https://doi.org/10.7251/SSH2101065M
Original scientific paper

UDC: 796.012.1:616.7-085.851
Originalni naučni rad

The Effect of the Training Process on the Stability and Mobility of the Locomotor System

Uticaj trenažnog procesa na stabilnost i mobilnost lokomotornog aparata

Zoran Milić[1], Dejan Savićević[2], Aleksandar Tomić[3], Darijan Ujsasi[3], Nenad Jerković[1]

[1]College of Vocational Studies for the Education of Preschool Teachers and Sports Trainers in Subotica, Serbia
[2]College of Vocational Studies for Preschool Teachers i Business Informatics Specialists, Sirmium, Sremska Mitrovica, Serbia
[3]Doctoral student of the Faculty of Sports and Physical Education, University Novi Sad, Serbia

[1]Visoka škola strukovnih studija za obrazovanje vaspitača i trenera, Subotica, Srbija
[2]Visoka škola strukovnih studija za vaspitače i poslovne informatičare Sirmijum, Sremska Mitrovica, Srbija
[3]Student doktorskih studija Fakulteta za sport i fizičko vaspitanje, Univerzitet Novi Sad, Srbija

Correspondence:
Zoran Milić
College of Vocational Studies for the Education of Preschool Teachers and Sports Trainers in Subotica, Serbia
zoranmilic@yahoo.com

Korespondencija:
Zoran Milić
Visoka škola strukovnih studija za obrazovanje vaspitača i trenera Subotica, Srbija
zoranmilic@yahoo.com

Abstract: *The assessment of the locomotor system functionality is of great importance for both athletes and those not doing any kind of sport. It is assumed that a structured physical activity has a number of positive effects to the locomotor system. The study included 31 samples that are active athletes and 25 samples not involved in any kind of training process. The aim of the study was to evaluate the effect of the training process on the functional stability and mobility of the locomotor system. The results indicate that there is a significant statistical difference in four analyzed variables: hurdle step (χ2=7,52; p=0,02), active straight leg raise (χ2=9,65; p=0,01), trunk stability push up (χ2=9,81; p=0,01) and rotatory trunk stability (χ2=11,63; p=0,00) in favor of the athlete group.*

Key words*: functional movement, mobility, stability, locomotor system.*

Sažetak: *Procena funkcionalnosti lokomotornog aparata je od velike važnosti kako kod sportista tako i kod onih koji se sportom ne bave. Pretpostavlja se da programirana fizička aktivnost ostvaruje niz pozitivnih adaptacija na lokomotorni sistem. Istraživanjem je bio obuhvaćen 31 ispitanik koji se aktivno bave sportom i 25 ispitanika koji nisu u trenažnom procesu. Cilj studije je bio da se sagleda uticaj trenažnog sadržaja na funkcionalnu stabilnost i mobilnost kretnog aparata. Rezultati ukazuju da postoji statistički značajna razlika u četiri analizirane varijable: Prekorak preko prepone (χ^2=7,52; p=0,02), Aktivno prednoženje (χ^2=9,65; p=0,01), Stabilnost trupa u skleku (χ^2=9,81; p=0,01) i Rotaciona stabilnost trupa (χ^2=11,63; p=0,00) u korist grupe sportista.*

Ključne reči: *funkcionalnost pokreta, mobilnost, stabilnost, lokomotorni aparat.*

Introduction

Functional movement is defined as the ability to maintain the correct relationship between mobility and stability through the kinetic chain in performing movement patterns with precision and efficiency (Iskrić, 2017). Any insufficiency of the skeletal and joint system can be viewed as a mismatch between endogenous and exogenous forces, which act on the body and thus disrupt the functionality of the locomotor apparatus (Mahdieh et al., 2020).

The appearance of muscle asymmetries can be caused by poor postural adaptations which in turn are caused by bad habits (in relation with standing, sitting, kneeling and other postures) which can later lead to pain in muscles

Uvod

Funkcionalno kretanje je definisano kao sposobnost održavanja pravilnog odnosa između mobilnosti i stabilnosti kroz kinetički lanac u vršenju kretnih obrazaca sa preciznošću i efikasnošću (Iskrić, 2017). Bilo koja insuficijencija koštano zglobnog sistema može da se posmatra kao nesklad između endogenih i egzogenih sila, koje deluju na organizam i time narušava funkcionalnost lokomotornog aparata (Mahdieh i sar., 2020).

Pojava mišićnih asimetrija može da bude uzrokovana lošim posturalnim adaptacijama koje su opet uzrokovane lošim navikama (stajanja, sedenje, klečanje i drugi položaji) koje kasnije mogu da dovedu do bolne

(Mackinnon and Novak, 2002). Long-term sedentary activities lead to changes in postural status, changes in the position of the head, thoracic and lumbar spine (Claus et al., 2016). A well balanced, aligned and functional relationship of muscle groups can affect postural stability (Kong Y et al., 2013) and muscle efficiency. Muscle imbalance is formed when the agonist muscle produces a much stronger force than its antagonist or when one or the other is shortened or elongated beyond their physiological limits (Norris, 2000). Therefore, if there is no clear synergy between agonists and antagonists accompanied by an unbalanced joint position, impaired function of the entire locomotor system can occur (Milić, 2020). Only the synchronized synergistic action of the muscles ensures the tonal balance, which is the basis for the stability of the functional units of the lumbar part. Muscles are the drivers of the human body, and are one of the most important elements of the locomotor system. They are responsible for all movements performed by the human body (except the movements of autonomous systems in the body). Favoring one or more muscle structures over another leads to muscle imbalance and their mutual dysfunction (Wilke et al., 1995; Cresswell et al., 1994). Muscle imbalance, can affect certain changes in the level of motor impulse generation. The research of Nosko et al., (2016) indicates higher bioelectric activity of the convex side of the body in disturbed posture in the frontal plane. Study (Milić et al., 2015) emphasized the connection between muscle disharmony and the manifestation of strength in children with impaired posture.

