimalnih 22,80 kg, i intervalom pouzdanosti od 14,06 do 15,9 kg mase proteina. U odnosu na utvrđenu masu skeletnih mišića (SMM) prosječna vrijednost kod uzorka je bila  $43,26 \pm 7,96$  kg sa rasponom od minimalnih 32,00 do maksimalnih 66,90 kg, i intervalom pouzdanosti od 40,50 do 46,02 kg mase skeletnih

skeletal muscle mass. The value of the percentage of protein in the body (Proteins%) was at the level of  $18.33 \pm .70\%$  proteins/kg TM (reliability interval = 17.86 - 18.79%), while in relation to the tested sample of elite wrestlers the percentage of skeletal muscle was  $52.79 \pm 2.06\%$  SMM/kg TM (reliability interval = 51.45 - 54.13%). As a measure of the ratio of protein and fat component an innovative index (PFI) was used in this study, and it was found that top wrestlers at 1 kg of adipose tissue have 2.69 kg of protein mass, i.e. the given value of the index was at a level of  $2.69 \pm 0.70\%$  proteins/BFM with a reliability interval from 2.18 to 3.21%.

Bearing in mind the fact that in wrestling there are weight classes, aspiration of all wrestlers to have a greater percentage of muscle tissue cannot be realized with forced muscle hypertrophy. In fact, even gain of lean muscle mass can be a problem if the wrestlers are brought into a situation to have to change competitor category. So in training of wrestlers strength training based on the improvement of neurogenic factors must be dominant, which aims to enable the greatest number of motor units with best frequency of the discharge. That is achieved by higher intensity and lesser extent of training. In doing so, it is necessary to use the same training exercises for different muscle groups, but also use distinct exercises for the same muscle groups. In this way we get musculature typical for wrestlers, characterized by a strong tendon and not too hypertrophied muscles. A big problem is the loss of muscle mass during weight reduction. It is known that muscles have a three times higher specific weight than fat, so weight loss is often not a true indicator of the efficiency of the reduction of body weight. It happens that the wrestlers lose more than 8 pounds and that their percentage of body fat increases, which is best illustrated by the fact that the regulation of weight was constructed without taking into account some basic principles. This research has also registered a case of wrestlers who lost even 9.6 kg in weight, and thereby "failed" to increase the absolute value of fat for .1kg, respectively to increase the amount of fat by .7%. Such a pronounced weight loss was caused by loss of 7.1 liters of water, or even 5.4 kg of lean muscle mass. Of course, the result of such a regulation of weight is participation at the competition, which is not worth mentioning.

It has already been established that with wrestlers as athletes are dominated highly developed contractile characteristics (different aspects of expressing muscle force and muscle strength characteristics) as an adaptive response to training and competition with expressed mesomorphic constitution, i.e. expressed musculature - the muscle component. Consequently, the aforementioned adaptation, besides muscle component reflects to the oily component as well, where it was established that during the competitive

mišića. Vrijednost procenta proteina u tijelu (Proteins%) je bila na nivou od  $18,33 \pm 0,70\%$  proteina/kg TM (interval pouzdanosti = 17,86 – 18,79%), dok je u odnosu na testirani uzorak vrhunskih rvača procenat skeletnih mišić bio  $52,79 \pm 2,06\%$  SMM/kg TM (interval pouzdanosti = 51,45 – 54,13%). Kao mjera odnosa proteinske i masne komponente, u ovom radu je korišćen inovativni index (PFI) i utvrđeno je da kod vrhunskih rvača na 1 kg masnog tkiva ima 2,69 kg proteinske mase, odnosno vrijednost datog indeksa je bila na nivou od  $2,69 \pm 0,70\%$  proteina/BFM uz interval pouzdanosti od 2,18 do 3,21%.

Imajući u vidu činjenicu da u rvanju postoje težinske kategorije, težnju svih rvača da imaju što veći procenat mišićnog tkiva nije moguće realizovati forsiranom hipertrofijom mišića. Naime, čak i dobitak čiste mišićne mase može predstavljati problem ako rvača dovodi u situaciju da prinudno mijenja takmičarsku kategoriju. Zato u treningu rvača mora da dominira trening snage zasnovan na unapređenju neurogenih faktora, čiji je cilj aktiviranje najvećeg broja motornih jedinica sa najboljom frekvencijom pražnjenja, što se postiže visokim intenzitetom i nešto manjim obimom treninga. Pri tome, potrebno je na istom treningu koristiti vježbe za različite grupe mišića, ali i koristiti različite vježbe za iste grupe mišića. Na taj način se dobija muskulatura koja je tipična za rvače, koju karakterišu snažne tetive i ne previše hipertofirani mišići. Veliki problem predstavlja i gubitak mišićne mase prilikom redukovanja tjelesne težine. Poznato je da mišići imaju čak tri puta veću specifičnu težinu nego masno tkivo, tako da gubitak težine vrlo često nije pravi pokazatelj efikasnosti redukovanja tjelesne težine. Nije rijetkost da rvači izgube i više od 8 kilograma a da im se procenat masnog tkiva poveća, što najbolje ilustruje činjenicu da je regulisanje težine rađeno stihijski i bez uvažavanja neki osnovnih principa. I ovo istraživanje registrovalo je slučaj rvača koji je izgubio čak 9,6 kg tjelesne težine, a pri tome "uspjeo" da poveća apsolutnu vrijednost masti za 0,1 kg, odnosno da procenatualno poveća količinu masti za 0,7%. Ovako naglašen gubitak mase bio je posljedica gubitka 7,1 litra vode, odnosno čak 5,4 kg čiste mišićne mase. Naravno, rezultat ovakvog regulisanja težine je nastup na takmičenju koji nije ni vrijedan spomena.

Već je ranije utvrđeno da rvači kao sportisti, gde dominiraju visoko razvijene kontraktilne karakteristike (različiti aspekti ispoljavanja karakteristika mišićne sile i mišićne snage) kao posljedica adaptacije na trening i takmičenje imaju i naglašenu mezomorfnu konstituciju, odnosno imaju naglašenu muskulaturu – mišićnu komponentu. Posljedično, pomenuta adaptacija se pored mišićne komponente reflektuje i na masnu komponentu, gdje je utvrđeno da se u toku takmičarskog

part of the season, the percentage value of body fat (PBF) at the top wrestlers is in the range of 4 to 10%, with the exception of the super heavyweight category in which there is a large degree of diversity in the given variable (Yoon, 2002). Almost same results of PBF were determined in this study, because the average value of the given variable was  $8.49 \pm 3.36\%$  BF/BM with a reliability interval from 6.28 to 10.70%. In relation to the total value body fat in the organism the average of tested wrestlers was at the level of only  $6.99 \pm 3.28$  kg with a reliability interval of 4.74 to 9.23 kg. The average value of visceral fat was  $49.71 \pm 8.72$  cm<sup>2</sup> (reliability interval = 36.57 to 56.64 cm<sup>2</sup>), while the average values of two index variables (BMI/PBF index and VFA/BF), as indicators of fat distribution in the body (Deurenberg, 2001) were at a level of  $3.79 \pm 2.11$  kg/m<sup>2</sup> per 1% of fat, and  $7.267 \pm 2.959$  cm<sup>2</sup> of visceral fat per 1 kg of body fat mass, respectively (Table 2).

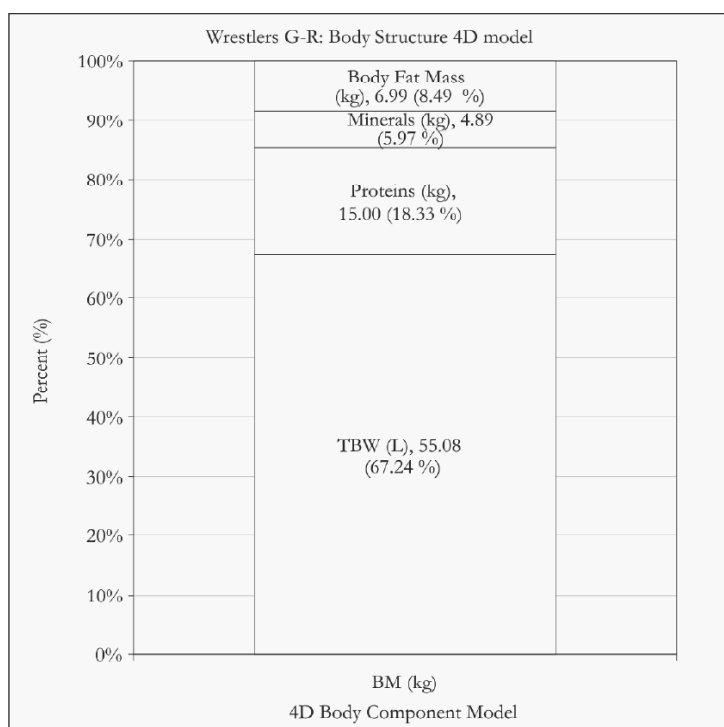
It is known that the prolonged duration stresses (more than 30 minutes), as well as moderate intensity, with pulse of 60 - 70% from the maximum, even 85% of energy derives from fat (Đorđević, 2005). This fact is the reason why the competition meso-cycle training of wrestlers often includes intensities of moderate loads that are not characteristic for the wrestling match. It is already common for wrestlers who seriously reduce their weight to run in circles around the halls in which they had previously solved the technical and tactical tasks at the end of their training. Of course, a load of greater intensity also includes fat as an energy source, but it is a smaller percentage of energy obtained in that way, but with pulse of 80% from maximum, only 50% of energy is gained from fat. In each case, the percentage of body fat should be minimized, and the data obtained from the sample of high-quality wrestlers may represent reference values and some kind of recommended values. These indicators may vary during the year and are slightly lower in the competition than pre-competition mesocycle, but these differences are usually not statistically significant (Schmidt et al., 2005).

However, when the weight of competition meso-cycle is compared with the weights in the transition period, statistically significant differences were stated (Buford, Rossi, Smith, O'Brien, & Pickering, 2006). In the transition period certain relaxation is possible in the control of body weight, but the deviation from the standard weight ought not to be too large, because the process of burning fat in the body requires gradualness and time. It is recommended that the removal of fat per week is between 1.2 and 2 kilograms, and in this period athletes should take food without fat, which contains minerals and vitamins, especially the B complex, as well as a reduced amount of carbohydrates and protein (Kasum, Jovanović, & Ćirko-

dijela sezone vrijednost procenta masnog tkiva (PBF) kod vrhunskih rvača nalazi u rasponu od 4 do 10%, sa izuzetkom superteške kategorije kod koje postoji veliki stepen različitosti kod date varijable (Yoon, 2002). Skoro istovijetni rezultati o PBF su utvrđeni i u ovom istraživanju jer je prosječna vrijednost date varijable bila  $8,49 \pm 3,36\%$  BF/BM uz interval pouzdanosti od 6,28 do 10,70%. U odnosu na ukupnu vrijednost masti u organizmu prosjek testiranih rvača je bio na nivou od samo  $6,99 \pm 3,28$  kg uz interval pouzdanosti od 4,74 do 9,23 kg. Prosječna vrijednost visceralne masti je bila  $49,71 \pm 8,72$  cm<sup>2</sup> (interval pouzdanosti = 36,57 do 56,64 cm<sup>2</sup>), dok su prosječne vrijednosti dvije indeksne varijable (BMI/PBF index i VFA/BF), kao indikatori distribucije masnog tkiva u telu (Deurenberg-Yap, Schmidt, vanStaveren, Hautvast i Deurenberg, 2001) bile na nivou od  $3,79 \pm 2,11$  kg/m<sup>2</sup> po 1% masti i  $7,267 \pm 2,959$  cm<sup>2</sup> visceralne masti po 1 kg masne mase tijela (Tabela 2).

Poznato je da se pri opterećenjima produženog trajanja (duže od 30 minuta), kao i umjerenog intenziteta, pri pulsu 60 – 70% od maksimalnog, čak 85% energije dobija iz masti (Đorđević, 2005). Ova činjenica je razlog što u takmičarskom mezociklusu trening rvača često uključuje i opterećenja umerjenog intenziteta, koja inače nisu karakteristična za rvačku borbu, već je uobičajeno da rvači, koji ozbiljnije redukuju svoju težinu, pri kraju treninga trče u krug oko sale u kojoj su prethodno rješavali tehničko-taktičke zadatke. Naravno, opterećenja nešto većeg intenziteta takođe uključuju masti kao izvor energije, ali je manji procenat energije dobijen iz masti, a već pri pulsu 80% od maksimalnog svega 50% energije dobija se iz masti. U svakom slučaju, procenat masnog tkiva se mora minimizirati, a pokazatelji dobijeni na uzorku vrlo kvalitetnih rvača mogu predstavljati referentne vrijednosti i neku vrstu preporučenih vrijednosti. Ovi pokazatelji mogu varirati u toku godine i nešto su niži u takmičarskom nego u predtakmičarskom mezociklusu, ali te razlike obično nisu statistički značajne (Schmidt i saradnici, 2005).

Međutim, kada su tjelesne težine iz takmičarskog mezociklusa upoređene sa težinama u prelaznom periodu, konstatovne su i statistički značajne razlike (Buford, Rossi, Smith, O'Brien i Pickering, 2006). U prelaznom periodu su moguća određena opuštanja po pitanju kontrole tjelesne težine, ali ta odstupanja od standardne težine ne bi smjela da budu suviše velika, zato što i proces sagorjevanja masti u organizmu zahtijeva postupnost i vrijeme. Preporučuje se da nedeljno skidanje masti bude između 1,2 i 2 kilograma, a u ovom periodu treba uzimati hranu bez masti, koja sadrži minerale i vitamine, naročito B kompleks, kao i smanjenu količinu ugljenih hidrata i bjelancevina

**FIGURE 1***4D model of body composition tested wrestlers.***SLIKA 1***4D model sastava tijela testiranih rvača.*

Legend: Wrestlers G-R (Greco-Roman): Body structure 4D model - Rvači G-R (grčko-rimski): 4D model strukture tijela; Body Fat Mass - Masa masti u tijelu; Minerals - Minerali; Proteins - Proteini; **TBW** - Total body water (Ukupna voda u tijelu); **BM** - Body mass (Tjelesna masa); 4D Body Component Model - 4D model komponenti tijela; Percent - Procenat.

vić, 2002). If the weight of the body is much higher than usual, it requires entering into the problem of regulating weight and its reduction to a limit values.

In relation to the mineral component it was found that the total mass of minerals in the body is from  $4.89 \pm .99$  kg with a reliability interval from 4.55 to 5.24 kg, that the mineral part of bone mass (Osseous) is  $4.00 \pm .83$  kg with a reliability interval of 3.71 to 4.29 kg. Percentage of the mineral part of bone mass relative to body mass is at the level of  $4.86 \pm .24\%$  (from 4.73 to 4.98%), and observed through the BSI index with the average value of  $.0486 \pm .0024$ , on 1 kilogram of body weight in proportion there are 48.6 grams of bone tissue minerals (Table 2).

Tested sample of wrestlers had  $49.71 \pm 8.73$  kg mass of living cells in the body (BMC - Body Cell Mass) which is  $60.74 \pm 2.32\%$  representation in the body (Tables 1 and 2).

In the end, the average estimated body composition (Fitness SCORE) was  $96.90 \pm 8.11$  points, with a range of reliability interval from 93.05 to 100.00 points.

(Kasum, Jovanović i Ćirković, 2002). Ukoliko je težina tijela znatno veća od uobičajene, ulazi se u problem regulisanja težine i njenog redukovanja do propisane granične vrijednosti.

U odnosu na mineralnu komponentu utvrđeno je da je ukupna masa minerala u tijelu  $4,89 \pm 0,99$  kg uz interval pouzdanosti od 4,55 do 5,24 kg, da mineralna masa koštanog dijela (Osseous) iznosi  $4,00 \pm 0,83$  kg uz interval pouzdanosti od 3,71 do 4,29 kg. Procentualna zastupljenost mineralnog dijela koštane mase u odnosu na masu tijela nalazi se na nivou od  $4,86 \pm 0,24\%$  (od 4,73 do 4,98%), odnosno posmatrano preko BSI indeksa, čija je prosječna vrijednost  $0,0486 \pm 0,0024$ , na 1 kilogram tjelesne mase proporcijalno postoji 48,6 grama minerala koštanog tkiva (Tabela 2).

Testirani rvači iz uzorka su imali  $49,71 \pm 8,73$  kg mase živih ćelija u organizmu (BMC – Body Cell Mass) što predstavlja  $60,74 \pm 2,32\%$  zastupljenosti u organizmu (Tabele 1 i 2).

Na kraju, prosječna ocjena sastava tijela (Fitness SCORE) je bila  $96,90 \pm 8,11$  bodova, sa rasponom intervala povjerenja od 93,05 do 100,00 bodova.

Figure 1 shows the 4D model of body composition of tested wrestlers with the following model characteristics: in relation to the average body weight of wrestlers from the sample - 81.95 kg, the water content is 55.08 L and 67.24%, amount of proteins is 15.00 kg or 18.33%, the mass of minerals is 4.98 kg or 5.97% and fat weight is 6.99 kg or 8.49%.

## CONCLUSION

Results of this study showed that quality wrestlers have the percentage of average fat in the body of 8.49% of the total body mass, with minimum and maximum values for total body mass at the level of 2.95% and 17.17%, respectively with a reliability interval from 6.28 to 10.70%. Bearing in mind the fact that in wrestling there are weight classes, larger amounts of fat are unnecessary ballast, which must be maximally reduced.

In contrast to adipose tissue, with wrestlers is very desirable to have high percentage of muscle tissue. Results of this study showed that with quality wrestlers, the percentage of lean body mass on average is 52.79% of the total body mass, with a minimum recorded values of 47.78% and a maximum value of up to 56.79% of the total body mass, i.e. with a confidence interval of 51.45 to 54.13%. Bearing in mind the fact that in wrestling there are weight classes, aspiration of all wrestlers to have a greater percentage of muscle tissue cannot be realized by muscle hypertrophy. In fact, gain of lean muscle mass can even be a problem if the wrestlers are brought into a situation to change competitor category.

In any case, the amount of water is important information for the wrestlers. Excessive loss of fluids leads to dehydration of the body, and each dehydration leads to the loss of electrolytes. Results of this study showed that the average measure of hydration of quality wrestlers was at a level of  $34.71 \pm 6.10$  liters of liquid content in the cells (ICW),  $20.37 \pm 3.83$  liters of liquid contents in the extracellular space (ECW), and that the total amount of water in the body was at the level of  $55.08 \pm 9.91$  liters (TBW). Measured amount of TBW was  $67.24 \pm 2.51\%$  of total body weight (TBW%). Given variable had the characteristics of a very homogeneous size with a reliability interval of 65.61 to 68.88%.

However, the most important result of this study is defining of generic (general) four-dimensional model (4D model) of body composition in a function of quality international-class wrestlers, which has the following characteristics: in relation to the average body weight of wrestlers from the sample - 81.95 kg, the water content is 55.08 L or 67.24%, amount

Na Slici 1 je prikazan 4D model sastava tijela kod testiranih rvača sa sljedećim modelnim karakteristikama: u odnosu na prosječnu tjelesnu masu rvača iz uzorka – 81,95 kg, sadržaj vode iznosi 55,08 L ili 67,24 %, količina proteina iznosi 15,00 kg ili 18,33 %, masa minerala iznosi 4,98 kg ili 5,97% i masa masti iznosi 6,99 kg ili 8,49%.

## ZAKLJUČAK

Rezultati ovog istraživanja su pokazali da kod kvalitetnih rvača, procenat masnog tkiva u prosjeku iznosi 8,49% ukupne mase tijela, uz minimalnu i maksimalnu vrijednost ukupne mase tijela na nivou od 2,95% i 17,17%, odnosno uz interval pouzdanosti od 6,28 do 10,70%. Imajući u vidu činjenicu da u rvanju postoje težinske kategorije, veće količine masnog tkiva predstavljaju nepotreban balast, koji se mora maksimalno redukovati.

Nasuprot masnom tkivu, kod rvača je veoma poželjan visok procenat mišićnog tkiva. Rezultati ovog istraživanja su pokazali da kod kvalitetnih rvača, procenat čiste mišićne mase u prosjeku iznosi 52,79% ukupne mase tela, uz minimalnu zabelježenu vrijednost 47,78% i maksimalnu vrijednost od čak 56,79% ukupne mase tijela, odnosno uz interval pouzdanosti od 51,45 do 54,13%. Imajući u vidu činjenicu da u rvanju postoje težinske kategorije, težnju svih rvača da imaju što veći procenat mišićnog tkiva nije moguće realizovati forsiranom hipertrofijom mišića. Naime, čak i dobitak čiste mišićne mase može predstavljati problem ako rvača dovodi u situaciju da prinudno mijenja takmičarsku kategoriju.

U svakom slučaju i količina vode je podatak koji ima veliki značaj za rvače. Prekomjerno gubljenje tečnosti dovodi do dehidracije organizma, a svaka dehidracija dovodi i do gubljenja elektrolita. Rezultati ovog istraživanja su pokazali da je kod kvalitetnih rvača prosječna mjera hidriranosti bila na nivou od  $34,71 \pm 6,10$  litara sadržaja tečnosti u ćelijama (ICW),  $20,37 \pm 3,83$  litara sadržaja tečnosti u vanćelijskom prostoru (ECW), odnosno da je ukupna količina vode u tijelu bila na nivou od  $55,08 \pm 9,91$  litara (TBW). Izmjerena količina TBW je predstavljala  $67,24 \pm 2,51\%$  ukupne mase tijela (TBW%). Data varijabla je imala karakteristike veoma homogene veličine sa intervalom pouzdanosti od 65,61 do 68,88%.

Međutim, najvažniji rezultat ovog istraživanja je definisanje generičkog (opšteg) četvorodimenzionalnog modela (4D model) sastava tijela u funkciji kvalitetnih rvača međunarodne klase, koji ima sljedeće karakteristike: u odnosu na prosječnu tjelesnu masu rvača iz uzorka – 81,95kg, sadržaj vode iznosi 55,08 l ili 67,24%, količina proteina iznosi 15,00 kg ili 18,33%, masa

of proteins is 15.00 kg, or 18.33%, mineral mass is 4.98 kg or 5.97% and fat weight is 6.99 kg or 8.49%.

minerala iznosi 4,98 kg ili 5,97% i masa masti iznosi 6,99 kg ili 8,49%.

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## PROFILO DESCRITTIVO DELLA STRUTTURA CORPOREA DEI LOTTATORI DI ALTO LIVELLO DELLA LOTTA DELLO STILE GRECO-ROMANO DEFINITO DAL METODO DELL'IMPEDENZA BIOELETTRICA MULTIFREQUENZA

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La maggior parte degli esperti e degli scienziati che si occupano della morfologia degli atleti ritiene che esiste un rapporto dialettico tra lo sport che un atleta fa e le sue caratteristiche morfologiche. È stato dimostrato che quanto maggiori sono i risultati sportivi, tanto più connessi sono con la composizione e

struttura corporea degli atleti, e la composizione e struttura corporea sono molto importanti negli sport con le categorie di peso, come per esempio la lotta. Per questo motivo lo stato morfologico dei lottatori viene osservato ed analizzato come il punto di partenza, all'inizio del processo di allenamento, ma



anche come uno scopo da perseguire durante le preparazioni. L'effetto di allenamento durevole su alcuni parametri morfologici può essere significativo ma su di loro non è possibile avere un effetto più significativo in modo pianificato. È stato osservato che i campioni d'Europa, del mondo e dei giochi olimpici differiscono da altri lottatori del team per il fatto che loro hanno un maggior valore assoluto e relativo del tessuto osseo e muscolare e il valore più basso del tessuto adiposo sottocutaneo, interno e totale.

Con lo sviluppo delle nuove tecnologie di misura, si aprono nuove possibilità per lo sviluppo di metodi per ottenere le informazioni necessarie al sistema sportivo. Una delle più recenti tecnologie utilizzate nella misurazione della struttura della composizione corporea è il metodo del bioimpedenza bioelettrica multifrequenza, un metodo che sta diventando lo standard d'oro negli studi della morfologia del corpo umano. L'obiettivo di questo studio è di definire il modello morfologico dei lottatori di alto livello dell'età di senior, utilizzando i più recenti metodi tecnologici in modo tale da rivalutare le conoscenze già esistenti in quest'area. Il campione era composto da 22 candidati di sesso maschile, che hanno gareggiato nella lotta greco-romana, ad alto livello di seniores. Misurazione della composizione corporea è stata effettuata utilizzando il metodo dell'impedenza bioelettrica (Bioelectrical Impedance Analysis – BIA), usando il dispositivo professionale di ultima generazione - In-Body 720 Tetrapolar 8-Point Tactile Electrode System (Biospace, co, Ltd.), che utilizza la più recente tecnologia di misurazione della composizione corporea utilizzando il metodo DSM-BIA (Analisi di impedenza bioelettrica segmentale diretta, multi-frequenza). (Direct Segmental Multi-frequency Bioelectrical Impedance Analysis).

I risultati di questo studio hanno dimostrato che dai lottatori di qualità la percentuale di tessuto adiposo in media ammonta 8,49% della totale massa corporea, con un valore minimo e massimo della massa totale del corpo a livello di 2,95% e 17,17%, cioè, con un intervallo di confidenza da 6,28 a 10,70%. Tenendo presente il fatto che nella lotta esistono le categorie di peso, maggiori quantità di tessuto adiposo rappresentano un carico inutile che deve essere ridotto al massimo.

A differenza del tessuto adiposo, è molto desiderabile che i lottatori hanno un alta percentuale di tessuto muscolare. I risultati di questo studio hanno dimostrato che dai lottatori di qualità la percentuale di massa muscolare magra ammonta, in media, a 52,79% della massa totale del corpo, con un valore minimo registrato di 47,78% ed un valore massimo pari al 56,79% della massa totale del corpo, cioè con un intervallo di confidenza da 51,45 a 54,13%. Tenendo presente il fatto che nella lotta esistono le categorie di peso, l'ambizione di tutti i lottatori di avere la percentuale di tessuto muscolare più alta possibile non può essere realizzata tramite l'ipertrofia muscolare forzata. Cioè, perfino l'aumento della massa muscolare magra può essere un problema, se il lottatore si troverebbe nella situazione di dover cambiare forzatamente la categoria competitiva.

In ogni caso anche la quantità di acqua è un dato che ha molta importanza per i lottatori. L'eccessiva perdita di liquidi porta alla disidratazione dell'organismo ed ogni disidratazione porta alla perdita di elettroliti. I risultati di questo studio hanno dimostrato che il valore medio di idratazione dei lottatori di qualità era al livello di  $34,71 \pm 6,10$  litri del contenuto del liquido nelle cellule (ICW),  $20,37 \pm 3,83$  litri del contenuto del liquido nello spazio extracellulare (ECW), cioè la quantità totale di acqua nel corpo era al livello di  $55,08 \pm 9,91$  litri (TBW). La quantità misurata del TBW era  $67,24 \pm 2,51\%$  della massa corporea totale (TBW%). La variabile specificata aveva le caratteristiche del valore molto omogeneo con un intervallo di confidenza da 65,61 a 68,88%.

Il risultato più importante di questo studio è la definizione di un modello generico (generale) a quattro dimensioni (modello 4D) della composizione corporea in funzione dei lottatori di classe internazionale che ha le seguenti caratteristiche: rispetto alla massa corporea media dei lottatori del campione – 81,95 kg, il contenuto di acqua è 55,08 l oppure 67,24%, la quantità di proteine è 15,00 kg oppure 18,33%, la massa dei minerali ammonta a 4,98 kg oppure 5,97% e la massa di grasso è 6,99 kg oppure 8,49%

**Parole chiavi:** lottatori della lotta greco-romana, bioimpedenza, la composizione corporea, modello

## LATENTNA STRUKTURA PARAMETARA SITUACIONE EFIKASNOSTI KOD HRVATSKIH VRHUNSKIH KOŠARKAŠA SENIORA

### LATENT STRUCTURE OF SITUATIONAL EFFICIENCY PARAMETERS AT CROATIAN TOP BASKETBALL PLAYERS

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#### SUMMARY

The aim of this study was to determine the structure of dimensions that are based on different parameters of the standard situational efficiency of top Croatian players. The insight into the structure and relationships of the latent dimensions of situational success in basketball could contribute to better understand the overall effectiveness of situational players. We analyzed twelve standard and seven derived parameters of situational efficiency in a intentional sample of players in nine senior basketball teams from the A-1 Croatian Basketball League Championship in 2006/2007. Principal components analysis of the standard situational efficiency parameters obtained the existence of three main components, which all together explain over 76% of the total variance of the space of standard parameters of situational efficiency. Univariate correlations and results of principal components analysis showed that the most standard and most of the derived parameters of situational efficiency are statistically significantly correlated.

**Key words:** basketball, component analysis, correlation, latent dimensions.

#### SAŽETAK

Cilj istraživanja bio je utvrditi strukturu dimenzija koje se temelje na različitim standardnim parametrima situacione efikasnosti hrvatskih vrhunskih košarkaša. Otkrivanje strukture i odnosa latentnih dimenzija u situacionoj uspješnosti u košarci bi moglo pridonijeti boljem razumijevanju ukupne situacione efikasnosti košarkaša. Analizirano je dvanaest standardnih, te sedam izvedenih parametara situacione efikasnosti u namjernom uzorku košarkaša devet seniorskih timova iz A-1 Hrvatske košarkaške lige u prvenstvu 2006/2007. Analizom glavnih komponenti kod standardnih parametara situacione efikasnosti utvrdili smo postojanje tri glavne komponente, koje sve zajedno tumače preko 76 % ukupne varijanse prostora standardnih parametara situacione efikasnosti. Univarijatne korelacije i analiza glavnih komponenti pokazuju da je i većina standardnih i većina izvedenih parametara situacione efikasnosti međusobno statistički značajno povezana.

