

YOUNG ATHLETES UPPER KNEE MUSCULAR STRENGTH ISOKINETIC TESTING

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Abstract: This research main goal is to determine differences in maximum upper knee musculature torque moment of judo, football and handball players. For the needs of the research, 30 respondents were tested, of which 10 were football, 10 handball players and 10 judo athletes. Testing was conducted in Isokinetic Diagnostic Cabinet of the Provincial Institute for Sports and Sports Medicine in Novi Sad on the isokinetic dynamometer "Easytech prima DOC". Significant differences were noted in the maximum torque moment of both legs extensors force (PTQR, PTQL) between judo athletes and football players, in favor of judo. Obtained results between observed groups can be attributed to the various sports branches training processes specificities, i.e. performing certain techniques in the sport itself.

Keywords: isokinetic diagnostics, football players, judo athletes, handball players.

INTRODUCTION

Modern training process today is unimaginable without quality athletes' training diagnostics. In this way, a sports expert meets their athlete, i.e. their good and bad sides, and in that way they are ready to enter the training process with them.

Muscles and joints function assessment is of utmost importance in sports and recreation (exercise), not only for performance purpose, but also for the assessment and injuries rehabilitation (Baltzopoulos and Brodie, 1989). Isokinetic devices can serve as diagnostic devices for estimating different elements of strength, force, speed, average power, fatigue, acceleration and deceleration of segmental training and velocity (Bašćevan, Bašćevan, Janković, 2008).

Isokinetic testing is an examination of the functional muscles and joints parameters in active movement

IZOKINETIČKO TESTIRANJE SNAGE NATKOLENE MUSKULATURE MLADIH SPORTISTA

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Apstrakt: Osnovni cilj ovog istraživanja je da se utvrde razlike maksimalnog obrtnog momenta sile natkolene muskulature džudista, fudbalera i rukometaša. Za potrebe istraživanja testirano je 30 ispitanika od kojih je 10 fudbalera, 10 rukometaša i 10 džudista. Testiranje je sprovedeno u kabinetu za izokinetičku dijagnostiku Pokrajinskog zavoda za sport i medicinu sporta u Novom Sadu na izokinetičkom dinamometru „Easytech prima DOC“. Signifikantne razlike su uočene u maksimalnom obrtnom momentu sile ekstenzora obe noge (PTQR, PTQL) između džudista i fudbalera, u korist džudista. Dobijeni rezultati između posmatranih grupa se mogu pripisati specifičnostima trenažnog procesa različitih sportskih grana, tj. izvođenja određenih tehnika u samom sportu.

Cljučne riječi: izokinetička dijagnostika, fudbaleri, džudisti, rukometaši.

UVOD

Savremeni trenažni proces danas je nezamisliv bez kvalitetne dijagnostike treniranosti sportista. Na taj način sportski stručnjak upoznaje svog sportistu, tj. njegove dobre i loše strane, i na taj način spreman ulazi u trenažni proces sa njim.

Procena funkcije mišića i zglobova su od izuzetnog značaja u sportu i rekreaciji (vežbanju), ne samo u cilju performansi, već i za procenu i rehabilitaciju od povreda (Baltzopoulos i Brodie, 1989). Izokinetički uređaji mogu poslužiti kao dijagnostički uređaji za procenu različitih elemenata snage, sile, brzine, prosečne snage, zamora, ubrzanja i usporenja segmentarnog rada i brzine (Bašćevan, Bašćevan, Janković, 2008).

Izokinetičko testiranje predstavlja ispitivanje funkcionalnih parametara mišića i zglobova u aktivnom po-

and in real time in relation to age, gender, body weight, daily sports activity and individual needs. Isokinetics is applied for the purpose of measurement-diagnostics, exercise-training and rehabilitation. What is relevant to the isokinetic movement is that the subject is never opposed to a resistance that cannot be overcome, because the resistance is even equal to the applied force. This means that isokinetic training is safe (Mikić, Bajrić, Selimović, Hrnjić, Ivanek, 2018). Isokinetics is a method of measuring muscle force in conditions of concentric and eccentric muscular contractions on a special isokinetic dynamometer. This method allows the definition of maximum force depending on the angle between the segments (knee), the force between agonists and antagonists ratio (lower extremities: *m. Quadriceps* - *m. Biceps femoris*).