Functional Movement Screen - FMS is a set of tests that combines sports and medicine, and quantifies certain parameters of mobility and functionality of the locomotor system (Nicolozakes et al., 2018). These tests are used in many sports. Very often, FMS assessment is defined as an indicator of the quality of movement (Dorrel et al., 2018), which is important for athletes and the population of people who do not engage in sports, because it indicates the condition of the locomotor system, primarily muscle condition. Functional mobility testing consists of seven tests that require a harmonious relationship between mobility and balance. FMS identifies functional limits and movement asymmetries, which are responsible for reduced motor performance of athletes, but also for the general condition of recreational athletes (Cook et al., 2010). It can also be used for muscular asymmetries of the bone-and-joint apparatus, but not in the prediction of injuries (Dinç & Arslan, 2020). This group of tests provides information on the structure of movement, i.e. they are divided into stability and mobility tests. Tests that are often conducted to assess strength and range of motion are not relevant for

muskulature (Mackinnon i Novak, 2002). Dugotrajne sedentarne aktivnosti dovode do promena u posturalnom statusu, promeni položaja glave, torakalne i lumbalne kičme (Claus i sar., 2016). Izbalansiran, skladan i funkcionalni odnos mišićnih grupa može da utiče na posturalnu stabilnost (Kong Y i sar, 2013) i mišićnu efikasnost. Mišićni disbalans se formira kada mišić agonista produkuje znatno snažniju silu nego njegov antagonista ili kada su jedan ili drugi skraćeni, tj. izduženi preko svojih fizioloških granica (Norris, 2000). Zbog toga, ukoliko nema jasne sinergije između agonista i antagonista praćene necentriranim zglobnim položajem može da dođe do narušene funkcije celog lokomotornog aparata (Milić, 2020). Samo u sinhronizovanom sinergičkom dejstvu mišića, obezbeđena je tonusna ravnoteža koja je osnov za stabilnost funkcionalnih jedinica lumbalnog dela. Mišići su pokretači ljudskog tela, te su jedan od najbitnijih elementa lokomotornog sistema. Odgovorni su za sve pokrete koje izvodi ljudski organizam (osim pokreta autonomnih sistema u organizmu). Favorizovanje jedne ili više mišićnih struktura u odnosu na drugu, vodi u mišićni disbalans i njihovu međusobnu disfunkcionalnost (Wilke i sar., 1995; Cresswell i sar., 1994). Mišićni disbalans, može da utiče na određene promene u nivou generisanja motornih impulsa. Istraživanje Nosko i sar., (2016) ukazuje na veću bioelektričnu aktivnost konveksne strane tela kod narušene posture u frontalnoj ravni. Istraživanje (Milić i sar.,2015) naglašava povezanost mišićnog nesklada i manifestacije snage kod dece sa narušenom posturom.

Functional Movement Screen – Funkcionalni skrining pokreta- FMS) je sklop testova koji objedinjuje sport i medicinu, a kvantifikuje određene parametre mobilnosti i funkcionalnosti lokomotornog aparata (Nicolozakes i sar., 2018). Testovi se koriste u mnogim sportskim disciplinama. Vrlo često se FMS procena definiše kao pokazatelj kvaliteta pokreta (Dorrel i sar., 2018) koja je bitna za sportiste i populaciju ljudi koja se sportom ne bavi, jer ukazuje na stanje lokomotornog aparata, pre svega stanje mišića. Testiranje funkcionalne pokretljivosti se sastoji od sedam testova koji zahtevaju skladan odnos pokretljivosti i ravnoteže. FMS identifikuje funkcionalne limite i kretne asimetrije, koji su odgovorni za umanjene motoričke performanse sportista, ali i za opšte stanje rekreativaca (Cook i sar., 2010), ali i za mišićne asimetrije koštano zglobnog aparata, dok se ne može koristiti u predikciji nastajanja povreda (Dinç, & Arslan, 2020). Ova grupa testova pruža informacije o strukturi pokreta odnosno podeljeni su na testove stabilnosti i mobilnosti. Testovi koji se često sprovode za procenu snage assessing neuromuscular damage through certain motor structures, so preference is given to FMS (Malnar et al., 2007; Kiesel et al., 2011; Mikić et al., 2016; Mokha et al., 2016; Pfeifer et al., 2019). Some researchers measured joint mobility and compared these measures with the results of FMS (Chimera et al., 2017) and pointed out the advantages of FMS tests. They are easier to perform and require a shorter testing time. They can always be applied to the population of athletes and non-athletes.

The aim of the study is to determine the differences in the functionality and mobility of the locomotor system of active athletes and those who are not in the training process.

Method

the methodological research procedure was of the transversal type. When it comes to the nature of scientific research, we used the empirical method, and regarding the goal of research, we used applied method, while regarding the knowledge of the problem, we used the confirmatory method. Regarding the degree of control, we applied the field method. Data were collected using standardized motor field tests. An appropriate statistical approach was applied for data analysis, and the obtained data were interpreted using the bibliographic-speculative method.