**Ključne riječi:** košarka, komponentna analiza, korelacije, latentne dimenzije

## INTRODUCTION

Basketball is a complex, variable poly-structural activity, characterized by cyclic and acyclic types of motions that precede primary goal of the game, basketball shooting, as well as preventing an opponent to win, and to make a shot. The basketball game in its course is divided into three main phases: defense, attack and transition (Jukić, 1998), and can be observed as a series of activities and tasks performed by each player regarding the place and role within a team concept game (Trninić, Perica, & Dizdar, 1999). Basketball is a sport with contradictory tactics model of the game with infinite number of options to address specific situations in the game, while at the team level it is required opposition cooperation model (Hernandez, 1988). Therefore, the adjustment of individual and team goals, i.e. individual and team decisions is extremely important (Gréhaigine, Bouthier, & Godbout, 1997; Trninić et al., 1999; Trninić & Dizdar, 2000). The fundamental precondition for the successful operation of the individual in terms of performing the above series of operations is a set of selected features of the anthropological status, linked to an integrated set of optimal sports fitness. Characteristics that determine success in basketball are defined by the specification equation, which determines the optimal "sum" of characteristics that are the correlates of maximum sports performance (Milanović, Jukić, & Dizdar, 1996). Monitoring and analysis of the situational efficiency of the players and teams in basketball games contribute to easier monitoring of the spectators, and coaches and basketball professionals find them useful as a material that enables a comparative analysis of the players and teams as a whole and have their place in the planning and programming training process, indicates Maršić (Nakić, 2004). In order to monitor events at the basketball games FIBA (Federation International Basketball Association) has standardized thirteen situational efficacy indicators that are monitored at every official match. On that basis, it is possible to calculate various derived parameters. There have been conducted numerous scientific studies about the measuring problems of the actual quality of basketball players (Dežman, 1996; Dizdar, 2002; Elbel & Allen, 1941; Erčulj, 1995; Swalgin, 1994, 1998). These studies were mainly focused on the development of expert systems to evaluate the actual quality of basketball players (Swalgin, 1994, 1998; Trninić et al., 1999). Dizdar (2002) has classified two basic methods for overall performance evaluation or actual quality of the players. The first method is a set of procedures for objective evaluation of the situational efficacy of the players, such as: a simple linear combination, a simple linear combination of z-values, partially pondered linear combination of the index of absolute and relative efficacy of the basketball players, MVP

## UVOD

Košarka je kompleksna polistrukturalna varijabilna aktivnost za koju su karakteristični ciklički i aciklički tipovi kretanja koji prethode osnovnom cilju igre, ubacivanju lopte u koš, kao i sprečavanju protivničkog igrača da osvoji i ubaci loptu u koš. Sama košarkaška igra u svom toku podijeljena je na tri osnovne faze: odbrane, napada i tranzicije (Jukić, 1998), a može se posmatrati i kao određeni niz poslova i zadataka koje svaki igrač obavlja s obzirom na mjesto i ulogu u timu unutar određenog koncepta igre (Trninić, Perica i Dizdar, 1999). Košarka je sport sa kontradiktornim modelom taktike igre s beskonačnim brojem mogućnosti za rješavanje određene situacije u igri, dok je na ekipnom nivou potreban model saradnje – opozicije (Hernandez, 1988). Zato je usklađivanje pojedinačnih i timskih ciljeva, odnosno individualnih i timskih rješenja, izuzetno važno (Gréhaigine, Bouthier i Godbout, 1997; Trninić i saradnici, 1999; Trninić i Dizdar, 2000). Temeljna pretpostavka za uspješno djelovanje pojedinca u smislu obavljanja navedenog niza poslova je skup biranih obilježja antropološkog statusa, povezanih u integralni sklop optimalne sportske pripremljenosti. Obilježja koja determinišu uspjeh u košarci definišu se jednačinom specifikacije, koja određuje optimalni "zbir" karakteristika koje su korelati maksimalnog sportskog postignuća (Milanović, Jukić i Dizdar, 1996). Praćenje i analiza situacione efikasnosti igrača i ekipe u košarkaškoj igri doprinose lakšem praćenju igre od strane gledalaca, a od velike su pomoći trenerima i košarkaškim stručnjacima kao materijal koji omogućuje komparativnu analizu igrača i ekipe u cjelini te imaju svoje mjesto pri planiranju i programiranju trenažnog procesa, ukazuje Maršić (Nakić, 2004). U svrhu praćenja događanja na košarkaškim utakmicama FIBA (Federation International Basketball Association) je standardizovala trinaest pokazatelja situacione efikasnosti koji se prate na svakoj službenoj utakmici. Na osnovu njih je moguće izračunati različite izvedene parametre. O problemima mjerenja stvarne kvalitete košarkaša sprovedena su brojna naučna istraživanja (Dežman, 1996; Dizdar, 2002; Elbel i Allen, 1941; Erčulj, 1995; Swalgin, 1994, 1998). Ovakva istraživanja uglavnom su bila usmjerena na razvijanje ekspertnih sistema za procjenu stvarne kvalitete košarkaša (Swalgin, 1994, 1998; Trninić i saradnici, 1999). Dizdar (2002) je klasifikovao dvije osnovne metode za procjenu ukupne uspješnosti ili stvarne kvalitete košarkaša. Prvu čine postupci za objektivnu procjenu situacione efikasnosti košarkaša, među kojima su: jednostavna linearna kombinacija, jednostavna linearna kombinacija z-vrijednosti, djelomično ponderisane linearne

(most valuable player)-evaluation of the player's efficacy, Swalgin's (1994, 1998) systems for players evaluation (BES BES 1 and 2), the PC system for evaluating the performance of basketball players. The second group of methods includes the procedures for the subjective evaluation of the situational efficacy of the players, consisting of a group of independent basketball experts that evaluate certain group of basketball players according to one or more criteria. Although, of all the methods cited the "PC system for evaluating the performance of basketball players" proven to be most effective, equally efficient is the method of partly pondered linear combination (Dizdar, 2002), which uses the coefficients of shot efficacy rather than mere statistical data on the number of points scored and the number of unsuccessful shots.

In the context of this research, we review studies of authors who have studied the standard indicators of situational efficacy of the players. Trninić, Perica, and Dizdar (2001) gave a list of criteria for the situational evaluation of elite basketball players' efficacy in attack and defence, finding seven criteria for evaluating players in the set and the transition phase of defence, and twelve criteria of stage attacks. Milošević, Jukić, and Bračić (2001) found how much the variables of basketball shooting affected the results of the European Championship in Barcelona in 1997, and came to the conclusion that from the seven variables, only three appear as significant predictors of the final results of the match, while the most important one is the number of successful free throws. The other two significant variables were unsuccessful shots for two and three points. Abrams, Barnes, and Clement (2008) tried to determine the relationship between the statistical parameters that players had prior to the championship in the NBA league (National Basketball Association) and the duration of sports career in the NBA (number of played seasons). The sample of the participants included consisted of guards, power forwards and centers. It has been analyzed eleven standard parameters of situational efficacy, and it turned out that there is a significant possibility of duration of the career forecasts based on these parameters, but only for basketball players at the position of guards and power forwards (not for the centers). For the players of American universities, Swalgin (1994) has established standards for evaluation for the efficacy of situational players by position in the game and playing time. He designed a computer program to evaluate the efficacy of basketball players, in relation to the position at which he plays and his presence in the game. In other sports games, Janković (1988) investigated and defined the latent structure of the technical-tactical elements in volleyball, on a sample of the four best volleyball teams that participated in the final tournament of the League Cup in former Yugoslavia 1981. Based on

kombinacije, indeks apsolutne i relativne uspješnosti košarkaša, MVP-procjena korisnosti igrača, Swalginovi (1994, 1998) sistem za evaluaciju košarkaša (BES 1 i BES 2), PC sistem za vrednovanje efikasnosti košarkaša. U drugu grupu metoda uvrštavaju se postupci za subjektivnu procjenu situacione efikasnosti košarkaša, koju čine grupe nezavisnih košarkaških eksperata koji određenu grupu košarkaša procjenjuju prema jednom ili više kriterija. Premda je od nabrojanih metoda "PC sustav za vrednovanje efikasnosti košarkaša" dokazano najefikasniji, podjednako efikasna je i metoda djelomično ponderisane linearne kombinacije (Dizdar, 2002), koja koristi koeficijente šuterske efikasnosti umjesto pukih statističkih podataka o broju postignutih poena, te broja neuspješnih šuteva.

U kontekstu ovog istraživanja, dajemo pregled istraživanja autora koji su proučavali standardne pokazatelje situacione efikasnosti košarkaša. Trninić, Perica i Dizdar (2001) dali su spisak kriterijuma za situacijsku evaluaciju efikasnosti elitnih košarkaša u fazi napada i odbrane, utvrdivši sedam kriterija za vrednovanje košarkaša u postavljenoj i tranzicijskoj fazi odbrane, te dvanaest kriterijuma za fazu napada. Milošević, Jukić i Bračić (2001) su utvrdili koliko varijable ubacivanja lopte u koš utiču na rezultate košarkaških utakmica Prvenstva Europe u Barceloni 1997, te su došli do zaključaka da se od sedam varijabli samo tri javljaju kao značajni prediktori konačnog rezultata utakmice, dok je najznačajnija od njih broj uspješnih izvođenja ubacivanja lopte u koš sa linije slobodnih bacanja. Ostale dvije značajne varijable bile su neuspješna ubacivanja za dva i tri poena. Abrams, Barnes i Clement (2008) su nastojali utvrditi odnos između statističkih parametara koje su košarkaši imali prije nastupanja u prvenstvu NBA lige (National Basketball Association) i trajanja sportske karijere u NBA ligi (brojem sezona nastupanja). Uzorak učesnika sadržavao je bekove, krila i centre. Analizirano je jedanaest standardnih parametara situacione efikasnosti, a pokazalo se da postoji značajna mogućnost prognoze trajanja karijere na temelju tih parametara, ali samo za košarkaše na poziciji bekova i krila (ne i za centre). Kod košarkaša Američkih univerziteta, Swalgin (1994) je uspostavio standarde za procjenu situacione efikasnosti košarkaša prema položaju u igri i vremena za igru. Dizajnirao je računarski program za procjenu efikasnosti košarkaša, u odnosu na poziciju na kojoj igra i njegovu prisutnost u igri. U ostalim sportskim igrama, Janković (1988) je istražio i definisao latentnu strukturu tehničko-taktičkih elemenata u odbojci, na uzorku četiri najbolje odbojkaške ekipe koje su učestvovala u finalnom turniru Kupa bivše Jugoslavije 1981. Na temelju osnovnih tehničko-taktičkih elemenata u odbojci,

basic technical-tactical elements in volleyball, the author used a principal components analysis and extracted the following four latent dimensions: overall game efficacy, raising efficacy, efficacy of the back-court play and efficacy after fast break. Trninić, Viskiće-Štalec, Štalec, Dizdar, and Birkić (1995) conducted a quantitative analysis of the basketball game using multivariate mathematical-statistical methods (principal components analysis). The analysis was made taking into account the general and specific attributes of the game and tasks of the players in the game, based on the evaluation of top basketball experts (players and coaches) and knowledge of scientists-practitioners. Factor solutions have shown that there are three dimensions of a basketball game, the three components: information, energy and socio-motor interactions. The correlation between information and socio-motor interaction component was .38, whereas the correlation between energy and socio-motor interaction component was negative. Trninić et al (2005) have attempted to determine the latent structure of a basketball game with alpha-factor analysis, using 13 standard situational efficacy indicators in the basketball game, from the games of the World Basketball Championships held in Toronto in 1994, and they found four relatively independent latent dimensions: (1) efficacy of the internal players or players in the back line of defense and attack in the front lines; (2) efficacy of external players or players in front of line of defense and back line of attack; (3) overall efficacy of the attack; (4) efficacy of throwing the ball into the basket from a distance. Thomson (1994) differentiates internal players and post-technique (facing back the basket), while Wissel (1994) describes the external players and specificity of the technique facing the basket. On the other hand, Javier (1992) divides players into two broad categories according to their roles in the game: external (organizer, producer and forward) and internal (post and pivot) players. Exploratory strategy of factor analysis of the main components of 13 standard indicators of situational efficacy on a sample of top junior basketball players who have participated in junior basketball championship in Zadar in 2000, there have been isolated two relatively independent latent dimensions and named as: technical and tactical situational activity (1) internal and (2) external players (Jeličić, Trninić, & Jelaska, 2010). The authors conclude that neither the use of standard indicators of situational efficacy as well as the use of latent dimensions derived from them is not sufficient to explain the complex structure of the basketball game. The aim of the research conducted by Šeparović and Nuhanović (2008) was to determine the latent structure in basketball using factor analysis (alpha method, oblimin criteria of transformation) on 15 standard indicators of situational success (FIBA), on the sample of 30 games in League six of Bosnia and Herzegovina, played for the championship of the state. Analyzing

autor je koristio analizu glavnih komponenti te izdvojio četiri sljedeće latentne dimenzije: cjelokupna igračka efikasnost, efikasnost u podizanju, efikasnost u zadnjem polju te efikasnost igre nakon brzih prekida. Trninić, Viskiće-Štalec, Štalec, Dizdar i Birkić (1995) su proveli kvantitativnu analizu igre košarke korišćenjem matematičko-statističkih multivarijantnih postupaka (analiza glavnih komponenti). Analiza je napravljena uzevši u obzir opšte i specifične attribute utakmice i zadatke košarkaša u igri, na osnovu procjena vrhunskih košarkaških stručnjaka (igrača i trenera) te znanja naučnika-praktičara. Faktorska rješenja su pokazala da postoje tri dimenzije košarkaške igre, tri komponente: informaciona, energetska, te socio-motorna interakcija. Korelacija između informacione i socio-motorne interakcijske komponente bila je 0,38, dok je korelacija između energetske i socio-motorne interakcijske komponente bila negativna. Trninić i saradnici (1995) su pokušali odrediti latentnu strukturu košarkaške igre Alpha - faktorskom analizom, na utakmicama Svjetskog prvenstva u košarci u Torontu 1994, te su pronašli četiri relativno nezavisne latentne dimenzije: (1) efikasnost unutrašnjih igrača ili igrača unutar zadnje linije obrane i prednje linije napada; (2) efikasnost vanjskih igrača ili igrača ispred linije obrane i zadnje linije napada; (3) opšta efikasnost napada; (4) efikasnost bacanja lopte u koš iz daljine. Thomson (1994) razlikuje unutrašnje igrače i post-tehniku (okrenutih leđa košu), dok Wissel (1994) opisuje vanjske igrače i specifičnosti tehnike okrenutosti lica prema košu. S druge strane, Javier (1992) dijeli igrače u dvije velike kategorije s obzirom na njihove uloge u igri: vanjske (organizator, realizator i krilo) i unutrašnje (post i pivot) igrače. Eksplorativnom strategijom faktorske analize glavnih komponenata 13 standardnih pokazatelja situacione efikasnosti na uzorku vrhunskih juniorskih košarkaša koji su učestvovali na Juniorskom košarkaškom prvenstvu u Zadru 2000, izolovane su dvije relativno nezavisne latentne dimenzije i imenovane su kao: situaciona tehnička i taktička aktivnost (1) unutrašnjih i (2) vanjskih igrača (Jeličić, Trninić i Jelaska, 2010). Autori zaključuju da niti korišćenje standardnih pokazatelja situacione efikasnosti, a niti korišćenje iz njih izvedenih latentnih dimenzija nisu dovoljni za objašnjenje kompleksne strukture košarkaške igre. Cilj istraživanja Šeparovića i Nuhanovića (2008) bio je utvrđivanje latentne strukture u košarci primjenom faktorske analize (alpha metoda, oblimin kriterijum transformacije) na 15 standardnih pokazatelja situacione uspješnosti (FIBA), na uzorku od 30 utakmica u Bosanskohercegovačkoj Ligi 6 koja se igrala za prvaka države. Analizirajući strukturu situacionih pokazatelja koji utiču na uspješnost najjačih košarkaških klubova

the structure of situational indicators that affect the success of the strongest basketball teams in Bosnia and Herzegovina state champion in basketball, it was shown that there are four latent dimensions, which are named: the success of a shot from close range, the success of the shot from moderate distance, the general success of defensive players and specific defensive mobility. However, the authors believe that for a complete analysis of latent structures it is necessary to expand the base of situational indicators.

The aim of the study was to determine the structure of the dimensions that can be found in the base of different standard parameters of situational efficacy in Croatian top basketball players. The discovery of the structure and relations of the latent dimensions of situational efficacy in basketball could contribute to better understanding of the overall situational efficacy of Croatian top basketball players. On the other hand, it could contribute to quality work of coaches and the training process could be organized in a more systematic way, in terms of differentiated action on important latent dimensions in the base of overall situational efficacy of the basketball players.

## METHODS

### Participants

The population from which the intentional sample of participants were drawn top players, who played in nine men's team A-1 Croatian men's basketball championship in 2006/2007: "Cedevita", "Svjetlost", "Borik", "Kvarner", "Dubrava", "Dubrovnik", "Alkar", "Šibenik", and "Osijek". The final sample of participants (74 players) is selected from an initial sample of 107 participants. The requirement for the selection of players in the final sample of participants was the number of minutes spent in the game (at least ten minutes in the game per match), or the number of matches played (at least eight matches in which the individual performed). Team players are examined with the permission of Croatian Basketball Federation, clubs and the players themselves, within a period of playing from the sixth to eighth round of the A-1 League championship (since December 2006 to mid-January 2007).

### Variables

Criteria for the quantitative evaluation of the players were taken from the previously referenced papers in Croatia (Dizdar, 2002). In this paper we used the method of partial pondered linear combinations to evaluate the overall quality of basketball players (Ibid). There are thirteen standard parameters

u Bosni i Hercegovini u borbi za titulu šampiona države u košarci, pokazalo se da postoje četiri latentne dimenzije, koje su imenovane: uspješnost šuta sa bliske udaljenosti, uspješnost šuta sa srednje udaljenosti, generalna odbrambena uspješnost igrača i specifična odbrambena pokretljivost. Međutim, autori smatraju da je za kompletnu analizu latentne strukture neophodno proširiti bazu situacionih pokazatelja.

Cilj ovog istraživanja bio je utvrditi strukturu dimenzija koja su u osnovi različitih standardnih parametara situacione efikasnosti kod hrvatskih vrhunskih seniorskih košarkaša. Naime, otkrivanje strukture i relacija latentnih dimenzija u osnovi ove situacione efikasnosti u košarci moglo bi doprinijeti lakšem razumijevanju ukupne situacione efikasnosti vrhunskih hrvatskih seniorskih košarkaša. S druge strane, ono bi moglo doprinijeti i kvalitetnijem radu trenera, koji bi više sistemski mogao organizovati trenažni proces, u smislu diferenciranog djelovanja na bitne latentne dimenzije u osnovi ukupne situacione efikasnosti košarkaša.

## METODE

### Učesnici

Populacija iz koje je namjerni uzorak učesnika izvučen bili su vrhunski seniorski košarkaši, koji su igrali u devet muških seniorskih timova A-1 Hrvatske muške košarkaške lige iz prvenstva 2006/2007. godine: "Cedevita", "Svjetlost", "Borik", "Kvarner", "Dubrava", "Dubrovnik", "Alkar", "Šibenik" te "Osijek". Finalni uzorak učesnika (74 košarkaša) je selekcionisan iz inicijalnog uzorka od 107 učesnika. Uslov za izbor igrača u finalni uzorak učesnika bio je broj minuta provedenih u igri (minimalno deset minuta provedenih u igri po utakmici), odnosno broj odigranih utakmica (minimalno osam utakmica u kojima je pojedinac nastupio). Igrači ekipa su ispitani uz dopuštenje Hrvatskog košarkaškog saveza, klubova i samih igrača, unutar perioda odigravanja šestog do osmog kola prvenstva A-1 lige (od decembra 2006. do polovine januara 2007.).

### Varijable

Kriterijumi za kvantitativnu evaluaciju igrača preuzeti su iz prethodno referisanih radova kod nas (Dizdar, 2002). U ovom se radu koristila metoda djelomično ponderisane linearne kombinacije za procjenu ukupne kvalitete košarkaša (Ibid). Trinaest je standardnih parametara situacione efikasnosti, koji

of situational efficacy, which include data on the shots success, rebounds, steals and turnovers, assists, blocks, personal fouls. On the basis of standard parameters of situational efficacy, it has been deduced seven derived coefficients of the situational efficacy of the basketball players: utilization of two points shots, utilization of for three-point shoots, utilization of free throw efficacy, efficacy of two-point shots, efficacy of three-point shoots, efficacy of free throws and efficacy of overall situational efficacy (Ibid). Data on the number of blocks of a shot in this study was omitted as it occurs rarely and we have no data about that. Derived parameters of situational effectiveness: Efficiency coefficient of the two points shot -  $XK2IS = XP2 / (XP2 + XN2)$ ; Coefficient of efficiency for the three points shot -  $XK3IS = XP3 / (XP3 + XN3)$ ; Coefficient of efficiency of free throws -  $XK1IS = XP1 / (XP1 + XN1)$ ; Coefficient of efficiency of the two points shot -  $XK2UC = 2 \times XK2IS \times XP2$ ; Coefficient of efficiency for the three-point shot -  $XK3UC = 3 \times XK3IS \times XP3$ ; Coefficient of efficiency of free throws -  $XK1UC = XK1IS \times XP1$ ; Overall situational efficiency -  $XDLK = XP1 + 2 \times XP2 + 3 \times XP3 + XSO + XSN + XA + XOL - .5 \times XN1 - XN2 - XN3 - XIL - XOP$ . We analyzed all the championship matches (using official statistics from the Croatian Basketball Federation website [www.kosarka.hr](http://www.kosarka.hr)), i.e. sixteen matches for each of the nine teams in the "bicircular" system of competition.

## Statistical analysis

To determine the structure of the dimensions that are basically a set of standard parameters of situational efficacy in basketball, it has been carried the procedure of Principal Components Analysis, where a number of significant principal components is determined by Guttman-Kaiser's criteria, while Varimax rotation has been applied afterwards. For a detailed analysis of the relationships of individual variables within the set of variables, there have been also determined intercorrelations (Pearson) between all the variables of the parameters set of the situational efficacy of basketball players.

## RESULTS

In the Table 1, descriptive statistics of all situation-related parameters of efficacy at male basketball players in senior A-1 Croatian Basketball league was given.

In Table 2 is evident that it has been found even 48 (from the theoretically possible 72) statistically significant correlations, mostly medium-sized. The complementary variables highly and significantly

uključuju podatke o uspješnosti šuteva, skokove, osvojene i izgubljene lopte, asistencije, blokade, lične greške. Na osnovu standardnih parametara situacione efikasnosti, deducirano je i sedam izvedenih koeficijenata situacione efikasnosti košarkaša: iskorišćenost šuta za dva poena, iskorišćenost šuta za tri poena, iskorišćenost slobodnih bacanja, efikasnost šuta za dva poena, efikasnost šuta za tri poena, efikasnost slobodnih bacanja te ukupne situacione efikasnosti (Ibid). Podatak o broju blokada šuta je u ovom istraživanju izostavljen, kao rijedak događaj o čijoj zastupljenosti nismo imali podatke. Izvedeni parametri situacione efikasnosti: Koeficijent iskorišćenosti šuta za dva poena -  $XK2IS = XP2 / (XP2 + XN2)$ ; Koeficijent iskorišćenosti šuta za tri poena -  $XK3IS = XP3 / (XP3 + XN3)$ ; Koeficijent iskorišćenosti slobodnih bacanja -  $XK1IS = XP1 / (XP1 + XN1)$ ; Koeficijent efikasnosti šuta za dva poena -  $XK2UC = 2 \times XP2 \times XK2IS$ ; Koeficijent efikasnosti šuta za tri poena -  $XK3UC = 3 \times XP3 \times XK3IS$ ; Koeficijent efikasnosti slobodnih bacanja -  $XK1UC = XP1 \times XK1IS$ ; Ukupna situaciona efikasnost -  $XDLK = XP1 + 2 \times XP2 + 3 \times XP3 + XSO + XSN + XA + XOL - 0,5 \times XN1 - XN2 - XN3 - XIL - XOP$ . Analizirane su sve utakmice prvenstva (koristeći službenu statistiku Hrvatskog košarkaškog saveza s portala [www.kosarka.hr](http://www.kosarka.hr)), tj. po šesnaest utakmica za svaki od devet timova, u "dvokružnom" sistemu takmičenja.

## Metode obrade podataka

Da bi se utvrdila struktura dimenzija koja su u osnovi skupa standardnih parametara situacione efikasnosti u košarci, sproveden je postupak komponentne analize, gdje je broj značajnih glavnih komponenti određen Guttman-Kaiserovim kriterijumom. Kao metoda ekstrakcije primijenjena je metoda glavnih komponenti s Varimax rotacijom. Za detaljnu analizu međusobnih odnosa pojedinačnih varijabli unutar skupa promjenljivih, utvrđene su i interkorelacije (Pearson) između svih varijabli skupa parametara situacione efikasnosti učinkovitosti košarkaša.

## REZULTATI

U Tabeli 1 je data deskriptivna statistika standardnih i izvedenih parametara situacione efikasnosti kod košarkaša seniorske A-1 Hrvatske košarkaške lige.

U Tabeli 2 je uočljivo da je pronađeno čak 48 (od teoretski mogućih 72) statistički značajnih korelacija, većinom srednje veličine. Visoko i značajno koreliraju međusobno komplementarne varijable: broj uspješnih

**TABLE 1**

*Descriptive statistics of all situation-related parameters of efficacy at male basketball players in senior A-1 Croatian Basketball league.*

**TABELA 1**

*Deskriptivna statistika parametara situacijske učinkovitosti kod košarkaša seniorske A-1 Hrvatske košarkaške lige.*

Variable	<i>M</i>	Min	Max	<i>R</i>	Var	<i>SD</i>	Skew	Kurt	Max D	<i>p</i>
XP2	34.03	2.00	115.00	113.00	515.53	22.71	1.07	1.14	.12	.20
XN2	26.99	4.00	79.00	75.00	246.81	15.71	.93	.92	.08	.20
XP3	12.00	.00	39.00	39.00	85.18	9.23	.74	.07	.11	.20
XN3	23.12	.00	61.00	61.00	272.90	16.52	.51	-.56	.12	.20
XP1	24.12	1.00	72.00	71.00	262.16	16.19	.94	.51	.14	.15
XN1	10.22	.00	97.00	97.00	153.35	12.38	4.90	33.01	.21	.01
XA	22.51	1.00	105.00	104.00	371.18	19.27	2.23	6.13	.18	.05
XSN	13.88	1.00	48.00	47.00	114.11	10.68	1.28	1.32	.17	.05
XSO	31.20	2.00	87.00	85.00	376.22	19.40	.84	.35	.09	.05
XOL	14.45	.00	34.00	34.00	60.41	7.77	.24	-.60	.07	.20
XOP	33.23	4.00	64.00	60.00	146.40	12.10	.08	-.49	.09	.20
XIL	21.39	3.00	55.00	52.00	134.41	11.59	-.69	-.31	.13	.20
XK2IS	.54	.17	.72	.55	.01	.10	-.72	1.05	.08	.15
XK3IS	.31	.00	.70	.70	.02	.15	-.39	.68	.16	.20
XK1IS	.73	.40	1.00	.60	.02	.13	-.12	-.29	.07	.10
XK2UC	38.88	.67	147.77	147.10	855.97	29.26	.74	.14	.14	.20
XK3UC	8.84	.00	34.97	34.97	58.89	7.67	.51	-.44	.13	.15
XK1UC	17.52	.50	55.74	55.24	146.79	12.12	1.99	7.35	.14	.20
XDLK	100.51	-1.41	287.68	289.09	4217.37	64.94	.72	.34	.08	.20

Legend: **M** - Mena (Aritmetička sredina); **Min** - Minimum (Minimum); **Max** - Maximum (Maksimum); **R** - Range (Rang); **Var** - Variance (Varijansa); **SD** - Standard deviation (Standardna devijacija); **Skew** - Skewness (Skjunis); **Kurt** - Kurtosis (Kurtozis); **p** - Probability (Vjerovatnoća); **XP2** - Number of successful two-point shots (Broj uspješnih šuteva za dva poena); **XN2** - Number of unsuccessful two-point shots (Broj neuspješnih šuteva za dva poena); **XP3** - Number of successful three-point shots (Broj uspješnih šuteva za tri poena); **XN3** - Number of unsuccessful three-point shots (Broj neuspješnih šuteva za tri poena); **XP1** - Number of successful free throws (Broj uspješnih slobodnih bacanja); **XN1** - Number of unsuccessful free throws (Broj neuspješnih slobodnih bacanja); **XA** - Number of assists (Broj asistencija); **XSN** - Number of offensive rebounds (Broj skokova u napadu); **XSO** - Number of defense rebounds (Broj skokova u odbrani); **XOL** - Steals (Broj osvojenih lopti); **XOP** - Number of personal fouls (Broj ličnih grešaka); **XIL** - Turnovers (Broj izgubljenih lopti); **XK2IS** - Utilization coefficient for two-points shot (Koeficijent iskorištenosti šuta za dva poena); **XK3IS** - Utilization coefficient for three-points shot (Koeficijent iskorištenosti šuta za tri poena); **XK1IS** - Utilization coefficient of free throws (Koeficijent iskorištenost slobodnih bacanja); **XK2UC** - Utilization coefficient for two-points shot (Koeficijent efikasnosti šuta za dva poena); **XK3UC** - Utilization coefficient for three-points shot (Koeficijent efikasnosti šuta za tri poena); **XK1UC** - Utilization coefficient for free throws (Koeficijent efikasnosti slobodnih bacanja); **XDLK** - Overall situational efficacy (Ukupna situaciona efikasnost).