Isokinetic diagnostics represents the best way to determine maximum muscle strength, muscular endurance, which are strong, and which weak athlete points. Taking into account specifics of football, judo and handball specifics, upper knee muscular power control is of great importance both in prevention of injuries and in creation of training process. In the study of upper knee muscular power of footballers, athletes, judoists and wrestlers, Vujkov, Golik-Perić, Drid, Vujkov, Drapšin (2008), proved statistically significant differences in variables which show maximum knee torque of extensors of both legs and the maximum knee torque of flexors of both legs in favor of the judoists and wrestlers.

By measuring the strength of individual muscle groups that trigger certain extremities, we get parameters that define this movement. One of the basic parameters is, of course, knee moment of force (torque), that is, the value of the force that the tested muscle develops around the axis of rotation during the measured motion (moment of rotation), (Iossifidou, 2000).

During the motion, a constant force moment is not developed, so that the mean force mean value (Nm) - (mean torque) represents the mean value of the rotational force generated during the measured motion for a given angular velocity. Maximum torque moment (Nm) (peak torque) represents the maximum value of the rotational force generated during the measured motion at a certain angular velocity (Jarić 2002; Lindsdrom 2006; Sykaras 2003; Veloso 2002).

Modern football game and the increasing demands for achieving top results imply the need for a better scientific and professional quality approach, both in terms of the selection of future footballers and training technology application in the work with younger age categories. Modern training technology in the work with younger selections of footballers implies the develop-

mentu i realnom vremenu u odnosu na uzrast, pol, telesnu težinu, svakodnevnu sportsku aktivnost i individualne potrebe. Izokinetika se primenjuje u svrhu merenja-dijagnostike, vežbanja-treninga i rehabilitacije. Ono što je bitno za izokinetički pokret jeste da subjekt nikad nije suprotavljen otporu koji ne može savladati, jer je otpor celo vreme jednak primenjenoj sili. To znači da je izokinetički trening siguran (Mikić, Bajrić, Selimović, Hrnjić, Ivanek, 2018). Izokinetika je metoda merenja mišićne sile u uslovima koncentričnih i ekscentričnih mišićnih kontrakcija na specijalnom izokinetičkom dinamometru. Ova metoda omogućuje definisanje maksimalne sile u zavisnosti od ugla između segmenata (koleno), odnos sile između agonista i antagonista (donji ekstremiteti: *m. quadriceps* - *m. biceps femoris*).

Izokinetička dijagnostika predstavlja najbolji način da se odredi kakva je maksimalna snaga mišića, mišićna izdržljivost, koje su jake, a koje slabe tačke sportiste. Uzimajući u obzir specifičnosti fudbala, džudoa i rukometa, kontrola snage natkolene muskulature od velikog je značaja, kako u prevenciji povreda, tako i u samom kreiranju trenažnog procesa. U istraživanju natkolene muskulature fudbalera, atletičara, džudista i rvača Vujkov, Golik-Perić, Drid, Vujkov, Drapšin (2008) su dokazali statistički značajne razlike u varijablama maksimalni obrtni moment ekstenzora kolena obe noge i maksimalni obrtni moment fleksora obe noge u korist džudista i rvača.

Merenjem snage pojedinih mišićnih grupa koji pokreću određene delove ekstremiteta, dobijaju se parametri koji definišu taj pokret. Jedan od osnovnih parametara je, svakako, moment sile (torque), odnosno vrednost sile koju testirani mišić razvija oko ose rotacije tokom merenog pokreta (moment rotacije), (Iossifidou, 2000).

U toku izvođenja pokreta ne razvija se konstantan moment sile, tako da parametar srednja vrednost momenta sile (Nm) - (mean torque) predstavlja prosečnu vrednost rotacione sile ostvarene u toku merenog pokreta za određenu vrednost ugaone brzine. Maksimalni moment sile (Nm) (peak torque) predstavlja maksimalnu vrednost rotacione sile ostvarene u toku merenog pokreta pri određenoj ugaonoj brzini (Jarić 2002; Lindsdrom 2006; Sykaras 2003; Veloso 2002).

Savremena fudbalska igra i sve veći zahtevi za postizanjem vrhunskih rezultata nameću potrebu za što kvalitetnijim naučnim i stručnim pristupom, kako po pitanju same selekcije budućih fudbalera tako i po pitanju primene trenažne tehnologije u radu sa mlađim uzrasnim kategorijama. Savremena trenažna tehnologija u radu sa mlađim selekcijama fudbalera podrazumeva izradu takvih programa trenažnog rada koji će u potpunosti biti

ment of such training programs that will be completely subordinate to the characteristics and individual abilities of each individual, thereby contributing to the optimal development of all the qualities and abilities that define the anthropological status of the individual at all stages of its development (Lolić, Bajrić, Lolić, 2011). Analyzing component structure, considerably greater opportunities for managing and guiding football training techniques as well as the selection of future young generations are opened, and with the help of such analysis it is possible to provide monitoring and directing of connections functions between each subsystem within the football game (Radosav, Molnar, Smajić, 2003; Bajrić, 2008).