Assessment of functional mobility was performed on a total sample of 56 subjects (AGE=22.58±2.41 years). Of these, 31 respondents were active athletes from the College of Vocational Studies for the Education of Preschool Teachers and Sports Trainers in Subotica (AGE=21.88±1.43 years), while the control group also consisted of students from the College of Vocational Studies for the Education of Preschool Teachers and Sports Trainers in Subotica who are not actively involved in sports (N=25 AGE=23.97±2.93 years). Athletes who were considered for research purposes were characterized as healthy individuals capable of training and competition. The scope of training on a weekly basis included 12 to 15 hours per week.

A battery of functional mobility tests (FMS) was used for the research. This battery included the following tests: *Deep Squat, Hurdle Step, Lunge, Shoulder Mobility, Active Straight Leg Raise, Trunk Stability Push-up and Rotary Stability* (Cook., 2010) on the basis of which the overall score of the FMS test is formed. FMS battery of tests is a simple and quantitative method of assessing the functionality and mobility of movements. A battery of joint functional stability tests is a system composed of a series of simple tests with a simple rating system with a degree of reliability (0.95) that has been confirmed in previous research (Cuchna et al., 2016). Each of the individual tests is quantified with a score

i obima pokreta nisu relevantni za procenu nervno-muskularnih oštećenja kroz određene kretne strukture, zato se prednost daje FMS-u (Malnar i sar., 2007; Kiesel i sr., 2011; Mikić i sar., 2016; Mokha i sar., 2016; Pfeifer i sar., 2019). Neki istraživači su merili pokretljivost zglobova i te mere poredili sa rezultatima FMS-a (Chimera i sar., 2017) i ukazali su na prednosti FMS testova. Lakši su za izvođenje i potrebno je kraće vreme testiranja. Mogu se uvek primeniti na populaciji sportista i nesportista.

Cilj studije je da se utvrde razlike u funkcionalnosti i mobilnosti lokomotornog aparata aktivnih sportista i kod onih koji nisu pod trenažnim procesom.

Metod rada

metodski postupak istraživanja je bio transverzalnog tipa. Prema prirodi naučnih istraživanja koristio se empirijski metod, a prema cilju preduzimanja aplikativna metoda, dok je prema poznavanju problema bila korištena konfirmativna metoda. U odnosu na stepen kontrole primenjivao se terenski metod. Podaci su bili prikupljeni primenom standardizovanih motoričkih terenskih testova. Za analizu podataka primenjen je odgovarajući statistički postupak, a dobijeni podaci su interpretirani korišćenjem bibliografsko – spekulativne metode.

Procena funkcionalne pokretljivosti je bila izvršena na ukupnom uzorku od 56 ispitanika muškog pola (GOD=22,58±2,41 godinu). Od toga 31 ispitanik je bio aktivan sportista sa Visoke škole strukovnih studija za obrazovanje vaspitača i trenera iz Subotice (GOD=21,88±1,43 godinu), dok su kontrolnu grupu činili takođe studenti Visoke škole strukovnih studija za vaspitače i trenere iz Subotice koji se ne bave aktivno sportom (N=25 GOD=23,97±2,93 godinu). Sportisti koji su bili uzeti u obzir za potrebe istraživanja, okarakterisani su kao zdrave osobe sposobne za trening i takmičenje. Obim treninga na nedeljnom nivou iznosio je od 12 do 15 časova nedeljno.

Za potrebe istraživanja bila je primenjena baterija testova funkcionalne pokretljivosti (FMS). Baterija je podrazumevala primenu sledećih testova: *Duboki čučanj, Prekorak preko prepone, Iskorak, Pokretljivost ramenog pojasa, Aktivno prednoženje, Stabilnost trupa u skleku i Rotaciona stabilnost* (Cook., 2010), na osnovu kojih se formira ukupna ocena FMS testa. FMS baterija testova jednostavna i kvantitativna metoda procene funkcionalnosti i mobilnosti pokreta. Baterija testova funkcionalne stabilnosti zglobova je sistem sačinjen od serije jednostavnih testova sa jednostavnim sistemom ocenjivanja sa stepenom pouzdanosti (0.95) koja je potvrđena u ranijim istraživanjima (Cuchna i sar., 2016). Svaki od pojedinačfrom 0 to 3. A score of 0 is given if pain occurs during performance. Score 1, if the trainee cannot perform the movement pattern even with compensations, score 2 is given if the trainee can perform the movement but has poorer mechanics and compensatory patterns during the movement, score 3 is given if the trainee can perform the movement in accordance with adopted criteria (Cook, et al., 2006). Combined result was obtained by summing all values (Cook et al., 2006) - Total FMS test score.

For all parameters (variables), frequencies and percentage values are shown in relation to the subsample to which they belong. For the variable Total FMS Test Score, descriptive statistics were calculated, namely arithmetic mean (AS), standard deviation (S), coefficient of variation (KV). The normality of the distribution was checked by the Shapiro Wilk test for small samples. In order to establish the differences in the variables, a nonparametric statistical method, chi square test, was applied, with a level of statistical significance of $p \leq 0.05$. The Mann-Whitney test was used to determine the difference between the groups in the variable Total FMS Test Score, since a deviation from the normal distribution was observed for the mentioned variable.

