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The Effects of Plyometric Training on Motor Skills of Top Volleyball Players

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Abstract: *The plyometric method is ranked among the most commonly used methods for fitness volleyball training. It leads to the development of explosive strength and reactive velocity of the muscular system based on improving the CNS response and the power required to absorb the stress when landing. The study was of longitudinal type, involving two measurements, an initial measurement for all subjects to determine the initial level of motor ability, and a final measurement where the effects of the experimental program were studied after a programmed experimental process to develop specific motor skills of the analyzed sample of subjects. The entire study was conducted on a sample of 72 senior subjects, which were divided into two sub-samples, one sub-sample comprised of the experimental group and the other comprising the control group. The primary objective of the research was to test the influence and effect of special treatment of kinesiological activities based on plyometric exercises on the motor skills of the subjects.*

Keywords: *Volleyball, plyometric training, the effects of programmed exercise.*

Introduction

Management of training technology primarily refers to the problem of management during the transformative process of sports training and is based on the fact that when bringing athletes from the initial (initial, current) state to some newly formed (transitive, final) state, which is generally higher level, it results in the adaptation of athletes to conditions that consist of constantly changing and directing towards achieving the greatest possible sports performance in a certain time interval (Fratric, 2012). This approach to optimizing technological training process requires the establishment of relations, on one hand, modeled sports ac-

Efekti pliometrijskog treninga na motoričke sposobnosti vrhunskih odbojkaša

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Apstrakt: *Pliometrijska metoda je rangirana među najčešće korišćenim metodama za kondicione vežbe u odbojci. Ona dovodi do razvijanja eksplozivne snage i reaktivne brzine mišićnog sistema zasnovanih na poboljšanju reakcije CNS-a i snage koja je potrebna za apsorbovanje stresa prilikom doskoka. Istraživanje je bilo longitudinalnog karaktera, gde su se podrazumevala dva merenja, inicijalno merenje da se utvrdi početni nivo motoričkih sposobnosti, i finalno merenje gde su se ispitivali efekti uticaja eksperimentalnog programa nakon programiranog eksperimentalnog procesa za razvijanje specifičnih motoričkih sposobnosti analiziranog uzorka ispitanika. Celokupno istraživanje je sprovedeno na uzorku od 72 ispitanika seniorskog uzrasta, koji su podeljeni na dva subuzorka, jedan subuzorak koji su činili ispitanici eksperimentalne grupe i drugi koji su činili ispitanici kontrolne grupe. Primarni cilj istraživanja je bio provera uticaja i efekta posebnog tretmana kinezioloških aktivnosti zasnovanih na pliometrijskim vežbama na motoričke sposobnosti ispitanika eksperimentalne grupe*

Ključne reči: *Odbojka, pliometrijski trening, efekti programiranog vežbanja.*

Uvod

Upravljanje trenažnom tehnologijom prvenstveno se odnosi na problem upravljanja u toku transformacionog procesa sportskog treninga i zasniva se na tome, da se prilikom dovođenja sportista iz inicijalnog (početnog, trenutnog) stanja u neko novoformirano (tranzitivno, finalno) stanje, koje je po pravilu na višem nivou, ostvaruje prilagođavanje sportista uslovima koji se sastoje u neprekidnom menjanju i usmeravanju u pravcu postizanja što većeg sportskog učinka u određenom vremenskom intervalu (Fratrić, 2012). Ovakav pristup optimizaciji tehnologije trenažnog procesa zahteva uspostavljanje re-

tivities through constructed situational equation specifications, and on the other hand, the implementation of more efficient operationalization and organization of training activities based on diagnosis, planning, programming and implementation of control transformational processes of anthropological characteristics of athletes in achieving high sports creativity (Malacko, 2005). Muscle strength is important for most sports games at the moment. In volleyball, the achieved level of explosive strength is of fundamental importance. Explosive power is the most important part of the skills of most players. It enables such activity of the player during the game that he is not only at the required height of the task and with the required strength, but also at the right moment. The maximum use of explosive force in vertical, horizontal and lateral movements of volleyball players is very difficult. The ratio of explosive power and technically tactical level of the players is particularly obvious when we look at the activities of players on the net, the attack from the field and first serve. Power use during the game is determined by the fact that using maximum power lasts from 0.5 to 0.7 seconds; however, most explosive movements significantly reduce time. For this reason, optimal use and transformation of the resulting maximum muscle strength into the "explosiveness" of the major lower extremity muscle groups participating in the jump require special training and energy. According to Vechoshanski (1995), this type of training should be clearly aimed at activating the adaptive mechanism of a sport organism that responds to the needs of specific sport activity. Appropriate choice of training methods, exercises and individual intensity and volume of training are among the key aspects of player strength training and strength training programs. The plyometric method is ranked among the most commonly used methods for fitness volleyball exercises. It leads to the development of explosive power and reactive velocity of the muscular system based on improving the CNS response and the power required to absorb the stress when landing. The method is based on the contraction of muscles, which gives a response to rapid growth, mainly caused by kinetic energy during deceleration phases of movement. In addition to the contractile and elastic muscle attributes, there can be an improvement in muscle proprioception and stretching tolerance. The advantage of this type of training is that it increases functional strength and allows the muscles to achieve greater levels of strength than maximum willpower. The plyometric method also reduces the inhibition of muscle reflexes, increases the sensitivity of Golgi tendon organs, improves the sensitivity of muscle spindles, increases muscle tension, and at the same time, it can reduce the risk of injury (Bompa, & Carrera, 2005; Boyle, 2004; Chu, 1998; Gambetta, 1999; Potač &

lacija, s jedne strane, modelovanih sportskih aktivnosti putem konstruisane situacione jednačine specifikacije, a sa druge strane, primenu što efikasnije operacionalizacije i organizacije trenažnih aktivnosti na osnovama dijagnostikovanja, planiranja, programiranja i sprovođenja kontrole transformacionih procesa antropoloških karakteristika sportista u postizanju visokog sportskog stvaralaštva (Malacko, 2005). Snaga mišića je veoma važna za većinu sportskih igara. U odbojci, postignuti nivo eksplozivne snage je od fundamentalne važnosti. Ona omogućava igračima tokom igre da oni budu ne samo na potrebnoj visini zadatka i uz potrebnu snagu, već i u pravom trenutku. Maksimalno iskorišćenje eksplozivne snage u vertikalnim, horizontalnim i bočnim kretanjima odbojkaša je veoma teško.Odnos eksplozivne snage i tehničko - taktičkog nivoa igrača naročito je očigledan kada posmatramo aktivnosti igrača na mreži, napad sa polja i prve serve. Korišćenje snage tokom igre određuje činjenica da upotreba maksimalne snage traje od 0.5 do 0.7 sekundi; međutim, većina eksplozivnih pokreta značajno smanjuje vreme. Iz tog razloga optimalna upotreba i transformacija dobijene maksimalne snage mišića u "eksplozivnost" glavnih mišićnih grupa donjih ekstremiteta, koji učestvuju u skoku, zahtevaju posebnu obuku i energiju. Ova vrsta treninga trebalo bi, prema Verchoshanski (1995), iti jasno usmerena na aktivaciju adaptivnog mehanizma organizma sportiste koji odgovara potrebama konkretne sportske aktivnosti. Odgovarajući izbor metoda obuke, vežbi i individualnog intenziteta i obima treninga spada među ključne aspekte u pripremi snage igrača i programa za razvijanje snage. Pliometrijska metoda je rangirana među najčešće korišćenim metodama za kondicione vežbe u odbojci. Ona dovodi do razvijanja eksplozivne snage i reaktivne brzine mišićnog sistema zasnovanih na poboljšanju reakcije CNS-a i snage koja je potrebna za apsorbovanje stresa prilikom doskoka. Metoda se zasniva na kontrakciji muskulature, koja daje odgovor na brzi rast, izazvan uglavnom kinetičkom energijom tokom faze kretanja usporenja. Pored kontraktilnog i elastičnog atributa mišića, može se uočiti poboljšanje mišićne propriocepcije i tolerancije za istezanje. Prednost ovakvog vida treninga je u tome što povećava funkcionalnu snagu i omogućava mišićima da postignu veći nivo snage. Pliometrijska metoda takođe smanjuje inhibiciju refleksa mišića, povećava osetljivost goldžijevih tetivnih organa, poboljšava osetljivost mišićnih vretena, povećava napetost mišića i istovremeno može smanjiti rizik od povreda (Bompa, & Carrera, 2005; Boile, 2004; Chu, 1998; Gambetta, 1999; Potač, & Chu, 2000; Zatsiorski, & Kraemer, 2006). Cilj ovog istraživanja bio je da

Chu, 2000; Zatsiorski, & Kraemer, 2006). This study aimed to investigate the effects of the plyometric training on motor skills of top volleyball players.