**TABLE 2**

*Intercorrelations between the standard situation-related parameters of efficiency at male basketball players in senior A-1 Croatian Basketball league.*

**TABELA 2**

*Interkorelacije standardnih parametara situacione efikasnosti kod košarkaša seniorske A-1 Hrvatske košarkaške lige.*

Variables	XP2	XN2	XP3	XN3	XP1	XN1	XA	XSN	XSO	XOL	XOP	XIL
XP2	1.000											
XN2	<b>.825</b>	1.000										
XP3	.004	.066	1.000									
XN3	.041	.134	<b>.838</b>	1.000								
XP1	<b>.645</b>	<b>.635</b>	<b>.292</b>	<b>.328</b>	1.000							
XN1	<b>.504</b>	<b>.477</b>	-.118	.081	<b>.618</b>	1.000						
XA	<b>.269</b>	<b>.322</b>	.206	.165	<b>.399</b>	<b>.288</b>	1.000					
XSN	<b>.717</b>	<b>.543</b>	-.133	-.089	<b>.421</b>	<b>.268</b>	-.037	1.000				
XSO	<b>.714</b>	<b>.607</b>	.030	.127	<b>.485</b>	<b>.381</b>	.117	<b>.759</b>	1.000			
XOL	<b>.488</b>	<b>.568</b>	<b>.378</b>	<b>.369</b>	<b>.592</b>	<b>.386</b>	<b>.562</b>	.201	<b>.415</b>	1.000		
XOP	<b>.457</b>	<b>.546</b>	.147	.212	<b>.591</b>	<b>.368</b>	<b>.464</b>	<b>.429</b>	<b>.477</b>	<b>.656</b>	1.000	
XIL	<b>.677</b>	<b>.678</b>	.193	<b>.300</b>	<b>.735</b>	<b>.533</b>	<b>.679</b>	<b>.363</b>	<b>.476</b>	<b>.637</b>	<b>.630</b>	1.000

Legend: **XP2** - Number of successful two-point shots (Broj uspješnih šuteva za dva poena); **XN2** - Number of unsuccessful two-point shots (Broj neuspješnih šuteva za dva poena); **XP3** - Number of successful three-point shots (Broj uspješnih šuteva za tri poena); **XN3** - Number of unsuccessful three-point shots (Broj neuspješnih šuteva za tri poena); **XP1** - Number of successful free throws (Broj uspješnih slobodnih bacanja); **XN1** - Number of unsuccessful free throws (Broj neuspješnih slobodnih bacanja); **XA** - Number of assists (Broj asistencija); **XSN** - Number of offensive rebounds (Broj skokova u napadu); **XSO** - Number of defense rebounds (Broj skokova u odbrani); **XOL** - Steals (Broj osvojenih lopti); **XOP** - Number of personal fouls (Broj ličnih grešaka); **XIL** - Turnovers (Broj izgubljenih lopti).

correlate with each other: the number of successful and unsuccessful two-point shots, the number of successful and unsuccessful three-point shots, the number of successful and unsuccessful free throw. The smallest number of significant correlations with the others is found in the number of successful and unsuccessful three-point shots. Except for the high and significant correlation between the mutually complementary variables, there are successful and unsuccessful shots for two, three and one point for each standard parameter there have been found at 9 or 10 significant correlations with the others. It is therefore realistic to conclude that the standard indicators of situational efficacy show, on average, the relatively high mutual connectivity.

Table 3 gives an overview of intercorrelation matrix for the set of variables from derived parameters of situational efficacy for a sample of senior

i neuspješnih šuteva za dva poena, broj uspješnih i neuspješnih šuteva za tri poena, broj uspješnih i neuspješnih slobodnih bacanja. Najmanji broj značajnih korelacija s ostalima pronađen je kod broja uspješnih i neuspješnih šuteva za tri poena. Izuzev visokih i značajnih korelacija između međusobno komplementarnih varijabli, dakle uspješnih i neuspješnih šuteva za dva, tri i jedan poen, za svaki standardni parametar pronađeno je po 9 ili 10 značajnih korelacija s ostalima. Stoga je realno zaključiti da standardni pokazatelji situacione efikasnosti pokazuju u prosjeku relativno visoku međusobnu povezanost.

U Tablei 3 dat je prikaz interkorelacijske matrice za grupu varijabli izvedenih parametara situacione efikasnosti za uzorak košarkaša seniorskih momčadi A-1 Hrvatske muške košarkaške lige. Ukupno je pronađeno 10 (od teoretski mogućih 28) statistički

basketball player from Team A-1 Croatian men's basketball league. There have been found 10 (of theoretically possible 28) statistically significant positive correlations that variate at values from low to very high. The largest number of statistically significant correlations (4) was found between overall situational efficacy (XDLK) and: the utilization of two-point shot, the efficacy of two-point shot, the efficacy of three-point shot, XK1UC i.e. efficacy of one-point shot. Also, four significant positive correlations were found between the efficacy of three-point shot, and: overall situational efficacy, efficacy of one-point shot, efficacy of three-point shot and utilization of one-point shot. Three significant correlations were found for XK1UC, i.e. efficacy of one-point shot and efficacy of two-point shot, the overall situational efficacy and efficacy of three-point shot. Also, there are three significant correlations found between XK2UC therefore efficacy of two-point shot, and utilization of two point shot, efficacy of one-point shot and overall situational efficacy. Significant positive correlations were found between the derived parameters related to the two-point shot, i.e., the efficacy coefficient of two-point shots) and the utilization coefficient of two-point shot. Significant correlation was also found between efficacy of three point shot and the efficacy coefficient of three-point shot. Between efficacy coefficient of free throws and

značajnih pozitivnih korelacija koje po vrijednostima variraju od niskih do vrlo visokih. Najveći broj statistički značajnih korelacija (4) pronađen je između ukupne situacione efikasnosti (XDLK) i: iskorišćenosti šuta za dva poena, efikasnosti šuta za dva poena; efikasnosti šuta za tri poena, XK1UC dakle efikasnosti šuta za jedan poen. Takođe, četiri značajne pozitivne korelacije pronađene su između efikasnosti šuta za tri poena, i: ukupne situacione efikasnosti, efikasnosti šuta za jedan poen, iskorišćenosti šuta za tri poena te iskorišćenosti šuta za jedan poen. Tri su značajne korelacije pronađene za XK1UC, dakle efikasnost šuta za jedan poen, i: efikasnost šuta za dva poena, ukupna situaciona efikasnost, te efikasnost šuta za tri poena. Takođe, tri su značajne korelacije pronađene i između XK2UC, dakle efikasnost šuta za dva poena, i: iskorišćenost šuta za dva poena, efikasnost šuta za jedan poen i ukupne situaciona efikasnost. Značajne pozitivne korelacije pronađene su između izvedenih parametara koji se odnose na šut za dva poena, tj. koeficijenta efikasnosti šuta za dva poena) i koeficijenta iskorišćenosti šuta za dva poena. Značajna povezanost pronađena je i između koeficijenta efikasnosti šuta za tri poena i koeficijenta iskorišćenosti šuta za tri poena. Između koeficijenta efikasnosti slobodnih bacanja i koeficijenta iskorišćenosti slobodnih bacanja, korelacija nije

**TABLE 3**

*Intercorrelations between the derived situation-related parameters of efficiency at male basketball players in senior A-1 Croatian Basketball league.*

**TABELA 3**

*Interkorelacije izvedenih parametara situacijske učinkovitosti kod košarkaša seniorske A-1 Hrvatske muške košarkaške lige.*

Variables	XK2IS	XK3IS	XK1IS	XK2US	XK3US	XK1US	XDLK
XK2IS	1.000						
XK3IS	.055	1.000					
XK1IS	-.113	.244	1.000				
XK2UC	<b>.568</b>	-.047	-.169	1.000			
XK3UC	.065	<b>.613</b>	<b>.349</b>	-.022	1.000		
XK1UC	.172	.187	.170	<b>.530</b>	<b>.370</b>	1.000	
XDLK	<b>.484</b>	.196	-.017	<b>.871</b>	<b>.340</b>	<b>.683</b>	1.000

Legend: **XK2IS** - Utilization coefficient for two-points shot (Koeficijent iskorišćenosti šuta za dva poena); **XK3IS** - Utilization coefficient for three-points shot (Koeficijent iskorišćenosti šuta za tri poena); **XK1IS** - Utilization coefficient of free throws (Koeficijent iskorišćenosti slobodnih bacanja); **XK2UC** - Utilization coefficient for two-points shot (Koeficijent efikasnosti šuta za dva poena); **XK3UC** - Utilization coefficient for three-points shot (Koeficijent efikasnosti šuta za tri poena); **XK1UC** - Utilization coefficient for free throws (Koeficijent efikasnosti slobodnih bacanja); **XDLK** - Overall situational efficacy (Ukupna situaciona efikasnost).

utilization coefficient of free throws, the correlation is not statistically significant.

In Table 4 the method of principal components analysis showed the existence of three latent dimensions, which together account for over 76% of the variance of the variables of standard situational efficacy parameters (whose characteristic roots are statistically significant according to the Kaiser-Guttman criteria, i.e., larger than 1). After varimax rotation, the first extracted component explains almost 29% of explained variance, and it is in the highest correlations with variables in the defensive and offensive rebounds in the phase of attack (XSO and XSN), and successful and unsuccessful two-point shots (XP2 and XN2).

It is the most frequent standard parameters of situational efficacy, which usually serves as a "predominance" of the final result of the game. The second extracted component explains 17% of the overall variance, and the highest correlations with variables with successful and unsuccessful three-point shots (XP3 and XN3). Thus, it is a relatively rare but often decisive event for the outcome of the basketball game (three-point shot). The third extracted component explains 30% of the variance, and it is in the highest correlation with the variables of the remaining standard parameters of situational efficacy of the players (except for parameters that are in high correlations with the first and the second factor). One can roughly say that these are essentially "medium frequent" events at a basketball game. The highest values of communalities obtained for the variables: the number of successful two-point shots, i.e. XP2 and the number of turnovers, i.e. XIL (.83). They can explain most of the variance. It is possible that the highest communality values obtained for relatively frequent events at a basketball game, which are equally present for players at all positions in the team. The lowest communality values were obtained for the variables: the number of unsuccessful free throws, i.e. XN1, number of steals, i.e. XOP (.64), and the number of assists, i.e. XA (.66), which are probably characteristic only for the individual players' positions, i.e., defenders and playmakers.

## DISCUSSION

Component analysis results show that in the space of standard parameters of situational efficacy we can single out three factors. The first factor is mostly saturated at a basketball game by the most frequent standard parameters of situational efficacy, which usually bring in basketball the "predominance" of the results of the game (rebounds in the phase of offense and defense and successful and unsuccessful two

statistički značajna.

U Tabeli 4 je vidljivo da je metodom analize glavnih komponenata utvrđeno postojanje tri latentne dimenzije, koje zajedno objašnjavaju preko 76 % varijance varijabli standardnih parametara situacione efikasnosti (čiji su karakteristični korijeni statistički značajni prema Kaiser-Guttmanovom kriterijumu, tj. veći od 1). Nakon varimax rotacije, prva ekstrahirana komponenta objašnjava skoro 29% objašnjene varijance, a u najvećim je korelacijama s varijablama skokovi u fazi odbrane i skokovi u fazi napada (XSO i XSN), te uspješni i neuspješni šutevi za dva poena (XP2 i XN2).

Riječ je o najfrekventnijim standardnim parametrima situacione efikasnosti, koji u košarci najčešće donose i "prevagu" za konačni rezultatski ishod utakmice. Druga ekstrahirana komponenta objašnjava 17% ukupne varijance, a u najvećim je korelacijama sa varijablama sa uspješnim i neuspješnim šutevima za tri poena (XP3 i XN3). Dakle, riječ je o relativno rijetkom, ali često za ishod meča presudnom događaju na košarkaškoj utakmici (šut za tri poena). Treća ekstrahirana komponenta objašnjava 30% varijance, a u najvećim je korelacijama sa varijablama preostalih standardnih parametara situacione efikasnosti košarkaša (izuzev parametara koji su u visokim korelacijama s prvim i drugim faktorom). Može se okvirno reći da su to u principu "srednje česti" događaji na košarkaškoj utakmici. Najveće vrijednosti komunaliteta dobijene su za varijable: broj uspješnih šuteva za dva poena, tj. XP2, te broj izgubljenih lopti, tj. XIL (0,83). Njima se može objasniti najveći dio varijance. Vjerojatno je da su najveće vrijednosti komunaliteta dobijene za relativno česte događaje na košarkaškoj utakmici, koje su podjednako zastupljeni za igrače na svim pozicijama u timu. Najmanje vrijednosti komunaliteta dobijene su za varijable: broj neuspješnih slobodnih bacanja, tj. XN1, broj osvojenih lopti, tj. XOP (0,64), te broj asistencija, tj. XA (0,66), koje su najvjerojatnije karakteristične samo za pojedine pozicije igrača, tj. bekove i "playmakere".

## DISKUSIJA

Rezultati komponentne analize pokazuju kako se u prostoru standardnih parametara situacione efikasnosti izdvajaju tri faktora. Prvi faktor najviše saturiraju na košarkaškoj utakmici najfrekventniji standardni parametri situacione efikasnosti, koji u košarci najčešće donose i "prevagu" za krajnji rezultatski ishod utakmice (skokovi u fazi napada te odbrane i uspješni i neuspješni šutevi za dva poena). Drugi faktor u prostoru standardnih

**TABLE 4**

*Principal components analysis with Varimax rotation (standard situation-related parameters of efficiency at male basketball players in senior A-1 Croatian Basketball league).*

**TABELA 4**

*Analiza glavnih komponenti s varimax rotacijom (standardni parametri situacione efikasnosti košarkaša seniorske A-1 Hrvatske muške košarkaške lige).*

Variables	Factor			R <sup>2</sup>
	1	2	3	
XP2	<b>.810</b>	-.034	.431	.840
XN2	<b>.679</b>	.045	.526	.737
XP3	-.057	<b>.955</b>	.101	.820
XN3	.027	<b>.927</b>	.146	.797
XP1	.497	.253	<b>.640</b>	.744
XN1	.346	-.161	<b>.587</b>	.594
XA	-.155	.077	<b>.869</b>	.657
XSN	<b>.915</b>	-.105	.021	.747
XSO	<b>.866</b>	.084	.180	.687
XOL	.256	.355	<b>.720</b>	.669
XOP	.407	.165	<b>.619</b>	.637
XIL	.379	.149	<b>.820</b>	.827
CR	3.473	2.064	3.611	
%EV	28.940	17.198	30.088	

Legend: **XP2** - Number of successful two-point shots (Broj uspješnih šuteva za dva poena); **XN2** - Number of unsuccessful two-point shots (Broj neuspješnih šuteva za dva poena); **XP3** - Number of successful three-point shots (Broj uspješnih šuteva za tri poena); **XN3** - Number of unsuccessful three-point shots (Broj neuspješnih šuteva za tri poena); **XP1** - Number of successful free throws (Broj uspješnih slobodnih bacanja); **XN1** - Number of unsuccessful free throws (Broj neuspješnih slobodnih bacanja); **XA** - Number of assists (Broj asistencija); **XSN** - Number of offensive rebounds (Broj skokova u napadu); **XSO** - Number of defense rebounds (Broj skokova u obrani); **XOL** - Steals (Broj osvojenih lopti); **XOP** - Number of personal fouls (Broj ličnih grešaka); **XIL** - Turnovers (Broj izgubljenih lopti); **R<sup>2</sup>** - Square of multiple correlation (Kvadrat multiple korelacije); **CR** - Characteristic root (Karakteristični korijenovi); **%EV** - % of explained variance (% objašnjene varijanse).

-point shots). Another factor in the area of standard parameters describes relatively rare but often decisive events for the outcome of the match at a basketball game (successful and unsuccessful three-point shots). The third factor in the area of standard parameters describes "medium frequent" events at a basketball game: assists, free throws, steals and turnovers. The relative contribution of these factors explains the importance of certain parameters of situational efficacy for the interpretation of the entire area of situational efficacy of basketball players. The most common (first factor) and medium common (third factor) in the area of situational efficacy parameters together make almost 60% of overall variability. The

parametara opisuje relativno rijetke, ali često za ishod meča presudne događaje na košarkaškoj utakmici (uspješni i neuspješni šut za tri poena). Treći faktor u prostoru standardnih parametara opisuje "srednje česte" događaje na košarkaškoj utakmici: asistencije, šuteve slobodnih bacanja, osvojene i izgubljene lopte, lične greške. I relativni doprinos ovih faktora tumači važnost pojedinih parametara situacione efikasnosti za tumačenje cijelog prostora situacione efikasnosti košarkaša. Najčešći (prvi faktor) i srednje česti (treći faktor) u prostoru parametara situacione efikasnosti zajedno tumače skoro 60 % ukupnog varijabiliteta. Šutevi za tri poena izdvajaju se kao izolovani entitet,

three-point shots stand out as an isolated entity, which in relative relationship (defined using only two variables) provides a significant contribution to the interpretation of situational efficacy area. There is a certain similarity between the results obtained in the research of Trninić et al (1995), since the dimensions of the efficacy of internal players or players in the back line of defense and the front line of offense corresponds to a certain extent in our study to the first factor, while our second factor is more like a dimension of the efficacy of throwing a ball into the basket from a distance. There is a similarity with latent dimensions that have received Jeličić et al. (2010): the first factor corresponds primarily to the situational technical and tactical activities of the internal players, and the second factor and third factor of the external players activities. There is a certain correspondence with research of Šeparović and Nuhanović (2008), where latent structure obtained in our study shows a certain correspondence between the success of a shot from close range and our first factor, the success of a shot from the middle distance and other factors, the general success of the defensive players and defensive specific mobility and our third factor. At the level of analysis of the individual relationship between variables, standard parameters of situational efficacy in this study indicate, on average, relatively high positive, mutual correlation. And in this way it can be shown that the standard parameters of situational efficacy describe coherent "general" situational efficacy of basketball players in a series of basketball games. Thus, the derived parameter of overall situational efficacy represents a justified measure of the area of the situational efficacy of the players. Mutually complementary variables showed the strongest connections, which means that the most successful basketball players, shooting for two or three points or one point, also have the most unsuccessful shots. This may be another indication of the justification of the interpretation that the basketball players differ not only in terms of overall time spent in the game (as a member of the first team or reserve players), but also in terms of the position and role in the team that determines their shapes (parameters) of situational efficacy (point guard, shooting guard, small forward, center, power forward). The smallest number of significant correlations with other variables of situational efficacy parameters was found in successful and unsuccessful three point shots, which further confirms the results of the factor analysis, i.e. isolated factor that describes three-point shot. It is likely that the three-point shots represent a technical element which depends on the specific training, and it is used selectively during a basketball game. On the other hand, they are relatively rare in the basketball game. To discuss intercorrelations of derived parameters of situational efficacy is only partly justified, because of

koji u relativnom odnosu (definisan je pomoću samo dvije varijable) daje značajan doprinos tumačenju prostora situacione efikasnosti. Postoji određena sličnost rezultatima koje su dobili Trninić i saradnici (1995), budući da dimenzija efikasnosti unutrašnjih igrača ili igrača unutar zadnje linije odbrane i prednje linije napada odgovara donekle prvom faktoru iz našeg istraživanja, dok naš drugi faktor podsjeća na dimenziju efikasnosti bacanja lopte u koš iz daljine. Sličnost postoji i s latentnim dimenzijama koje su dobili Jeličić i saradnici (2010): prvi faktor odgovara prvenstveno situacionoj tehničkoj i taktičkoj aktivnosti unutrašnjih, a drugi i treći faktor aktivnosti vanjskih igrača. Sa istraživanjem Šeparovića i Nuhanovića (2008), latentna struktura dobijena u našem istraživanju pokazuje određenu podudarnost između efikasnosti šuta s bliske udaljenosti i našeg prvog faktora, efikasnosti šuta sa srednje udaljenosti i drugog faktora, generalne odbrambene efikasnosti igrača i specifične odbrambene pokretljivosti i našeg trećeg faktora. I na nivou analize pojedinačnih povezanosti između varijabli, standardni parametri situacione efikasnosti i u ovom istraživanju pokazuju u prosjeku relativno visoku međusobnu pozitivnu povezanost. I na ovaj način može se pokazati da standardni parametri situacione efikasnosti koherentno opisuju "opštu" situacionu efikasnost košarkaša u nizu košarkaških utakmica. Dakle, izvedeni parametar ukupne situacione efikasnosti su praktično opravdana mjera prostora situacione efikasnosti košarkaša. Međusobno komplementarne varijable pokazale su najveću povezanost, što znači da košarkaši koji najviše uspješno šutiraju za dva, tri poena ili za jedan poen, češće i neuspješno šutiraju. To može biti još jedan pokazatelj opravdanosti tumačenja da se košarkaši razlikuju ne samo po ukupnom vremenu koje provode u igri (kao član prve petorke ili kao rezervni igrači), već i u odnosu na poziciju odnosno ulogu u timu, koja im određuje i oblike (parametre) situacione efikasnosti (bek, krilo, centar, krilni centar). Najmanji broj značajnih korelacija s ostalim varijablama parametara situacione efikasnosti pronađen je kod uspješnih i neuspješnih šuteva za tri poena, što dodatno potvrđuje rezultate faktorske analize, dakle izdvojenog faktora koji opisuje šut za tri poena. Vjerojatno je da su šutevi za tri poena tehnički element koji zavisi od specifičnog treningu, pa se stoga i selektivno koristi u situacijama košarkaške utakmice. S druge strane, oni su i relativno rijetki na košarkaškim utakmicama. Komentaranje interkorelacije izvedenih parametara situacione efikasnosti samo je djelomično opravdano, zbog većeg broja spurioznih korelacija uslovljenih istim standardnim parametrima situacione efikasnosti u formulama za

the larger number of spurious correlations conditioned by the same standard parameters of situational efficacy in the formulas for calculating the derived parameters. The correlation between the efficacies of derived parameters is probably a logical consequence of the different concepts of logic of derived parameters, which contain virtually three different types of coefficients: efficacy of shots, utilization of shots, and overall situational efficacy. Coefficients of two, three and one point shot efficacy are more significantly associated than utilizations coefficients of shots. The utilization coefficients of shots are better linked with overall situational efficacy of basketball players. One reason for this is certainly the fact that the correlations between overall situational efficacy and coefficient of shots efficacy spurious, because they are result of defining the formula of calculating mentioned coefficient. Overall situational efficacy is derived from the coefficients of shots efficacy, not from shots utilization coefficient. Coefficients of shots efficacy (and overall situational efficacy) include not only the percentage of successful shots (i.e. the proportion of the number of successful shots in relation to the total number of shots), but the number of successful shots. However, a better interconnection of efficacy coefficients compared to the utilization coefficients can indicate a greater possibility that the efficacy coefficients better describe what has been called "better quality" (overall situational efficacy) of the players. Specifically, situationally more effective or "quality" basketball player is one that is not only optimally effective in a relatively narrow domain of given tasks, either by the coach or what the position he plays in the team requires. Quality basketball player is willing to take responsibility for the team as a whole, for example in terms of shooting at the basket in the situation when the co-player who is primarily responsible for that task is being well-guarded by the opponent player. Therefore, it is likely that efficacy coefficients reflect better the real (rather than only mathematical) overall situational efficacy of basketball player who, regardless of his position in the team, is "good enough" in all kinds of shots, and decides more often to shot than the average basketball player the team (Sindik, 2009).

The main advantage of this study was the fact that all available basketball players in the studied championship of A-2 basketball league were tested. From there, there have been discovered laws that may be applied to the specific sample (virtually the population) of basketball players, which can be an incentive for quality coach work. However, to the smaller the possibility of generalization of the results there are several reasons that may affect: lower and multiply selected sample of participants, the specificity of the Croatian population of top senior basketball players, the specificity of a particular event (in the investigated championship, there were no teams that could fall

izračunavanje izvedenih parametara. Povezanost između izvedenim parametrima efikasnosti je vjerojatno logična posljedica različite logike koncepata izvedenih parametara, koji sadrže praktički tri različite vrste koeficijenata: efikasnost šuteva, iskorišćenost šuteva, te ukupnu situaciona efikasnost. Koeficijenti efikasnosti šuteva za dva, tri i jedan poen međusobno su značajnije povezani nego koeficijenti iskorišćenosti šuteva. Takođe, koeficijenti efikasnosti šuteva bolje su povezani s ukupnom situacionom efikasnošću košarkaša. Jedan razlog za to je svakako činjenica da su korelacije između ukupne situacione efikasnosti i koeficijenata efikasnosti šuteva spuriozne, jer su posljedica logike definisanja formule izračunavanja navedenih koeficijenata. Ukupna situaciona efikasnost izvodi se iz koeficijenata efikasnosti šuta, a ne iz koeficijenata iskorišćenosti šuta. Koeficijenti efikasnosti šuta (kao i ukupna situaciona efikasnost) uključuju ne samo procenat uspješnih šuteva (dakle odnos broja uspješnih šuteva u odnosu na ukupni broj šuteva), već i broj uspješnih pokušaja šuta. Međutim, bolja međusobna povezanost koeficijenata efikasnosti u odnosu na koeficijente iskorišćenosti može indicirati i veću vjerovatnoću da koeficijenti efikasnosti bolje opisuju ono što je nazvano "bolja kvaliteta" (ukupna situaciona efikasnost) košarkaša. Naime, situaciona efikasnost ili "kvalitetan" košarkaš je onaj koji je ne samo optimalno efikasan u relativno uskom domenu zaduženja koja su mu "propisani" instrukcijama koje mu je dao trener ili pozicijom koju igra u timu. Kvalitetan košarkaš je spreman preuzeti odgovornost za tim u cjelini, npr. u smislu šutiranja na koš u situaciji kad je suigrač koji je primarno zadužen za to dobro čuvan od protivnika. Stoga je vjerojatnije da upravo koeficijenti efikasnosti bolje odražavaju realnu (a ne samo matematičku) ukupnu situacionu efikasnost košarkaša, koji je, bez obzira na poziciju u timu, "dovoljno dobar" u svim vrstama šuteva, a za njih se odlučuje češće nego prosječno efikasni košarkaš u timu (Sindik, 2009).

Glavna prednost istraživanja bila je u činjenici da su ispitani praktično svi dostupni košarkaši u istraživanom prvenstvu A-2 košarkaške lige. Odatle, pronađene zakonitosti mogu vrijediti upravo za konkretni uzorak (praktično populaciju) košarkaša, što može biti podsticaj za kvalitetniji rad trenera. Međutim, na manju mogućnost generalizacije rezultata mogu utjecati razlozi: mali i višestruko selekcionisani uzorak učesnika, specifičnost hrvatske populacije vrhunskih seniorskih košarkaša, specifičnost konkretnog takmičenja (u istraživanom prvenstvu niti jedna ekipa nije mogla ispasti iz lige, što je moglo utjecati na manje zalaganje ekipe koje su

out of the league, which could affect competitiveness of teams fought for survival in the A-1 league). In future research we could try to slightly increase number of participants (try to examine the injured and for other reasons absent players), which can be achieved only minimally. The term "top basketball players" in relation to the abovementioned specifics really varies considerably from country to country, depending on the quality of the competition in the specific state (which often depends on the financial resources of clubs to hold to their own perspective players). On the quality of the basketball competitions in our country generally it cannot be significantly affected, except for long-term, systemic change of competitions and financial possibilities of the teams. Consequently, one of the solutions for the future research is multiple replication of equivalent research over a number of basketball championships, where these small differences in the concept of Croatian "top basketball players" may be reflected. For long-term increase of competitive uncertainty (i.e. tie of the teams competing in the championship), maybe we could implement solutions similar to the one in the American NBA league. A kind of "draft"-list, where less successful teams resulting could have an advantage in the selection of quality young players, could equalize the competitive quality of the team. At the level of practical implications, based on the latent structure data it would be possible to divide the situational basketball training into three parts: (1) situational training of rebounds combined with a two-point shots; (2) situational training of three – point shots; (3) situational training of other parameters of situational efficacy - assists, free throws, steals and decrease the number of turnovers and personal faults.

## CONCLUSIONS

Distribution of situational efficacy parameters, on average, follows a "normal" distribution of events at basketball games and basketball competitions in general, and they are significantly mutually associated. There are three fundamental latent dimensions that explain the area of situational efficacy of basketball players. The dimensions can differ from each other by the frequency of representation of events at the basketball game.