Results

When we apply the nonparametric method, chi square test, it can be stated that there is a statistically significant difference in the four analyzed variables: *Hurdle Step* (χ^2=7,52; p=0,02), *Active Straight Leg Raise* (χ^2=9,65; p=0,01), *Trunk Stability Push-up* (χ^2=9,81; p=0,01) and *Rotary Trunk Stability* (χ^2=11,63; p=0,00) in favor of the athletes group. In the last-mentioned variable, the athletes group had a higher percentage of respondents with a score of 2 (90.3%) compared to the respondents from the control group (64.0%). By observing the results in the variable *Hurdle Step*, it can be seen that athletes had a much higher incidence of score 3 (41.9%) compared to the control group of respondents (12.0%). In the second variable, *Active Straight Leg Raise*, athletes group had a significantly higher percentage of respondents with a score of 3 (61.3% versus 20.0% in the control group). Also, in variables *Trunk Stability Push-up* (74.2% vs. 20.0%) and *Rotary Trunk Stability* (9.7% vs. 4.0%) there was a higher percentage of respondents in the group of athletes with a score of 3 compared to the control. It should be noted that in the athletes group there were no respondents who could not perform the movement pattern even with compensations (score 1) in the variables *Deep Squat, Trunk Stability Push-up* and *Rotary Trunk Stability.*

nih testova se kvantifikuje ocenom od 0 do 3. Ocena 0 se daje ukoliko se javi bol u toku izvođenja. Ocena 1, ukoliko vežbač ne može da izvede obrazac pokreta ni sa kompenzacijama, ocena 2 se dobija ukoliko vežbač može da izvede pokret, ali ima lošiju mehaniku i kompenzatorne obrasce tokom izvođenja pokreta, ocena 3 je ukoliko vežbač može da izvede pokret u skladu sa uspostavljenim kriterijumima (Cook, i sar., 2006). Kompozitni rezultat se dobija sabiranjem svih vrednosti (Cook i sar., 2006) - ukupan rezultat FMS testa.

Za sve parametre (varijable) prikazane su frekvencije i procentualne vrednosti u odnosu na subuzorak kojem pripadaju. Za varijablu Ukupan skor FMS testa izračunati su deskriptivni statistici, aritmetička sredina (AS), standardna devijacija (S), koeficijent varijacije (KV). Normalnost distribucije je proverena Šapiro Vilk testom za male uzorke. Kako bi se ustanovile razlike u varijablama, primenjena je neparametrijska statistička metoda „hi“-kvadrat test, sa nivoom statističke značajnosti od $p \leq 0{,}05$. Za utvrđivanje razlike između grupa u varijabli Ukupan skor FMS testa, korišćen je Men Vitnijev test s obzirom na to da je utvrđeno odstupanje od normalne distribucije kod navedene varijable.

Rezultati

primenjujući neparametrijsku metodu „hi“-kvadrat test, može se konstatovati da postoji statistički značajna razlika u četiri analizirane varijable: *Prekorak preko prepone* (χ^2=7,52; p=0,02), *Aktivno prednoženje* (χ^2=9,65; p=0,01), *Stabilnost trupa u skleku* (χ^2=9,81; p=0,01) i *Rotaciona stabilnost trupa* (χ^2=11,63; p=0,00) u korist grupe sportista. U poslednjoj navedenoj varijabli, grupa sportista je imala veći procenat ispitanika sa ocenom 2 (90,3%) u odnosu na ispitanike kontrolne grupe (64,0%).

Posmatrajući rezultate u varijabli *Prekorak preko prepone*, može se uvideti da su sportisti imali mnogo veću zastupljenost ocena 3 (41,9%) u odnosu na kontrolnu grupu ispitanika (12,0%). U drugoj varijabli, *Aktivno prednoženje*, sportisti su imali znatno veći procenat ispitanika sa ocenom 3 (61,3% prema 20,0% kod kontrolne grupe). Takođe i u varijablama *Stabilnost trupa u skleku* (74,2% prema 20,0%) i *Rotaciona stabilnost trupa* (9,7% prema 4,0%) bio je veći procenat ispitanika grupe sportista sa ocenom 3 u odnosu na kontrolnu. Treba istaći da kod grupe sportista nije bilo ispitanika koji nisu mogli da izvedu obrazac pokreta ni sa kompenzacijama (ocena 1) u varijablama *Duboki čučanj, Stabilnost trupa u skleku* i *Rotaciona stabilnost trupa.* U varijabli *Rotaciona stabilnost trupa* kod

In the variable *Rotary Trunk Stability* in the athletes group, there is a higher prevalence of score 2 (90.3%), which indicated that the respondents can perform the movement, but have slightly poorer movement mechanics and compensatory patterns when performing the movement. A similar conclusion can be drawn for the control group respondents in the variable *Hurdle Step* (score 2, 72% of respondents).

grupe sportista, uviđa se veća zastupljenost ocene 2 (90,3%), što je ukazivalo da ispitanici mogu da izvedu pokret, ali da poseduje nešto lošiju mehaniku pokreta i kompenzatorne obrasce prilikom izvođenja pokreta. Sličan zaključak se može izvući za ispitanike kontrolne grupe u varijabli *Prekorak preko prepone* (ocena 2, 72% ispitanika).