Method

The study was of a longitudinal type, involving two measurements, an initial measurement for all subjects to determine the initial level of all the analyzed characteristics and abilities, and a final measurement where the effects of the experimental program were investigated after a programmed experimental process to develop certain capabilities of the analyzed sample of the subjects. The entire survey was conducted on a sample of 72 senior subjects divided into two sub-samples, one sub-sample experimental group consisted of volleyball players of VC "Radnik" Bijeljina, VC "Majevica" Lopare, VC "Jedinstvo" Brčko, 36 of them, while second sub-sample composed of volleyball players of VC "Jahorina" Pale, VC "Tempo" Ražljevo, VC "Drina" Zvornik, these respondents were representatives of the control group and there were also 36 respondents.

A specific battery of volleyball motor tests was used to assess motor skills.

I For the evaluation of the explosive strength of the lower limbs:

1) Reachable height with one arm (cm)
2) Block reach (cm)

II For the lexibility assessment:

1) Back saver (cm)

III To evaluate the speed of alternative arm movements:

1) Plate tapping test (frequency)

IV To evaluate agility:

1) Japan test (s)

V To assess the velocity of the arm and torso muscles:

1) Throwing medicine ball from lying position with arms outstretched (2kg) (cm)

VI To evaluate the repetitive strength of abdominal muscles andhip joint flexors:

1) Sit – ups 30s (frequency)

VII To evaluate repetitive strength of back muscles:

1) Back 30s (frequency)

se ispitaju efekti pliometrijskog treninga na motoričke sposobnosti vrhunskih odbojkaša.

Metod

Istraživanje je bilo longitudinalnog karaktera, gde su se podrazumevala dva merenja, inicijalno merenje da se utvrdi početni nivo svih analiziranih karakteristika i sposobnosti, i finalno merenje gde su se ispitivali efekti uticaja eksperimentalnog programa nakon programiranog eksperimentalnog procesa za razvijanje određenih sposobnosti analiziranog uzorka ispitanika. Celokupno istraživanje je sprovedeno na uzorku od 72 ispitanika seniorskog uzrasta, koji su podeljeni na dva subuzorka. Jedan subuzorak- eksperimentalnu grupu činili su odbojkaši OK „Radnik" Bijeljina, OK „Majevica" Lopare, OK „Jedinstvo" Brčko i to njih 36, dok je drugi subuzorak sastavljen od odbojkaša OK „Jahorina" Pale, OK „Tempo" Ražljevo, OK „Drina" Zvornik i ovi ispitanici bili su predstavnici kontrolne grupe kojih je takođe bilo 36.

Za procenu motoričkih sposobnosti primenjena je specifična baterija motoričkih testova za odbojkaše.

I Za procenu eksplozivne snage donjih ekstremiteta:

1) Dohvatna visina sa jednom rukom (cm),
2) Dohvat za blok (cm),

II Za procenu fleksibilnosti:

1) Pretklon na klupici (cm),

III Za procenu brzine alternativnih pokreta ruku:

1) Taping rukom (frekv),

IV Za procenu agilnosti:

1) Japan test (s.),

V Za procenu brzinske snage mišića opružača ruku i trupa:

1) Bacanje medicinke iz ležećeg položaja ispruženih ruku (2kg) (cm),

VI Za procenu repetitivne snage mišića ruku i ramenog pojasa:

1) Sklek 30 sekundi (frekv),

VII Za procenu repetitivne snage trbušnih mišića i pregibača zgloba kuka:

1) Ležanje - sed 30 sekundi (frekv),

The experimental program that was implemented based on plyometric exercises in the experimental group was represented for twelve weeks, twice a week in the period from December 2017 to February 2018.

The players were presented, verbally and visually, with the exercises and how they are performed to provide feedback on kinesiological treatment.

Statistical data processing included the calculation of basic descriptive indicators (arithmetic mean, standard deviation, minimum measured values, maximum measured values, skewness, kurtosis), Kolmogorov distribution normality test by Smirnov test, and calculation of multivariate and univariate (MANOVA and ANOVA) analysis of variance of it „t" test for dependent samples.

Results

Table 1. *Basic descriptive indicators of motor variables of experimental groups (E) at initial measurement.*

Varijable / *Variables*	MIN	MAX	AS	S	Sk	Kurt
Dohvatna visina sa jednom rukom / *Reachable height with one arm*	20,0	59,0	39,28	11,99	0,088	-0,856
Dohvat za blok / *Block reach*	2,0	39,0	18,92	10,22	-0,008	-0,206
Pretklon na klupici / *Back saver*	7,0	50,0	25,27	14,97	0,320	-1,960
Taping rukom / *Plate tapping test*	46	74	64,86	7,26	-0,998	2,404
Japan test / *Japan test*	12,84	14,92	13,20	0,697	0,275	-1,067
Bacanje medicinke iz ležećeg pol. / *Medicine ball throwing from lying position*	6,2	13,0	9,79	1,96	0,089	-0,532
Sklek 30s / *Push – ups 30s*	12	40	27,00	8,91	-0,213	-0,880
Ležanje-sed 30s / *Sit – ups 30s*	21	34	27,57	4,43	-0,347	-1,057
Leđa 30s / *Back 30s*	29	50	39,14	5,94	0,006	-0,621

Legend: *MIN – minimum recorded measurment result; MAX – the maximum recorded measurment result; AM – arithmetic mean; S – standard deviation; Sk – skewness (the inclination of the distribution of results); Kurt – kurtosis (the elongation of the distribution of results)*

Table 1 gives an overview of the basic descriptive statistics of the motor variables of the experimental group at the initial measurement. By examining the values in the table, one can conclude that there is good discriminability of measurements in all variables for motor estimation except for two variables, the variable for assessing the explosive strength of the lower extremities Block reach and the variable for assessing the flexibility of the biceps femoris Back saver, as can be seen from the relation between standard deviation and arithmetic mean, where it is not possible to classify three standard deviations in one arithmetic mean. The minimum and maximum measurement values have a normal range in almost all measured variables, except for two variables

Eksperimentalni program koji je realizovan na bazi pliometrijskih vežbi u eksperimentalnoj grupi bio je zastupljen dvanaest nedelja po dva puta sedmično u periodu od decembra 2017. do februara 2018. godine.

Igračima je usmeno i vizuelno prikazano koje vežbe i na koji način se realizuju, kako bi bila obezbeđena povratna informacija kineziološkog tretmana.

Statistička obrada podataka podrazumevala je izračunavanje osnovnih deskriptivnih pokazatelja, testiranje normalnosti distribucije, te izračunavanje multivarijatne i univarijatne (MANOVA i ANOVA) analize varijanse i „t" testa za zavisne uzorke.