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se borile za opstanak u A-1 ligi). U budućim bi se istraživanjima moglo pokušati donekle povećati broj učesnika (u smislu pokušaja ispitivanja povrijeđenih i iz drugih razloga odsutnih igrača), što je moguće postići samo u minimalnoj mjeri. Pojam "vrhunskih košarkaša" u odnosu na nabrojane specifičnosti uistinu značajno varira od države do države, zavisno o takmičarskom kvaliteti takmičenja u konkretnoj državi (koja često zavisi o finansijskim mogućnostima klubova da zadrže vlastite perspektivne igrače). Na kvalitet košarkaških takmičenja u našoj zemlji se u principu ne može bitno utjecati, izuzev dugoročno, promjenom sistema takmičenja te finansijskih mogućnosti klubova. Zato je jedno od rješenja za buduća istraživanja i višestruka replikacija istovrsnog istraživanja tokom većeg broja košarkaških prvenstava, gdje bi se te male razlike u pojmu hrvatskog "vrhunskog košarkaša" možda mogle reflektirati. Za dugoročno povećanje takmičarske neizvjesnosti (tj. izjednačenosti ekipa koje se takmiče u prvenstvu), možda bi se moglo posegnuti za rješenjima sličnim onom u američkoj NBA-ligi. Svojevrsna "draft"-lista, gdje bi rezultatski neuspješnije ekipe iz prethodnog prvenstva mogle imati prednost pri izboru kvalitetnih mladih igrača, moglo bi ujednačiti takmičarsku kvalitetu pojedinih timova. Na nivou praktičnih implikacija, na osnovu podataka o latentnoj strukturi bilo bi moguće košarkaški situacioni trening podijeliti u tri dijela: (1) situaciono uvježbavanje skokova kombinovanih sa šutevima za dva poena; (2) situaciono uvježbavanje šuteova za tri poena; (3) situacionog uvježbavanja ostalih parametara situacione efikasnosti - asistencija, šuteva slobodnih bacanja, osvojenih lopti, a smanjenja broja izgubljenih lopti te ličnih grešaka.

## ZAKLJUČCI

Distribucija parametara situacione efikasnosti u prosjeku slijedi "uobičajenu" distribuciju događaja na nivou košarkaške utakmice te košarkaškog takmičenja u cjelini, koji su međusobno u velikoj mjeri statistički značajno povezani. Pronađene su tri osnovne latentne dimenzije koje tumače prostor situacione efikasnosti košarkaša, koje se međusobno mogu razlikovati po velikoj zastupljenosti događaja na košarkaškoj utakmici.

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## STRUTTURA LATENTE DEI PARAMETRI DI EFFICIENZA SITUAZIONALE DEI TOP CESTISTI SENIOR CROATI

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Con lo scopo di monitorare gli eventi durante le partite di pallacanestro, FIBA (Federation International Basketball Association) ha standardizzato tredici indicatori dell'efficienza situazionale che vengono controllati durante ogni partita ufficiale. Sulla base di questi è possibile calcolare vari parametri derivati. La rivelazione dell'interdipendenza tra l'efficienza situazionale in pallacanestro con altre variabili potrebbe contribuire ad una migliore comprensione della totale efficienza situazionale dei cestisti. Lo scopo di questa ricerca era di determinare la struttura delle dimensioni basate su vari parametri standard dell'efficienza situazionale dei top cestisti croati. La rivelazione della struttura e del rapporto tra le dimensioni latenti di efficienza situazionale in pallacanestro potrebbe contribuire ad una migliore comprensione della totale efficienza situazionale dei giocatori.

Il campione finale (74 giocatori) è stato selezionato da un campione iniziale di giocatori da nove squadre maschili senior della croata Serie A-1, i quali hanno giocato un minimo di dieci minuti per partita in almeno otto partite del campionato. Le variabili, cioè i criteri di valutazione quantitativa dei giocatori sono basati sul metodo di parzialmente ponderata combinazione lineare per la valutazione della qualità totale dei giocatori (Dizdar, 2002), con i dati sull'efficacia di tiri, salti, palle conquistate e perse, assistenze, blocchi, errori individuali. Sulla base di parametri standard dell'efficienza situazionale, sono stati derivati sette coefficienti dell'efficienza situazionale dei giocatori: utilizzo di tiri a due e tre punti, utilizzo di tiri liberi,

efficienza di tiri a due e tre punti, efficienza di tiri liberi e totale efficienza situazionale (Dizdar, 2002).

Le analisi dei dati sono state fatte usando il pacchetto statistico SPSS. Per la determinazione delle dimensioni latenti dello spazio di efficienza situazionale dei giocatori abbiamo usato l'analisi delle componenti principali con rotazione varimax, mentre per la determinazione dell'interdipendenza all'interno dei gruppi di parametri standard e derivati dell'efficienza situazionale abbiamo usato il coefficiente di correlazione di Pearson.

Sulla base dei risultati ottenuti è stato mostrato che la distribuzione dei parametri di efficienza situazionale segue la distribuzione prevista degli eventi a livello di una partita di pallacanestro e della gara di pallacanestro in generale. Le correlazioni univariate e l'analisi delle componenti principali mostrano che la maggior parte dei parametri dell'efficienza situazionale sia standard che derivati è statisticamente in correlazione significativa tra loro. Abbiamo dimostrato l'esistenza di tre componenti principali che insieme possono spiegare oltre il 76% della varianza totale di spazio dei parametri standard dell'efficienza situazionale. Esse si possono distinguere tra loro sulla base di frequenza della rappresentazione di eventi in una partita. Il successo del tiro a due punti è un criterio importante che dirige gli allenatori nella scelta della squadra, mentre i giocatori che hanno più successo nel tiro a due punti giocano di breve durata.

**Parole chiave:** pallacanestro, analisi in componenti principali, correlazioni, dimensioni latenti

# RAZLIKE U EKSPLOZIVNOJ I REPETITIVNOJ SNAZI DVANAESTOGODIŠNJIH UČENIKA SA RAZLIČITIM MORFOLOŠKIM POKAZATELJIMA

## DIFFERENCES IN THE EXPLOSIVE AND REPETITIVE STRENGTH OF TWELVE-YEAR-OLD SCHOOLCHILDREN WITH DIFFERENT MORPHOLOGICAL CHARACTERISTICS

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### SUMMARY

In this research we attempted to define the procedure which could be used to provide optimally distinct groups of school children in terms of the morphological structure of their bodies, and which could further be used to define the possible differences in explosive and repetitive strength. With this aim in mind, a sample of 269 school children aged  $12 \pm 6$  months were included in a study where three of their morphological measures were taken (body height, body mass, skinfolds) and five motor tests for the evaluation of explosive and repetitive strength carried out. First the K-means cluster analyses were used to define three distinct groups of participants in each individual morphological segment, with low, average, and high values. On the basis of the maximal number of possible combinations of previously defined groups from the overall sample of school children, three groups with different morphological structures of the body were determined, including: 104 school children with low values, 113 school children with average values and 52 school children with high values for all three morphological measurements. These defined groups of school children were used to determine the possible differences in the tests of explosive and repetitive strength.

On the basis of the obtained results we can conclude that the group with low values of morphological indicators (height, body mass, skinfolds) achieved the best results on the test for the evaluation of repetitive strength of the arms (MSKL), the group with average values on the tests for the evaluation of explosive strength (MSDM and MT20V), while for the rest of the tests there was no statistically significant difference between the distinct groups.

The definition of the potential possibilities for the manifestation of certain motor skills, on the basis of these morphological indicators for each age category of school children, would be made possible through the application of a small number of anthropometric measures. The classification of a certain child into a suitable (appropriate for his affinities) group would enable the realization of a special work program which would enable the most effective improvement of his qualities.

**Key words:** explosive and repetitive strength, distinct groups, morphological structure.

### SAŽETAK

U ovom istraživanju je napravljen pokušaj da se definiše postupak kojim bi se obezbjedile optimalno distiktne grupe učenika, uzimajući u obzir morfološku strukturu tijela, kroz koji će se definisati eventualne razlike u eksplozivnoj i repetitivnoj snazi. S tim ciljem na uzorku od 269 učenika uzrasta 12 godina + 6 mjeseci su izmjerene tri morfološke mjere (visina, tjelesna masa, kožni nabor) i pet motoričkih testova za procjenu eksplozivne i repetitivne snage. Najprije su primjenom K-means klaster analize definisane tri distinktna grupe ispitanika u svakom pojedinačnom antropometrijskom segmentu, sa niskim, prosječnim i visokim vrijednostima. Na osnovu maksimalnog broja mogućih kombinacija prethodno definiranih grupa ukupnog uzorka učenika, utvrđene su tri grupe sa različitim morfološkim strukturama tijela i to: 104 učenika sa niskim vrijednostima, 113 učenika sa prosječnim vrijednostima i 52 učenika sa visokim vrijednostima u sve tri antropometrijske mjere. Kroz ovako definisane grupe učenika utvrđivane su eventualne razlike u izmjerenim testovima eksplozivne i repetitivne snage.

Na osnovu dobijenih rezultata može se konstatovati da je grupa sa niskim vrijednostima morfoloških pokazatelja (visina, tjelesna masa, kožni nabor) postigla najbolje rezultate u testu za procjenu repetitivne snage ruku (MSKL), grupa sa prosječnim vrednostima u testovima za procjenu eksplozivne snage (MSDM i MT20V), dok u ostalim testovima nije bilo statistički značajne razlike između distinktnih grupa.

Definisanje potencijalnih mogućnosti za manifestaciju određenih motoričkih sposobnosti, na osnovu ovih morfoloških pokazatelja za svaku uzrasnu kategoriju učenika, omogućilo bi se primjenom malog broja antropometrijskih mjera. Svrstati određenog učenika u odgovarajuću (za njegove afinitete) grupu i omogućiti mu realizaciju takvog posebnog programa rada koji bi dao neefikasnije usavršavanje njegovih kvaliteta.

**Cljučne riječi:** eksplozivna i repetitivna snaga, distinktna grupe, morfološka struktura.

## INTRODUCTION

As part of the curriculum for physical education classes, the evaluation, that is, the definition of the levels of physical characteristics and the abilities of school children represents one of the more important preconditions for the realization for adequate curricular content. Depending on the extent of the manifestation of the individual qualities, it is necessary to predict and realize the adapted curricular content which would have the most optimal effect. Experts in the field of physical education methodology (Анастасовски, Клинчаров, & Анастасовски, 2000; Findak, 2003; Matić, 1978; among others) point out that the evaluation of special segments of the morphological and motor status of the school children should be used for gaining insight into the abilities and skills of school children, and on the basis of real indicators which are manifested by the school children, for gaining access to a differentiated (individual) approach during the realization of the curriculum itself.

Physical education classes play an important part in the education of an individual, and have as their aim to, through adequate physical activities, contribute to the optimal development of the abilities of an individual, his growth, physical and psycho-social features (Hardman, 2007). Being familiar with the principles and guidelines of the abilities of school children in the manifestation of certain motor skills is one of the primary needs of every physical education teacher. Considering the specific nature of a child's body (International Life Sciences Institute, 2000; Годоровска, 1997), it is possible to define and implement suitable curricular content (Šukov, Živković, Šukova-Stojmanovska, & Klinčarov, 1998) in order to achieve the desired effects.

The determination of the relations between certain anthropometric measures and motor skills has been the focus of a lot of attention, and the significant interdependencies in the case of various groups of the population have been defined (Клинчаров, 2003; Клинчаров & Христовски, 2003; Klinčarov & Stojanović, 2001). In the period of the growth and development of a child's body (Kuczmarski et al., 2000) these interdependencies are individually expressed and inevitably must be taken into consideration during the realization of physical education classes. The guidelines defined in the principle of individualization and the availability of the classes should represent the starting point for the application of impulses which will have a positive influence on transformation. The monitoring and valuing of the physical features of school children must lead to determined scientific views on the relationships between anthropometric characteristics and motor skills, which are specific for each age group, developmental group and gender category.

In this research, we have analyzed the prediction of the general ability for the manifestation of explosive and iterative qualities of strength among school

## UVOD

U nastavi predmeta fizičko i zdravstveno vaspitanje, procjena, odnosno definisanje nivoa fizičkih karakteristika i sposobnosti učenika predstavlja jedan od važnijih predušlova za realizaciju adekvatnih nastavnih sadržaja. U zavisnosti od stepena manifestacije individualnih kvaliteta, potrebno je da se predvide i realizuju takvi prilagođeni nastavni sadržaji koji će imati optimalan efekat. Stručnjaci u oblasti metodike fizičkog vaspitanja (Анастасовски, Клинчаров i Анастасовски, 2000; Findak, 2003; Matić, 1978; i dr.) ističu da procjenom posebnih segmenata morfološkog i motoričkog statusa učenika treba da se napravi uvid u mogućnosti i kapacitete učenika i na osnovu realnih pokazatelja koje manifestuju učenici, da se pristupi diferenciranom (individualnom) pristupu u samoj realizaciji nastave.

Nastava fizičkog vaspitanja ima značajan udio u obrazovanju pojedinca, i ima za cilj da pomoću adekvatnih fizičkih aktivnosti doprinese optimalnom razvoju mogućnosti pojedinca, njegov rast i razvoj, fizičke i psihosocijalne osobine (Hardman, 2007). Poznavanje principa i načela mogućnosti učenika u manifestaciji određenih motoričkih sposobnosti je jedna od primarnih potreba nastavnika fizičkog vaspitanja. Poznavajući specifičnosti dječjeg organizma (International Life Sciences Institute, 2000; Годоровска, 1997), moguće je definisati i implementirati odgovarajuće nastavne sadržaje (Šukov, Živković, Šukova-Stojmanovska i Klinčarov, 1998) za postizanje traženih efekata.

Određivanje relacija između određenih antropometrijskih mjera i motoričkih sposobnosti je dosta eksponirana, pri čemu su definisane značajne međuzavisnosti kod različitih populacionih grupa (Клинчаров, 2003; Клинчаров i Христовски, 2003; Klinčarov i Stojanović, 2001). U periodu rasta i razvoja dječjeg organizma (Kuczmarski i saradnici, 2000) ove međuzavisnosti su individualno izražene i neminovno se moraju imati u vidu u realizaciji nastave fizičkog vaspitanja. Načela definisana u principu individualizacije i dostupnosti nastave treba da predstavljaju polaznu osnovu za primjenu impulsa koji će imati pozitivan transformacijski uticaj. Praćenje i vrjednovanje fizičkih sposobnosti učenika mora da se vodi prema determinisanim naučnim pogledima na odnose antropometrijskih karakteristika i motoričkih sposobnosti, koji su specifični za svaku uzrasnu, razvojnu i kategoriju polova.

U ovom istraživanju je analizirana predikcija generalne sposobnosti za manifestaciju eksplozivnih i repetitivnih kvaliteta sile kod učenika uzrasta 12 godina, kao i pokušaj da se definiše postupak sa kojim

children aged 12, as well as the attempts to define the procedure which would determine the distinct groups with optimally different manifestations in terms of morphological indicators, with the aim of homogenizing the groups in the classroom, for the purpose of the optimization of the effects of physical education on the development of psycho-somatic characteristics of school children, as the basic subject matter of this research.

The development of iterative and explosive strength of school children, as the two general abilities which are to be found at the core of the realization of human movement in sports (Verhošanski, 1979), requires an individual approach to their training. In order to provide optimal conditions during physical education classes, for the application of an individual approach to the development of these abilities and the uniformity of the load on the school children, it is necessary to define the procedure of group homogenization, which is the subject matter of this research.

The aim of this research was to use these results to facilitate the procedure of group differentiation of students with the same and similar abilities for physical education teachers in schools, so as to enable the planning of in-class load, which would be optimal for each individual child.

The assumption behind the research (hypothesis) is that the differentiation of the homogenized groups of school children, based on their morphological measures, will project statistically significant differences between distinct groups in terms of explosive and iterative strength, so that the group with high morphological measures will have significantly smaller results in comparison to the remaining two groups.

## METHODS

### Sample of participants

The sample of participants was extracted from a population of school children, fifth-graders, all males, with a chronological age of 12 ( $\pm 6$  months), who at the time of the research took part in their regular physical education classes, who satisfied all of the health criteria, and who regularly attended physical education classes. The sample included 269 school children, fifth-graders from elementary schools in the Paraćin region.

### Sample of measuring instruments

The following morphological characteristics and motor tests were included:

- Body height (AVIS)
- Body mass (AMAS)
- Skinfoldds (upper arm - triceps surae) (KNNL)
- Standing depth jump (MSDM)
- Triple standing jump (MTRS)
- 20 meter run with a high start (MT20V)

bi se utvrdile distinktnne grupe sa optimalno različitim manifestacijama u morfološkim pokazateljima, sa ciljem homogenizacije grupa na času, radi optimizacije efekata fizičkog vaspitanja na razvoj psihosomatskih karakteristika učenika, kao osnovnog problema kojim se ovo istraživanje bavi.

Razvoj repetitivne i eksplozivne snage učenika, kao dvije generalne sposobnosti koje se nalaze u osnovi realizacije čovjekovih sportskih pokreta (Verhošanski, 1979), zahtijeva individualni pristup njihovom treningu. Da bi se na času fizičkog vaspitanja omogućili optimalni uslovi za primjenu individualnog pristupa razvoju ovih sposobnosti i ujednačavanju opterećenja učenika, neophodno je definisati postupak homogenizacije grupa, što je i predmet ovog istraživanja.

Cilj istraživanja je bio da se kroz rezultate istog nastavnica fizičkog vaspitanja u školama olakša postupak diferencijacije grupa učenika sa istim i sličnim sposobnostima, kako bi mogli da planiraju opterećenje na času koje će biti optimalno za svakog pojedinog učenika.

Pretpostavka istraživanja (hipoteza) je da će diferencijacija homogenizovanih grupa učenika prema morfološkim mjerama projektovati statistički značajne razlike između distinktnih grupa u eksplozivnoj i repetitivnoj snazi, te da će grupa sa visokim morfološkim mjerama imati značajno slabije rezultate u odnosu na ostale dvije grupe.

## METODE

### Uzorak ispitanika

Uzorak ispitanika izveden je iz populacije učenika petog razreda muškog pola hronološke starosti 12 godina ( $\pm 6$  mjeseci), koji su u trenutku istraživanja bili obuhvaćeni redovnom nastavom fizičkog vaspitanja, koji su zadovoljavali sve zdravstvene kriterijume i koji su redovno pohađali časove fizičkog vaspitanja. Uzorak je obuhvatio 269 učenika petog razreda osnovnih škola paraćinskog regiona.

### Uzorak mjernih instrumenata

Izmjerene su sljedeće morfološke karakteristike i motorički testovi:

- Visina tijela (AVIS)
- Masa tijela (AMAS)
- Kožni nabor (nadlaktica - triceps surae) (KNNL)
- Skok u dalj s mjesta (MSDM)
- Trskok iz mjesta (MTRS)
- Trčanje na 20 metara visokim startom (MT20V)

- Push-ups (MSKL)
- Torso lifts on a vaulting box (MDTK).

The morphological characteristics were measured by specialists of sports medicine, and according to the recommendations of the International Biological Program (Weiner & Lourie, 1969). Measuring body height was carried out by using a standardized anthropometer based on Martin with an accuracy of .1 cm, the measuring of subcutaneous fatty tissue was carried out with a caliper of the "John Bull" type with a measuring span of 0 to 40 mm (the pointer goes two rounds around a scale calibrated 0 to 20 mm), with a standard pressure with which the grippers of the instrument press the skin and the subcutaneous fatty tissue of 10gr/mm<sup>2</sup> and an accuracy of .2 mm, while body mass was measured using the Body Composition Analyser scales (Gaia Jawon 357), with an accuracy of .1 kg. The motor tests were carried out by the authors according to the recommendations of Kurelić et al. (1975).

## Procedure and statistical analysis

For the determination of the optimally distinct groups in the determined segment of morphological space, by applying the cluster analysis in the space of the participants, with the aim of the decrease in the variability within groups and a maximization of the variability between groups (K-means clustering), with the added condition of the existence of 3 groups (Number of clusters = 3), groups with low, average and high values of certain morphological characteristics were defined. Through the application of combinatorics, on the basis of all of the possible permutations with repetitions, following two iterations (Number of iterations = 2), three groups with different values in all three measures were defined.

On the basis of this these kinds of various morphological types of participants, with the aim of the extraction of distinct groups, three groups were extracted with low, average and high values in terms of body height, body mass and skinfolds of the upper arm. Between these groups of participants differences were determined in the manifestation of the analyzed motor skills of explosive and iterative strength by using a multivariate analysis of variance (MANOVA), a univariate analysis of variance (ANOVA) and the last significant differences test (LSD - test).

All of the statistical analyses were carried out using the STATISTICA for Windows 8.0 statistical package.

## RESULTS

First by using the cluster analysis (K-means clustering), groups with various manifestations of all the measured morphological measures were defined, where groups with low (G-N), average (G-P) and

- Sklekovi (MSKL)
- Podizanje trupa na švedskoj klupi (MDTK)

Morfološke karakteristike su mjerene od strane ljekara specijaliste sportske medicine, a prema uputstvima internacionalnog biološkog programa (Weiner i Lourie, 1969). Mjerenje visine tijela je vršeno primjenom standardnog antropometra po Martinu sa tačnošću od 0,1 cm, mjerenje debljine potkožnog masnog tkiva vršeno je kaliperom tipa "John Bull" sa mjernim rasponom od 0 do 40 mm (kazaljka opisuje dva kruga oko skale baždarene od 0 do 20 mm), sa standardnim pritiskom kojim hvataljke instrumenta sabijaju kožu i potkožno tkivo koji iznosi 10 gr/mm<sup>2</sup> i tačnošću očitavanja od 0,2 mm, a masa tijela je mjerena pomoću vage Body Composition Analyser (Gaia Jawon 357), sa tačnošću mjerenja od 0,1 kg. Motoričke testove su mjerili autori rada prema uputstvu Kurelića i saradnika (1975).

## Procedura i statistička analiza

Za utvrđivanje optimalno distinktnih grupa u određenom segmentu morfološkog prostora primjenom klaster analize u prostoru ispitanika, sa ciljem smanjenja varijabilnosti unutar grupa uz maksimizaciju varijabilnosti između grupa (K-means clustering), uz uslov postojanja 3 grupe (Number of clusters = 3), bile su definisane grupe se niskim, prosječnim i visokim vrijednostima u pojedinim morfološkim karakteristikama. Primjenom kombinatorike, na osnovu svih mogućih permutacija sa ponavljanjima, nakon 2 ponavljanja (Number of iterations = 2) definisane su tri grupe sa različitim vrijednostima u sve tri mjere.

Na osnovu ovako definisanih različitih morfotipova grupa ispitanika sa ciljem ekstrahiranja distinktnih grupa izdvojene su tri grupe koje imaju niske, prosječne i visoke vrijednosti u tjelesnoj visini, tjelesnoj masi i kožnom naboru nadlaktice. Između ovih grupa ispitanika utvrđivane su razlike u manifestaciji analiziranih motoričkih sposobnosti eksplozivne i repetitivne snage primjenom multivarijantne analize varijanse (MANOVA), univarijantne analize varijanse (ANOVA) i Last significant differences testa (LSD - test).

Sve statističke analize su realizovane primjenom statističkog paketa STATISTICA for Windows 8.0.

## REZULTATI

Najprije su primjenom klaster analize (K-means clustering) definisane grupe za različitim manifestacijama u svim mjerenim morfološkim mjerama, pri čemu su utvrđene grupe sa niskim (G-N), prosječnim (G-P) i

high (G-V) manifestations OF the variables of body height, body mass and upper arm (triceps surae) skinfolds were determined (Table 1).

visokim (G-V) manifestacijama u varijablama tjelesna visina, tjelesna masa i kožni nabor nadlaktice (triceps surae) (Tabela 1).

**TABLE 1**

*Arithmetic means of the morphological characteristics of distinct groups.*

**TABELA 1**

*Aritmetičke sredine morfoloških karakteristika distinktnih grupa.*

Variables	G-N ( <i>n</i> = 104)		G-P ( <i>n</i> = 113)		G-V ( <i>n</i> = 52)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
AVIS	141.02	3.55	149.75	4.01	151.35	5.12
AMAS	32.22	3.26	38.73	3.21	51.72	4.12
AKNN	11.97	3.23	13.92	3.76	20.51	3.75

Legend: **G** - Group (Grupa); **N** - Low (Nizak); **P** - Average (Prosječan); **V** - High (Visok); **n** - Number of respondent (Broj ispitanika); **M** - Mean (Aritmetička sredina); **SD** - Standard deviation (Standardna devijacija); **AVIS** - Body Height (Tjelesna visina); **AMAS** - Body mass (Tjelesna težina); **AKNN** - Skinfolds /upper arm - triceps surae/ (Kožni nabor /nadmuktica - triceps surae/).

On the basis of the applied cluster analysis of the overall sample of participants, 104 participants were included in the group with low values of morphological characteristics, whose mean values for height, body mass and skinfold thickness were AVIS ( $M = 141.02$ ;  $SD = 3.55$ ), AMAS ( $M = 32.22$ ;  $SD = 3.26$ ) and AKNN ( $M = 11.97$ ;  $SD = 3.23$ ), 113 participants were included in the group with average levels, whose means had a value of AVIS ( $M = 149.75$ ;  $SD =$

Na osnovu primjenjene klaster analize ukupnog uzorka ispitanika, u grupi sa niskim vrijednostima morfoloških karakteristika grupisano je ukupno 104 ispitanika, čije srednje vrijednosti visine, tjelesne mase i kožnog nabora iznose AVIS ( $M = 141,02$ ;  $SD = 3,55$ ), AMAS ( $M = 32,22$ ;  $SD = 3,26$ ) i AKNN ( $M = 11,97$ ;  $SD = 3,23$ ), u grupi sa srednjim (prosječnim) nivoom je izdvojeno 113 ispitanika, čije srednje vrijednosti iznose AVIS ( $M = 149,75$ ;  $SD = 4,01$ ),

**TABLE 2**

*Arithmetic means of the motor skills of distinct groups.*

**TABELA 2**

*Aritmetičke sredine motoričkih sposobnosti distinktnih grupa.*

Variables	G-N ( <i>n</i> = 104)		G-P ( <i>n</i> = 113)		G-V ( <i>n</i> = 52)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
MSDM	166.17	1.75	170.88	1.68	148.29	2.48
MTRS	482.22	4.37	474.24	4.20	474.60	6.18
MT20V	4.28	.04	4.12	.04	4.42	.06
MSKL	11.72	.66	10.35	.63	5.73	.93
MDTK	7.17	.45	6.46	.43	5.44	.63

Legend: **G** - Group (Grupa); **N** - Low (Nizak); **P** - Average (Prosječan); **V** - High (Visok); **n** - Number of respondent (Broj ispitanika); **M** - Mean (Aritmetička sredina); **SD** - Standard deviation (Standardna devijacija); **MSDM** - Standing depth jump (Skok u dalj s mesta); **MTRS** - Triple standing jump (Trokok iz mjesta); **MT20V** - 20 meter run with a high start (Trčanje na 20 metara visokim startom); **MSKL** - Push-ups (Sklekovi); **MDTK** - Torso lifts on a vaulting box (Podizanje trupa na švedskoj klupi).

4.01), AMAS ( $M = 38.73$ ;  $SD = 3.21$ ) and AKNN ( $M = 13.92$ ;  $SD = 3.76$ ), while the group with high values of morphological characteristics consisted of 52 participants, whose means had a value of AVIS ( $M = 141.02$ ;  $SD = 3.55$ ), AMAS ( $M = 32.22$ ;  $SD = 3.26$ ) and AKNN ( $M = 11.97$ ;  $SD = 3.23$ ).

The noted differences in the analyzed motor space between these extracted groups, were determined using a multivariate analysis of variance (MANOVA), univariate analysis of variance (ANOVA) and the last significant differences test (LSD - test) for variables where a difference was determined between groups for certain motor variables, and are shown in tables 3, 4, 5, 6, and 7.

**TABLE 3**

*Differences in the variables of explosive and iterative strength between the distinct groups at the multivariate level.*

**TABELA 3**

*Razlike u varijablama eksplozivne i repetitivne snage između distinktnih grupa na multivarijantnom nivou.*

$\Lambda$	F	Effect - df	Error - df	p
.743	8.39	10	524	.000

Legend:  $\Lambda$  - Wilks' lambda – the value of the coefficient of Wilks' test for the equality of group centroids (Wilks lambda – vrednost koeficijenta Wilksovog testa za jednakost centrioda grupa); **F** - Value of the coefficient of the F-test for testing the significance of the differences (Vrijednost koeficijenta F-testa za za testiranje značajnosti razlika); **df** - Degrees of freedom (Stepeni slobode); **p** - Probability (Vjerovatnoća).

**TABLE 4**

*The differences in the variables of explosive and iterative strength between the distinct groups at the univariate level.*

**TABELA 4**

*Razlike u varijablama eksplozivne i repetitivne snage između distinktnih grupa na univarijantnom nivou.*

Variables	Group			MS	MSE	F (df1,2) 2.226	p
	G-N	G-P	G-V				
MSDM	166.17	170.88	148.29	9271.00	320.00	28.96	.000
MTRS	482.22	474.24	474.60	1978.00	1989.00	.99	.371
MT20V	4.28	4.12	4.42	1.78	.18	9.67	.000
MSKL	11.72	10.35	5.73	634.99	45.33	14.01	.000
MDTK	7.17	6.46	5.44	52.53	20.84	2.52	.082

Legend: **G** - Group (Grupa); **N** - Low (Nizak); **P** - Average (Prosječan); **V** - High (Visok); **MSDM** - Standing depth jump (Skok u dalj s mjesta); **MTRS** - Triple standing jump (Troskok iz mjesta); **MT20V** - 20 meter run with a high start (Trčanje na 20 metara visokim startom); **MSKL** - Push-ups (Sklekovi); **MDTK** - Torso lifts on a vaulting box (Podizanje trupa na švedskoj klupi); **MS** - Mean square (Suma kvadrata aritmetičkih sredina); **MSE** - Mean square error (Greška sume kvadrata aritmetičkih sredina); **F** - Value of the coefficient of the F-test for testing the significance of the differences (Vrijednost koeficijenta F-testa za za testiranje značajnosti razlika); **df** - Degrees of freedom (Stepeni slobode); **p** - Probability (Vjerovatnoća).