From the structural judo analysis itself, it follows that various manifestations of power, and then coordination are most important capabilities that determine success in judo fighting. From various types of strengths, it is considered that the ability to maximize energy mobilization in a unit of time is of utmost importance, ability to perform the maximum number of contractions with certain resistance, and the ability to develop maximum muscular strength. Modern superb judo fighter is characterized by the pronounced body muscularity and as far as motor skills are concerned, exceptional absolute, repetitive and explosive strength, perfect coordination, enviable speed, excellent balance and superb flexibility. The main goal of each judo athlete is to gain good competitive advantages in relation to its sport opponents (Lolić, Nurkić, 2011).

Handball game structure, match duration, technical-tactical activities during the match and training, requires that the team has handball players with highly developed physical characteristics. In relation to the position in the team, motor-functional abilities of individuals are also different. The power of the upper knee muscular is of great importance to the players in all positions. All of this suggests that isokinetic diagnostics is necessary in order to determine the current strength in order to program the training process and to prevent injury.

The aim of this paper is to determine upper knee muscular strength of football and handball players, judo athletes, and the existence of similarities or differences in the maximum torque of upper knee muscular between athletes' groups.

WORK METHOD

The research involved 30 respondents aged 14-18, divided into three groups: 10 football players, 10 judoists and 10 handball players. Testing was done at the premises of the Provincial Institute for Sport and Sports Medicine in Novi Sad. For the needs of the test, the isokinetic dynamometer "Easytech Prima DOC" was used, at a torque of 60 step° / sec.

podređeni uzrasnim karakteristikama i individualnim sposobnostima svakog pojedinca i time doprineti optimalnom razvoju svih osobina i sposobnosti koji definišu antropološki status individue u svim fazama njenog razvoja (Lolić, Bajrić, Lolić, 2011). Analizom komponentne strukture otvaraju se znatno veće mogućnosti za upravljanje i usmeravanje trenažne tehnologije u fudbalu kao i samoj selekciji budućih mladih naraštaja, a ujedno uz pomoć takve analize moguće je obezbediti praćenje i usmeravanje funkcija veza između svakog sistema unutar fudbalske igre (Radosav, Molnar, Smajić, 2003; Bajrić, 2008).

Iz same strukturalne analize džudoa proizlazi da su različite manifestacije snage, a zatim i koordinacije najvažnije sposobnosti koje determinišu uspeh u džudo borbi. Od različitih vidova snage smatra se da su za borbu od najvećeg značaja sposobnost maksimalne mobilizacije energije u jedinici vremena, sposobnost izvođenja maksimalnog broja kontrakcija uz određeni otpor, te sposobnost razvijanja maksimalne mišićne sile. Modernog vrhunskog džudo borca krasí naglašena muskuloznost građe tela, a što se tiče motoričkih sposobnosti izuzetna apsolutna, repetitivna i eksplozivna snaga, perfektna koordinacija, zavidna brzina, odlična ravnoteža i nadprosečna fleksibilnost. Glavni cilj svakog džudiste je da stekne dobre takmičarske prednosti u odnosu na svoje sportske protivnike (Lolić, Nurkić, 2011).

Struktura rukometne igre, trajanje utakmice, tehničko-taktičke aktivnosti u toku treninga i meča zahteva da ekipa u svom sastavu ima rukometaše sa visoko razvijenim fizičkim karakteristikama. U odnosu na poziciju u ekipi, razlikuju se i motoričko-funkcionalne sposobnosti pojedinaca. Snaga natkolene muskulature je od izuzetnog značaja za igrače na svim pozicijama. Sve ovo nas upućuje da je izokinetička dijagnostika neophodna radi utvrđivanja trenutne snage u cilju programiranja trenažnog procesa i prevencije povreda.

Cilj rada je utvrđivanje snage natkolene muskulature fudbalera, džudista i rukometaša i postojanja sličnosti ili razlika maksimalnog obrtnog momenta natkolene muskulature između grupa sportista.

METOD RADA

U istraživanju je učestvovalo 30 ispitanika, uzrasta 14-18 godina, podeljenih u tri grupe: 10 fudbalera, 10 džudista i 10 rukometaša. Testiranje je izvršeno u prostorijama Pokrajinskog zavoda za sport i medicinu sporta u Novom Sadu. Za potrebe testiranja korišćen je izokinetički dinamometar "Easytech Prima DOC", pri obrtnom momentu sile 60 step/sec.