Rezultati

Tabela 1. *Osnovni deskriptivni pokazatelji motoričkih varijabli eksperimentalne grupe (E) na inicijalnom merenju*

Legenda: *MIN – minimalni zabeleženi rezultat merenja; MAX – maksimalni zabeleženi rezultat merenja; AS – aritmetička sredina; S – standardna devijacija; Sk – skjunis (nagnutost distribucije rezultata); Kurt – kurtosis (izduženost distribucije rezultata)*

U tabeli 1. dat je prikaz osnovnih deskriptivnih statistika motoričkih varijabli eksperimentalne grupe na inicijalnom merenju. Pregledom vrednosti u tabeli može se zaključiti postojanje dobre diskriminativnosti merenja u svim varijablama za procenu motorike sem u dve varijable i to u varijabli za procenu eksplozivne snage donjih ekstremiteta *Dohvat za blok i varijabli* za procenu fleksibilnosti lumbalnih ekstenzora i zadnje lože buta *Pretklon na klupici*, što se vidi iz odnosa standardne devijacije i aritmetičke sredine gde se uočava da nije moguće svrstati tri standardne devijacije u jednu aritmetičku sredinu. Minimalne i maksimalne vrednosti merenja imaju normalan raspon u skoro svim izmerenim varijablama, sem u dve varijable gde se uočavaju povećane vrednosti ras-

that show increased values of the range of results, the variables for evaluating the explosive power of the lower extremities Block reach and the variable for assessing the flexibility of the biceps femoris *Back saver.* Acceptable negative asymmetry of the distribution in the variable for estimating the speed of alternative movements by *Plate tapping test* is observed based on the skewness values, in all other variables, the skewness coefficients are within the good values of the results. The analysis of kurtosis coefficients shows the increased values of the four variables: *Back saver, Hand tapping, Japan test, Sit -ups 30s*. *The Hand tapping* variable has increased positive kurtosis coefficients indicating greater clustering of results around the arithmetic mean resulting in an elongated leptokurtic distribution. The remaining three variables Back saver, Japan test, Sit - ups 30s have acceptably increased values of the kurtosis coefficients with a negative sign characterizing the platykurtic distribution of the result having a flattened peak of the distribution curve. This distribution indicates increased dispersion of results in the three analyzed variables.

Table 2. *The normality of distribution tested by Kolmogorov - Smirnov test of motor variables for the experimental group at the initial measurement.*

pona rezultata i to u varijablama za procenu eksplozivne snage donjih ekstremiteta *Dohvat za blok* i varijabli za procenu fleksibilnosti lumbalnih ekstenzora i zadnje lože buta *Pretklon na klupici*. Na osnovu skjuničnih vrednosti uočava se prihvatljiva negativna asimetričnost distribucije u varijabli za procenu brzine alternativnih pokreta rukom *Taping rukom,* dok su u svim ostalim varijablama skjunični koeficijenti u okviru dobrih vrednosti rezultata. Analizom kurtičnih koeficijenata primećuje se povećane vrednosti u četiri varijable, i to: *Pretklon na klupici, Taping rukom, Japan test, Ležanje-sed 30s.* Varijabla *Taping rukom* ima povećane pozitivne kurtične koeficijente koji ukazuju na veće grupisanje rezultata oko aritmetičke sredine što za posledicu ima izduženu leptokurtičnu distribuciju. Preostale tri varijable *Pretklon na klupici, Japan test, Ležanje-sed 30s*. imaju prihvatljivo povećane vrednosti kurtičnih koeficijenata sa negativnim predznakom koji karakteriše platikurtičnu distribuciju rezultata koja ima spljošten vrh krive distribucije. Ovakva distribucija ukazuje na povećanu disperziju rezultata u ove tri analizirane varijable.

Tabela 2. *Normalnost distribucije testirana Kolmogorov – Smirnov testom motoričkih varijabli za eksperimentalnu grupu na inicijalnom merenju*

Varijable / *Variables*	MEA	K-S	p
Dohvatna visina sa jednom rukom / *Reachable height with one arm*	0,112	0,421	0,994
Dohvat za blok / *Block reach*	0,116	0,434	0,992
Pretklon na klupici / *Back saver*	0,247	0,923	0,362
Taping rukom / *Plate tapping test*	0,134	0,501	0,963
Japan test / *Japan test*	0,124	0,464	0,983
Bacanje medicinke iz ležećeg pol. / *Medicine ball throwingfrom lying position*	0,139	0,520	0,949
Sklek 30s / *Push-ups 30s*	0,141	0,528	0,943
Ležanje-sed 30s / *Sit-ups 30s*	0,163	0,610	0,851
Leđa 30s / *Back 30s*	0,150	0,562	0,911

Legend: *K-S – Kolmogorov – Smirnov Z coefficient; p – the level of statistical significance of Kolmogorov - Smirnov Z coefficient; MEA – the maximum extreme difference between the obtained and the expected distribution.*

Legenda: *K-S – Kolmogorov – Smirnov Z koeficijent; p – nivo statističke značajnosti Kolmogorov – Smirnov Z koeficijenta; MEA – maksimalna ekstremna razlika između dobijene i očekivane distribucije.*

By presenting the tabulated values in the table 2, where the results of the distribution normality testing are presented using the Kolmogorov Smirnov test for motor variables at the initial measurement with the examinees in the experimental group, it is concluded that there is no statistically significant deviation of the tested distribution from the normal one. No maximum extreme deviation value exceeds the K-S test value. Based on the p coefficient, it is noticed that there is no statistical significance of the

Prikazom tabelarnih vrednosti u tabeli 2, gde su predstavljeni rezultati testiranja normalnosti distribucije primenom Kolmogorov Smirnov testa za motoričke varijable na inicijalnom merenju kod ispitanika eksperimentalne grupe, zaključuje se da ne postoji statistički značajno odstupanje testirane distribucije od normalne. Nijedna vrednost maksimalnog ekstremnog odstupanja ne prelazi vrednosti K-S testa. Na osnovu *p* koeficijenta uočava se da ne postoji statistička značajnost K-S testa ni

K-S test in any of the analyzed variables, which enables the further application of the parametric statistical methods of data processing in the continuation of the research.

Table 3. *Basic descriptive indicators of the control group (C) motor variables at the initial measurement.*

Varijable / *Variables*	MIN	MAX	AS	S	Sk	Kurt
Dohvatna visina sa jednom rukom / *Reachable height with one arm*	21,0	58,0	38,24	11,73	0,06	-1,05
Dohvat za blok / *Block reach*	3,0	37,0	17,54	9,18	0,11	-0,66
Pretklon na klupici / *Back saver*	9	49	26,61	13,99	-0,01	-1,75
Taping rukom / *Plate tapping test*	44	72	62,56	6,30	-0,989	2,07
Japan test / *Japan test*	12,21	14,22	13,66	0,60	0,19	-1,11
Bacanje medicinke iz ležećeg pol. / *Medicine ball throwing from lying position*	7,1	13,2	9,20	1,75	0,55	-0,80
Sklek 30s. / *Push-ups 30s*	14	38	25,39	7,2	0,04	-0,65
Ležanje-sed 30s. / *Sit-ups 30s*	23	36	26,53	2,77	0,37	0,05
Leđa 30s. / *Back 30s*	31	46	35,17	3,53	0,58	0,95

Legend: *MIN - minimum recorded measurement result; MAX - maximum recorded measurement result; AM - arithmetic mean; S - standard deviation; Sk - skewness (the inclination of the distribution of results); Kurt - kurtosis (the elongation of the distribution of results)*