**TABLE 5***LSD test for variable MSDM.***TABELA 5***LSD test variable MSDM.*

Group	G-N (166.17)	G-P (170.88)	G-V (148.29)
G-N		.054	<b>.000</b>
G-P	.054		<b>.000</b>
G-V	<b>.000</b>	<b>.000</b>	

Legend: **G** - Group (Grupa); **N** - Low (Nizak); **P** - Average (Prosječan); **V** - High (Visok).**TABLE 6***LSD test for variable MT20V.***TABELA 6***LSD test variable MT20V.*

Group	G-N (4.28)	G-P (4.12)	G-V (4.42)
G-N		<b>.007</b>	<b>.044</b>
G-P	<b>.007</b>		<b>.000</b>
G-V	<b>.044</b>	<b>.000</b>	

Legend: **G** - Group (Grupa); **N** - Low (Nizak); **P** - Average (Prosječan); **V** - High (Visok).**TABLE 7***LSD test for variable MSKL.***TABELA 7***LSD test variable MSKL.*

Group	G-N (11.72)	G-P (10.35)	G-V (5.73)
G-N		.136	<b>.000</b>
G-P	.136		<b>.000</b>
G-V	<b>.044</b>	<b>.000</b>	

Legend: **G** - Group (Grupa); **N** - Low (Nizak); **P** - Average (Prosječan); **V** - High (Visok).

By analyzing these tables we can conclude that the groups displayed statistically different manifestations in the variables for the standing depth jump (MSDM), the 20 meter run with a high start (MT20V) and push-ups (MSKL). From the analyzed differences between the pairs of groups by using the LSD – test, it was concluded that the participants with average values for all of the morphological variables (group G-P) have a significantly pronounced manifestation of explosive strength, but in comparison to the participants from the groups with pronounced low manifestations, this difference is statistically significant only for the 20 m run with a high start test.

The group with pronounced low manifestations in all of the morphological variables (group G-N)

Analizom ovih tabela može se konstatovati da grupe imaju statistički različite manifestacije u varijablama skok u dalj s mjesta (MSDM), trčanje na 20 metara visokim startom (MT20V) i sklekovi (MSKL). Iz analiziranih razlika između parova grupa primjenom LSD - testa konstatovano je da ispitanici sa prosječnim vrijednostima u svim morfološkim varijablama (grupa G-P) imaju signifikantno izraženu manifestaciju eksplozivne snage u odnosu na ispitanike grupe sa visokim vrijednostima morfoloških karakteristika, ali u odnosu na ispitanike grupe sa izrazitim niskim manifestacijama ta razlika je statistički značajna samo u testu trčanja na 20 metara visokim startom.

Grupa sa izrazitim niskim manifestacijama u svim



had statistically better results in the manifestation of iterative strength than the group with high values of morphological characteristics, but this was not the case in comparison to the group with average values. This difference is pronounced for the push-ups test, while for the torso lift on the vaulting box test it was not statistically significant.

## DISCUSSION

These results can be accounted for in a logical way, considering that in the manifestation of iterative strength, greater body mass and subcutaneous fatty tissue represent a ballast weight, and as such decrease the ability of school children for any long-term repetition of movements which are not aided by the effects of gravity, which in turn increases with body mass. It is also important to point out that the extent of the load force velocity hinders the manifestation of iterative strength, and that in such cases of greater velocity, greater muscle strength will be needed to establish a greater force momentum in comparison to the load momentum, which is necessary for overcoming mechanical work which could overcome it [ $F_m \cdot f > G \cdot q$  (where  $F_m$  – muscle force,  $f$  – its velocity,  $G$  – gravity,  $q$  – its velocity)]. Thus, we can conclude that the participants with greater longitudinal measures and greater body mass will need greater muscle force to overcome the resistance of the load which acts upon the greater velocity, and thus the duration of the repetitive work in that case will be significantly shorter than in the case of participants with low values of morphological measures, due to quicker muscle force expenditure.

In order to explain the mechanisms for long-term repetitive work, it is necessary to explain the relationship between relative strength and body mass, considering that by definition the concept of relative strength is bound to overcoming the resistance of one's own body mass. From the definition itself it can be understood that the participants with the same muscle force and smaller body mass will have greater relative strength, and that the mechanical work of the muscles which overcomes the resistance of the load of the bodies of these participants will last longer in the case of participants with a smaller relative strength (greater body mass).

Explosive strength primarily depends on the possibility of manifesting maximal strength in as short a period of time as possible. Considering that in the manifestation of explosive strength, the relationship between strength and speed is primarily defined by the extent of the outer resistance when performing explosive movements, we should point out that explosive strength of the speed kind is characterized by the extent of relative muscle strength and the maximum

morfološkim varijablama (grupa G-N) ima statistički značajno bolje rezultate u manifestaciji repetitivne snage od grupe sa visokim vrijednostima morfoloških karakteristika, ali ne i u odnosu na grupu sa prosječnim vrijednostima. Ta razlika je izražena u testu sklekovi, dok u testu dizanje trupa na klupici razlika nije statistički značajna.

## DISKUSIJA

Dobijeni rezultati ukazuju na konstataciju da je sa visokim vrijednostima tjelesne mase i potkožnog masnog tkiva nivo eksplozivne i repetitivne snage značajno niži, da učenici sa niskim vrijednostima morfoloških mjera posjeduju viši nivo repetitivne snage, a da učenici sa prosječnim vrijednostima imaju viši nivo eksplozivne snage.

Ovakvi rezultati imaju logično objašnjenje, obzirom da u manifestaciji repetitivne snage veća tjelesna masa i potkožno masno tkivo predstavljaju balastnu masu i kao takvi umanjuju sposobnost učenika za dugotrajno ponavljanje pokreta koji se suprotstavljaju dejstvu sile zemljine teže, koja je veća sa većom masom tijela. Takođe je važno naglasiti da je i dužina kraka sile tereta otežavajući faktor u manifestaciji repetitivne snage, te će u slučaju takvog dužeg kraka biti potrebna veća mišićna sila za uspostavljanje većeg momenta sile u odnosu na moment tereta, koji je neophodan za vršenje savladavajućeg mehaničkog rada [ $F_m \cdot f > G \cdot q$  (gde je  $F_m$  – mišićna sila,  $f$  – njen krak,  $G$  – gravitacija,  $q$  – njen krak)]. Na osnovu ovoga se može konstatovati, da će ispitanicima sa većim longitudinalnim mjerama i većom tjelesnom masom biti potrebna veća mišićna sila za savladavanje otpora tereta koji djeluje na dužem kraku, a samim tim će i dužina ponavljajućeg rada kod istih biti značajno manja nego kod ispitanika sa niskim vrijednostima morfoloških mjera, a usled brže potrošnje energije mišića.

Da bi se razjasnili mehanizmi dugotrajnog ponavljajućeg rada, neophodno je objasniti i odnos relativne snage i tjelesne mase, obzirom da se u definiciji pojam relativne snage vezuje za savladavanje otpora mase sopstvenog tijela. Iz same definicije je razumljivo da će ispitanici sa istom mišićnom silom i manjom tjelesnom masom imati veću relativnu snagu, te će i mehanički rad mišića koji savladavaju otpor tereta sopstvenog tijela tih ispitanika trajati duže u odnosu na ispitanike sa manjom relativnom snagom (većom tjelesnom masom).

Eksplozivna snaga prvenstveno zavisi od mogućnosti ispoljavanja maksimalne snage u što kraćem vremenu. Obzirom da je u manifestaciji eksplozivne snage odnos snage i brzine prije svega definisan veličinom spoljnog

speed of movement performance, where the external resistance is minimal.

The relationship between body mass and maximal strength is significantly high if the dependence refers only to the maximal strength of the muscles, and not to the speed of its manifestation. If we take into consideration the speed of the manifested strength, then the connection between body mass and the manifested strength significantly decreases, that is, has no significant importance, or to be more precise, has no significant effect on the exercises of the explosive type, especially jumping exercises (Verhošanski, 1979).

Force and strength can also significantly influence muscle architecture (Blazevich, Cannavan, Coleman, & Horne, 2007), that is, the relationship between the length of muscle fibers and the surface of their physiological cross-section. The length of the fibers especially has an effect on the extent of the movement which a muscle can perform, with a maximal speed of the reduction, as well as the relation of force-extent (Knežević & Mirkov, 2011). This can be explained by the example of the determination of the muscle torque force, when the muscle is viewed in natural conditions. Thus, muscle force momentum can be manifested in the production of a tangential (active) component of muscle force and the distance between the center of the joint and the center of the mobile muscle connection. This fact leads us to the conclusion that under the conditions of equal muscle force, its momentum increases with the increase in the length of the lever, that is, the athletes with the same muscle force and longer levers will manifest a greater force momentum in relation to athletes with shorter levers, under the conditions of muscle work without external resistance, which is the case in the manifestation of explosive strength of the speed type. With an increase in muscle momentum, the tangential speed of the distal parts of the lever increases, and thus the product of these two components will be a greater explosive strength in the given movement.

The results of our research are in agreement with the results obtained in previous studies, and indicate the negative influence of increased body mass and subcutaneous fatty tissue on the level of motor skills among male school children aged 12, but also on the positive relations between longitudinal measures and explosive strength. A certain number of studies have confirmed these positive relations (Jarić & Kukolj, 1996; Pincivero, Campy, & Karunakara, 2004).

A great number of studies indicate the increase in obesity among children and adolescents and the great negative influence of obesity and extensive body weight on the health of individuals (Eisenmann, Welk, Wickel, & Blair, 2007; Kovač, Leskošek, & Strel, 2008; Starc & Strel, 2010; Steele, Brage, Corder, Wareham, & Ekelund, 2008). The negative influence

otpora pri izvođenju eksplozivnih kretnji, moramo naglasiti da eksplozivnu snagu brzinskog tipa karakterišu veličine relativne mišićne snage i maksimalne brzine izvođenja pokreta, gdje je spoljni otpor minimalan.

Odnos između tjelesne mase i maksimalne snage je značajno visok ako se zavisnost odnosi samo na maksimalnu snagu mišića, a ne na brzinu njenog ispoljavanja. Ako se uzme u obzir brzina ispoljavanja snage, onda se veza između tjelesne mase i ispoljene snage značajno smanjuje, odnosno nema suštinski značaj, ili tačnije, nema suštinski značaj na vježbe eksplozivnog tipa, posebno za vježbe skakanja (Verhošanski, 1979).

Na silu i snagu može značajno uticati i arhitektura mišića (Blazevich, Cannavan, Coleman i Horne, 2007), odnosno, odnos između dužine mišićnih vlakana i površine njihovog fiziološkog presjeka. Dužina vlakana posebno ima uticaj na obim pokreta koji mišić može izvesti, maksimalnu brzinu skraćanja kao i relaciju sila-dužina (Knežević i Mirkov, 2011). To se može objasniti primjerom određivanja obrtnog momenta sile mišića, kada se mišić posmatra u prirodnim uslovima. Na osnovu toga se moment sile mišića može izraziti proizvodom tangencijalne (aktivne) komponente sile mišića i rastojanja između centra zgloba i centra pokretnog mišićnog pripoja. Ova činjenica navodi na zaključak da se u uslovima jednake sile mišića njen moment povećava sa povećanjem dužine poluge, odnosno, sportisti sa istom mišićnom silom i dužim polugama će ispoljavati veći moment sile u odnosu na sportiste sa kraćim polugama, u uslovima rada mišića bez spoljnog otpora, što je slučaj u manifestaciji eksplozivne snage brzinskog tipa. Sa povećanjem momenta sile mišića, uvećava se i tangencijalna brzina distalnih dijelova poluge, te će proizvod te dvije komponente biti veća eksplozivna snaga u datom pokretu.

Rezultati našeg istraživanja su u relaciji sa dosadašnjim saznanjima i ukazuju na značajan negativni uticaj uvećane mase tijela i potkožnog masnog tkiva na nivo motoričkih sposobnosti kod učenika muškog pola 12-godišnjeg uzrasta, ali i na pozitivne relacije longitudinalnih mjera i eksplozivne snage. Jedan broj istraživanja je potvrdio te pozitivne relacije (Jarić i Kukolj, 1996; Pincivero, Campy i Karunakara, 2004).

Veliki broj istraživanja potencira porast gojaznosti kod djece i adolescenata i veliki negativni uticaj gojaznosti i prekomerne tjelesne težine na zdravstveno stanje pojedinaca (Eisenmann, Welk, Wickel i Blair, 2007; Kovač, Leskošek i Strel, 2008; Starc i Strel, 2010; Steele, Brage, Corder, Wareham i Ekelund, 2008). Negativni uticaj uvećane mase tijela, a posebno potkožnog masnog tkiva, na uspješnost u realizovanju

of body mass, and especially subcutaneous fatty tissue, on the success in the realization of various motor tasks has been confirmed in a great number of studies (Deforche et al., 2003; Kim et al., 2005; Mota et al., 2002; Strel, 2006). The findings from the national study of the health and diet of 12-19-year-old adolescents of both genders in the USA indicate that the motor skills of adolescents with normal body weight are greater than of those considered overweight individuals (Pate, Wang, Dowda, Farrell, & O'Neill, 2006).

This research is in accordance with previous analyses obtained from research that dealt with the same issue (Клиничаров, 2003; Клиничаров, 2008; Клиничаров, Христовски, & Апески, 2005; Klinčarov & Stojanović, 2005; Klinčarov & Stojanović, 2006), which indicates that in this period of adolescence, in the case of young boys, motor skills were analyzed under the significantly negative influence of body mass and subcutaneous fatty tissue (estimated via skinfolds of the triceps).

In the end, we can conclude that even though the interdependence in the motor space of a school age population were studied further, there is still room for seeking deeper insight into this segment, especially in the period of early adolescence.

## CONCLUSION

With the aim of differentiating groups with low, medium and high values of body height, body mass and subcutaneous body tissue, and thus determining the differences between groups differentiated in terms of explosive and iterative strength, a study was carried out on a population of 12-year-old boys.

The obtained results have confirmed the results from previous studies, and thus we can conclude that it is necessary, in the realization of the content of physical education classes, to differentiate between homogenous groups of school children with the same or similar characteristics. The definition of homogenous groups on the basis of morphological parameters of the body, as practically the easiest measurable indicators, would enable a more efficient organization of physical education classes. The definition of potential possibilities for the manifestation of certain motor qualities, on the basis of these morphological indicators for each age group of school children would be made possible through the implementation of a small number of morphological measures. This would enable the classification of a certain child into a suitable group and the realization of a special work program, which would enable the most effective improvement in his qualities. In this paper we have attempted to define the procedure which would optimally evaluate the motor qualities

raznih motoričkih zadataka je potvrđen u velikom broju naučnih istraživanja (Deforche i saradnici, 2003; Kim i saradnici, 2005; Mota i saradnici, 2002; Strel, 2006). Saznanja iz sprovedene Nacionalne studije za istraživanje zdravlja i ishrane kod 12-19 godišnjih adolescenata oba pola u SAD, ukazuju da je motorička sposobnost veća kod onih adolescenata koji imaju normalnu tjelesnu težinu u odnosu na one u kategoriji sa prekomjernom tjelesnom težinom (Pate, Wang, Dowda, Farrell i O'Neill, 2006).

Sprovedeno istraživanje je u saglasnosti i sa prethodnim analizama dobijenih iz istraživanja koja su se bavila istim problemom (Клиничаров, 2003; Клиничаров, 2008; Клиничаров, Христовски и Апески, 2005; Klinčarov i Stojanović, 2005; Klinčarov i Stojanović, 2006), koji pokazuju da su u ovom periodu adolescencije kod učenika muškog pola analizirane motoričke sposobnosti pod značajno negativnim uticajem nivoa tjelesne mase i potkožnog masnog tkiva (procjenjene preko kožnog nabora tricepsa).

Na kraju može da se konstatuje da su interzavisnosti u motoričkom prostoru kod školske populacije istraživane, no ipak postoji prostor za produbljivanje saznanja u ovom segmentu, posebno za period rane adolescencije.

## ZAKLJUČAK

Sa ciljem da se diferenciraju grupe sa niskim, srednjim i visokim vrijednostima tjelesne visine, tjelesne mase i potkožnog masnog tkiva, te da se utvrde razlike između tako diferenciranih grupa u eksplozivnoj i repetitivnoj snazi, izvršeno je istraživanje na populaciji 12-to godišnjih učenika.

Dobijeni rezultati su potvrdili saznanja iz ranijih sličnih istraživanja, te na osnovu njih može da se konstatuje da je neophodno u realizaciji sadržaja nastave fizičkog vaspitanja diferencirati homogene grupe učenika sa istim ili sličnim karakteristikama. Definisane homogenih grupa na osnovu morfoloških parametara tijela, kao praktično najlakše mjerljivih pokazatelja, omogućilo bi efikasniju organizaciju časa fizičkog vaspitanja. Definisane potencijalnih mogućnosti za manifestaciju određenih motoričkih kvaliteta, na osnovu ovih morfoloških pokazatelja za svaku uzrasnu kategoriju učenika, omogućilo bi se primjenom malog broja morfoloških mjera. Time će se omogućiti svrstavanje određenog učenika u odgovarajuću grupu i realizacija takvog posebnog programa rada, koji bi dao neefikasnije usavršavanje njegovih kvaliteta. U ovom radu je napravljen pokušaj da se definiše postupak kojim bi se optimalno procijenili motorički kvaliteti

of explosive and iterative strength among distinct groups of morphological types of participants.

eksplozivne i repetitivne snage kod distinktnih morfoloških grupa ispitanika.

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## UNTERSCHIEDE IN DER EXPLOSIVEN UND WIEDERHOLENDEN KRAFT VON ZWÖLFJÄHRIGEN SCHÜLERN MIT UNTERSCHIEDLICHEN MORPHOLOGISCHEN MERKMALEN

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In dieser Forschung wurde sowohl die Prädiktion der generellen Fähigkeit für die Manifestation der Qualitäten der explosiven und wiederholenden Kraft bei den Schülern im Alter von 12 Jahren als auch ein Versuch analysiert, ein Verfahren zu definieren, mit dem distinkte Gruppen mit optimal unterschiedlichen Manifestationen in morphologischen Indikatoren festgestellt würden, mit dem Ziel, Gruppen in Sportstunden zu homogenisieren, zwecks Optimierung der Effekte der Sporterziehung auf die Entwicklung psychosomatischer Schülercharakteristika, als Hauptproblem, mit dem sich diese Forschung beschäftigt.

Die Entwicklung der wiederholenden und explosiven Kraft von Schülern, als zwei generelle Fähigkeiten, die der Realisierung menschlicher Sportbewegungen zugrunde liegen (Verhošanski, 1979), verlangt den individuellen Zugang zu ihrem Training. Um optimale Bedingungen für die Anwendung des individuellen Zugangs zur Entwicklung dieser Fähigkeiten und der Angleichung der Belastung von Schülern im Sportunterricht zu ermöglichen, ist es notwendig, das Verfahren der Gruppenhomogenisierung zu definieren, was der Gegenstand dieser Forschung darstellt.

Das Ziel der Forschung war es, durch Ergebnisse derselben das Verfahren der Differenzierung von Schülergruppen mit denselben oder ähnlichen Fähigkeiten für Sportlehrer an Schulen zu erleichtern, um Belastungen in einer Sportstunde planen zu können, die optimal für jeden einzelnen Schüler wären.

Die Forschungsannahme (Hypothese) ist, dass die Differenzierung von homogenisierten Schülergruppen nach morphologischen Maßen statistisch signifikante Unterschiede zwischen distinkten Gruppen in der explosiven und wiederholenden Kraft projizieren werden, und dass die Gruppe mit hohen morphologischen Maßen deutlich schwächere Ergebnisse im Bezug auf andere zwei Gruppen zeigen wird.

Die Probandenmenge ist aus der männlichen Schülerpopulation in der Jahrgangsstufe 5 abgeleitet, chronologisches Alter 12 Jahre (+, - 6 Monate), die zur Zeit der Untersuchung durch den ordentlichen Sportunterricht umfasst wurde, die alle Gesundheitskriterien erfüllte, und die regelmäßig Sportunterricht besuchte. Die Probe umfasste 269 Schüler in der Jahrgangsstufe 5 an den Grundschulen im Region von Paracin.

Der Test der morphologischen Merkmale und motorischen Fähigkeiten umfasste folgendes: Körpergröße (AVIS), Körpermasse (AMAS), Hautfalte (Oberarm- triceps surae) (KNNL), Weitsprung aus dem Stand (MSDM), Dreisprung aus dem Stand (MTRS), 20-Meter-Lauf mit Hochstart (MT20V), Liegestütze (MSKL) und Rumpfhoben auf der Bank (MDTK).

Durch die Anwendung der Clusteranalyse (K-means clustering) wurden zuerst die Gruppen mit unterschiedlichen Manifestationen in allen gemessenen morphologischen Maßen definiert, wobei die Gruppen

mit niedrigen (G-N), durchschnittlichen (G-P) und hohen (G-V) Manifestationen in folgenden Variablen festgestellt wurden: Körpergröße, Körpermasse und Hautfalte des Oberarms. Aufgrund der angewendeten Clusteranalyse der gesamten Probandenmenge sind in der Gruppe mit den niedrigen Werten der morphologischen Merkmale insgesamt 104 Probanden gruppiert, in der Gruppe mit dem mittleren (durchschnittlichen) Niveau sind 113 Probanden ausgesondert, während die Gruppe mit den hohen Werten der morphologischen Merkmale 52 Probanden bildeten.

Die evidenzierten Unterschiede im analysierten motorischen Bereich, unter so extrahierten Gruppen, die durch die Anwendung der multivariaten Varianzanalyse (MANOVA), der univariaten Varianzanalyse (ANOVA) und des Least significant difference test (LSD-Test) festgestellt wurden, weisen darauf hin, dass die Gruppen statistisch unterschiedliche Manifestationen in folgenden Variablen haben: Weitsprung aus dem Stand (MSDM), 20-Meter-Lauf mit Hochstart (MT20V) und Liegestütze (MSKL).

Aufgrund der analysierten Unterschieden zwischen den Gruppen-Paaren durch die Anwendung des LSD-Tests ist es festgestellt worden, dass die Probanden mit den durchschnittlichen Werten in allen morphologischen Variablen (Gruppe G-P) eine signifikant ausgeprägte Manifestation der explosiven Kraft im Bezug auf die Probanden aus der Gruppe mit den hohen Werten der morphologischen Merkmale haben, aber im Bezug auf die Probanden aus der Gruppe mit den deutlich niedrigen Manifestationen ist dieser Unterschied nur beim Test des 20-Meter-Laufs mit Hochstart statistisch signifikant.

Die Gruppe mit den deutlich niedrigen Manifestationen in allen morphologischen Variablen (Gruppe G-N) hat statistisch signifikant bessere Ergebnisse in

der Manifestation der wiederholenden Kraft als die Gruppe mit den hohen Werten der morphologischen Merkmale, nicht aber im Bezug auf die Gruppe mit den durchschnittlichen Werten. Dieser Unterschied ist beim Liegestütze-Test ausgeprägt, während der Unterschied beim Test des Rumpfhebens auf der Bank statistisch nicht signifikant ist.

Die gewonnenen Ergebnisse haben die Erkenntnisse aus früheren ähnlichen Untersuchungen bestätigt, daher kann aufgrund deren festgestellt werden, dass es notwendig ist, bei der Realisierung der Inhalte des Sportunterrichts homogene Schülergruppen mit den gleichen oder ähnlichen Merkmalen zu differenzieren. Das Definieren von homogenen Gruppen aufgrund der morphologischen Körperparameter als praktisch der am leichtesten meßbaren Indikatoren würde die effizientere Organisation einer Sportstunde ermöglichen. Das Definieren von potentiellen Möglichkeiten zur Manifestation bestimmter motorischer Qualitäten, aufgrund dieser morphologischen Indikatoren für jede Schüler-Altersklasse, würde durch die Anwendung einer kleinen Anzahl von morphologischen Maßen ermöglicht werden. Dadurch wird die Zuordnung eines bestimmten Schülers zur entsprechenden Gruppe und die Realisierung eines solchen besonderen Arbeitsprogramms ermöglicht werden, das die effizienteste Verbesserung seiner Qualitäten ergeben würde. In dieser Arbeit wurde ein Versuch gemacht, ein Verfahren zu definieren, mit dem die motorischen Qualitäten der explosiven und wiederholenden Kraft bei den distinkten Morphotypen der Probanden optimal eingeschätzt werden könnten.

**Schlüsselwörter:** explosive und wiederholende kraft, distinkte gruppen, morphologische struktur.

## SINDROM PRENAPREZANJA U TRČANJU

### OVERUSE SYNDROME IN THE RUNNING

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### SUMMARY

Walking and running are natural way of human motion. Today running is effective aerobic exercise to maintain vital human functions, mostly cardiovascular and breathing functions. Modern human's lack of movement results in numerous health problems and generally reduce the quality of his life. The impact of regular physical exercise on the body is proven beyond any doubt; but we can also see the growing negative effects of physical exercise, which are typically a result of the unadjusted and to demanding exercise programs. Walking and running are human's the most effective and health activities, but running can have large load on joints, bones, tendons, ligaments and muscular system. The negative effects of physical exercise are manifested in the form of overuse which often leads to injuries. Running injuries and their development takes place at the beginning relatively unnoticed, obvious symptoms with pronounce consequences for the runner occur relatively late. Identifying overuse factors of the human can help runners and all other athletes who run in their sport disciplines; it is a huge challenge for sports science. Correct and in time answers on overuse can have important contribution to a more humane and safe practice.

**Key words:** running, biomechanics, overuse syndrom.

### SAŽETAK

Hodanje i trčanje su prirodni načini ljudskog kretanja. U današnje vrijeme trčanje je efikasna aerobik vježba za održavanje vitalnih ljudskih funkcija, uglavnom kardiovaskularne i respiratorne funkcije. Nedostatak kretanja savremenog čovjeka dovodi do brojnih zdravstvenih problema i uopšte smanjuje kvalitet života. Uticaj redovnog fizičkog vježbanja na tijelo dokazan je bez ikakve sumnje, ali takođe možemo vidjeti negativne efekte fizičkog vježbanja koji su obično rezultat neprilagođenih i zahtjevnih programa vježbanja. Hodanje i trčanje su najefikasnije i najzdravije ljudske aktivnosti, ali trčanje može imati veliko opterećenje na zglobove, kosti, tetive, ligamente i mišićni sistem. Negativni efekti fizičkog vježbanja manifestuju se u vidu prenaprezanja koji često dovodi do povreda. Povrede pri trčanju i njihov razvoj odvijaju se u početku relativno neprimjetno. Očigledni simptomi sa vidljivim posljedicama po trkača nastaju relativno kasno. Identifikovanje faktora prenaprezanja čovjeka može da pomogne trkaču a i svim ostalim sportistima koji trče u svojim sportskim disciplinama. To je veliki izazov za sportsku nauku. Pravilni odgovori u pravo vrijeme na prenaprezanje mogu imati značajan doprinos humanijem i bezbjednijem treningu.

**Ključne riječi:** trčanje, biomehanika, sindrom prenaprezanja.



## INTRODUCTION

Running is besides walking the most natural man movement; which he used in his evolutionary development on a daily basis to survive. Today running is basic content of aerobic exercise, one of the most effective ways of maintaining functional systems, in particular cardiac vascular and respiratory system. Modern way of life, when people are working longer and longer, more and more tiring and stressful, more time spent in a sitting position, running can be the best counterweight to such a lifestyle. Quality of life of the modern "Homo sitter", the lack of movement decreased markedly with all the consequences that are evident in many diseases of our time. Nothing destroys the human body more than the non-movement (Aristotle).

Running as a physical activity is genetically determined. The basic running structural unit is double step. Within the cycle running cycle alternates support and flight phase. Support phase begins at the moment when the foot strikes the surface and ends when the foot leaves the ground. Moment of leaving foot from support delimits both phases. When foot touches the ground with heel is the first support, and when the take off is done with finger is called last support. Between a supporting phase is the flight phase. The distance between the two phases defines the stride length. In addition to the frequency step is the most important step length parameter of running. Step length and step frequency are in inverse proportion and are individually conditioned. They depend on runner's characteristics and capabilities. At higher frequency is smaller stride length and vice versa. Parameter stride length depends on the morphological characteristics of runners, especially the length of the lower extremities, from the ground reaction force, contact time and take off angle. The average stride length of the recreational runner is 100 to 150 cm, a top runner 150 to 220 cm. Frequency step, which is manifested by the number of steps per unit time depends on the intra and inter muscular coordination and operation of the central nervous system that regulates the movement of agonist and antagonistic muscle groups (Donatti, 1995; Komi & Nicol, 2000; Mero, Komi, & Gregory, 1992; Novacheck, 1997). The relationship between length and step frequency steps is largely automated and fixed in locomotor central nervous system (Enoka, 2003). Human running technique is very individual and independent with stage of training.