Testing Protocol: On test day, athletes didn't have training, and only testing was done according to standard protocol in identical manner for everyone. Each athlete was introduced to the protocol individually before the test, then heated up adequately and prepared for testing. Dynamometer was calibrated before each test. For each respondent the dynamometer seat was specially adjusted. They were immobilized by seatbelts in order to maximally isolate tested musculature. Testing started with heating, then 2min break, and then starts the test itself. During the test, 4 maximum contractions were carried out, first with the front upper knee muscles, and then with rear, rotating. The same procedure was performed with one leg, and the other leg later. Body mass was measured before isokinetic testings on In Body 270 (bioelectric impedance) where athletes were in shorts and barefoot.



Photo 1. Testing on Isokinetic dynamometer "Easytech Prima DOC"

Slika 1. Testiranje na izokinetičkom dinamometru "Easytech Prima DOC"

In this study, 8 tests were applied. Tests for assessment of upper knee muscular strength:

- Maximum torque of right knee extension - PTQR
- Maximum torque of left knee extension - PTQL
- Maximum torque of right knee flexion - PTHR
- Maximum torque of left knee flexion - PTHL
- Relative maximum torque of right knee extension - PTQR / W
- Relative maximum torque of left knee extension - PTQL / W
- Relative maximum torque of right knee flexion - PTHR / W
- Relative maximum torque of left knee flexion - PTHL / W
- Body mass -BM

Software package SPSS 20.0 was used for data processing. Data analysis was carried out using descriptive statistics for calculating basic descriptive parameters of the observed variables. To determine statistically significant differences in muscular strength between subjects, a univariate variance analysis (ANOVA) was used, a level of statistical significance ($p < 0.05$).

Protokol testiranja: Na dan testiranja sportisti nisu trenirali, a samo testiranje izvedeno po standardnom protokolu na identičan način za svakog. Svaki sportista pojedinačno pre testa upoznat sa protokolom, zatim se adekvatno zagrejavao i pripremio za testiranje. Dinamometar je pre svakog testiranja kalibriran. Za svakog ispitanika posebno se podešavalo sedište dinamometra. Ispitanici su bili imobilizirani trakama za sedište kako bi se maksimalno izolovala testirana muskulatura. Testiranje je počinjalo zagrevanjem, zatim 2 minuta pauze, a nakon toga se prešlo na sam test. Tokom testa izvodile su se 4 maksimalne kontrakcije, prvo prednjom, a zatim zadnjom ložom, neizmenično. Identičan postupak je izvođen prvo jednom, pa drugom nogom.

U ovom istraživanju primenjeno je 8 testova. Uzorak varijabli za procenu snage natkolene muskulature:

- Maksimalni obrtni moment ekstenzije desnog kolena - PTQR
- Maksimalni obrtni moment ekstenzije levog kolena - PTQL
- Maksimalni obrtni moment fleksije desnog kolena - PTHR
- Maksimalni obrtni moment fleksije levog kolena - PTHL
- Relativni maksimalni obrtni moment ekstenzije desnog kolena - PTQR/W
- Relativni maksimalni obrtni moment ekstenzije levog kolena - PTQL/W
- Relativni maksimalni obrtni moment fleksije desnog kolena - PTHR/W
- Relativni maksimalni obrtni moment fleksije levog kolena - PTHL/W

Za obradu podataka korišćen je programski paket SPSS 20,0. Analiza podataka se sprovodila pomoću deskriptivne statistike za izračunavanje osnovnih deskriptivnih statistika posmatranih varijabli. Radi utvrđivanja statistički značajnih razlika snage natkolene muskulature

RESULTS AND DISCUSSION

Correct development of upper knee muscles, unilateral relationship (relationship within a single muscular composition) and bilateral relationship (relationship between left and right side of the body that can be in the torso and extremities) are of utmost importance for sports structure such as football, judo, handball, both in terms of performance and in terms of injury prevention. Right time diagnosis and taking certain actions can help us with proper physical development of the athlete, and therefore in injuries prevention.

Descriptive statistics analysis (Table 1) of the observed variables based on the significance of Leven homogeneity variance test ($p < 0.05$) indicates the homogeneity of all tested variables results in all three groups of athletes. The values of the asymmetry coefficient (Sk-Skewness) and the coefficient of curvature (Kurt-Kurtosis) indicate that the distributions of the analyzed variables do not deviate significantly from normal distribution. Average body weight of athletes involved in this study is $53-120\text{kg} \pm 14.66\text{SD}$. Mean values of measured variables that reflect upper knee musculature strength of the entire sample are shown in Table 1.