Table 1. *Functional mobility status differences in respondents from different groups*

Tabela 1. *Razlike u stanju funkcionalne pokretljivosti ispitanika različitih grupa*

Variable / Varijable	*Group* / Grupa	*Score 1*	*Score 2*	*Score 3*	*χ2*	*p*	*df*
Deep Squat / Duboki čučanj	A	0	17 (54.8%)	14 (45.2%)	2.72	0.26	2
	C	1 (4.0%)	17 (68.0%)	7 (28.0%)			
Hurdle Step / Prekorak preko prepone	A	1 (7.1%)	17 (54.8%)	13 (41.9%)	7.52	0.02	2
	C	4 (16.0%)	18 (72.0%)	3 (12.0%)			
Lunge / Iskorak	A	1 (3.2%)	18 (58.1%)	12 (38.7%)	1.40	0.50	2
	C	2 (8.0%)	11 (44.0%)	12 (48.0%)			
Shoulder Mobility / Pokretljivost ramenog pojasa	A	2 (6.5%)	13 (41.9%)	16 (51.6%)	7.85	0.02	2
	C	4 (16.0%)	17 (68.0%)	4 (16.0%)			
Active Straight Leg Raise / Aktivno prednoženje	A	2 (6.4%)	10 (32.3%)	9 (61.3%)	9.65	0.01	2
	C	3 (12.0%)	17 (68.0%)	5 (20.0%)			
Trunk Stability Push-up / Stabilnost trupa u skleku	A	0 (0%)	8 (25.8%)	23 (74.2%)	9.81	0.01	2
	C	5 (20%)	10 (40.0%)	10 (20.0%)			
Rotary Trunk Stability / Rotaciona stabilnost trupa	A	0 (0%)	28 (90.3%)	3 (9.7%)	11.76	0.00	2
	C	8 (32.0%)	16 (64.0%)	1 (4.0%)			

Legend: *S - athletes; K - control group; χ^2 - value of chi-square test; p - level of statistical significance of chi square test; df - degrees of freedom*

Legenda: *S - sportisti; K - kontrolna grupa; χ^2 –vrednost hi-kvadrat testa; p – nivo statističke značajnosti hi kvadrat testa; df - stepeni slobode*

Based on the obtained results for the variable *TOTAL FMS TEST SCORE* in Table 2, it can be stated that the average results of the respondents engaged in sports are higher (17.00 points), compared to the average results of the control group (14.56 points). Based on the coefficient of variation, the homogeneity of the athlete group of respondents and the relative homogeneity of the control group of respondents in the analyzed variable for the assessment of functional mobility can be stated.

Based on the values of the Shapiro Wilk test (Table 2), the normality of the distribution of results in the subsample of respondents from the control group (ShWp = 0.31) can be ascertained. A statistically significant deviation from the normal distribution was observed in respondents who are engaged in sports (ShWp=0.04).

Na osnovu dobijenih vrednosti rezultata, varijable *UKUPAN SKOR U FMS testa* u Tabeli 2, može se konstatovati da su viši prosečni rezultati kod ispitanika koji se bave sportom (17,00 poena), u odnosu na prosečne rezultate kontrolne grupe (14,56 poena). Na osnovu koeficijenta varijacije može se konstatovati homogenost ispitanika sportista i relativna homogenost kod kontrolne grupe ispitanika u analiziranoj varijabli za procenu funkcionalne pokretljivosti.

Na osnovu vrednosti Šapiro Vilk testa (Tabela 2) može se konstatovati normalnost distribucije rezultata kod subuzorka ispitanika kontrolne grupe (ŠVp=0,31). Statistički značajno odstupanje od normalne distribucije je uočeno kod ispitanika koji se bave sportom (Švp=0,04).

Table 2. *Differences between groups in the final score of the functional test TOTAL FMS TEST SCORE*

Tabela 2. *Razlike između grupa u konačnoj oceni funkcionalnog testa UKUPAN SKOR FMS*

Variable / Varijabla	*Athletes* / Sportisti (*N=31*)			*Control* / Kontrolna (*N=25*)		
	AM±S / AS±S	*CV* / KV	*ShWp* / ŠVp	*AM±S* / AS±S	*CV* / KV	*ShWp* / ŠVp
TOTAL FMS TEST SCORE / UKUPAN SKOR FMS TESTA	17.00±1.71	10.06	0.04	14.56±2.63	18.06	0.31

Legend: *AM - arithmetic mean; S - standard deviation; CV - coefficient of variation; ShWp - significance level of Shapiro Wilk test*

Legenda: *AS - aritmetička sredina; S - standardna devijacija; KV - koeficijent varijacije; ŠVp - nivo značajnosti Shapiro Wilk testa*

The analysis of Table 3 shows the existence of a statistically significant difference between athletes and the control group (non-athletes) in the variable Total FMS Test Score, with higher values of the arithmetic mean of ranking found in the athletes group (p=0.00).

Analizom Tabele 3 primećuju se postojanje statistički značajne razlike između sportista i kontrolne grupe (nesportista) u varijabli Ukupan skor FMS testa, pri čemu su veće vrednosti aritmetičke sredine ranga konstatovane kod grupe sportista (p=0,00).

Table 3. *Differences between groups*

Tabela 3. *Razlike između grupa*

Variable / Varijabla	*Group* / Grupa	*M*	*U*	*p*
TOTAL FMS TEST SCORE / UKUPAN SKOR FMS TESTA	*Athletes* / Sportisti	35.42	173.00	0.00
	Control / Kontrolna	19.92		

Legend: *M - arithmetic mean of ranking; U - value of the Mann-Whitney U test; p - level of statistical significance*

Legenda: *M - aritmetička sredina ranga; U - vrednost Men-Vitnijev U testa; p - nivo statističke značajnosti*