## BIOMECHANICS OF RUNNING

Maximum load on human body is created the first and last support phase (Figure 1), vertical reaction

## UVOD

Trčanje je, pored hodanja, najprirodnije čovjekovo kretanje koje je on koristio svakodnevno u svom evolutivnom razvoju da bi preživio. U današnje vrijeme trčanje je osnovni sadržaj aerobnog vježbanja, jedan od najefikasnijih načina za održavanje funkcionalnog sistema, posebno kardiovaskularnog i respiratornog. Savremeni način života, kada ljudi rade sve duže i duže, sve napornije i pod stresom, sve više vremena provode u sjedećem položaju. Trčanje može da bude najbolja protivteža takvom načinu života. Kvalitet života modernog "sedentarnog čovjeka", nedostatak kretanja koje je značajno smanjeno ogleda se, sa svim evidentnim posljedicama, u mnogim bolestima našeg vremena. Ništa više ne uništava ljudsko tijelo nego nekretanje (Aristotel).

Trčanje kao fizička aktivnost je genetski određena. Osnovna strukturna jedinica trčanja je dvostruki korak. U okviru ciklusa trčanja postoji naizmjenični ciklus faza oslonca i faza leta. Faza oslonca počinje u trenutku kada stopalo dotakne tlo, a završava kada stopalo napusti površinu tla. Momenat odvajanja noge od tla razgraničava ove dvije faze. Kada stopalo dotakne petom tlo to je prvi oslonac, a kada se uradi odraz prstima to se naziva posljednim osloncem. Između faza oslonca je faza leta. Rastojanje između dvije faze definiše se kao dužina koraka. Pored frekvencije koraka najvažniji parametar trčanja je dužina koraka. Dužina i frekvencija koraka su u obrnutoj proporciji i individualno su uslovljeni. Oni zavise od karakteristika trkača i njegovih mogućnosti. Pri većoj frekvenciji koraka manja je njihova dužina i obrnuto. Parametri dužine koraka zavise od morfoloških karakteristika trkača, posebno od dužine njegovih ekstremiteta, od reakcione sile podloge, vremena kontakta i ugla odraza. Prosječna dužina koraka rekreativnog trkača je 100 do 150 cm, a vrhunskog 150 do 220 cm. Frekvencija koraka, koja se manifestuje po broju koraka u jedinici vremena, zavisi od unutar i među mišićne koordinacije i funkcionisanja centralnog nervnog sistema koji reguliše kretanje mišićnih grupa agonista i antagonista (Donatti, 1995; Komi i Nicol, 2000; Mero, Komi i Gregory, 1992; Novacheck, 1997). Odnos između dužine i frekvencije koraka je u velikoj mjeri automatizovan i pohranjen u lokomotornom centralnom nervnom sistemu (Enoka, 2003). Tehnika ljudskog trčanja je izrazito individualna i nezavisna od nivoa treninga.

## BIOMEHANIKA TRČANJA

Maksimalno opterećenje na ljudsko tijelo stvaraju prva i poslednja faza oslonca (Slika 1). Vertikalna sila

force is between 2000 to 2500 N, during sprint even up to 3500 N (Cavagna, Komarek, & Mazzoleni, 1971; Mero et al., 1992, Škof & Strojnik, 2007). Gait reaction forces are three times smaller (Novacheck, 1997). The main difference between walking and running is flight phase, which do not exist in walking. During walking the human body is always in contact with one foot on the ground.

reakcije je između 2000 do 2500 N, a tokom sprinta čak i 3500 N (Cavagna, Komarek i Mazzoleni, 1971; Mero i saradnici, 1992, Škof i Strojnik, 2007). Snage reakcije hoda su tri puta manje (Novacheck, 1997). Osnovna razlika između hodanja i trčanja je faza leta koja ne postoji u hodanju. Tokom hodanja ljudsko tijelo je uvijek sa jednom nogom u kontaktu sa podlogom.

**FIGURE 1**

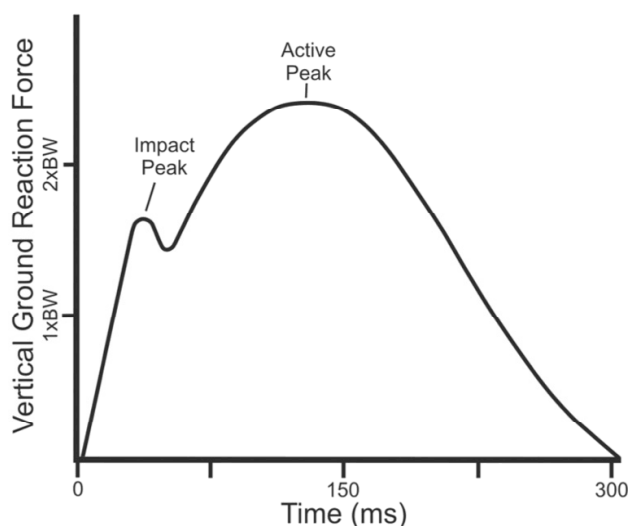
*Vertical ground reaction force in the touch-down and take-off phases*

*(Source: Foot strike in runners: Influence on injury risk, 2012).*

**SLIKA 1**

*Vertikalna reakciona sila podloge u fazama kontakta i odraza*

*(Izvor: Foot strike in runners: Influence on injury risk, 2012).*



Legend: Vertical ground reaction force - Vertikalna reakciona sila podloge; Time - Vrijeme; Impact peak - Vrh kontakta; Active peak - Aktivni vrh.

The foot is one of the most loaded segments of the locomotor system during running. The foot has 26 bones of different shapes and features, 19 muscles and more than 100 ligaments. In the course of 10 km, the foot strikes the ground about 5.000 times, the average stride length of 2 m. With average runner's mass (70 kg) and regarding to the number of steps, we can conclude that the total absorption reaction of surface forces for each foot is 3430 kN. This force is then transmitted to the knee and hip joint. Undoubtedly, these burdens are on the borderline of human adaptive capacities.

Runner's reaction force depends on the running technique, how foot is placed on ground in the moment of the first contact. We differentiate three types (Daoud et al., 2012; Hasegawa, Takeshi, & Kramer,

Stopalo je jedno od najopterećenijih segmenata lokomotornog sistema tokom trčanja. Stopalo ima 26 kostiju različitih oblika i funkcije, 19 mišića i više od 100 ligamenata. Tokom trčanja na 10 km, stopalo dotakne tlo 5.000 puta pri prosječnoj dužini koraka od 2 m. Sa prosječnom masom trkača (70 kg) i sa pethodnim brojem koraka možemo zaključiti da je ukupna reakcija apsorpcije snage podloge 3430 kN po svakom stopalu. Ova se snaga onda prenosi na koljeno i zglob kuka. Bez sumnje ova su opterećenja na granici adaptivnih ljudskih sposobnosti.

Reakciona sila trkača zavisi od tehnike trčanja, kako se noga postavlja na podlogu u trenutku prvog kontakta. Razlikujemo tri vrste kontakta (Daoud i saradnici, 2012; Hasegawa, Takeshi i Kramer, 2007; Lieberman i saradnici, 2009; Novacheck, 1997): petom

2007; Lieberman et al., 2009; Novacheck, 1997): with heel (RFS rear-heel foot strike), mid foot (MFS mid-foot strike) and fingers (FFS fore foot strike) – Figure 2. Hasegawa et al. (2007) found that 75% of marathon runners use RFS, 24% MFS and only 4% FFS. Which of the run models are the most effective researches up to date did not give a single answer (Lieberman et al., 2009). Superior results were achieved during the marathon runners with all three types.

(RFS zadnjim dijelom stopala - petom), središnjim dijelom stopala (MFS kontakt sredinom stopala) i prstima (FFS gornjim dijelom stopala) - Slika 2. Hasegawa i saradnici (2007) utvrdili su kod trkača maratonaca da koriste 75% RFS, 24% MFS, a samo 4% FFS. Istraživanja do danas nisu dala odgovor koji je najbolji model trčanja (Lieberman i saradnici, 2009). Vrhunski rezultati su postignuti sa sva tri tipa kontakta kod trkača maratonaca.

**FIGURE 2**

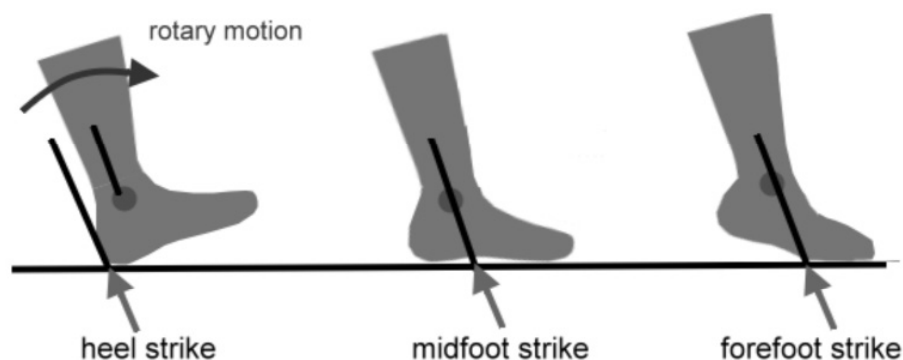
*The foot plant techniques in running*

*(Source: Foot strike and injury rates, 2012).*

**SLIKA 2**

*Tehnike trčanja tabanom stopala*

*(Izvor: Foot strike and injury rates, 2012).*



Legend: Rotary motion - Rotacioni pokret; Heel strike - Dodir petom; Midfoot strike - Dodir sredinom stopala; Forefoot strike - Dodir gornjim dijelom stopala.

Placing foot is closely related to the function of modern running shoes, which are constructed according to the latest knowledge of biomechanics and functional anatomy of the foot. The basic task of running shoes is the mechanical protection of the feet, partial neutralization of reaction forces and injury prevention. Rear – foot strike means in terms of burden "shock" to the ankle, knee and hip joint. Reaction force in this case is oriented in the opposite direction of motion of body center of gravity. In part, this force is absorbed by running shoes sole, which must be appropriately thick and elastic.

In terms of biomechanics of running a more efficient technique is to place foot in the first contact to the front outside part (Figure 3). In this mode, the foot like a spring partially neutralizes the reaction force. Contact with the front foot, however, requires proper coordination and activation of agonist and antagonist muscles (m. tibialis and m. gastrocnemius medialis and lateralis). M. Gastrocnemius muscle

Položaj stopala je usko povezan sa funkcijom savremenih patika za trčanje koje su izrađene u skladu sa najnovijim saznanjima biomehanike i funkcionalne anatomije stopala. Osnovni zadatak patike za trčanje je mehanička zaštita stopala, djelimična neutralizacija reaktivne snage i sprječavanje povreda. Kontakt sa podlogom zadnjeg dijela stopala u smislu opterećenja znači "šok" za skočni, koljeni i zglob kuka. Reakciona sila u ovom slučaju usmjerena je u suprotnu stranu od kretanja centra težišta tijela. Jednim dijelom ovu silu absorbuju đonovi patika za trčanje koji moraju biti odgovarajuće debljine i elastičnosti.

U odnosu na biomehaniku trčanja efikasnija tehnika je ostvariti prvi kontakt sa stopalom njegovim prednjim vanjskim dijelom (Slika 3). Na taj način stopalo kao opruga neutrališe reakcionu silu. Kontakt sa prednjim dijelom stopala, međutim, zahtijeva određenu koordinaciju i aktiviranje mišića agonista i antagonista (m. tibialis i m. gastrocnemius medialis i lateralis). Mišić m. gastrocnemius obezbjeđuje neophodnu predaktivaciju

provides necessary preactivation needed for proper foot stiffness (Komi & Nicol, 2000). When are muscles activated 50 milliseconds before touchdown, less energy is lost than a passive setting foot on the heel. Efficiency and economy of running is not only dependent on the production of chemical energy, but also on the amount of mechanical - elastic energy that is generated in the eccentric phase (the first phase of foot contact with the ground). Economic running technique is combination of efficiency of chemical and elastic energy. According to researches (Enoka, 2003; Komi & Nicol, 2002; Mero et al., 1992) the proportion of chemical energy and, elastic energy is 75 : 25%.

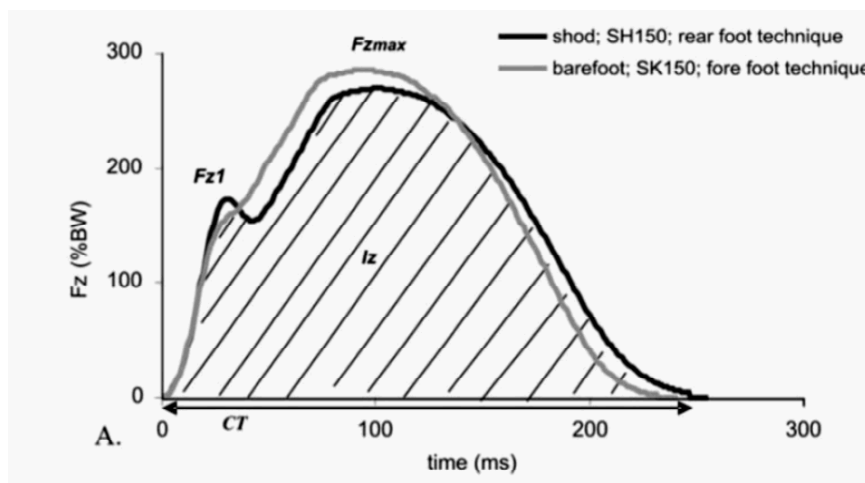
potrebnu za pravilnu krutost stopala (Komi i Nicol, 2000). Kada se mišići aktiviraju 50 milisekundi prije nego se stopalo spusti na tlo gubi se manje energije nego kod pasivnog spuštanja stopala na petu. Efikasnost i ekonomičnost trčanja ne zavisi samo od proizvodnje hemijske energije nego i od količine mehaničke energije - elastična energija koja se generiše u ekscentričnoj fazi (prva faza kontakta stopala sa podlogom). Ekonomična tehnika trčanja je kombinacija efikasnosti hemijske i elastične energije. Istraživanja (Enoka, 2003; Komi i Nicol, 2002; Mero i saradnici, 1992) su pokazala da je odnos hemijske i elastične energije 75 : 25%.

**FIGURE 3**

*The differences in the development of the ground reaction force – the rearfoot and fore-foot techniques (Source: Divert et al., 2008).*

**SLIKA 3**

*Razlike u razvoju reakcione sile podloge – tehnika zadnji i prednji dio stopala (Izvor: Divert i saradnici, 2008).*



During evolution walk and run have helped man to survive in raw nature. The man ran and walked barefoot for about four million years. Only in the modern era has started using shoes. Running shoes are little more than sixty years old, which is in context of the history of time. Running shoes have changed the technique of running. Barefoot man ran through the front foot and by exploiting the elasticity of muscles, tendons and ligaments (Lieberman et al., 2009). Today's modern runner sets foot on the heel and exploits the elasticity of the lower part of running shoes. The basic functions of running shoes are absorption of impact forces at the feet with ground, stabilization of ankle and foot and provide a good grip (friction). It is important that the front part of the sole is rigid enough, which prevents excessive foot supination and plantar fasciitis development.

Tokom evolucije šetanje i trčanje pomogli su čovjeku da preživi surovu prirodu. Čovjek je trčao i hodao bos oko četiri miliona godina. Tek u modernom dobu počeo je da koristi cipele. Patike za trčanje postoje malo više od šezdeset godina u okviru vremenske istorije. Patike za trčanje se promijenile tehniku trčanja. Bosonog čovjek trčao je na prednjem dijelu stopala iskoristavajući elastičnost mišića, tetiva i ligamenata (Lieberman i saradnici, 2009). Današnji moderni trkač spušta stopalo na tlo na petu i iskoristava elastičnost donjeg dijela patika za trčanje. Osnovne funkcije patike za trčanje je apsorpcija uticaja sila tla na stopalo, stabilizacija skočnog zgloba i stopala i pružanje dobrog prijanjanja (trenja). Važno je da je prednji dio đona dovoljno krut što sprječava razvoj prekomjerne supinacije i plantarnog fascitisa stopala.

## OVERUSE SYNDROM

Despite the fact that running is one of the most effective and healthy human motor activity, it can also have high impact on locomotor system, especially for joints, tendons, ligaments and muscle system of lower extremities (DeRuisseau et al., 2004; Halson & Jeukendrup, 2004; Hartmann & Mester, 2000; Mujika, 2009). The negative effects of sports training show as "collateral damage" in the form of various injuries. The first type of injury is acute one that occurs immediately with the known mechanism of injury and place. The second type chronic injuries are primarily due to overuse of the motor system, in particular segment of the lower extremities. Chronic injury is taking place in the beginning usually completely unnoticed, obvious symptoms with noted consequences for the runner occurs relatively late. First signs of chronic injuries are attributed to bad warm up, excessive load, unfavorable external influences; runner continues with sports activity, problems are not heavy and there is no sign of injury (Urhausen & Kindermann, 2002). To the difficulties which are associated with overuse syndrome runners react late or too late. On muscle, tendon, ligament, cartilage, bone, nerve and blood vessel is continuous load which can cause micro-trauma and micro-stress. The most common external causes of overuse syndrome are: improper motor preparation, running technique, rapid changes in the intensity of training, inadequate configuration of the terrain, frequent one-sided load, inadequate rest and recovery, inadequate climatic conditions and inadequate equipment. The internal causes of overuse syndrome may be genetic or acquired. In general the morphologic characteristics of the body manifest different level of asymmetry. The reason may be also the biochemical change in the organism. Important role play age and gender as well. It is important to identify and analyze causes and act accordingly. The entire process of eliminating both external and internal causes of overusing the motor system requires a team approach with work-oriented specialists. These are coaches, physiotherapists, masseurs, doctors, orthopedic surgeons. Kinesiology profession and science can play a key role in early identification and prevention of the occurrence of overuse syndrome. This applies to all those athletes, who use running in their sport (weather monostructure or polystructure).

With load increase body adapts to stress with muscle fibers hypertrophy, with collagen tendons and ligaments reinforcing structure and bone tissue density increase. Overusing can instead adapt to stress in the athlete's body causes various pathological respon-

## SINDROM PRENAPREZANJA

Pored činjenice da je trčanje jedan od najefikasnijih i najzdravijih ljudskih motornih aktivnosti ono takođe može imati veliki uticaj na lokomotorni sistem, posebno na zglobni, tetivni, ligamentarni i mišićni sistem donjih ekstremiteta (DeRuisseau i saradnici, 2004; Halson i Jeukendrup, 2004; Hartmann i Mester, 2000; Mujika, 2009). Negativni aspekti sportskog treninga pojavljuju se kao "kolateralna šteta" u vidu raznih povreda. Prva vrsta povreda je akutna koje se neposredno dešavaju uz poznati mehanizam povrede i mjesta. Druga vrsta su hronične povrede zbog prenaprezanja motornog sistema posebno segmenata donjih ekstremiteta. Hronična povreda u početku je obično potpuno neprimjetna. Jasni simptomi sa poznatim posljedicima za trkača dešavaju se relativno kasno. Prvi znaci hronične povrede pripisuju se lošem zagrijavanju, pretjeranom opterećenju, nepovoljnim spoljašnjim uticajima; trkač nastavlja sa sportskim aktivnostima, problemi nisu teški i nema znakova povrede (Urhausen i Kindermann, 2002). Na teškoće koje su vezane sa sindromom prenaprezanja trkači reaguju kasno ili suviše kasno. Na mišiće, tetive, ligamente, hrskavice, kosti, nerve i krvne sudove kontinuirano opterećenje može da prouzrokuje mikrotraume i mikrostrses. Najčešći spoljni uzroci sindroma prenaprezanja su: nepravilna motorna priprema, tehnika trčanja, nagle promjene u intenzitetu treninga, neadekvatna konfiguracija terena, često jednostrano opterećenje, neadekvatan odmor i oporavak, neadekvatni klimatski uslovi i neodgovarajuća oprema. Unutrašnji uzroci sindroma prenaprezanja mogu da budu genetski i stečeni. U principu, morfološke karakteristike tijela očigledno su različitog nivoa asimetrije. Razlog mogu da budu biohemijske promjene u organizmu. Važnu ulogu takođe igraju starost i pol. Važno je da se uzroci identifikuju i analiziraju i da se djeluje u skladu sa tim. Cijeli proces eliminacije i spoljašnjih i unutrašnjih uzroka prenaprezanja motornog sistema zahtijevaju timski pristup sa uključivanjem specijalista. To su treneri, fizioterapeuti, maseri, doktori, hirurzi ortopedi. Kineziološka profesija i nauka mogu da odigraju ključnu ulogu u ranoj identifikaciji i spriječavanju pojave sindroma prenaprezanja. Ovo se odnosi na sve sportiste koji imaju trčanje u svom sportu (i na monostrukturne i na polistrukturne).

Na povećano opterećenje tijelo se prilagođava stresu hipertrofijom mišićnih vlakana, sa kolagenskim povećanjem strukture tetiva i ligamenata i povećanjem gustine koštanog tkiva. Prenaprezanje, umjesto toga, može se prilagoditi na stres u tijelu sportiste izazivajući

ses, which result in metabolic disturbances, inadequate supply tissues with oxygen and aseptic inflammation (Hartmann & Mester, 2000). Survey (Auersperger, Ulaga, & Škof, 2009; Auersperger, et al., 2012) showed that the eight week endurance exercise had negative effect on iron balance in women. Hepcidin was significantly lower after three weeks and after the end of the survey. After the end of the study two-thirds of subjects had reduced iron reserves. At a certain stage overuse syndrome is reversible with appropriate therapeutic and regenerative processes. However, when this threshold is exceeded appears tissue metaplasia. At muscle insertion and muscle tissues appear scar tissue, calcium reserves, insertion ossification in tendons ossification and muscle ossification. The entire process takes six to eight weeks. Results show in deterioration of the muscle-tendon structures, cartilage and bones, which are no longer able to fully carry the load. Musculoskeletal system responds with pain and swelling, damaged muscles, ligaments, tendons and bone stress fractures. Most are affected muscles insertions, some tendons (most often Achilles tendon) and fascia. A common feature overuse syndrome is indicated with pain and impaired function of the locomotor system (Zatsiorsky & Kraemer, 2006).

Achilles tendon is undoubtedly the most critical part in runners. Painful Achilles tendon may remove athlete from training for several months. Achilles tendon is a thick fibrous bundle which connects muscle *gastrocnemius lateralis* and *medialis*, and *soleus* with heel. Tendinopathy is one of the most common injuries in runners. Tendinopathy means painful and swollen Achilles tendon accompanied by reduced functionality, which can cause tendinitis (inflammation) or paratenonitis (inflammation of the fascia). Tendinopathy occurs approximately 2-6 cm above tendon insertion. Tendon pain occurs due to the high forces and long-lasting load. With tendinopathy microscopic tears occur in tendon and fascia. On tendon scar tissue begins to accumulate. The basic function of the Achilles tendon is the transmission of force generated by muscle to bone, besides it also works as shock-absorber against external forces and prevents muscle's damage. This feature requires appropriate elasticity, flexibility and tensile strength. Achilles tendon load in sprint can reaches 9 kN and 2.6 kN with slow running (Lieberman et al., 2009; Urhausen & Kindermann, 2002). At peak forces tendon can partly or totally breaks. Tendon partly can break up the first degree (when are interrupted 5% to 50% fibers) and the second degree (when are interrupted 50% to 80% fibers). Point of complete rupture occurs when tendon extends 10% to 20% of initial length.

različite patološke reakcije koje su rezultat metaboličkih poremećaja, neodgovarajućim snadbjevanjem tkiva kiseonikom i aseptičkim zapaljenjima (Hartmann i Mester, 2000). Istraživanja (Auersperger, Ulaga i Škof, 2009; Auersperger i saradnici, 2012) su pokazala da osmonedjeljni trening izdržljivosti ima negativan uticaj na ravnotežu gvožđa kod žena. Hepcidin je bio statistički značajno niži nakon tri nedjelje i nakon završetka istraživanja. Nakon završetka istraživanja dvije trećine ispitanica imalo je smanjene rezerve željeza. U određenom stadijumu sindrom prenaprezanja je reverzibilan sa odgovarajućim terapijskim i regenerativnim procesima. Međutim, kada se taj prag prekorači dolazi do pojave metaplazmičnog tkiva. Na završetcima mišića i mišićnom tkivu pojavljuje se ožiljak, zadržavanje kalcija i okoštavanje mišića. Cijeli proces traje šest do osam nedjelja. Rezultati pokazuju pogoršanje mišićno-tetivne strukture, hrskavice i kostiju, koji više nisu u stanju da se nose sa opterećenjem. Mišićno koštani sistem reaguje bolom i oticanjem, oštećenjem mišića, ligamenata, tetiva i sters frakturama kostiju. Najviše su pogođeni mišićni završetci, neke tetive (najčešće ahilova tetiva) i ovojnice. Zajednička karakteristika sindroma prenaprezanja ogleda se u pojavi bola i smanjenjem funkcije lokomotornog sistema (Zatsiorsky i Kraemer, 2006).

Ahilova tetiva je, bez sumnje, najkritičniji dio tijela za trkača. Bolna ahilova tetiva može da udalji sportistu nekoliko mjeseci od treninga. Ahilova tetiva je gust vlaknasti snop koji povezuje mišiće *m. gastrocnemius lateralis* i *medialis* i *m. soleus* sa petom. Tendinopatija je jedna od najčešćih povreda trkača. Tendinopatija znači bolna i natečena ahilova tetiva sa smanjenjem funkcionalnosti, što može da dovede do tendinitisa (zapaljenja) ili paratenonitisa (zapaljenja ovojnice). Tendinopatija se dešava približno 2-6 cm iznad završetka tetive. Tetivni bol se javlja zbog visokih sila i dugotrajnog opterećenja. Kod tendinopatije javljaju se mikroskopska cijepanja na tetivi i tetivnoj ovojnici. Tetivni ožiljak počinje da se gomila. Osnovna funkcija ahilove tetive je da prenese snagu mišića koji je proizvode na kosti. Osim toga ona funkcioniše kao šok amortizer protiv spoljnih sila i spriječava oštećenje mišića. Ta funkcija zahtijeva određenu elastičnost, fleksibilnost i čvrstoću vlakana. Opterećenje u sprintu ahilove tetive može da dostigne 9 kN a 2,6 kN kod laganog trčanja (Lieberman i saradnici, 2009; Urhausen i Kindermann, 2002). Kod vršnih opterećenja tetiva može djelomično ili potpuno da pukne. Djelomično kidanje tetive može da bude prvog stepena (kada je pokidano 5 do 50% vlakana) i drugog stepena (kada je pokidano 50 do 80% vlakana). Tačka potpune rupture tetive nastaje kada se proteže 10 do 20% od njene početne dužine.

## CONCLUSION

Running is an integral part of many competitive sports. Walking and running are natural forms of exercise, one of the most appropriate ways of maintaining good physical fitness and wellness. There is ample evidence that walking and running reduces stress, lowers blood pressure and total blood cholesterol levels. These are all important reasons for the popularity of walking and running as a regular form of recreation, which in recent years continually growing. Nevertheless running have indisputably proven positive impact on human, in recreational and competitive sport we have noticed growing negative effects of wrong sport training, which usually results from unadjusted and to demanding exercise programs. Many injuries are also associated with different running content. Running can have also high load, especially for joints, ligaments, tendons and muscles of the lower extremities. As a result of excessive load number of injuries of the locomotor system can be seen: running knee, Achilles tendon tendinitis, iliotibial syndrome, plantar fasciitis, ankle sprain and other physiological-biochemical changes in the organism.

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## ZAKLJUČAK

Trčanje i hodanje su najčešće aerobne aktivnosti u rekreativnom sportu. Hodanje i trčanje su prirodni načini vježbanja, jedan od najprikladnijih načina održavanja dobre fizičke kondicije i blagostanja organizma. Postoje brojni dokazi da hodanje i trčanje smanjuje stres, snižava krvni pritisak u ukupan nivo holesterola u krvi. To su važni razlozi za popularnost hodanja i trčanja kao uobičajenog oblika rekreacije koji je posljednjih godina u stalnom porastu. Ipak, iako je neosporno da trčanje ima pozitivan uticaj na čovjeka, u rekretaivnom i takmičarskom sportu primjetili smo porast negativnih efekata pogrešnog sportskog treninga koji je obično rezultat neprilagođenog i zahtjevnog programa vježbanja. Mnogobrojne povrede su takođe povezane sa različitim sadržajem trčanja. Trčanje, takođe, može imati velika opterećenja, posebno za zglobove, ligamente, tetive i mišiće donjih ekstremiteta. Kao rezultat prekomjernog opterećenja mogu se vidjeti brojne povrede lokomotornog sistema: trkačko koljeno, tendinitis ahilove tetive, iliotibilani sindrom, plantrani fasciitis, uganuće skočnog zgloba i druge fiziološko-biohemijske promjene u organizmu.