Table 3 shows the basic descriptive statistical motor variables of the control group at the initial measurement. Based on the results presented in the table, it can be concluded that there is a good measuring discriminability in most of the measured values except in the variables for the estimation of lower extremities explosive power *Block reach* and in the variable for the estimation of the posterior line of the thigh flexibility *Back saver*. Considering the relationship between the arithmetic mean and standard deviation with these variables, it is not possible to place the three standard deviations in one arithmetic mean, which indicates the poorer discriminability of the measurements in these variables. By comparing the measured minimum and maximum values in the table, the increased values of the results in the span of two variables are noticed, and those are: in the variable for the estimation of lower extremities explosive power *Block reach* and in the variable for the estimation of the posterior line of the thigh flexibility *Back saver*. The measure of the shape of the distribution, the skewness which denotes the slope of the distribution, has good values in all variables except in the variable for the velocity of the alternative hand movement *Plate tapping test* where the negative asymmetry of distribution is expressed. The kurtosis values in the table have good and acceptable values in most analyzed variables except in the variable for the estimation of lower extremities explosive power *Reachable height with one arm*, the variable for the

u jednoj analiziranoj varijabli što omogućava dalju primenu parametrijskih statističkih metoda obrade podataka u nastavku istraživanja.

Tabela 3. *Osnovni deskriptivni pokazatelji motoričkih varijabli kontrolne grupe (K) na inicijalnom merenju*

Legenda: *MIN – minimalni zabeleženi rezultat merenja; MAX – maksimalni zabeleženi rezultat merenja; AS – aritmetička sredina; S – standardna devijacija; Sk – skjunis (nagnutost distribucije rezultata); Kurt – kurtosis (izduženost distribucije rezultata)*

U tabeli 3, prikazani su osnovni deskriptivni statistici motoričkih varijabli kontrolne grupe na inicijalnom merenju. Na osnovu prikazanih rezultata u tabeli, može se konstatovati dobra diskriminativnost merenja većine izmerenih vrednosti sem u varijablama za procenu eksplozivne snage donjih ekstremiteta *Dohvat za blok* i u varijabli za procenu fleksibilnosti lumbalnih ekstenzora i zadnje lože buta *Pretklon na klupici*. Kod ovih varijabli posmatrajući odnos aritmetičke sredine i standardne devijacije nije moguće svrstati tri standardne devijacije u jednu aritmetičku sredinu što ukazuje na lošiju diskriminativnost merenja u ovim varijablama. Komparacijom izmerenih minimalnih i maksimalnih vrednosti u tabeli uočavaju se povećane vrednosti rezultata raspona u dve varijable, i to: u varijabli za procenu eksplozivne snage donjih ekstremiteta *Dohvat za blok* i u varijabli za procenu fleksibilnosti lumbalnih ekstenzora i zadnje lože buta *Pretklon na klupici*. Mera oblika distribucije, skjunis koji označava nagnutost distribucije ima dobre vrednosti u svim varijablama sem u varijabli za procenu brzine alternativnih pokreta ruku *Taping rukom* gde je izražena negativna asimetrija distribucije. Kurtične vrednosti iz tabele imaju dobre i prihvatljive vrednosti u većini analiziranih varijabli sem u varijablama za procenu eksplozivne snage donjih ekstremiteta *Dohvatna visina sa jednom rukom,* varijabli za procenu fleksibilnosti lumbalnih ekstenzora i zadnje

estimation of the posterior line of the thigh flexibility *Back saver*, the variables for the velocity of the alternative hand movement *Plate tapping test*, and the variables for agility estimation *Japan test*. In the variable for the velocity of the alternative hand movement *Plate tapping test*, the kurtosis coefficient has a positive value which is characterized by the tip of the curve. The leptokurtic form of distribution shows the increased homogeneity of the result distribution. The other three variables have a negative sign that is characterized by a flattened peak of the distribution curve. The platykurtic shape of distribution depicts an increased dispersion of the results or a decreased homogeneity of results in these measured variables.

lože buta *Pretklon na klupici,* varijabli za procenu brzine alternativnih pokreta ruku *Taping rukom,* i varijabli za procenu agilnosti *Japan test*. U varijabli za procenu brzine alternativnih pokreta ruku *Taping rukom* kurtični koeficijent ima pozitivnu vrednost koja se karakteriše izraženim vrhom krive. Leptokurtičan oblik distribucije ukazuje na povećanu homogenost distribucije rezultata. Preostale tri varijable imaju negativan predznak koji se karakteriše spljoštenim vrhom krive distribucije. Platikurtičan oblik distribucije ukazuje na povećanu disperziju rezultata odnosno smanjenu homogenost rezultata u ovim izmerenim varijablama.

Table 4. *The normality of distribution tested by Kolmogorov - Smirnov test of motor variables for the control group at the initial measurement.*

Tabela 4. *Normalnost distribucije testirana Kolmogorov – Smirnov testom motoričkih varijabli za kontrolnu grupu (K) na inicijalnom merenju*

Varijable / *Variables*	MEA	K-S	p
Dohvatna visina sa jednom rukom / *Reachable height with one arm*	0,142	0,855	0,458
Dohvat za blok / *Block reach*	0,154	0,925	0,359
Pretklon na klupici / *Back saver*	0,185	1,113	0,168
Taping rukom / *Plate tapping test*	0,120	0,718	0,681
Japan test / *Japan test*	0,136	0,813	0,523
Bacanje medicinke iz ležećeg pol. / *Medicine ball throwing from lying position*	0,149	0,892	0,403
Sklek 30s. / *Push-ups 30s*	0,160	0,957	0,319
Ležanje-sed 30s. / *Sit-ups 30s*	0,103	0,617	0,840
Leđa 30s. / *Back 30s*	0,120	0,723	0,673

Legend: *K-S – Kolmogorov – Smirnov Z coefficient; p – the level of statistical significance of Kolmogorov - Smirnov Z coefficient; MEA – the maximum extreme difference between the obtained and the expected distribution.*

Legenda: *K-S – Kolmogorov – Smirnov Z koeficijent; p – nivo statističke značajnosti Kolmogorov – Smirnov Z koeficijenta; MEA – maksimalna ekstremna razlika između dobijene i očekivane distribucije.*

By comparing the results in table 4, where the normality of distribution tested by Kolmogorov - Smirnov test of the motor variables for the control group (C) at the initial measurement is shown, it can be seen that there is no statistically significant deviation of the tested distribution from the normal one. All the analyzed results of the maximum extreme deviation are such that they are within the K-S test value. There is no statistical significance of the p coefficient in the observed variables, which led to the further application of parametric statistical methods of data processing in the continuation of this research.

Komparacijom rezultata u tabeli 4, gde je prikazana normalnost distribucije testirana Kolmogorov – Smirnov testom motoričkih varijabli za kontrolnu grupu (K) na inicijalnom merenju, uočava se da ne postoji statistički značajno odstupanje testirane distribucije od normalne. Svi analizirani rezultati maksimalnog ekstremnog odstupanja su takvi da se nalaze u okviru vrednosti K-S testa. Ne postoji statistička značajnost *p* koeficijenta u posmatranim varijablama, što je dovelo do toga da se pristupi daljoj primeni parametrijskih statističkih metoda obrade podataka u nastavku ovog istraživanja.