Table 1. Basic descriptive statistics for maximum knee torque and athletes body mass (whole sample)

Variable / Variables	N	MIN	MAX	AS	SD	Sk	Kurt	Levenov test F p
uzrast / age	30	14.00	18.00	15.80	1.03	0.63	-0.49	0.04 0.96
TM	30	53.00	120.00	74.47	14.66	0.89	1.73	2.26 0.12
PTQR	30	123.00	335.00	233.27	54.95	-0.41	-0.71	0.95 0.40
PTQL	30	80.00	337.00	230.50	67.55	-0.58	-0.38	0.42 0.66
PTHR	30	52.00	192.00	112.60	36.87	0.43	-0.58	0.04 0.97
PTHL	30	32.00	182.00	107.40	36.38	0.12	-0.73	0.32 0.73
PTQR/W	30	2.08	4.10	3.10	0.48	-0.26	0.38	0.63 0.54
PTQL/W	30	0.98	4.25	2.84	0.90	-0.71	-0.34	1.81 0.18
PTHR/W	30	0.77	4.16	1.77	0.74	1.47	2.54	1.87 0.17
PTHL/W	30	0.60	3.18	1.49	0.52	1.13	2.44	1.23 0.31

Legend: N-number of research entities, TM- body mass, Min-minimum values, Max-peak values, AS-arithmetic mean, S-standard deviation, Sk-asymmetry factor, Kurt- curvature coefficient, maximum torque of right knee extension – PTQR, maximum torque of left knee extension – PTQL, maximum torque of right knee flexion – PTHR, maximum torque of left knee flexion – PTHL, relative maximum torque of right knee extension - PTQR / W, relative maximum torque of left knee extension - PTQL / W, relative maximum torque of right knee flexion - PTHR / W, relative maximum torque of left knee flexion - PTHL / W

između ispitanika korišćena je univarijatna analiza varijanse (ANOVA), nivo statističke značajnosti ($p < 0.05$).

REZULTATI I DISKUSIJA

Pravilna razvijenost natkolene muskulature, unilateralni odnos (odnos unutar jednog mišićnog sastava) i bilateralni odnos (odnos između leve i desne strane tela koji može biti u trupu i ekstremitetima) od izuzetnog su značaja za samu strukturu sportova kao što su fudbal, džudo, rukomet, kako u pogledu uspešnosti, tako i u pogledu prevencije povreda. Pravovremena dijagnostika i preduzimanje određenih radnji može nam pomoći pri pravilnom fizičkom razvoju sportiste, a samim tim i u prevenciji povreda.

Analiza deskriptivnih statistika (Tabela 1) posmatranih varijabli na osnovu vrednosti statističke značajnosti Levenovog testa homogenosti varijansi ($p < 0.05$), ukazuje na homogenost rezultata svih testiranih varijabli kod sve tri grupe sportista. Vrednosti koeficijenta asimetričnosti (Sk-skjunis) i koeficijenta zakrivljenosti (Kurt-kurtosis) ukazuju da distribucije analiziranih varijabli ne odstupaju značajno od normalne distribucije. Prosečna telesna masa sportista obuhvaćena ovim istraživanjem iznosi $53,00-120,00\text{kg} \pm 14,66\text{SD}$. Srednje vrednosti izmerenih varijabli koje oslikavaju snagu natkolene muskulature čitavog uzorka su prikazane u tabeli 1.

Tabela 1. Osnovni deskriptivni statistici za maksimalni obrtni moment zgloba kolena (ceo uzorak)

Legenda: N-broj entiteta u istraživanju, TM- telesna masa, Min-minimalne vrednosti, Max-maksimalne vrednosti, AS-aritmetička sredina, S-standardna devijacija, Sk-koeficijent asimetričnosti, Kurt-koeficijent zakrivljenosti, PTQR- max obrtni moment ekstenzije desnog kolena, PTQL- max obrtni moment ekstenzije levog kolena, PTHR- max obrtni moment fleksije desnog kolena, PTHL- max obrtni moment fleksije levog kolena, PTQR/W- relativni max obrtni moment ekstenzije desnog kolena, PTQL/W- relativni max obrtni moment ekstenzije levog kolena, PTHR/W- relativni max obrtni moment fleksije desnog kolena, PTHL/W- relativni max obrtni moment fleksije levog kolena

Analysis of the basic descriptive parameters for the maximum torque of knee joint extension and flexion of football players, judo and handball players is shown in Table 2. Of all tested athletes, highest average body weight is found in judoists (AS = 83.30kg), then handball players (AS = 74.90kg), and the lowest footballers (AS = 65.20kg). From the table, we can notice that there are differences in the variables that describe the force of upper knee musculature in absolute and relative values.