Discussion

The aim of the study was to determine the differences in the functionality and mobility of the locomotor system between the group of athletes and those who are not in the training process. Based on the obtained values of the results of the variable TOTAL FMS TEST SCORE, it can be stated that the average score is higher among the respondents who are engaged in sports (17.00 points), compared to the average score of the control group (14.56 points). Research (Booden et al., 2013; Duncan et al., 2012: Klusemann et al., 2012) also suggests a connection between programmed training and movement functionality, where greater mobility in athletes can be explained by both greater muscle strain and better tone of muscles caused by systematic daily specialized training activities. Better motor control of movement in a group of athletes manifested through these tests, can be explained by the greater role of fusimotors (excitation of striated muscles leads to simultaneous and increased activity of sensory fibers of the neuromuscular spindle, because it is thought to occur as a result of intrafusal fibers contraction). In intentional, targeted, precisely defined movements, as was

Diskusija

cilj studije je bio da se utvrde razlike u funkcionalnosti i mobilnosti lokomotornog aparata kod grupe sportista i onih koje nisu u trenažnom procesu. Na osnovu dobijenih vrednosti rezultata varijable UKUPAN SKOR U FMS, može se konstatovati da su viši prosečni rezultati kod ispitanika koji se bave sportom (17,00 poena), u odnosu na prosečne rezultate kontrolne grupe (14,56 poena). Istraživanja (Booden i sar., 2013; Duncan i sar., 2012: Klusemann i sar., 2012) takođe ukazuju na povezanost programiranog treninga i funkcionalnosti pokreta, pri čemu se veća mobilnost pokreta kod sportista može objasniti i većim mišićnim naprezanjima i boljim tonusom muskulature prouzrokovane sistematskim trenažnim svakodnevnim aktivnostima usmerenog tipa. Bolja motorna kontrola pokreta kod grupe sportista manifestovana kroz navedene testove, može se objasniti i većom ulogom fuzimotora (pri ekscitaciji poprečnoprugastih mišića dolazi do istovremene i pojačane aktivnost senzornih vlakana neuromišićnog vretena, jer se smatra da ona nastaje kao posledica kontrahovanja intrafuznih vlakana). Kod the case with performing FMS tests, fusimotor activity does not precede, but only follows, comes after the alpha motor activity, but with a slight delay (Galeano et al., 2000). The appearance of a minimal time difference occurs probably due to the lower pulse rate through the gamma fibers, but the existence of alpha-gamma coactivation can be confirmed. It can be assumed that fusimotor innervations in a group of people in the training process prevent the relaxation of intrafusal fibers during extrafusal contraction and provide better motor control of movement. If they fail to activate in the right time, the neuromuscular spindles as motion sensors would remain inactive. Better intramuscular coordination of movements in respondents engaged in sports led to better scores in the analyzed variables. It should be emphasized that muscle strength is determined by intramuscular coordination. In order to manifest maximum muscle strength, they must be activated in an appropriate way. The more complex the movement, the greater the activity of the muscle fibers as well as their mutual cooperation. Individuals who are in the training process can better coordinate the activation of fibers in individual muscles, which is a consequence of good nerve adaptation.

Better independent innervation, in people engaged in sports, two types of intrafusal fibers, provided a more adequate static and dynamic response when performing the movement in relation to the group of non-athletes.

Large differences are observed in the variables where trunk stability was crucial for a high FMS score. The results obtained in this way can be observed from the point of activation of certain muscle groups in the athletes population. Namely, when moving the arms, legs or trunk, local stabilizers of the lumbar region of the spine are activated before activating the global muscles, and the most important are: m.transversus abdominis, mm.multifidus, diaphragm and pelvic floor muscles. These intrinsic stabilizers, in coordination with intra-abdominal pressure, enable dynamic stability of the spinal column, act at the "subconscious" level of the "feed-forward mechanism" and precede any conscious and intentional movement (Frank et al., 2013). Statistically significant difference in the variable *Hurdle Step* can be observed through the fact that athletes have better motor control (Kahle et al., 2009). Control of the lower and upper extremities may be more "affected" by neuromuscular control of the nucleus i.e. trunk (Brumitt et al., 2016), which may be one of the reasons why athletes achieved better results in the Hurdle Step test.

On the other hand, differences in the variable *Active Straight Leg Raise* can be explained through aspects of

namernih, ciljanih, tačno definisanih pokreta, kao što je bio slučaj sa izvođenjem FMS testova, fuzimotorna aktivnost ne prethodi, nego ona samo sledi, nadovezuje se na alfa motornu aktivnost, ali sa malim neznatnim zakašnjenjem (Galeano i sar., 2000). Pojava minimalne vremenska razlike pojavljuje se verovatno zbog manje brzine impulsa kroz gama vlakna, ali se može prihvatiti postojanje alfa-gama koaktivacije. Za pretpostaviti je da fuzimotorne inervacije kod grupe ljudi u trenažnom procesu sprečavaju relaksacije intrafuznih vlakana u toku ekstrafuzne kontrakcije i obezbeđuju bolju motornu kontrolu pokreta. Ako se oni ne bi uključili na vreme, neuromišićna vretena kao senzori pokreta ostali bi van aktivnosti. Bolja intramuskularna koordinacija pokreta kod ispitanika koji se bave sportom, dovela je do boljih ocena u analiziranim varijablama. Treba posebno naglasiti da mišićnu silu određuje intramuskularna koordinacija. Da bi se ispoljila maksimalna sila mišića, oni se moraju na odgovarajući način aktivirati. Što je pokret složeniji, potrebna je i veća aktivnost mišićnih vlakana kao i njihova međusobna saradnja. Lica koja su u trenažnom procesu, mogu bolje da usklađuju aktiviranje vlakana u pojedinačnim mišićima, što je posledica dobre nervne adaptacije.