Table 5: *Differences between groups in motor ability at the initial measurement.*

Tabela 5. *Razlike između grupa u motoričkim sposobnostima na inicijalnom merenju*

Varijable / *Variables*	Grupa / *Group*	AS	S	f	p	η^2
Dohvatna visina sa jednom rukom / *Reachable height with one arm*	E	39,28	11,99	0,496	0,484	0,017
	K	38,24	11,73			
Dohvat za blok / *Block reach*	E	18,92	10,22	1,793	0,185	0,025
	K	17,54	9,18			
Pretklon na klupici / *Back saver*	E	25,27	14,97	1,101	0,980	0,012
	K	26,61	13,99			
Taping rukom / *Plate tapping test*	E	64,86	7,26	2,059	0,156	0,029
	K	62,56	6,30			
Japan test / *Japan test*	E	13,20	0,697	3,917	0,012	0,111
	K	13,66	0,60			
Bacanje medicinke iz ležećeg pol. / *Medicine ball throwing out of lying position*	E	9,79	1,96	1,009	0,925	0,012
	K	9,20	1,75			
Sklek 30s / *Push-ups 30s*	E	27,00	8,91	1,088	0,767	0,011
	K	25,39	7,2			
Ležanje-sed 30s / *Sit-ups 30s*	E	27,57	4,43	1,110	0,741	0,032
	K	26,53	2,77			
Leđa 30s / *Back 30s*	E	39,14	5,94	8,816	0,004	0,122
	K	35,17	3,53			

Legend: *Group: E-experimental, C-control; AM- arithmetic mean; S - standard deviation; f-value of univariate f-test; p - the level of statistical significance of univariate f-test; η2 - partial eta square (effect size)*

Legenda: *Grupa: E-eksperimentalna, K-kontrolna; AS- aritmetička sredina; S - standardna devijacija; f-vrednost univarijatnog f-testa; p-nivo statističke značajnosti univarijatnog f-testa;* η^2 *– parcijalni eta kvadrat (veličina efekta)*

With the projection of the obtained results in table 5, where the differences between groups in motor abilities at the initial measurement were analyzed, it can be stated that statistically significant differences were noticed between the analyzed groups of subjects at the initial measurement (F = 2,14; P = 0,004; η2 = 0,112) with a satisfactory effect of influence η2 = 0,112. By analyzing each variable individually, we notice that the statistical significance is present in two variables, and those variables are the variables for assessing the agility *Japan test* in favor of the experimental group and the variables for assessing the repetitive strength of the back muscles *Back 30s.*

Projekcijom dobijenih rezultata u tabeli 5, gde su analizirane razlike između grupa u motoričkim sposobnostima na inicijalnom merenju, može se konstatovati da su uočene statistički značajne razlike između analiziranih grupa ispitanika na inicijalnom merenju (F=2,14; P=0,004; η^2=0,112) uz zadovoljavajući efekat uticaja η^2=0,112. Analizirajući svaku varijablu pojedinačno uočava se da je statistička značajnost prisutna u dve varijable, i to varijabli za procenu agilnosti *Japan test* u korist eksperimentalne grupe i varijabli za procenu repetitivne snage leđnih mišića *Leđa 30s.*

Table 6. *Basic descriptive indicators of motor variables of the experimental group (E) at the final measurement.*

Tabela 6. *Osnovni deskriptivni pokazatelji motoričkih varijabli eksperimentalne grupe (E) na finalnom merenju*

Varijable / *Variable*	MIN	MAX	AS	S	Sk	Kurt
Dohvatna visina sa jednom rukom / *Reachable height with one arm*	20,0	59,0	41,80	10,26	-0,00	-0,46
Dohvat za blok / *Block reach*	8,0	39,0	23,44	7,01	0,196	0,971
Pretklon na klupici / *Back saver*	10	50	28,78	13,32	0,140	-1,54
Taping rukom / *Plate tapping test*	50	74	65,47	5,67	-0,78	0,56
Japan test / *Japan test*	12,0	14,22	13,07	0,59	0,289	-0,75
Bacanje medicinke iz ležećeg pol. / *Medicine ball throwing out of lying position*	7,9	13,0	10,09	1,52	0,632	-0,57

Sklek 30s / *Push-ups 30s*	16	41	28,03	6,99	0,293	-0,98
Ležanje-sed 30s / *Sit-ups 30s*	20	34	28,17	3,40	-0,31	-0,17
Leđa 30s / *Back 30s*	29	50	39,69	4,92	0,164	-0,38

Legend: *MIN - minimum recorded measurement result; MAX - maximum recorded measurement result; AM - arithmetic mean; S - standard deviation; Sk - skewness (the inclination of the distribution of results); Kurt - kurtosis (the elongation of the distribution of results).*

Legenda: *MIN – minimalni zabeleženi rezultat merenja; MAX – maksimalni zabeleženi rezultat merenja; AS – aritmetička sredina; S – standardna devijacija; Sk – skjunis (nagnutost distribucije rezultata); Kurt – kurtosis (izduženost distribucije rezultata).*

By analyzing table 6, where the basic descriptive indicators of the motor variables of the experimental group (E) are shown at the final measurement, a good discriminability of the measurements is found in all variables, except the variable for the estimation of the posterior line of the thigh flexibility *Back saver*. The minimum and maximum measured values in all variables are within the range of normal range results, and there aren't any increased range results as a measure of variability in the analyzed variables for motor skills assessment. Skewness coefficients are all within good and acceptable values and there is no significant asymmetry of the distribution. By examining the kurtosis, one can see that in the variable for the estimation of the posterior line of the thigh flexibility *Back saver* there is a dispersion of the measurement results, that is, a reduced homogeneity of the distribution, which is characterized by the flattened tip of the distribution curve, which is in a platykurtic shape.

Analizirajući tabelu 6, gde su prikazani osnovni deskriptivni pokazatelji motoričkih varijabli eksperimentalne grupe (E) na finalnom merenju, konstatuje se dobra diskriminativnost merenja u svim varijablama sem u varijabli za procenu fleksibilnosti lumbalnih ekstenzora i zadnje lože buta *Pretklon na klupici*. Minimalne i maksimalne izmerene vrednosti u svim varijablama su u zoni normalnih rezultata raspona, te ni u jednoj analiziranoj varijabli za procenu motoričkih sposobnosti nema povećanih rezultata raspona kao mere varijabilnosti. Skjunični koeficijenti su svi u okviru dobrih i prihvatljivih vrednosti, te nema značajnije asimetrije distribucije. Pregledom kurtičnih vrednosti, uočava se da u varijabli za procenu fleksibilnosti lumbalnih ekstenzora i zadnje lože buta Pretklon na klupici postoji disperzija rezultata merenja, odnosno smanjena homogenost distribucije, što se karakteriše spljoštenim vrhom krive distribucije, koji je platikurtičnog oblika.

Table 7. *The normality of distribution tested by Kolmogorov - Smirnov test of motor variables for the experimental group (E) at the final measurement.*

Tabela 7. *Normalnost distribucije testirana Kolmogorov – Smirnov testom motoričkih varijabli za eksperimentalnu grupu (E) na finalnom merenju*

Varijable / *Variables*	MEA	K-S	p
Dohvatna visina sa jednom rukom / *Reachable height with one arm*	0,108	0,645	0,799
Dohvat za blok / *Block reach*	0,175	1,048	0,222
Pretklon na klupici / *Back saver*	0,200	1,200	0,112
Taping rukom / *Plate tapping test*	0,148	0,891	0,406
Japan test / *Japan test*	0,136	0,814	0,522
Bacanje medicinke iz ležećeg pol. / *Medicine ball throwing out of lying position*	0,159	0,952	0,325
Sklek 30s / *Push-ups 30s*	0,142	0,851	0,464
Ležanje-sed 30s / *Sit-ups 30s*	0,134	0,805	0,536
Leđa 30s / *Back 30s*	0,139	0,837	0,486

Legend: *K-S – Kolmogorov – Smirnov Z coefficient; p – the level of statistical significance of Kolmogorov - Smirnov Z coefficient; MEA – the maximum extreme difference between the obtained and the expected distribution.*

Legenda: *K-S – Kolmogorov – Smirnov Z koeficijent; p – nivo statističke značajnosti Kolmogorov – Smirnov Z koeficijenta; MEA – maksimalna ekstremna razlika između dobijene i očekivane distribucije.*

By comparing the results in table 7, where the normality of distribution was tested by the Kolmogorov - Smirnov test of the motor variables for the experimental

Komparacijom rezultata u tabeli 7, gde se testirala normalnost distribucije Kolmogorov – Smirnov testom motoričkih varijabli za eksperimentalnu grupu (E) na fi-

group (E) at the final measurement, it can be seen that there is no significant deviation of the tested distribution from the normal one. All coefficients of maximum extreme deviation (MEA) are less than the values of the K-S test, and the statistical significance of the K-S test was not detected in any of the motor variables analyzed.