Table 2. Basic descriptive statistics for the maximum knee torque and body mass of football players, judo and handball players

Varijabla / Variable	sport	N	AS	SD	Min	Max	Varijabla / Variable	sport	AS	SD	Min	Max
TM	1	10	65.20	6.41	53.00	75.00	TM	1	65.20	6.41	53.00	75.00
	2	10	83.30	16.92	56.00	120.00		2	83.30	16.92	56.00	120.00
	3	10	74.90	13.37	53.00	92.00		2	74.90	13.37	53.00	92.00
PTQR	1	10	198.00	35.98	157.00	271.00	PTQR/W	1	2.95	0.52	2.09	3.99
	2	10	262.00	52.25	152.00	335.00		2	3.19	0.57	2.08	4.10
	3	10	239.80	57.94	123.00	308.00		3	3.17	0.35	2.32	3.54
PTQL	1	10	190.70	62.11	83.00	293.00	PTQL/W	1	2.58	1.15	1.06	4.25
	2	10	267.00	51.98	157.00	337.00		2	3.02	0.60	1.91	3.77
	3	10	233.80	69.96	80.00	308.00		3	2.91	0.89	0.98	3.70
PTHR	1	10	97.20	38.80	67.00	192.00	PTHR/W	1	1.85	0.82	1.10	3.03
	2	10	132.40	32.67	92.00	182.00		2	1.87	0.92	0.77	4.16
	3	10	108.20	32.98	52.00	148.00		3	1.58	0.45	0.88	2.58
PTHL	1	10	89.20	34.78	63.00	156.00	PTHL/W	1	1.36	0.48	0.92	2.26
	2	10	125.10	26.16	84.00	154.00		2	1.55	0.36	0.79	1.95
	3	10	107.90	40.67	32.00	182.00		3	1.55	0.71	0.60	3.18

Legend: 1 - football, 2 - judo, 3 - handball

Using single-factor analysis of variance (ANOVA) of different groups, the results were compared between groups in the indicators of upper knee muscular strength of athlete, where we determined on the basis of F and the level of statistical significance ($p < 0.05$) that there are statistically significant differences between athletes in body mass ($F = 4.29$, $p = 0.02$), maximum torque extension of the right knee ($F = 4.29$, $p = 0.02$), maximum torque extension of the left knee ($F = 3.83$, $p = 0.03$). In other variables that describe the force of tested musculature, statistically significant differences were not observed (Table 3).

In order to determine among which athletes there are statistically significant differences at level ($p < 0.05$), LSD Post Hoc Tests was used (Table 3). Using the Tukey HSD test, it was found that in the variable Body Mass, where the

Analiza osnovnih deskriptivnih parametara za maksimalni obrtni moment ekstenzije i fleksije zgloba kolena fudbalera, džudista i rukometaša je prikazana u tabeli 2. Od testiranih sportista, najveću prosečnu telesnu masu imaju džudisti (AS=83,30kg), zatim rukometaši (AS=74,90kg), a najmanju fudbaleri (AS=65,20kg). Iz tabele možemo uočiti da postoje razlike i u varijablama koje opisuju silu natkolene muskulature u apsolutnim i relativnim vrednostima.

Tabela 2. Osnovni deskriptivni statistici za maksimalni obrtni moment zgloba kolena fudbalera, džudista i rukometaša

Legenda: 1-fudbaleri, 2-džudisti, 3-rukometasi

Primenom jednofaktorske analize varijanse (ANOVA) različitih grupa, poređeni su rezultati između grupa u pokazateljima snage natkolene muskulature sportista, gde smo utvrdili na osnovu vrednosti F, te nivoa statističke značajnosti ($p < 0.05$), da postoje statistički značajne razlike između grupa sportista u telesnoj masi ($F = 4,86$, $p = 0,02$), maksimalnom obrtnom momentu ekstenzije desnog kolena ($F = 4,29$, $p = 0,02$), maksimalnom obrtnom momentu ekstenzije levog kolena ($F = 3,83$, $p = 0,03$). U ostalim varijablama koje opisuju silu natkolene muskulature statistički značajne razlike nisu uočene (tabela 3).