Bolja nezavisna inervacija, kod ljudi koji se bave sportom, dva tipa intrafuznih vlakana, obezbedila je adekvatniji statički i dinamički odgovor prilikom izvođenja pokreta u odnosu na grupu nesportista.

Velike razlike se uočavaju u varijablama gde je stabilnost trupa bila presudna za visoko FMS skor. Ovako dobijeni rezultati se mogu posmatrati iz ugla aktivacije određenih grupa mišića kod populacije sportista. Naime, kod pokreta ruku, nogu ili trupa, pre aktiviranja globalnih mišića, uključuju se lokalni stabilizatori lumbalne regije kičmenog stuba, kao najvažniji: m.transversus abdominis, mm.multifidus, dijafragma i mišići karličnog dna. Ovi intrinzični stabilizatori u koordinaciji s intraabdominalnim pritiskom omogućuju dinamičku stabilnost kičmenog stuba, deluju na nivou „podsvesnog" putem „feed-forward mehanizma" i prethode svakom svesnom i namernom pokretu (Frank i sar., 2013). Statistički značajna razlika u varijabli *prekorak preko prepone* se može posmatrati kroz činjenicu da sportisti imaju bolju motornu kontrolu (Kahle i sar., 2009). Kontrola donjih i gornjih ekstremiteta može biti „pogođenija" nervno mišićnom kontrolom jezgra odnosno trupa (Brumitt I sar., 2016), što i može biti jedan od razloga iz kog su sportisti postizali bolje rezultate u testu prekorak preko prepone.

Sa druge strane varijabla *Aktivno prednoženje* se muscle and tendon elasticity. They play a significant role in increasing mechanical work during movement. If the active muscle or tendon lengthens, elastic energy accumulates within such biological structures. It is used to increase the results in the concentric phase of the eccentric-concentric cycle. It can be assumed that the higher level of flexibility in the group of athletes led to a difference in the manifested results in the mentioned variable.

Based on the obtained research results, it can be concluded that the programmed training process contributes to better stability of movement, flexibility and dynamic mobility. Changes occur through continuous training, neuromuscular adaptation, systematically guided activities, focused exercises and proper load dosing. Among other things, this testing served as an excellent control of the status of motor abilities and thus functional abilities in active athletes and respondents who are not engaged in sports.

može i objasniti sa aspekta elastičnosti mišića i tetiva. Ona ima značajnu ulogu u povećanju mehaničkog rada tokom pokreta. Ako se aktivni mišić ili tetiva izduže, unutar takvih bioloških struktura akumulira se elastična energija. Ona se iskorištava za povećavanje rezultata u koncentričnoj fazi ekscentrično-koncentričnog ciklusa. Za pretpostaviti je da je viši nivo fleksibilnosti kod grupe sportista doveo do razlike u rezultatima u navedenoj varijabli.

Na osnovu dobijenih rezultata istraživanja, može se zaključiti da programirani trenažni proces doprinosi boljoj stabilnosti pokreta, fleksibilnosti i dinamičkoj pokretljivosti. Promene nastaju zahvaljujući kontinuiranom treningu, nervno mišićnoj adaptaciji, sistematski vođenim aktivnostima, usmerenim vežbama i pravilnim doziranjem opterećenja. Ovo testiranje je između ostalog poslužilo kao odlična kontrola stanja motoričkih sposobnosti propraćenih funkcionalnim mogućnostima kod aktivnih sportista i ispitanika koji se ne bave sportom.

Announcemet
We announce that the authors have equally contributed to this paper.

Conflict of interests
There is no conflict of interests among the authors themselves.

Izjava
Izjavljujemo da su autori podjednako doprineli radu.

Konflikt interesa
Između autora ne postoji interesni konflikt.

References

Bodden, J. G., Needham, R. A., & Chockalingam, N. (2015). The effect of an intervention program on functional movement screen test scores in mixed martial arts athletes. *The Journal of Strength & Conditioning Research*, *29*(1), 219-225.

Brumitt, J., Heiderscheit, B. C., Manske, R. C., Niemuth, P., Mattocks, A., & Rauh, M. J. (2016). The lower-extremity functional test and lower-quadrant injury in NCAA Division III athletes: a descriptive and epidemiologic report. *Journal of sport rehabilitation*, *25*(3), 219-226.

Cook G. Movement (2010) Functional movement systems: Screening, assessment, corrective strategies. *USA: On Target Publications*

Cook, G., Burton, L., & Hoogenboom, B. (2006). Pre-participation screening: the use of fundamental movements as an assessment of function-part 1. *North American journal of sports physical therapy: NAJSPT*, *1*(2), 62-72.

Cook, G., Burton, L., & Hoogenboom, B. (2006). Pre-participation screening: the use of fundamental movements as an assessment of function-part 1. *North American journal of sports physical therapy: NAJSPT*, *1*(2), 62-72.

Cresswell, A. G., Oddsson, L. & Thorstensson, A. (1994). The influence of sudden perturbations on trunk muscle activity and intra-abdominal pressure while standing. *Experimental Brain Research*, 98(2), 336-341.

Cuchna, J. W., Hoch, M. C. & Hoch, J. M. (2016). The interrater and intrarater reliability of the functional movement screen: A systematic review with meta-analysis. *Physical Therapy in Sport*, 57-65.

Claus, A. P., Hides, J. A., Moseley, G. L., & Hodges, P. W. (2016). Thoracic and lumbar posture behaviour in sitting tasks and standing: *Progressing the biomechanics from observations to measurements. Applied ergonomics*, 53, 161-168.