Table 8. *Basic descriptive indicators of the control group (C) motor variables at the final measurement.*

Varijable / *Variable*	MIN	MAX	AS	S	Sk	Kurt
Dohvatna visina sa jednom rukom / *Reachable height with one arm*	21,0	58,0	38,50	11,40	0,117	-1,04
Dohvat za blok / *Block reach*	4,0	37,0	17,79	8,86	0,189	-,588
Pretklon na klupici / *Back saver*	9	49	26,89	14,02	-0,03	-1,79
Taping rukom / *Plate tapping test*	44	72	62,81	6,18	-1,01	2,655
Japan test / *Japan test*	12,0	14,19	13,23	0,55	-0,07	-0,92
Bacanje medicinke iz ležećeg pol. / *Medicine ball throwing out of lying position*	7,1	13,2	9,87	1,65	0,597	-0,70
Sklek 30s. / *Push-ups 30s*	16	38	26,22	5,80	0,374	-0,52
Ležanje-sed 30s. / *Sit-ups 30s*	22	34	26,97	2,42	0,457	1,021
Leđa 30s. / *Back 30s*	32	46	36,03	2,75	0,276	2,59

Legend: *MIN - minimum recorded measurement result; MAX - maximum recorded measurement result; AM - arithmetic mean; S - standard deviation; Sk - skewness (the inclination of the distribution of results); Kurt - kurtosis (the elongation of the distribution of results).*

Table 8 presents the results of the basic descriptive indicators of the control group (C) motor variables at the final measurement. By comparing their arithmetic means and standard deviations, a good discriminability in most variables is noted, except for two variables, the variable for the estimation of lower extremities explosive power *Block reach* and the variable for the estimation of the posterior line of the thigh flexibility *Back saver*. By analyzing the range of the results in all the variables it is seen that there are no major deviations and that all values of the range are in the area of normal and acceptable results. By examining the skewness values, the asymmetry of the distribution in the variable for the velocity of the alternative hand movement *Plate tapping test* is stated, in all other analyzed variables the obtained results were in the zone of good and acceptable values. The kurtosis values show an increased grouping of results around the arithmetic mean into two variables, namely the variable for the velocity of the alternative hand movement *Plate tapping test* and the variables for the estimation of the repetitive strength of the abdominal muscles *Sit-ups 30sec*. This type of distribution is characterized by an elongated tip of the curve that has a leptokurtic shape. The increased dispersion of the results which is noted based on the negative sign of the kurto-

nalnom merenju, uočljivo je da nema značajnog odstupanja testirane distribucije od normalne. Svi koeficijenti maksimalnog ekstremnog odstupanja (MEA) su manje od vrednosti K-S testa, a statistička značajnost K-S testa nije detektovana ni u jednoj analiziranoj motoričkoj varijabli.

Tabela 8. *Osnovni deskriptivni pokazatelji motoričkih varijabli kontrolne grupe (K) na finalnom merenju*

Legenda: *MIN – minimalni zabeleženi rezultat merenja; MAX – maksimalni zabeleženi rezultat merenja; AS – aritmetička sredina; S – standardna devijacija; Sk – skjunis (nagnutost distribucije rezultata); Kurt – kurtosis (izduženost distribucije rezultata).*

U tabeli 8, prezentovani su rezultati osnovnih deskriptivnih pokazatelja motoričkih varijabli kontrolne grupe (K) na finalnom merenju. Komparacijom njihovih aritmetičkih sredina i standardnih devijacija primećuje se dobra diskrimantivnost u većini varijabli, sem u varijablama za procenu eksplozivne snage donjih ekstremiteta *Dohvat za blok* i varijabli za procenu fleksibilnosti lumbalnih ekstenzora i zadnje lože buta *Pretklon na klupici*. Analizom raspona rezultata u svim varijablama konstatuje se da nema većih odstupanja i da su sve vrednosti raspona u zoni normalnih i prihvatljivih rezultata. Pregledom skjuničnih vrednosti konstatuje se asimetrija distribucije u varijabli za procenu brzine alternativnih pokreta ruku *Taping rukom*, a u svim drugim analiziranim varijablama su dobijeni rezultati u zoni dobrih i prihvatljivih vrednosti. Vrednosti kurtozisa pokazuju povećano grupisanje rezultata oko aritmetičke sredine u dve varijable i to varijabli za procenu brzine alternativnih pokreta ruku *Taping rukom* i varijabli za procenu repetitivne snage abdominalnih mišića *Ležanje-sed 30s*. Ovakav oblik distribucije karakteriše se izduženim vrhom krive koji ima leptokurtičan oblik. Povećana disperzija rezultata koja se uočava na osnovu negativnog predznaka kurtičnog koeficijenta zabeležena je u dve

sis coefficient was recorded in two variables: the variable for the estimation of lower extremities explosive power *Reachable height with one arm* and the variable for the estimation of the posterior line of the thigh flexibility *Back saver*. This negative distribution is characterized by the flattened tip of the curve, which has a platykurtic shape.

Table 9. *The normality of distribution tested by Kolmogorov - Smirnov test of motor variables for the control group (C) at the final measurement.*

Varijable / *Variables*	MEA	K-S	p
Dohvatna visina sa jednom rukom / *Reachable height with one arm*	0,156	0,933	0,349
Dohvat za blok / *Block reach*	0,148	0,887	0,411
Pretklon na klupici / *Back saver*	0,194	1,164	0,133
Taping rukom / *Plate tapping test*	0,158	0,949	0,329
Japan test / *Japan test*	0,180	1,079	0,195
Bacanje medicinke iz ležećeg pol. / *Medicine ball throwing from lying position*	0,186	1,117	0,165
Sklek 30s. / *Push-ups 30s*	0,126	0,758	0,613
Ležanje-sed 30s. / *Sit-ups 30s*	0,128	0,770	0,594
Leđa 30s. / *Back 30s*	0,171	1,024	0,245

Legend: *K-S – Kolmogorov – Smirnov Z coefficient; p – the level of statistical significance of Kolmogorov - Smirnov Z coefficient; MEA – the maximum extreme difference between the obtained and the expected distribution.*

By displaying the results in table 9, where the normality of distribution was tested by Kolmogorov - Smirnov test of motor variables for the control group (C) at the final measurement, it is concluded that there is no significant deviation of the tested distribution from the normal (theoretical). No value of the maximum extreme deviation (MEA) exceeds the values of the K-S test and is not statistically significant. This justifies the use of parametric statistical methods of data processing in the continuation of the research.