Da bi se utvrdilo između kojih grupa sportista postoje statistički značajne razlike na nivou ($p < 0.05$), pribeglo se korišćenju LSD Post Hoc Testa (Tabela 3). Primenom Tukeyevog HSD testa ustanovljeno je da se

mean value of the football players body mass (AS = 65.20, SD = 6.41) is statistically significantly lower ($p = 0.01$) than the mean value of judo athletes body mass (AS = 83.30, SD = 16.92), the observed difference in the AS weight of these athletes' groups is 18.10kg in favor of the judoists. Additional comparisons with the HSD test indicate that the mean value of the maximum torque of the right knee extensions of footballers is statistically significantly lower ($p = 0.02$) in relation to the judo athletes. Similar situation is with variables of maximum torque of the left knee extension ($p = 0.03$), where for 76.30 AS judo athletes higher than the footballers in the observed variable. Using statistical procedures, differences were found in other variables that describe the extension and flexion in the knee joint, but differences are not significant. However, the results tell us that in all variables the best results were achieved by the judo, and that handball players are better than the footballers.

u varijabli Telesna masa, gde je srednja vrednost TM fudbalera (AS=65,20, SD=6,41) statistički značajno manja ($p=0,01$) od srednje vrednosti TM džudista (AS= 83,30, SD=16,92), uočena razlika AS telesne mase ovih grupa sportista iznosi 18,10kg u korist džudista. Naknadna poređenja pomoću HSD testa kazuju da je srednja vrednost maksimalnog obrtnog momenta ekstenzije desnog kolena fudbalera statistički značajno manja ($p=0,02$) u odnosu na džudiste. Slična situacija je i sa varijablom maksimalni obrtni moment ekstenzije levog kolena ($p=0,03$), gde je za 76,30 AS džudista veća od fudbalera u posmatranoj varijabli. Primenom statističkih procedura ustanovljene su razlike u ostalim varijablama koje opisuju ekstenziju i fleksiju u zglobov kolena, te razlike nisu značajne. Međutim, rezultati nam govore da su u svim varijablama najbolje rezultate postigli džudisti, i da su rukometaši bolji od fudbalera.

Table 3. Results single-factor ANOVA analysis and Post Hoc Test TukeyHSD

Tabela 3. Rezultati jednofaktorske Anova analize i Post Hoc testa TukeyHSD

Dependent Variable	ANOVA		(I) sport	(J) sport	Mean Difference (I-J)	p
	F	p				
telesna masa / Body mass (TM)	4.86	.02	fudbaleri / footballers	džudisti / judoists	-18.10*	.01
				rukometaši / handballers	-9.70	.24
			džudisti / judoists	fudbaleri / footballers	18.10*	.01
				rukometaši / handballers	8.40	.34
			rukometaši / handballers	fudbaleri / footballers	9.70	.24
				džudisti / judoists	-8.40	.34
max obrtni moment ekstenzije desnog kolena (PTQR)	4.29	.02	fudbaleri / footballers	džudisti / judoists	-64.00*	.02
				rukometaši / handballers	-41.80	.16
			džudisti / judoists	fudbaleri / footballers	64.00*	.02
				rukometaši / handballers	22.20	.58
			rukometaši / handballers	fudbaleri / footballers	41.80	.16
				džudisti / judoists	-22.20	.58
max obrtni moment ekstenzije levog kolena (PTQL)	3.83	.03	fudbaleri / footballers	džudisti / judoists	-76.30*	.03
				rukometaši / handballers	-43.10	.28
			džudisti / judoists	fudbaleri / footballers	76.30*	.03
				rukometaši / handballers	33.20	.46
			rukometaši / handballers	fudbaleri / footballers	43.10	.28
				džudisti / judoists	-33.20	.46

Legend: BM-body mass, PTQR- maximum torque of right knee extension, PTQL- maximum torque of left knee extension, p-level of statistical significance of ANOVA

Legenda: PTQR- max obrtni moment ekstenzije desnog kolena, PTQL- max obrtni moment ekstenzije levog kolena p-nivo statističke značajnosti jednofaktorske Anova analize

From the above data we can conclude that the differences between the examined sub-surveys of our research made by footballers (10), judoists (10) and handball players (10) aged 14-18 from the area of AP Vojvodina were established. Significant differences were observed in the maximum torque of both legs (PTQR, PTQL) force between the judo and football players in favor of judo. A statistically si-

Iz gore navedenih podataka možemo konstatovati da su ustanovljene razlike između ispitivanih subuzoraka našeg istraživanja koji su činili fudbaleri (10), džudisti (10) i rukometaši (10) uzrasta od 14-18 godina starosti sa područja AP Vojvodine. Signifikantne razlike su uočene u maksimalnom obrtnom momentu sile ekstenzora obe noge (PTQR, PTQL) između džudista i fudbalera, u ko-

gnificant difference in maximum flexing torque moment of both knees was not established among athletes. Statistically significant differences in the rotational muscular force of the musculature in relation to the body weight of athletes were not observed. Differences in relative values were not seen in the tested variables of the judo and football players, as the TM judiciary was statistically significantly higher than the TM player, and in the calculation of the relative values influenced the obtained result.