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## PREOBREMENITVENI SINDROM PRI TEKU

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Tek kot gibalna dejavnost je genetsko pogojena. Osnovna strukturna enota teka je dvojni korak. Znotraj ciklusa tekaškega koraka se izmenjujeta oporni in zamašni fazi. Faza opore se začne v trenutku ko se stopalo dotakne podlage in konča, ko stopalo zapusti podlago. Moment vertikalne odzivne noge pa je tisti trenutek, ki loči ti dve fazi v dva dela. Prvi dotik stopala z podlago imenujemo faza sprednje opore, zadnji dotik stopala (odriv) pa zadnja opora. Med dvema opornima faza je faza leta tekača. Razdalja med dvema opornima fazam definira dolžino koraka. Poleg frekvence koraka je dolžina koraka najpomembnejši parameter teka. Dolžina in frekvenca korakov sta v obratnem sorazmerju in sta indivi-

dualno pogojena. Odvisna sta od značilnosti in sposobnosti tekača. Pri večji frekvenci je manjša dolžina koraka in obratno. Parameter dolžine koraka je odvisen od morfoloških značilnosti tekača, predvsem dolžine spodnjih ekstremitet, od sile reakcije podlage, od kontaktnega časa in odzivnega kota. Povprečna dolžina koraka rekreativnega tekača znaša 100 do 150 cm, vrhunškega tekača 150 do 220 cm. Frekvenca koraka, ki se manifestira z številom korakov v časovni enoti pa je odvisna od intra in intermišične koordinacije ter delovanja centralnega živčnega sistema, ki ureja gibanje agonističnih in antagonističnih mišičnih skupin (Donatti, 1995; Mero, Komi in Gregor, 1992; Novacheck, 1997). Razmerje med



dolžino korakov in frekvenco korakov je v veliki meri avtomatizirano in fiksirano v gibalnem programu centralnega živčnega sistema (Enoka, 2000). Lahko ugotovimo, da je model tehnike teka pri posameznem tekaču ne glede na stopnjo treniranosti zelo individualen.

Največja obremenitev na lokomotorni sistem se ustvarja prav v sprednji in zadnji oporni fazi. Vertikalna sila reakcije podlage pri teku znaša 2000 do 2500 Nevtonov, pri sprinterskem teku pa celo do 3500 Nevtonov (Cavagna, Komarek in Mazzoleni, 1971; Komi, Mero in Gregor, 1992). Pri hoji so sile reakcije podlage trikrat manjše kot pri teku (Novacheck, 1997). Hoja kot najosnovnejši gibalni vzorec lokomocije človeka se razlikuje od teka tudi glede faze leta. Pri hoji je človekovo telo vedno v kontaktu z enim stopalom s podlago, pri teku pa odzivu sledi letna (brez kontaktna faza). Kako veliko silo reakcije podlage ustvarja tekač je odvisno od njegove tehnike postavljanja stopala na tla. V osnovi obstajajo trije načini postavitve stopala pri teku (Hasegawa in sod., 2007; Lieberman in sod., 2009; Novacheck, 1997). Pri prvem načinu tekač postavlja stopalo na peto (RFS-rear foot strike), pri drugem načinu na srednji del (MFS-mid foot strike) in pri tretjem načinu na sprednji del (FFS-fore foot strike). Hasegawa s sod. (2007) je ugotovil, da 75 % tekačev maratoncev postavlja stopalo preko pete, 24 % jih teče preko celega stopala in samo 4 % postavlja stopalo na prste. Kateri od vzorcev teka je najbolj učinkovit dosedanje raziskave niso dale enotnega odgovora (Lieberman in sod., 2009). Vrhunske rezultate v maratonskem teku dosegajo tekači ne glede na modaliteto postavljanja stopal.

Z vidika biomehanike teka je učinkovitejša tehnika postavljanja stopala na sprednji zunanji del. Pri tem načinu deluje stopalo kot vzmet, ki deloma nevtralizira silo reakcije podlage. Kontakt s sprednjim delom stopala pa zahteva ustrezno koordinacijo in koaktivacijo sprednjih (m. tibialis) in zadnjih mečnih mišic m. gastrocnemius medialis in lateralis). Mečne mišice tako zagotovijo potrebno predaktivacijo-stiffness stopala (Komi, 2000). Pri pravočasno aktiviranem stopalu (50 milisekund pred dotikom) se izgubi bistveno manj energije kot pri pasivni postavitvi stopala na peto. Učinkovitost in ekonomičnost teka ni odvisna samo od produkcije kemične energije, ampak tudi od količine mehanske – elastične energije, ki se ustvarja v ekscentrični fazi (faza prvega kontakta stopala s podlago) tekaškega koraka. Racionalna tehnika teka pomeni optimalno kombinacijo izkoristka kemične in elastične energije. Glede na raziskave (Komi, Mero in Gregor, 1992; Komi in Nicol, 2002; Luhtanen in Komi, 1980) je delež kemične energije

75 %, elastične energije pa 25 % k skupni mehanski energiji pri teku.

Kljub dejstvu, da je tek ena najbolj učinkovitih in zdravih gibalnih dejavnosti človeka, predstavlja izjemno veliko obremenitev za lokomotorni sistem, zlasti za sklepe, kite, vezi in mišični sistem spodnjih ekstremitet. Negativni učinki športne vadbe, se kot "kolateralna škoda" manifestirajo v obliki raznih poškodb. Gre za akutne poškodbe, ki se zgodijo v določenem časovnem obdobju z znanim mehanizmom in krajem poškodbe. Drugi tip poškodb, gre predvsem za tekaške poškodbe pa so posledica preobremenitve gibalnega sistema, zlasti segmenta spodnjih ekstremitet. Spremembe se v začetku dogajajo običajno povsem neopazno, očitni simptomi z vsemi negativnimi posledicami za tekača se pojavijo relativno pozno. Prve znake preobremenjenosti pripisujejo tekači neogretosti, prevelikim obremenitvam, neugodnim zunanjim vplivom, nadaljujejo z športno aktivnostjo, težave niso ekstremno hude in nimajo značilnosti poškodb. Na težave, ki jih povezujemo z preobremenitvenim sindromom praviloma reagiramo pozno ali prepozno. Na gibalne strukture kot so mišice, kite, vezi, sklepni hrustanec, kosti, živčevje in žile pri teku neprestano delujejo mikro-travme in mikro-stresi. Najpogostejši zunanji vzroki pojava preobremenitvenega sindroma gibalnega sistema so: motorična priprava tekača, tehnika gibanja, hitre spremembe v intenzivnosti treninga, neustrezna konfiguracija terena, enostranska in prepogosta obremenitev gibalnih struktur, neustrezen odmor in regeneracija organizma, prevelike sile, ki delujejo na gibalni sistem, neustrezni klimatski pogoji in neustrezna oprema. Notranji i vzroki preobremenitvenega sindroma gibalnega sistema pa so lahko prirojeni ali pridobljeni. Praviloma so to morfološke značilnosti telesa, ki se manifestirajo anatomske strukturi gibal ali v različni stopnji asimetričnosti gibalnega sistema. Vzrok so lahko tudi biokemične spremembe v organizmu. Pomembno vlogo ima tudi starost tekača in spol. Vzrokov za preobremenitev gibalnega sistema je več, potrebno jih je pravočasno identificirati, analizirati in ustrezno ukrepati. Celoten proces odpravljanja tako zunanjih kot notranjih vzrokov za nastanek preobremenitev gibalnega sistema zahteva timski pristop, usmerjeno delo specialistov, ki vodijo trenajni proces. To so trenerji, fizioterapevti, maserji, zdravniki, ortopedi in kineziologi-specialisti trenajnega procesa. Kineziološka stroka in znanost imata lahko ključno vlogo pri zgodnji identifikaciji in preprečevanju pojava preobremenitvenega sindroma gibalnega sistema tekačev.

**Ključne besede:** tek, biomehanika, preobremenitev sindrom

## VALJANOST, POUZDANOST I OSJETLJIVOST TESTA UDARAC NOGOM - MAE GERI

### VALIDITY, RELIABILITY AND SENSITIVITY OF THE TEST STROKE WITH LEG - MAE GERI

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### SUMMARY

Specific motor abilities in modern sport are probably the determining factor for solving sports tasks and achieving sport success. Strokes with an arm and leg in karate sport are dominant techniques which help a karate athlete to score points or win a fight. Karate sport and particularly sports discipline fight (kumite) is characterized with poly structural movements, and the most important motor skills are explosiveness, speed and coordination. The subject of this research derives from the previous knowledge and arguments and it is directed toward determination of the measuring characteristics (reliability, sensitivity and validity) of the specific "Mae Geri" motor test.

The research has been conducted in the Republic of Macedonia with an intentional sample of 30 male examinees (karate athletes), at the age older than 18. During the research with the sample of examinees, 1 (one) manifest specific-motor variable (newly constructed composite test) was applied, characteristic for the karate sport. The aim of this research was to determine the measuring characteristics of the newly constructed test. Using the Hotelling method, the factor validity of this test was determined, as well as its latent dimensions, and the main component according to Kaiser-Gutman criterion were established. Based on the obtained results of the research, there have been some conclusions which refer to the measuring characteristics of the applied test, and primarily to the factor validity, sensitivity and reliability of the same

**Key words:** karate, Mae-Geri, measure characteristics.

### SAŽETAK

Specifične motoričke sposobnosti u modernom sportu vjerovatno su odlučujuć faktor u rešavanju sportskih zadataka i postizanju sportskog uspjeha. Udarci rukom i nogom u karate sportu su dominantne tehnike koje pomažu karatisti da osvaja poene ili pobjedi u borbi. Karate sport, a posebno sportsku disciplinu borba (kumite), karakterišu polustrukturalna kretanja, a kao najvažnije motorne sposobnosti ističu se eksplozivnost, brzina i koordinacija. Predmet ovog istraživanja proističe iz prethodnih znanja i argumenata, a usmjeren je ka određivanju mjernih karakteristika (pouzdanosti, osjetljivosti i valjanosti) specifičnog motoričkog testa "Mae Geri".

Istraživanje je rađeno u Republici Makedoniji na uzorku od 30 ispitanika (karatista), muškaraca, starijih od 18 godina. Tokom istraživanja na uzorku ispitanika primjenjena je jedna manifestna specifično-motorička varijabla (novokonstruisani složeni test), karakteristična za karate sport. Cilj ovog istraživanja bio je da se utvrde mjerne karakteristike novokonstruisanog testa. Korišćenjem Hotelling metode utvrđena je faktorska valjanost ovog testa kao i njegove latentne dimenzije, a uspostavljena je i glavna komponenta u skladu sa Kaiser-Gutman kriterijom. Na osnovu dobijenih rezultata istraživanja došlo se do zaključaka koji se odnose na mjerne karakteristike primjenjenog testa, a prije svega na faktor valjanost, osjetljivost i pouzdanost istog.

**Ključne riječi:** karate, Mae-Geri, mjerne karakteristike.

## INTRODUCTION

The karate sport, and particularly the fight (kumite) sport discipline, is characterized with poly structural movements, and the most significant motor abilities are explosiveness, velocity and coordination. The specific motor abilities in the modern sport are probably the crucial factor for solving sport tasks and achieving sport success. The arm and leg strokes in karate sport are dominant techniques that help the athlete to score points or win a fight. The poly structural movement characteristics in a karate fight (kumite) largely define the driving structure and its most important background motor characteristics: agility, explosiveness and speed. So far researches with modern technical and tactical indicators in karate fight show that different techniques have the greatest impact (Koropanovski, Dopsaj, & Jovanović 2008).

Some knowledge about the motor skills development level can be obtained by assessing various manifestations registered with appropriate motor tests, so-called measuring instruments. Since human motor skills are measured indirectly, the complete measuring procedure must be standardized, and motor tests (measuring instruments) should be characterized with satisfactory measurement characteristics such as: validity, reliability, sensitivity, accuracy and so on. In this case, the obtained results in a motor ability with a sample of respondents could be compared with the results obtained with another sample of respondents of the same capacity (Kostovski & Georgiev 2009a).

Major development of karate as a sport requires modern approaches, concepts, forms, activities and procedures in training the latest karate technologies, especially concerning the structure of anthropological features, their correlations and specific impacts on athletic performances. In addition, it is necessary to establish the diagnosis and the validity of the instruments used for modeling, diagnosis, planning, programming and monitoring of the effects of training process operationalization (Doder, Malacko, Stanković, & Doder, 2011).

Starting from this fact, some researches have been undertaken that refer to establishing tests for evaluation of some specific motor characteristics with karate athletes (Костовски 2005; Kostovski & Georgiev 2009b; Kostovski, Masić & Djukanović, 2011).

Some measurement instruments that showed as "good" for a population or sample, are not necessary "good" for other population or sample. Especially in a case when examinees are of different ages, different sex or have other different characteristics. According to this research problem, there is a need for constant checking of the measurement characteristics of the tests. In this regard Костовски (2004) conducted a research to determine the measurement characteristics of some standards and specific motor tests in karate athletes of a different chronological age. In

## UVOD

Karate sport, a posebno sportska disciplina borba (kumite), odlikuje se polistrukturalnim pokretima, a kao najznačajnije motoričke sposobnosti izdvajaju se eksplozivnost, brzina i koordinacija. Specifične motoričke sposobnosti u savremenom sportu su možda presudan faktor u rješavanju sportskih zadataka i postizanju sportskog uspeha. Udarci rukom i nogom u karate sportu su dominantne tehnike koje pomažu sportisti da skuplja poene ili pobjedi u borbi. Polustrukturalni pokreti koji karakterišu karate borbu (kumite) uveliko definišu strukturu pokreta i najvažnije motorne karakteristike koje stoje iza toga: agilnost, brzina i eksplozivnost. Dosadašnja istraživanja savremenih tehničkih i taktičkih pokazatelja karate borbe pokazuju da najveći uticaj imaju različite tehnike (Koropanovski, Dopsaj i Jovanović, 2008).

Neka saznanja o nivou razvoja motoričkih sposobnosti mogu se dobiti procjenom različitih ispoljavanja koje registrujemo odgovarajućim motoričkim testovima, tzv. mjernim instrumentima. Pošto se motorika čovjeka mjeri indirektno, cjelokupna procedura mjerenja mora da bude standardizovana, a testovi motorike (mjerni instrumenti) treba da karakteriše zadovoljavajuće mjerne osobine kao što su: validnost, pouzdanost, osjetljivost, tačnost i slično. U tom slučaju dobijeni rezultati neke motoričke sposobnosti na jednom uzorku ispitanika mogu se uporediti sa rezultatima koji utvrđenim na drugom uzorku ispitanika pod istim uslovima (Kostovski i Georgiev, 2009a).

Ozbiljan razvoj karatea kao sporta zahtijeva savremeni pristup, koncepte, obrazce, aktivnosti i postupke u treningu novijim karate tehnologijama, posebno u vezi sa strukturom antropoloških karakteristika i njihove korelacije i specifičnog uticaja na sportske vještine. Pored toga, neophodno je da se uspostavi dijagnoza i validnost instrumenata koji se koriste za modeliranje, dijagnostiku, planiranje, programiranje i praćenje efekata operacionalizacije trenažnog procesa (Doder, Malacko, Stanković i Doder, 2011).

Polazeći od te činjenice, mogu se uraditi određena istraživanja koje se odnose na utvrđivanje testova za procijenu nekih specifičnih motoričkih karakteristika u karate sportu (Костовски, 2005; Kostovski i Georgiev, 2009b; Kostovski, Masić i Đukanović, 2011).

Neki mjerni instrumenti koji su se pokazali kao "dobri" za jednu populaciju ili uzorak, ne znači da će biti "dobri" za drugu populaciju ili uzorak. To je posebno slučaj kod ispitanika različitog uzrasta, različitog pola i drugih različitih obilježja. Uskladu sa problemom ovog istraživanja postoji potreba za stalnom provjerom mjernih karakteristika testova. S tim u vezi Костовски (2004) je proveo istraživanje da se utvrde mjerne karakteristike nekih standardnih i

this regard Костовски (2004) conducted research to determine the measurement characteristics of some standard and specific motor tests in karate from a different chronological age.

Given the fact that the human motor reactions can be realized only with the assessment of motor skills through a variety of manifestations, they can be registered through various motor procedures - measuring instruments (Kostovski & Georgiev, 2009c)

Over the past period, researchers have used the existing tests for motor ability assessment of karate athletes (Koletić, 1992; Kuleš & Muratagić, 1993). However, these tests have not proved entirely specific to satisfy the needs of today's karate sport

The aforementioned conclusions point out the need for the implementation of new researches aimed for constructing and establishing new tests and checking their metric characteristics (Kostovski & Georgiev 2009c)

Since the application of diagnostic morphological characteristics and basic motor skills in the training process of karate athletes are related with interdisciplinary approach, where the complexity of movable structures and anthropological interdisciplinary characteristics of the character is high, it is necessary to include as many basic, specific and situational measuring instruments as possible. While for construction of instruments you have to bear in mind the information validity for each measuring instrument, which means that the applied instruments must have satisfactory measuring features, such as validity, objectivity, reliability, discrimination (Doder et al., 2011).

In order to conduct better kinesiology researches, in recent times measuring instruments have been used for registering and measuring specific motor ability manifestations (Sertić, Vidranski, & Segedi, 2010), and the athletes' training process has been largely planned, programmed and monitored

However, for a test to be valid and applicable it has to be reliable too. Knowledge of specific requirements in karate can help coaches, and even athletes to optimize the training program (Chaabène et. al., 2012).

Based on these considerations, this study was conducted with the main objective to identify, analyze and compare the measurement characteristics of the specific motor variable Mae Geri in top karate athletes.

## METHODS

### Sample of respondents

The research was covered with 30 karate athletes, standard and potential representatives from Macedonia, at the age of +18, defined as karate athletes-seniors. The research was realized on a target sample of male participants.

specifičnih motoričkih testova u karateu u različitim hronološkim uzrastima.

Obzirom na činjenicu da se ljudske motorne reakcije mogu ostvariti samo uz procjenu motoričkih sposobnosti u različitim ispoljavanjima, one se mogu zabilježiti kroz različite motoričke procedure - mjernim instrumentima (Kostovski i Georgiev, 2009c).

U prethodnom periodu istraživači su koristili postojeće testove za procjenu motoričkih sposobnosti karatista (Koletić, 1992; Kuleš i Muratagić, 1993). Međutim, ti testovi nisu se pokazali u potpunosti specifični da zadovolje potrebe današnjeg karate sporta.

Navedeni zaključci ukazuju na potrebu za provođenjem novih istraživanja u cilju konstruisanja i stvaranja novih testova i provjere njihovih metrijskih karakteristika (Kostovski i Georgiev, 2009c).

Pošto su primjena dijagnostičkih morfoloških osobina i osnovnih motoričkih vještina u procesu treninga karatista povezani sa interdisciplinarnim pristupom, gdje je složenost kretnih struktura i antropoloških interdisciplinarnih karakteristika ličnosti visoka, potrebno je uključiti što je moguće više osnovnih, specifičnih i situacionih mjernih instrumenata. Kod konstrukcije instrumenata mora se imati na umu informacija o valjanosti za svaki mjerni instrument, što znači da primjenjeni instrumenti moraju imati zadovoljavajuće mjerne karakteristike kao što su validnost, objektivnost, pouzdanost, diskriminantnost (Doder i saradnici, 2011)

U cilju da se omoguće bolja kineziološka istraživanja, u novije vrijeme koriste se mjerni instrumenti za registrovanje i mjerenje ispoljavanja specifičnih motoričkih sposobnosti (Sertić, Vidranski i Segedi, 2010), a proces treninga sportista u velikoj mjeri je planiran, programiran i nadgledan.

Ali, da bi jedan test bio validan i primjenljiv mora takođe da bude pouzdan. Znanja o specifičnim zahtjevima u karateu mogu pomoći trenerima, pa čak i sportistima, da optimizuju programa treninga (Chaabène i saradnici, 2012).

Na osnovu svega prethodno rečenog ovo istraživanje je sprovedeno sa glavnim ciljem da identifikuje, analizira i uporedi mjerne karakteristike specifične motorne varijable Mae Geri kod vrhunskih karatista.

## METODE

### Uzorak ispitanika

Tokom ovog istraživanja, obuhvaćeno je 30 karatista, potencijalnih i standardnih reprezentativaca Makedonije, starijih od 18 godina, profilisanih kao karatisti seniori. Istraživanje je sprovedeno na odabranom uzorku ispitanika muškog pola.

## Sample of variables

In this research on the sample of participants was applied 1 manifest specific motor variable for evaluating of the specific karate frequency of the more effective leg.

1. Stroke with leg on bag MAE GERI with the more effective leg in 10 s (MAEG)

## Test description

The test is performing in sport gym, in the gym where karate athletes have their training. For performing the test there must be a punching bag attached to the wall, and stopwatch with which the measure men will measure the time. The participant stands in front of the bag in characteristic fighting pose "fudo daci" on a distance which define himself according to the length of his leg. The sportsman task is to perform correct as much as possible more strokes "mae geri" with the effective leg in 10 seconds. The measure men stands on the side, turns on the stopwatch when the participant will start with the performance of the test and count the correct performed strokes in time of 10 seconds. The test is repeated 4 times with break between every repetition.

## Methods for data processing

The data's obtained from the manifested specific motor test, were processed with the necessary statistical methods which are in function of the goals and tasks of this research. In the data's processing the measurements of the specific motor test, for every composite repetition, were calculated the basic central and dispersive statistical parameters, arithmetic's mean ( $M$ ), standard deviation ( $SD$ ), minimal (Min), and maximal (Max) score. Based on symmetry of the distributions of the result it has been evaluated that some test represent easier or harder motor task for the participants (Skew.), and from the roundness of the distribution of the results it have been determine the homogeneity of the results in the same test (Kurt.). The sensitivity as measuring performance was determined by the relationship between the mean and standard deviation. For determent of the correlation between the items there was calculated Pierce coefficient of correlation ( $r$ ). Factor validity of the variables was determined with the Hotelling procedure, and there were calculated the latent dimensions of the variables, were the main components were determined by Kaiser-Guttman criteria, and there were obtained: item projections of the main component ( $H$ ), values of the isolated characteristic square root ( $\lambda$ ) and contribution of the isolated characteristic square roots in the explanation of the total variability

## Uzorak varijabli

Na uzorku ispitanika, u ovom istraživanju je primenjena jedna manifestna specifično motorička varijabla za procenu specifične karate frekvencije boljom nogom.

1. Udarac u vreću MAE GERI boljom nogom za 10 s (MAEG),

## Opis testa

Test se izvodi u sportskoj sali, odnosno u sali u kojoj karatisti treniraju. Za sprovođenje testa je potrebna bokserka vreća, zakačena na zidu i štoperica, kojom merač meri vreme. Ispitanik staje pred vreću u karakterističnom borbenom stavu "fudo daci", na odstojanju koje on sam određuje, na osnovu dužine svoje noge. Zadatak ispitanika je da pravilno izvede što je moguće veći broj udaraca "mae geri" boljom nogom, za vrijeme od deset sekundi. Mjerač stoji bočno od ispitanika, uključuje štopericu kada ispitanik počne sa izvođenjem testa i broji pravilno izvedene udarce za vreme od 10 sekundi. Test se ponavlja četiri puta, sa pauzom između svakog ponavljanja.

## Metode obrade podataka

Dobijeni rezultati mjerenja manifestnog specifično-motoričkog testa su obrađeni odgovarajućim statističkim metodima, koji su bile u funkciji postavljenog cilja i zadataka istraživanja. Tokom obrade rezultata mjerenja specifično-motoričkog testa, t.j. za svaku kompozitno ponavljanje, izračunate su sljedeće osnovne mjere centralne tendencije i dispercije: aritmetička sredina ( $M$ ), standardna devijacija ( $SD$ ), minimalni (Min) i maksimalni (Max) rezultat. Prema simetričnosti distribucije rezultata, procijenjeno je da li test predstavlja lak ili težak motorni zadatak ispitanika (Skew.), a prema zaobljenosti distribucije rezultata, utvrđena je homogenost rezultata u testu (Kurt.). Osjetljivost kao mjerna karakteristika je utvrđena prema odnosu između aritmetičke sredine i standardne devijacije. Za utvrđivanje povezanosti između ajtema, izračunat je Pirsonov koeficijent korelacije ( $r$ ). Faktorska validnost varijable utvrđena je Hotellingovim postupkom, kojom se utvrđuju latentne dimenzije varijable, gde je značajna glavna komponenta utvrđena prema Kaiser-Gutmanovom kriterijumu, pri čemu se dobijaju: projekcije ajtema prve glavne komponente ( $H$ ), vrijednosti izolovanih karakterističnih korijena ( $\lambda$ ) i doprinos izolovanih karakterističnih korijena u objašnjenju ukupnog varijabiliteta varijanse, izraženog u postotcima (%).

ty of the variance expressed in percents (%). Inter validity of the items was determined by the item projections of the first main component, or by the isolated characteristic square root ( $H$ ). The mutual subject of the measure was determined by the value of the characteristic square root ( $\lambda$ ). To determine the reliability there were calculated more coefficients and indexes of reliability, including: Cronbach index for reliability, calculated by the item projections with the first main component (Cronbach- $\alpha$ ), Spearman-brown coefficient of reliability ( $r_r$ ) - calculated on the base of middle correlations between composites measures for each test individually, and interclass correlation coefficient for every test individually ( $ICC$ ).

Interna validnost ajtema je utvrđena prema projekcijama ajtema prve glavne komponente, t.j. izolovanog karakterističnog korena ( $H$ ). Zajednički predmet mjerenja je utvrđen ako je izolovan jedan karakteristični korjen. Homogenost ajtema je utvrđena prema vrijednosti karakterističnog korjena ( $\lambda$ ). Za utvrđivanje relijabilnosti izračunato je više koeficijenata i indeksa relijabilnosti, među kojima se nalaze: Krombahov indeks varijabilnosti, izračunat prema projekcijama ajtema uz prvu glavnu komponentu (Cronbach- $\alpha$ ), Spirman-Braunov koeficijent pouzdanosti ( $r_r$ ) – izračunat na osnovu prosečnih korelacija između kompozitnih merenja, kao i koeficijent interne korelacije za svaki test posebno ( $ICC$ ).

## RESULTS AND DISCUSSION

Analyzing the values of the means of the four of the applied item of this variable, we can conclude next: in the first and fourth item there were achieved high results in relation with the rest two items, where there is moderate decline of the numbers of repetitions per unit time. All of the four values represent the real condition of the stability in terms of performing the treated test, and the small positive change which appears in these two items must be result of the motivation of the athletes, in performing of the first and fourth attempt to give their maximum. The test possesses relatively good discrimination, on which indicates the value of the variability, or the standard deviations.

## REZULTATI I DISKUSIJA

Analizom vrednosti aritmetičkih sredina četiri izmerenih ajtema može da se primeti sledeće: u prvom i četvrtom ajtemu su postignuti najviši rezultati u odnosu na ostala dva ajtema, gde postoji blago opadanje broja ponavljanja u jedinici vremena. Četiri izračunate vrednosti prikazuju stanje stabilnosti u odnosu na izvođenje testa. Pozitivna promena (minimalna), koja se pojavljuje u oba ajtema, daje rezultat kod motivisanosti samih sportista, da kod izvođenja prvog i četvrtog pokušaja daju svoj maksimum. Relativno dobra diskriminativnost testa koji je poseduje nam predočuje vrednosti varijabiliteta, odnosno standardnih devijacija.

**TABLE 1**

*Basic statistical parameters of the test Stroke with leg on bag - Mae Geri.*

**TABELA 1**

*Osnovni statistički parametri testa Udarac nogom u vreću - Mae Geri.*

	$n$	$M$	Min	Max	$SD$	Skew.	Kurt.
MAEG1	30	10.87	6	16	2.58	.22	-.80
MAEG2	30	9.43	5	16	2.53	.68	.44
MAEG3	30	9.47	5	15	2.40	.38	-.24
MAEG4	30	10.03	5	15	2.27	.09	-.97

Legend: **n** - Number of respondent (Broj ispitanika); **M** - Mean (Aritmetička sredina);

**Min** - Minimum (Minumum); **Max** - Maximum (Maksimum); **SD** - Standard deviation (Standardna devijacija); **Skew** - Skewness (Skjunis); **Kurt** - Kurtosis (Kurtozis);

**MAEG** - Stroke with leg on bag - Mae Geri (Udarac nogom u vreću - Mae Geri);

**1-4** - First, second, third and fourth repetition of the test (Prvo, drugo, treće i četvrto ponavljanja testa).

According to the tilt of the distribution of the results in the items, we can conclude that this test represents relatively easy task for the treated sample

Prema nagibu distribucije rezultata u ajtemama, moguća je konstatacija da ovaj test predstavlja relativno lak zadatak za tretirani uzorak ispitanika (aritmetičke

of participants (the mean of the four items is in the zone of middle results). For the four items of this test there was determined normal distribution of the results. The values of the correlation coefficient between the items are very high, positive and statistically significant with values of .87 to .95

sredine četiri ajtema u zoni srednjih rezultata). Za četiri ajteme u ovom testu utvrđena je normalna distribucija rezultata. Vrijednosti koeficijenta korelacije između ajtema su vrlo visoke, pozitivne i statistički značajne sa vrednostima od 0,87 do 0,95.