Table 10. *Quantitative differences between the initial and the final measurements of the experimental group in motor variables at the final measurement.*

Varijable/Grupe / *Variables/Groups*	AS_1-AS_2	p
Dohvatna visina sa jednom rukom / *Reachable height with one arm*	-1,63	0,005
Dohvat za blok / *Block reach*	-2,98	0,000
Pretklon na klupici / *Back saver*	-2,25	0,003
Taping rukom / *Plate tapping test*	-0,75	0,112
Japan test / *Japan test*	0,42	0,006
Bacanje medicinke iz ležećeg pol. / *Medicine ball throwing from lying position*	-0,34	0,101
Sklek 30s / *Push-ups 30s*	-2,08	0,000
Ležanje-sed 30s / *Sit-ups 30s*	-1,33	0,072
Leđa 30s / *Back 30s*	-1,19	0,060

Legend: *AS1-AS2-the first and the second measurement; p - the level of statistical significance of the t-test.*

varijable, i to: varijabli za procenu eksplozivne snage donjih ekstremiteta *Dohvatna visina sa jednom rukom* i varijabli za procenu fleksibilnosti lumbalnih ekstenzora i zadnje lože buta *Pretklon na klupici.* Ovakva negativna distribucija se karakteriše spljoštenim vrhom krive koja ima platikurtičan oblik.

Tabela 9. *Normalnost distribucije testirana Kolmogorov – Smirnov testom motoričkih varijabli za kontrolnu grupu (K) na finalnom merenju*

Legenda: *K-S – Kolmogorov – Smirnov Z koeficijent; p – nivo statističke značajnosti Kolmogorov – Smirnov Z koeficijenta; MEA – maksimalna ekstremna razlika između dobijene i očekivane distribucije.*

Prikazom rezultata u tabeli 9, gde je testirana normalnost distribucije testirana Kolmogorov – Smirnov testom motoričkih varijabli za kontrolnu grupu (K) na finalnom merenju, konstatuje se da nema značajnog odstupanja testirane distribucije od normalne (teorijske). Nijedna vrednost maksimalnog ekstremnog odstupanja (MEA) ne prelazi vrednosti K-S testa i nije statistički značajna. To opravdava primenu parametrijskih statističkih metoda obrade podataka u nastavku istraživanja.

Tabela 10. *Kvantitativne razlike između inicijalnog i finalnog merenja eksperimentalne grupe u motoričkim varijablama na finalnom merenju*

Legenda: *AS_1-AS_2-prvo i drugo merenje; p-nivo statističke značajnosti t-testa.*

Table 10 shows the quantitative differences between the initial and the final measurements of the experimental group in motor variables at the final measurement at a level of statistical inference of p <0.001. Statistically significant differences between the initial and the final measurements in motor ability in the experimental group were observed in five variables: the variable for the estimation of lower extremities explosive power *Reachable height with one arm* and *Block reach* and that was the goal of the programmed transformation process which was applied to top athletes, in the variable for the estimation of the posterior line of the thigh flexibility *Back saver*, the variables for agility estimation *Japan test*, and the variables for the estimation of the repetitive strength of the abdominal muscles *Sit-ups 30s.* By looking at the negative sign of the mentioned variables, we see that four statistically significant variables achieved better results on the final measurement, while in the variables for agility estimation *Japan test* sign is positive but since it is an inverse metric and a time unit where the worse result is actually better, we see that in this variable, the results were statistically significantly better at the final measurement. Based on everything stated in table number 10, it is concluded that the differences were the result of the applied experimental treatment.

U tabeli 10, prikazane se kvantitativne razlike između inicijalnog i finalnog merenja eksperimentalne grupe u motoričkim varijablama na finalnom merenju pri nivou statističkog zaključivanja od p<0,001. Statistički značajne razlike između inicijalnog i finalnog merenja u motoričkim sposobnostima kod eksperimentalne grupe uočene su u pet varijabli, i to: varijablama za procenu eksplozivne snage donjih ekstremiteta *Dohvatna visina sa jednom rukom* i *Dohvat za blok* a što je bio i cilj samog programiranog transformacionog procesa koji je primenjen na vrhunskim sportistima, u varijabli za procenu fleksibilnosti lumbalnih ekstenzora i zadnje lože buta *Pretklon na klupici*, varijabli za procenu agilnosti *Japan test*, i varijabli za procenu snage mišića ruku i ramenog pojasa *Sklek 30s*. Posmatrajući negativan predznak navedenih varijabli vidi se da su u četiri varijable dobijene statistički značajne razlike i ostvareni bolji rezultati na finalnom merenju, dok je u varijabli za procenu agilnosti *Japan test* predznak pozitivan, ali pošto se radi o inverznoj metrici i vremenskoj jedinici gde je lošiji rezultat ustvari bolji, vidi se da su u ovoj varijabli rezultati statistički značajno bili bolji na finalnom merenju. Na osnovu svega iznetog u tabeli 10. konstatuje se da su nastale razlike plod primenjenog eksperimentalnog tretmana.

Table 11. *Quantitative differences between the initial and the final measurements of the control group in motor variables at the final measurement.*

Tabela 11. *Kvantitativne razlike između inicijalnog i finalnog merenja kontrolne grupe u motoričkim varijablama na finalnom merenju*

Varijable/Grupe / *Variables/Groups*	Kontrolna / *Control*	
	AS_1-AS_2	p
Dohvatna visina sa jednom rukom / *Reachable height with one arm*	-0,25	0,202
Dohvat za blok / *Block reach*	-0,25	0,119
Pretklon na klupici / *Back saver*	-0,27	0,031
Taping rukom / *Plate tapping test*	-0,25	0,037
Japan test / *Japan test*	-0,03	0,818
Bacanje medicinke iz ležećeg pol. / *Medicine ball throwing from lying position*	-0,17	0,115
Sklek 30s. / *Push-ups 30sec*	-0,83	0,033
Ležanje-sed 30s. / *Sit-ups 30sec*	-0,44	0,016
Leđa 30s. / *Back 30sec*	-0,86	0,001

Legend: *AS1-AS2-the first and the second measurement; p - the level of statistical significance of the t-test.*

Legenda: *AS_1-AS_2-prvo i drugo merenje; p-nivo statističke značajnosti t-testa.*

Quantitative differences between the initial and the final measurements of the control group in motor variables at the final measurement are presented in table 11 at the statistical inference level p <0.001. By reviewing the results obtained in the table above, it is concluded that there are statistically significant differences in the two variables

Kvantitativne razlike između inicijalnog i finalnog merenja kontrolne grupe u motoričkim varijablama na finalnom merenju predstavljene su u tabeli 11, na nivou statističkog zaključivanja p<0,001. Pregledom dobijenih rezultata u navedenoj tabeli konstatuje se da postoje statistički značajne razlike u dve varijable na finalnom me-

at the final measurement: the variables for the estimation of the repetitive strength of the abdominal muscles *Sit-ups 30s* and the variables for assessing the repetitive strength of the back muscles *Back 30s.* Based on the sign, we can see that the statistical significance of the mentioned variables was achieved on the final measurement in both variables, which can be the result of accomplished training tasks in the control group of athletes.

Discussion

Plyometric training involves performance involving eccentric contraction of great intensity immediately after the fast and powerful concentric contraction (Malisoux, Francaux, Nielens, Theisen, 2006). The effects of plyometric training on vertical jump performance were studied heavily. Numerous studies on plyometrics showed improvements in jump height (Wilson, Murphy, Giorgi, 1996; Wilson, Newton, Murphy, 1993; Adams, O'Shea, O'Shea, 1992; Marković, Jukicć, Milanović, 2007; Malisoux, Francaux, Nielens, 2006; Kotzamanidis, 2006; Dvir, 1985 Blattner, Noble, 1979; Matavulj Kukolj, Ugarkovic 2001; Brown, Mayhew, Boleach, 1986 Fatouros, Jamurtas, Leontsini, 2000 Gehri, Ricard, Kleiner, 1998; Spurrs, Murphy, Watsford, 2003, Diallo, Dore, Duche, 2001, Chimera, Swanik, Swanik, 2004; Tricoli, Lamas, Carnevale, 2005; Holcomb, Lander, Rutland, 1996; Lehance, Cruising, Bury, 2005). These results are certainly consistent with the results obtained in this study on the positive impact of plyometric training on changes in explosive strength in elite athletes.