CONCLUSION

For the purpose of determining the differences in upper knee musculature, 30 athletes aged 14-18 participated, divided into three groups: 10 football players, 10 judoists and 10 handball players who play in the clubs from the area of AP Vojvodina. Testing was done at the premises of the Provincial Institute for Sport and Sports Medicine in Novi Sad. For the needs of the test, the isokinetic dynamometer "Easytech Prima DOC" was used, at a torque of 60 step° / sec.

The results of this study confirm results of *Vujkov and Associates Research (2008)* who found on the sample of 50 respondents (10 judoists, 10 footballers, 10 wrestlers, 10 athletes and 10 non-sportsers) that the wrestlers and judoists achieved the best results of the maximum torque of the knee extension, and judoists as far as knee flexors were concerned. Isokinetic diagnostics was subject of research for *Trivić, Vujkov and Drid (2008)*, where they studies muscle disbalance of upper knee musculature among different group of athletes and non-athletes.

Obtained results by isokinetic diagnosis can be used to compare the effects of therapeutic procedures in sports injuries, but also to analyze the effects of different training protocols. The main advantages of this method in relation to others in evaluating the function of the locomotor system are efficiency, reliability, objectivity and non-invasiveness (*Golik-Perić, 2016*). The training process itself can be enriched by certain motor skills from other sports that will not violate the techniques adopted so far, and will affect the "awakening" and the development of targeted muscles and muscle groups that dominantly participate in the structure of movements and movements of a particular sports branch.

rist džudista. Statistički značajna razlika u maksimalnom obrtnom momentu fleksije oba kolena nije ustanovljena među sportistima. Statistički značajne razlike u obrtnom mometnu sile natkolene muskulature u odnosu na telesnu masu sportista nisu uočene. Razlike u relativnim vrednostima nisu uočene kod testiranih varijabli džudista i fudbalera, jer je TM džudista statistički značajno veća od TM fudbalera, te je u proračunu relativnih vrednosti uticala na dobijeni rezultat.

ZAKLJUČAK

U cilju utvrđivanja razlika natkolene muskulature stotista učestvovalo je 30 ispitanika, uzrasta 14-18 godina, podeljenih u tri grupe: 10 fudbalera, 10 džudista i 10 rukometaša koji nastupaju u klubovima sa područja AP Vojvodine. Testiranje je izvršeno u prostorijama Pokrajinskog zavoda za sport i medicinu sporta u Novom Sadu. Za potrebe testiranja korišćen je izokinetički dinamometar "Easytech Prima DOC", pri obrtnom momentu sile 60 step/sec.

Rezultati ovog istraživanja potvrđuju rezultate istraživanja Vujkov i saradnika (2008) koji su na uzorku od 50 ispitanika (10 džudista, 10 fudbalera, 10 rvača, 10 atletičara i 10 nesportista) ustanovili da su rvači i džudisti postigli najbolje rezultate maksimalnih obrtnih momenata ekstenzora kolena, a džudisti kada su fleksori kolena u pitanju. Dobijena razlika u rezultatima između posmatranih grupa se mogu pripisati specifičnostima trenažnog procesa različitih sportskih grana, tj. izvođenja određenih tehnika u samom sportu. Sama struktura treninga u borilačkim sportovima je podređena usvajanju i usavršavanju pojedinih tehnika koje od sportista zahtevaju veliko angažovanje natkolene muskulature.

Rezultati dobijeni izokinetičkom dijagnostikom mogu se koristiti za poređenje efekata terapijskih procedura kod sportskih povreda, ali i za analizu efekata različitih trenažnih protokola. Glavne prednosti ove metode u odnosu na druge u evaluaciji funkcije lokomotornog sistema su efikasnost, pouzdanost, objektivnost i neinvazivnost (*Golik-Perić, 2016*). Sam trenažni proces može se obogatiti i određenim motoričkim znanjima iz drugih sportova koji neće narušiti do tada usvojene tehnike, a uticaće na "buđenje" i razvoj ciljanih mišića i mišićnih grupa koji dominantno učestvuju u strukturi kretanja i pokreta određene sportske grane.

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