Chimera, N., Knoeller, S., Cooper, R., Kothe, N., Smith, C., & Warren, M. (2017). Prediction of Functional movement screen performance from lower extremity range of motion and core tests. *The International Journal of Sports Physical Therapy*, *12*(2), 173-181

Duncan, M. J., & Stanley, M. (2012). Functional movement is negatively associated with weight status and positively associated with physical activity in British primary school children. *Journal of Obesity*, *2012*.

Dinç, E., & Arslan, S (2020). Relationship Between Functional Movement Screen Scores and Musculoskeletal Injuries in Youth Male Soccer Players: *One-year Retrospective Observation*.

Dorrel, B., Long, T., Shaffer, S., & Myer, G. D. (2018). The functional movement screen as a predictor of injury in national collegiate athletic association division II athletes. *Journal of athletic training*, *53*(1), 29-34.

Frank, C., Kobesova, A., & Kolar, P. (2013). Dynamic neuromuscular stabilization & sports rehabilitation. *International journal of sports physical therapy*, *8*(1), 62.

Galeano, R. M., Germana, A., Vazquez, M. T., Hidaka, H., Germana, G. & Vega, J. A. (2000). Immunohistochemical localization of neurocalcin in human sensory neurons and mehanoreceptors. *Neuroscience Letters*, 279(2), 89−92

Iskrić, P. (2017). Efekti pilatesa sa različitim rekvizitima kod žena. Diplomski rad. Zagreb: Sveučilište u Zagrebu Kineziološki Fakultet. [in Croatian]

Kahle, N. L. (2009). *The effects of core stability training on balance testing in young, healthy adults* (Doctoral dissertation, University of Toledo).

Kiesel, K., Plisky, P. & Butler, R. (2011) Functional movement test scores improve following a standardized off-season intervention program in professional football players. Scandinavian Journal of Medicine and Science in Sports, 21(2), 287-292.

Klusemann, M. J., Pyne, D. B., Fay, T. S., & Drinkwater, E. J. (2012). Online video–based resistance training improves the physical capacity of junior basketball athletes. *The Journal of Strength & Conditioning Research*, *26*(10), 2677-2684.

Kong, Y. S., Cho, Y. H., & Park, J. W. (2013). Changes in the activities of the trunk muscles in different kinds of bridging exercises. Journal of physical therapy science, 25(12), 1609-1612.

Mackinnon S. E. & Novak, C. B. (2002). Thoracic outlet syndrome. Current Problems in Surgery, 39(11), 1070-145.

Mahdieh, L., Zolaktaf, V., & Karimi, M. T. (2020). Effects of dynamic neuromuscular stabilization (DNS) training on functional movements. *Human Movement Science*, *70*, 102568.

Mikić, B., Bajrić, O., Stanković, N., Ivanek, V. i Petrović, Z. (2016). Primjena funkcionalnog treninga u vrhunskom sportu i rekreaciji. Sportske nauke i zdravlje, 6(2),120-120 [in Serbian]

Milić, Z. (2020). The Effects of Neuromuscular Stabilization on Increasing the Functionality and Mobility of the Locomotor System. *Sportske nauke i zdravlje*, *19*(1), 54-59. [in Serbian]

Milić, Z., Lepeš, J., & Halasi, S. (2015). Analiza snage pojedinih mišićnih grupa kod dece narušenog posturalnog statusa//Analysis of strength of particular muscle groups in children with postural disorders. Спортске науке и здравље, 9(1). [in Serbian]

Mokha, M., Sprague, P. A. & Gatens, D. R. (2016). Predicting Musculoskeletal Injury in National Collegiate Athletic Association Division II Athletes From Asymmetries and Individual-Test Versus Composite Functional Movement Screen Scores. Journal of Athltic Training, 51(4), 276-282.

Malnar, D., Šterbik, K., Fužinac-Smojever, A., Jerković, R., i Bobinac, D. (2007). Pilates tehnika vježbanja. Medicina Fluminensis: Medicina Fluminensis, 43(3), 241-245 [in Croatian]

Norris, C. M., (2003). Functional load abdominal training: part 1. *Journal of Bodywork and Movement Therapies, pp*. 29-30.

Nicolozakes, C. P., Schneider, D. K., Roewer, B. D., Borchers, J. R. & Hewett, T. E. (2018). Influence of Body Composition on Functional Movement Screen Scores in College Football Players. *Journal of Sport Rehabilitation*, 27(5), 431-437

Nosko, M., Razumeyko, N., Iermakov, S., & Yermakova, T. (2016). Correction of 6 to 10-year-old schoolchildren postures using muscular-tonic imbalance indicators. *Journal of Physical Education and Sport,* 16(3), 988

Pfeifer, C. E., Sacko, R. S., Ortaglia, A., Monsma, E. V., Beattie, P. F., Goins, J. & Stodden, D. F. (2019). Functional Movement Screen in Youth Sport Participants: Evaluating The Proficiency Barrier for Injury. *Internationaln Journal of Sports Physical Therapy*, 14(3), 436-444.

Wilke, H. J., Wolf, S., Claes, L. E., Arand, M. & Wiesend, A. (1995). Stability increase of the lumbar spine with different muscle groups: *a biomechanical in vitro study. Spine* 20(2), 192–198

Primljen: 06. decembar 2020. / Received: December 06, 2020
Prihvaćen: 16. decembar 2020. / Accepted: December 16, 2020