The tested quantitative differences between the initial and final measurements of the experimental group in the motor variables final measurements have shown positive effects in five analyzed variables, as follows: the variables for the evaluation of the explosive strength of the lower extremities Reachable height with one arm and Block reach which was the initial objective of the programmed transformation process that is applied to top athletes, the variables for assessing the flexibility of hamstring Back saver, variables for assessing agility Japan test, and variables for assessing muscle strength of arms and shoulders Push - up 30sec. Looking at the negative sign of the mentioned variables, we see that four statistically significant variables achieved better results on the final measurement, while in the agility assessment variable *Japan test*, the sign is positive but since it is an inverse metric and a time unit where the worse result is better, we see that in this variable, the results were statistically significantly better on the final measurement.

renju i to: u varijabli za procenu repetitivne snage trbušnih mišića i pregibača zgloba kuka *Ležanje-sed 30s*. i u varijabli za procenu repetitivne snage leđnih mišića *Leđa 30s*. Na osnovu predznaka vidi se da je statistička značajnost navedenih varijabli ostvarena na finalnom merenju u obe varijable, što može biti plod ostvarenih trenažnih zadataka u kontrolnoj grupi sportista.

Diskusija

Pliometrijski trening podrazumeva performanse koje uključuju ekscentričnu kontrakciju velikog intenziteta odmah nakon brze i snažne koncentrične kontrakcije (Malisoux, Francaux, Nielens, Theisen, 2006). Efekti pliometrijskog treninga na performanse vertikalnog skoka su proučavani u velikoj meri. Brojne studije o pliometriji pokazale su poboljšanja u visini skokova (Wilson, Murphy, Giorgi, 1996; Wilson, Newton, Murphy, 1993; Adams, O'Shea, O'Shea, 1992; Markovic, Jukic, Milanovic, 2007; Malisoux, Francaux, Nielens, 2006; Kotzamanidis, 2006; Dvir, 1985;Blattner, Noble, 1979;Matavulj, Kukolj, Ugarkovic, 2001; Brown, Mayhew, Boleach, 1986; Fatouros, Jamurtas, Leontsini, 2000; Gehri, Ricard, Kleiner, 1998; Spurrs, Murphy, Watsford, 2003; Diallo, Dore, Duche, 2001; Chimera, Swanik, Swanik, 2004; Tricoli, Lamas, Carnevale, 2005; Holcomb, Lander, Rutland,1996; Lehance, Croisier, Bury, 2005). Ovi rezultati su svakako u skladu sa dobijenim rezultatima u ovom istraživanju o pozitivnom uticaju pliometrijskog treninga na promene u eksplozivnoj snazi kod vrhunskih sportista.

Testirane kvantitativne razlike između inicijalnog i finalnog merenja eksperimentalne grupe u motoričkim varijablama na finalnom merenju pokazale su pozitivne efekte u pet analiziranih varijabli, i to: varijablama za procenu eksplozivne snage donjih ekstremiteta *Dohvatna visina sa jednom rukom i Dohvat za blok,* a što je bio i cilj samog programiranog transformacionog procesa koji je primenjen na vrhunskim sportistima, u varijabli za procenu fleksibilnosti lumbalnih ekstenzore i zadnje lože buta *Pretklon na klupici*, varijabli za procenu agilnosti *Japan test*, i varijabli za procenu repetitivne snage mišića ruku i ramenog pojasa *Sklek 30s*. Posmatrajući negativan predznak navedenih varijabli vidi se da su u četiri varijable ostvareni bolji rezultati na finalnom merenju, dok je u varijabli za procenu agilnosti *Japan test* predznak pozitivan, ali pošto se radi o inverznoj metrici i vremenskoj jedinici gde je lošiji rezultat ustvari bolji, vidi se da su i u ovoj varijabli rezultati statistički značajno bili bolji na finalnom merenju.

Conclusion

The primary objective of this longitudinal study was to determine the effects of special treatment of kinesiologic activities based on plyometric exercises on the motor abilities of experimental volleyball subjects. The study was conducted on a sample of 72 volleyball subjects divided into two groups (experimental and control group). The experimental group consisted of 36 volleyball subjects with whom a special treatment of kinesiological activities was implemented, structured in content from plyometric exercises. The control group also consisted of 36 volleyball subjects not covered by kinesiological treatment. The survey applied 9 variables to assess motor skills. Measurements of motor variables were performed at the beginning and end of treatment in both groups of subjects. Differences between initial and final measurements were found in both groups of subjects. The obtained results indicate that there were statistically significant changes in the experimental group compared to the control group. The resulting changes are evident in the five applied motor variables (single arm reach height, block reach, bench lean, 30 s push, and Japan test). Of course, the most important changes are those related to the improvement of the specific motor skills of volleyball players (one-handed reach, reach for the block), which can be attributed to the effects of applied plyometric training. Thus, the treatment applied in the experimental group participants contributed to the improvement of the explosive power of the lower extremities (vertical jump), which is one of the very important abilities for the success of the game of volleyball.

The results of the research can be useful for volleyball coaches in the quality creation and programming of training work with volleyball players, but also as an incentive for other researchers to design and implement new work programs and to monitor their effects.

Zaključak

Primarni cilj ovog longitudinalnog istraživanja bio je usmeren na utvrđivanje efekata posebnog tretmana kineziloških aktivnosti zasnovanih na pliometrijskim vežbama na motoričke sposobnosti ispitanika-odbojkaša eksperimentalne. Istraživanje je provedeno na uzorku od 72 ispitanika-odbojkaša podeljenih u dve grupe (eksperimentalnu i kontrolnu grupu). Eksperimentalnu grupu činilo je 36 ispitanika odbojkaša sa kojom je realizovan posebni tretman kineziloških aktivnosti sadržajno strukturiran od pliometrijskih vežbi. Kontrolnu grupu činilo je takođe 36 ispitanika-odbojkaša koji nisu obuhvaćeni kineziološkim tretmanom. U istraživanju je primenjeno 9 varijabli za procenu motoričkih sposobnosti. Izvršena merenja motoričkih varijabli provedena su na početku i na kraju tretmana kod obe grupe ispitanika. Razlike između inicijalnog i finalnog merenja utvrđivane su kod obe grupe ispitanika. Dobijeni rezultati ukazuju da je kod ispitanika eksperimentalne grupe došlo do statistički značajnijih promena u odnosu na ispitanike kontrolne grupe. Nastale promene su vidljive kod pet primenjenih motoričkih varijabli (dohvatna visina sa jednom rukom, dohvat za blok, pretklon na klupici, sklek 30 s i japan test). Svakako, da su najvažnije promene one koje se odnose na poboljšanje specifičnih motoričkih sposobnosti odbojkaša (dohvatna visina sa jednom rukom, dohvat za blok), što se može pripisati efektima primenjenog pliometijskog treninga. Dakle, primenjeni tretman kod ispitanika eksperimentalne grupe je doprineo poboljšanju eksplozivne snage donjih ekstremiteta (vertikalne skočnosti), što predstavlja jednu od vrlo važnih sposobnosti za uspešnost igre u odbojci.

Rezultati istraživanja mogu biti od koristi odbojkaškim trenerima u kvalitetnijem kreiranju i programiranju trenažnog rada sa odbojkašima, ali isto tako i kao poticaj drugim istraživačima za izradu i primenu novih programa rada kao i praćenje njihovih efekata.

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