**TABLE 2**

*Matrix of item intercorrelation of the test Stroke with leg on bag - Mae Geri.*

**TABELA 2**

*Matrica interkorelacije ajtema na testu Udarac nogom u vreću - Mae Geri.*

	MAEG1	MAEG2	MAEG3	MAEG4
MAEG1	1.00			
MAEG2	.93	1.00		
MAEG3	.94	.94	1.00	
MAEG4	.95	.87	.89	1.00

Legend: **MAEG** - Stroke with leg on bag - Mae Geri (Udarac nogom u vreću - Mae Geri);

**1-4** - First, second, third and fourth repetition of the test (Prvo, drugo, treće i četvrto ponavljanja testa).

**TABLE 3**

*Hotelling procedure.*

**TABELA 3**

*Hotelingov postupak.*

	<i>H</i>	<i>T</i> <sup>2</sup>
MAEG1	.985	<b>.86</b>
MAEG2	.965	<b>.86</b>
MAEG3	.971	<b>.90</b>
MAEG4	.956	<b>.86</b>

**TABLE 4**

*Reliability coefficient.*

**TABELA 4**

*Koeficijent relijabilnosti.*

$\alpha$	.977
$r_n$	.978
<i>ICC</i>	.923
$\lambda$	3.757
%	93.915

Legend: **MAEG** - Stroke with leg on bag - Mae Geri (Udarac nogom u vreću - Mae Geri);

**1-4** - First, second, third and fourth repetition of the test (Prvo, drugo, treće i četvrto ponavljanja testa); **H** - Item projections of the main component (Projekcije ajtema prve glavne komponente); **T**<sup>2</sup> - Hotelling's multivariate test (Hotelingov multivarijantni test);  $\alpha$  - Cronbach's index of internal consistency (Korombahov indeks unutrašnje konzistentnosti);  $r_n$  - Spearman-Brown coefficient of reliability (Spirman-Braunov koeficijent pouzdanosti); **ICC** - Interclass correlation coefficient (Koeficijent interne korelacije);  $\lambda$  - Characteristic square root (Karakteristični korijen); % - Variance expressed in percents (Varijabiliteta varijanse izraženog u postotcima).

In this variable there was determined that the all four items have mutual subject of measure, and relatively higher homogeneity of this variable, indicating on the value of the isolated characteristic square root of the first main component  $\lambda = 3.757$  and explains

Kod ove varijable utvrđeno je da četiri ajteme imaju jedan zajednički predmet mjerenja i relativno visoku homogenost, na šta nas upućuje vrijednost izolovanog karakterističnog korijena prve glavne komponente  $\lambda = 3,757$  i objašnjava 93,915 % ukupnog varijabiliteta

93.915 % of the total variability of the variance. The reliability coefficients (Cronbach  $\alpha = .977$  and Spearman-Brown = .978) are very high and with satisfying values, as for the inter correlation which is .923. According to the above mentioned for the variable "Mae Geri", we can say that: the test features with high degree of sensitivity and satisfying reliability coefficient. Also the test is simple for application and easy for explanation.

According to Bukvić (1982) every reliability coefficient with value bigger than .80 indicates to high reliability of the tests, and values bigger than .90 indicates on very high reliability.

## CONCLUSION

The research was conducted on target sample of 30 participants (karate athletes), males from Macedonia, at the age of + 18 (karate athletes-seniors). On the sample of participants was applied 1 (one) manifest specific motor variable (newly constructed composed test), characteristic for the karate sport.

The obtained results from the research lead us to the following conclusions which concern the measuring performance of the applied variable, and before all, the factor validity, sensitivity and reliability of the same.

The test "Mae Geri" features with high degree of sensitivity and satisfying reliability coefficients, which means that the eventual error in the measurements is very small.

- The reliability coefficients (Cronbach  $\alpha = .977$  and Spearman-Brown = .978) are very high and with satisfying values, as for the inter correlation which is .923. Also the test is simple for application and easy for explanation.

The test evaluates the motor dimensions defined as specific karate frequency of the lower extremities.

From the obtained results, the test should be recommended in the training technology and selection of the karate athletes in the test battery for evaluating of the specific karate frequency of the lower extremities (until constructing a new test).

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varijanse. Koeficijenti relijabilnosti (Cronbach  $\alpha = 0,977$  i Spearman-Brown = 0,978) imaju vrlo visoke i zadovoljavajuće vrednosti, kao i internu korelaciju koja iznosi 0,923. U odnosu na ono što je do sada izneseno za varijablu "Mae geri", može se reći sledeće: Test se odlikuje visokim stepenom osetljivosti i zadovoljavajućim koeficijentima varijabilnosti. Takođe, test je jednostavan za primenu i lak za objašnjenje.

Prema Bukviću (1982) svaki koeficijent varijabilnosti vrednosti veće od 0,80 ukazuje na visoku varijabilnost testova, a vrednosti veće od 0,90 ukazuju na vrlo visoku varijabilnost.

## ZAKLJUČAK

Izvršeno je istraživanje odabranog uzorka od 30 ispitanika (karatista), uzrasta starijih od 18 godina (karatisti seniori), muškog pola, u Makedoniji. Na primerku ispitanika je primenjena jedna manifestna specifično-motorna varijabla (novokonstruisani kompozitni test), karakteristična za karate sport.

Dobijeni rezultati iz ovog istraživanja ukazuju na zaključke koji se odnose na mjerne karakteristike primenjene varijable, a prije svega na njenu faktorsku validnost, osetljivost i relijabilnost.

Test "Mae geri" se odlikuje faktorskom validnošću, visokim stepenom osetljivosti i zadovoljavajućim koeficijentima varijabilnosti, što znači da je eventualna pogreška u merenju veoma mala.

Koeficijenti varijabilnosti (Cronbach  $\alpha = 0,977$  i Spearman-Brown = 0,978) su sa vrlo visokim i zadovoljavajućim vrijednostima, kao i interna korelacija koja iznosi 0,923. Takođe, test je jednostavan za primjenu i lak za objašnjenje.

Test procjenjuje motoričku dimenziju, definisanu kao specifična karate frekvencija donjih ekstremiteta.

Na osnovu dobijenih rezultata, test se preporučuje u trenajnoj tehnologiji i selekciji karatista u bateriji testova za procjenu specifične karate frekvencije donjih ekstremiteta (do konstruisanja novog testa).

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## ВАЛИДНОСТ, РЕЛИЈАБИЛНОСТ И ОСЕТЛИВОСТ НА ТЕСТОТ УДАР СО НОГА "МАЕ ГЕРИ"

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Специфичните моторички способности во современиот спорт се можеби пресуден фактор за решавање на спортските задачи и постигнување на спортскиот успех. Ударите со рака и нога во карате спортот се доминантните техники со кои каратистот ги добива поените или борбата. Карате спортот а особено спортската дисциплина борба (кумите) ја карактеризираат полиструктурални движења, а како најзначајни моторички способности се издвојуваат, експлозивноста, брзината и координацијата. Во изминатите периоди истражувачите користеле постоечки тестови за проценка на моторните способности кај карате спортистите (Колетиќ, 1992.; Кулеш, Муратагиќ, 1993.), кои во целост не се покажаа доволно специфични за да ги задоволат потребите на денешното спортско карате. Тргувајќи од овие аргументи, се превземаат истражувања кои се однесуваат на утврдување на тестови за проценка на специфичните моторни карактеристики кај карате-спортисти (Костовски 2004; Костовски и Георгиев 2009; Костовски, Машиќ и Ѓукановиќ, 2010). Со цел спроведување што е можно подобри кинезиолошки истражувања. Во поново време се користат мерни инструменти за регистрирање и мерење на манифестирањето на специфичните моторичките способности (Сертиќ, Видрански и Сегеди, 2008), а во голема мера да се планира, програмира, следи и контролира тренажниот процес на спортистите. Од досегашните сознанија и аргументи произлегува предметот на ова истражување кој се движи во насока на утврдување на мерните карактеристики (релијабилност, осетливост и валидност) на специфично моторниот тест "Мае гери". При ова истражување опфатени се 30 карате-спортисти (намерен примерок на испитаници од машки пол) потенцијални и стандардни репрезентативци на Р. Македонија, постари од 18 години, дефинирани како карате-спортисти сениори. На примерокот испитаници, во ова истражување, применета е 1 (една) манифестна специфично моторна варијабла за проценка на

специфичната карате фреквенција со протежирана нога.

Тестот се изведува во спортска сала односно во салата каде каратистите вежбаат. За изведување на тестот потребно е да се има боксерска вреќа закачена на ѕид, и штоперица со која мерачот го мери времето. Испитаникот застанува пред вреќата во карактеристичен борбрен став "фудо дачи" на растојание кое самиот го одредува според неговата должина на ногата. Задача на испитаникот е да изведе правилно што е можно поголем број на удари "мае гери" со подобрата нога за време од десет секунди. Мерачот стои бочно од испитаникот, ја вклучува штоперицата кога испитаникот ќе почне со изведување на тестот и ги брои правилно изведените удари за време од 10 секунди. Тестот се повторува четири пати со пауза помеѓу секое повторување.

Добиените резултати од мерењето на манифестниот специфично моторички тест, обработени се со адекватни статистички методи кои се во функција на поставената цел и задача на истражувањето. Пресметани се мерките на централна тенденција и дисперзија: аритметичка средина ( $M$ ), стандардна девијација ( $SD$ ), минимален ( $Min$ ) и максимален ( $Max$ ) резултат. Според симетричност на дистрибуцијата на резултатот проценето е дали тестот претставува лесна или тешка моторна задача на испитаници ( $Skew.$ ), а според заобленоста на дистрибуцијата на резултатите утврдена е хомогеност на резултатите во тестот ( $Kurt.$ ). За утврдување на поврзаноста меѓу ајтемите пресметан е Пирсоновиот коефициент на корелација ( $r$ ). Факторската валидност на варијаблата утврдена е со Хотелинговата постапка, со што утврдени се латентните димензии на варијаблата, каде што значајната главна компонента утврдена е според Каисер-Гутмановиот критериум, при што добиени се: проекциите на ајтемите на првата главна компонента ( $H$ ), вредностите на изолираните карактеристични корени ( $\lambda$ ) и придонесот на изолираните карактеристични

корени во објаснувањето на вкупниот варијабилитет на варијансата изразен во проценти (%). За утврдување на релијабилноста пресметани се повеќе коефициенти и индекси на релијабилност меѓу кои: Кромбаховиот индекс на релијабилност, (Cronbach- $\alpha$ ), Spearman-Brown коефициент ( $r_{\text{SB}}$ ) на релијабилност, како и интерната корелација на тестот (ICC).

Резултатите добиените од ова истражување, укажуваат на заклучоци кои се однесуваат на мерните карактеристики на применетата варијабла, а пред се на факторската валидност, осетливоста и релијабилноста на истата.

- Тестот "Мае гери", се одликува со факторска валидност, висок степен на осетливост и задоволителни коефициенти на релијабилност, што значи дека евентуалната погрешка во мерењето е многу мала.

- Коефициентите на релијабилност (Cronbach  $\alpha = .977$  и Spearman-Brown = .978) се со многу високи и задоволителни вредности, какао и интерната корелација која изнесува .923. Истотака тестот е едноставен за примена и лесен за објаснување.
- Тестот ја проценува моторичката димензија дефинирана како специфична карате фрекфрентност на долните екстремитети
- Врз основа на добиените резултати тестот се препорачува во тренажната технологија и селекцијата на каратистите во батеријата на тестови за проценка на специфичната карате фрекфрентност на долните екстремитети (до конструирање на подобар тест).

**Клучни зборови:** карате, факторска валидност, хотрлингова постапка, латентни димензии.

## GUIDELINES FOR AUTHORS

### Journal intention

SportLogia journal covers the areas of sports and physical education. It is issued twice a year and publishes original scientific papers, reviewed scientific papers, scientific gathering presentations, short scientific articles and professional articles from the area of sports, physical education, recreation, kinesiology anthropology, training methods, sport biology and exercise, sport medicine, biomechanics, sport history and sport management as well as contributions from other sciences (medicine, sociology, psychology, philosophy, exact sciences and mathematics) applied in sports.

### General remarks on papers

All manuscripts are submitted to the journal's editors, who, after reading the manuscripts, decide about the further procedure: (1) the manuscript is immediately sent for review; (2) if there are any objections and suggestions, the manuscript is sent back to the author for corrections; (3) rejection of the manuscript. The editor may decline the manuscript in the following cases: (1) the topic of the manuscript is not relevant; (2) a manuscript with a similar topic has already been published in the journal; (3) the manuscript does not conform to the standards of the journal. If the manuscript is not accepted, a short notice is sent to the author, but the manuscript is not sent back. The process of preliminary evaluation lasts up to 4 weeks.

If the author has corrected the text in accordance with the instructions from the editor, the manuscript is sent for review. In that case, the author will be given a form called *Copyrights Declaration*, which needs to be filled in and sent back to the editor. The signature of the author verifies the authenticity of the text, authorship and acceptance of the review procedure.

All articles must be reviewed. There will be two reviewers from the relevant scientific area for each article, and both reviews will be anonymous. The author's name will be unknown to the reviewers (double blind review). If a reviewer finds the article noncompliant with the criteria of the journal, the editorial will not accept the article. The review process lasts 8 to 12 weeks. If, on the other hand, the reviewers find the article acceptable, it will be put in one of the following categories:

- *Original scientific paper* is a first publication of original research results in a form that the research can be repeated, and the asserted facts verified. It is organized in accordance with the IMRAD

## UPUTSTVO AUTORIMA

### Namjera časopisa

Časopis SportLogia iz oblasti sporta i fizičkog vaspitanja izdaje se dva puta godišnje i objavljuje izvorne naučne članke, pregledne naučne članke, kratke naučne članke, izlaganje sa naučnog skupa i stručne članke iz područja sporta i sportskih aktivnosti, fizičkog vaspitanja, rekreacije, kineziološke antropologije, trening metoda, biologije sporta i vježbanja, sportske medicine, biomehanike, istorije sporta i menadžmenta u sportu kao i priloge iz drugih nauka (medicine, sociologije, psihologije, filozofije, prirodnih nauka i matematike) primjenjenih na sport.

### Opšte odredbe o priložima

Svi rukopisi dostavljaju se uredništvu časopisa koji, nakon što ih pročita, određuje dalji postupak: (1) odmah šalje rukopis na recenziju; (2) ako ima određenih primjedbi i sugestija, rukopis vraća autoru na doradu; (3) odbija rukopis. Urednik može da odbije rukopis u sledećim slučajevima: (1) tema koju obrađuje rukopis nije relevantna; (2) rukopis sa sličnom temom već je objavljen u časopisu; (3) rukopis ne ispunjava standarde časopisa. Ukoliko rukopis nije prihvaćen, autoru se šalje kratko obavještenje, ali rukopis se ne vraća. Proces preliminarne evaluacije traje do 4 sedmice.

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Svi članci obavezno podliježu recenziji. Za svaki članak predviđena su dva recenzenta iz relevantne naučne oblasti i oba su anonimna (Imena autora takođe su i za recenzente anonimna (double blind recension). Ukoliko članak, prema mišljenju recenzenta, ne zadovoljava kriterije časopisa, uredništvo članak ne prihvata. Postupak recenzije traje 8 do 12 sedmica. Ukoliko pak recenzenti pozitivno ocjene članak, svrstavaju ga u jednu od kategorija:

- *Izvorni naučni članak* predstavlja prvu objavu originalnih istraživačkih rezultata u takvom obliku da istraživanje može da se ponovi, a utvrđene činjenice da se provjere. Organizovan je po šemi IMRAD za eksperimentalna istraživanja

scheme for experimental research or in a descriptive way for descriptive science areas.

- *Scientific work review* is a review of papers on a specific topic, works of an individual researcher or a group of researchers whose aim is to summarize, analyze, evaluate or synthesize already published information. It brings new syntheses which also include results of author's own research.
- *Short scientific article* is an original scientific article which may skip some elements of IMRAD. It concisely presents results of a completed own research or of an ongoing research.
- *Scientific gathering presentation* is a comprehensive article that has previously been briefed to a scientific gathering, but it has not been published in its comprehensive form in the Paper Collection Book of the gathering.
- *Professional article* is a review of something that is already known, with an emphasis on the usability of the results of the original research and the spread of knowledge. The complexity of the text is adjusted to the needs of the professional and scientific aspects of the journal.

After reviews have been done, the editorial board will analyze them. If needed, the paper is sent back to the author who must comply with the suggestions and objections made by the reviewers. Once they have redone the paper, the authors need to specifically describe, on a *separate sheet of paper*, how they have resolved the reviewer's suggestions.

Only those papers that have been placed in one of the categories and which have *two positive reviews* will be published.

## Text style and organization

Scientific articles must adhere to the IMRAD scheme (Introduction, Methods, Results and Discussion).

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The title page of the manuscript should contain the following information: (1) a concise, but informative title. Use of abbreviations is not encouraged; (2) the author's names (do not include degrees); the last one is introduced by "&"; (3) the affiliation of the authors, town and state; (4) the name and address of the corresponding author (must include title, degree and position of the corresponding author, phone and fax numbers – zip code for the country and city, and email address).

### Summary, large summary and key words

The summary should be brief and Self-explanatory. It should cover a general presentation of the topic (the

ili na deskriptivan način za deskriptivna naučna područja.

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- *Stručni članak* predstavlja prikaz već poznatog, s naglaskom na upotrebljivost rezultata izvornih istraživanja i širenja znanja, a zahtijevnost teksta prilagođena je potrebama stručnosti i naučnosti časopisa.

Nakon primljenih recenzija uredništvo ih analizira. Ukoliko je to potrebno, rad se vraća autoru koji je dužan uvažiti sugestije i primjedbe recenzenata. Kada preradi svoj rad autor-i treba da, na *posebnoj listu papira*, konkretno navedete kako su razriješili sugestije vezane za recenziju.

Objavljuju se samo radovi koji su svrstani u jednu od kategorija i koji *imaju dvije pozitivne recenzije*.

## Stil i organizacija teksta

Naučni članci se organizuju po šemi IMRAD (Introduction, Methods, Results, i Discussion).

### Naslov rada

Naslov rada treba da sadrži sledeće informacije: (1) kratak ali informativan naslov u kome se ne preporučuje korištenje skraćenica; (2) ime autora bez titule gdje se ispred poslednjeg autora stavlja "i"; (3) institucija u kojoj autor-i radi, grad i država; (4) ime i adresa autora predviđenog za korespondenciju (naučno zvanje, položaj, broj telefona i faksa, poštanski broj grada, državu i e-mail adresu).

### Sažetak, veliki sažetak i ključne riječi

Sažetak treba da bude kratak i razumljiv sam po sebi. U sažetku se ne treba pozivati na tekst članka.

purpose and the objective of the paper), results and conclusions. Authors should not use abbreviations. The abstract should include 150-250 words. Authors from abroad write the large summary in their native language (the summary has to be reviewed), and the authors whose native language is BCS write the mentioned summary in one of the official languages of the IOC Assembly (article 27 of Olympic Charter), except English. The translation should be made by relevant person.

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Units of measurement, symbols and abbreviations must conform to international standards. Measurements of length, height, weight and volume should be given in metric units (meter, kilogram, liter).

## Results

The results should be presented as tables, graphs and pictures, possibly processed statistically and be concisely presented in the text.

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The authors are expected here to comment on the results and compare them with literature data. The discussion must be professional and correspond to experimental data. Practical implications are welcome.

## Conclusion

Contains clearly stated scientific assertions, open issues and recommendations for further research.

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Each table and any illustration (black and white only) must be submitted on a separate sheet of paper. Tables should be numbered in the order in which they

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Potrebno je izdvojiti i dati tri do šest ključnih riječi koje se ne nalaze u naslovu. Ključne riječi moraju da odražavaju suštinu sadržaja rada.

## Uvod

Ovaj dio rada treba da informiše čitaoca o problemima datog istraživanja i rezultatima prethodnih analiza. Cilj istraživanja takođe treba jasno navesti u ovom dijelu.

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Ovaj dio treba da se sastoji od sledećih podnaslova: uzorak entiteta, varijable, procedure testiranja, statistička analiza.

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## Rezultati

Rezultati bi trebalo da budu predstavljeni kroz, tabele, grafikone i slike, statistički obrađene i koncizno interpretirane.

Tabele, grafikoni i slike koje pokazuju rezultate pojedinih analiza trebaju da budu naznačene u tekstu kako bi se pažnja čitaoca skrenula na njih.

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## Zaključak

Sadrži jasno izrečene naučne tvrdnje, otvorena pitanja i preporuke za daljnja istraživanja.

## Tabele, grafikoni i slike

Svaka tabela, grafikon i slika (samo u crno bijeloj tehnici) treba da bude dostavljena na posebnom listu papira. Tabele treba da budu numerisane po redosli-

occur in the text and referred to as, for example, "Table 1.". Each table should be accompanied by a short title. Tables should be accompanied with interpretations (legends). It will also be deemed informative if the tables include indications of important correlations and relevant variables. Tables should be submitted separately

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Ilustracije, grafikoni i slike obilježavaju se sa "Slika 1". Fotografije se šalju u elektronskoj formi u rezuliciji najmanje 300 dpi i formatu .tif (slike) i .eps (grafike). Svaka slika treba da ima kratak naslov. U slučaju da su slike preuzete iz nekog drugog rada, u naslovu ne bi trebalo da se nalazi originalni naziv. U takvom slučaju potrebno je da se ispod slike nalazi Izvor odakle je slika preuzeta.

Ukoliko tabele, grafikoni i slike sadrže posebne znakove, te su rađeni u posebnom programu, dostavljaju se na posebnom fajlu, sa tačno navedenim rasporedom po kojem se uključuju u tekst.

## Tehničko oblikovanje članka

Članci se pišu i štampaju latiničnim pismom, po potrebi i drugim pismima, na srpskom (ijekavica) i engleskom jeziku. Svako odstupanje od navedenog, treba posebno unaprijed dogovoriti s Uredništvom. Ako se radi o autorima kojima maternji jezik nije srpski, hrvatski ili bošnjački njihove radove na srpski prevodi uredništvo. Autori su dužni da prilikom prevođenja rada na engleski jezik angažuju stručne osobe, najbolje one kojima je maternji jezik engleski.

Tekstovi se pišu u Microsoft Word Windows programu, na papiru A4 formata. Tekst se piše u Times New Roman fontu, veličine 12 pt u proredu 1,5, poravnat sa obje strane, sa uvlačenjem prvog reda pasusa od 1 tab, sa marginama papira 2,5 cm. Ukoliko je u tekstu potrebno posebno označiti neku riječ ili rečenicu, koriste se kosa slova (italik). Obim teksta treba da sadrži do 15 strana. Uredništvo može prihvatiti i malo duže radove ali će to činiti rijetko.

Članke i sažetke treba pisati u trećem licu, neutralno, pridržavajući se dobrog stila i utvrđenih jezičkih normi.

## Literatura

Časopis koristi Harvard reference system APA standard kod navođenja literture.

## Slanje radova

Radovi se šalju putem direktnog logovanja na web stranici časopisa <http://www.sportlogia.com>. U slučaju da trebate dodatne informacije molimo vas da se obratite na e-mail adresu [kri.pan@hotmail.com](mailto:kri.pan@hotmail.com).

## GUIDELINES FOR AUTHORS

### Journal intention

SportLogia journal covers the areas of sports and physical education. It is issued twice a year and publishes original scientific papers, reviewed scientific papers, scientific gathering presentations, short scientific articles and professional articles from the area of sports, physical education, recreation, kinesiology anthropology, training methods, sport biology and exercise, sport medicine, biomechanics, sport history and sport management as well as contributions from other sciences (medicine, sociology, psychology, philosophy, exact sciences and mathematics) applied in sports.

### General remarks on papers

All manuscripts are submitted to the journal's editors, who, after reading the manuscripts, decide about the further procedure: (1) the manuscript is immediately sent for review; (2) if there are any objections and suggestions, the manuscript is sent back to the author for corrections; (3) rejection of the manuscript. The editor may decline the manuscript in the following cases: (1) the topic of the manuscript is not relevant; (2) a manuscript with a similar topic has already been published in the journal; (3) the manuscript does not conform to the standards of the journal. If the manuscript is not accepted, a short notice is sent to the author, but the manuscript is not sent back. The process of preliminary evaluation lasts up to 4 weeks.

If the author has corrected the text in accordance with the instructions from the editor, the manuscript is sent for review. In that case, the author will be given a form called *Copyrights Declaration*, which needs to be filled in and sent back to the editor. The signature of the author verifies the authenticity of the text, authorship and acceptance of the review procedure.

All articles must be reviewed. There will be two reviewers from the relevant scientific area for each article, and both reviews will be anonymous. The author's name will be unknown to the reviewers (double blind review). If a reviewer finds the article noncompliant with the criteria of the journal, the editorial will not accept the article. The review process lasts 8 to 12 weeks. If, on the other hand, the reviewers find the article acceptable, it will be put in one of the following categories:

- *Original scientific paper* is a first publication of original research results in a form that the research can be repeated, and the asserted facts verified. It is organized in accordance with the IMRAD

## UPUTSTVO AUTORIMA

### Namjera časopisa

Časopis SportLogia iz oblasti sporta i fizičkog vaspitanja izdaje se dva puta godišnje i objavljuje izvorne naučne članke, pregledne naučne članke, kratke naučne članke, izlaganje sa naučnog skupa i stručne članke iz područja sporta i sportskih aktivnosti, fizičkog vaspitanja, rekreacije, kineziološke antropologije, trening metoda, biologije sporta i vježbanja, sportske medicine, biomehanike, istorije sporta i menadžmenta u sportu kao i priloge iz drugih nauka (medicine, sociologije, psihologije, filozofije, prirodnih nauka i matematike) primjenjenih na sport.

### Opšte odredbe o priložima

Svi rukopisi dostavljaju se uredništvu časopisa koji, nakon što ih pročita, određuje dalji postupak: (1) odmah šalje rukopis na recenziju; (2) ako ima određenih primjedbi i sugestija, rukopis vraća autoru na doradu; (3) odbija rukopis. Urednik može da odbije rukopis u sledećim slučajevima: (1) tema koju obrađuje rukopis nije relevantna; (2) rukopis sa sličnom temom već je objavljen u časopisu; (3) rukopis ne ispunjava standarde časopisa. Ukoliko rukopis nije prihvaćen, autoru se šalje kratko obavještenje, ali rukopis se ne vraća. Proces preliminarne evaluacije traje do 4 sedmice.

Ukoliko je autor usvojio primjedbu urednika i preradio tekst u skladu sa sugestijama, rukopisi se šalju na recenziju. U tom slučaju autoru se šalje formular *Izjava o autorskim pravima*, koju treba ispuniti, potpisati i vratiti uredniku. Svojim potpisom autor potvrđuje izvornost članka, svoje autorstvo i prihvatanje recenzentskog postupka.

Svi članci obavezno podliježu recenziji. Za svaki članak predviđena su dva recenzenta iz relevantne naučne oblasti i oba su anonimna (Imena autora takođe su i za recenzente anonimna (double blind recension). Ukoliko članak, prema mišljenju recenzenta, ne zadovoljava kriterije časopisa, uredništvo članak ne prihvata. Postupak recenzije traje 8 do 12 sedmica. Ukoliko pak recenzenti pozitivno ocjene članak, svrstavaju ga u jednu od kategorija:

- *Izvorni naučni članak* predstavlja prvu objavu originalnih istraživačkih rezultata u takvom obliku da istraživanje može da se ponovi, a utvrđene činjenice da se provjere. Organizovan je po šemi IMRAD za eksperimentalna istraživanja



scheme for experimental research or in a descriptive way for descriptive science areas.

- *Scientific work review* is a review of papers on a specific topic, works of an individual researcher or a group of researchers whose aim is to summarize, analyze, evaluate or synthesize already published information. It brings new syntheses which also include results of author's own research.
- *Short scientific article* is an original scientific article which may skip some elements of IMRAD. It concisely presents results of a completed own research or of an ongoing research.
- *Scientific gathering presentation* is a comprehensive article that has previously been briefed to a scientific gathering, but it has not been published in its comprehensive form in the Paper Collection Book of the gathering.
- *Professional article* is a review of something that is already known, with an emphasis on the usability of the results of the original research and the spread of knowledge. The complexity of the text is adjusted to the needs of the professional and scientific aspects of the journal.

After reviews have been done, the editorial board will analyze them. If needed, the paper is sent back to the author who must comply with the suggestions and objections made by the reviewers. Once they have redone the paper, the authors need to specifically describe, on a *separate sheet of paper*, how they have resolved the reviewer's suggestions.

Only those papers that have been placed in one of the categories and which have *two positive reviews will be published*.

## Text style and organization

Scientific articles must adhere to the IMRAD scheme (Introduction, Methods, Results and Discussion).

## Title

The title page of the manuscript should contain the following information: (1) a concise, but informative title. Use of abbreviations is not encouraged; (2) the author's names (do not include degrees); the last one is introduced by "&"; (3) the affiliation of the authors, town and state; (4) the name and address of the corresponding author (must include title, degree and position of the corresponding author, phone and fax numbers – zip code for the country and city, and email address).

## Summary, large summary and key words

The summary should be brief and Self-explanatory. It should cover a general presentation of the topic (the

ili na deskriptivan način za deskriptivna naučna područja.

- *Pregledni naučni članak* predstavlja pregled najnovijih radova o određenom predmetnom području, radova pojedinog istraživača ili grupe istraživača sa ciljem da se već publikovane informacije sažmu, analiziraju, evaluiraju ili sintetizuju. Donose nove sinteze koje, takođe, uključuju i rezultate sopstvenog istraživanja autora.
- *Kratki naučni članak* predstavlja izvorni naučni članak kod kojih neki elementi šeme IMRAD mogu da budu ispušteni. Ukratko sažima rezultate završenog izvornog istraživačkog rada ili rada koje je još u toku.
- *Izlaganje sa naučnog skupa* predstavlja cjelovit članak koji je prethodno referisan na načnom skupu, ali u obliku cjelovitog članka nije objavljen u zborniku naučnog skupa.
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jedu kojim se pojavljuju u tekstu i označena kao npr. "Tabela 1". Svaka tabela treba da ima kratak naslov. Potrebno je dodati legende za tabele. Takođe bilo bi informativno ako bi se u tabelama naznačile značajnije korelacije i značajnije varijable. Tabele treba posebno priložiti.

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