

REPEATED SPRINT ABILITY IN FOOTBALL PLAYERS AT DIFFERENT LEVELS OF COMPETITION

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Abstract: This research was conducted to identify differences in repeated sprint ability between football players at different levels of competition and to confirm the role of this ability as a predictor of elite performance in modern football. The study involved 30 football players from two ranks of competition (15 football players from the first rank of the competition and 15 football players from the third rank of the competition). The RSA test consisted of 6 sprints at a distance of 30 meters with an active rest between two sprints of 20 seconds. Total sprint time and average sprint time were calculated for all subjects in both groups. In addition to the total and average sprint time, a percentage decline in sprint performance was calculated. The results of the study showed a significant decline in the performance of sprint repetition in both groups of subjects. The sprint speed of all six reps was significantly higher for Division 1 football players, as shown by the times gained at a distance of 30 meters. In addition, Division 1 football players had a statistically better total and average sprint time compared to Division 3 players ($p < 0.01$). The only performance parameter in which the players of different competition rank did not differ was the percentage decline in performance ($p > 0.05$). The conclusion is that professional football players have a better developed ability to repeat sprints than amateurs, which confirms the previously proven role of this ability in modern football.

Keywords: sprint repetition ability, football, performance decline.

INTRODUCTION

Top-level football requires from players to constantly repeat activities of varying intensities and lengths throughout the game. Maximum or approximately maximum intensity activities are constantly alternated with periods of low or moderate intensity that allow partial

SPOSOBNOST PONAVLJANJA SPINTA KOD FUDBALERA RAZLIČITOG NIVOA TAKMIČENJA

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Apstrakt: Ovo istraživanje je provedeno sa ciljem da se utvrde razlike u izvedbi ponavljanja sprinta između fudbalera različitog nivoa takmičenja i da se potvrdi uloga ove sposobnosti kao prediktora vrhunske izvedbe u savremenom fudbalu. U istraživanju je učestvovalo 30 fudbalera iz dva ranga takmičenja (15 fudbalera iz prvog ranga takmičenja i 15 fudbalera iz trećeg ranga takmičenja). Test ponavljanja sprinta se sastojao od uzastopnog izvođenja 6 sprinteva na distanci od 30 metara sa aktivnim odmorom između dva sprinta od 20 sekundi. Ukupno vrijeme sprinta i prosječno vrijeme sprinta su izračunati za sve ispitanike u obe grupe. Pored ukupnog i prosječnog vremena sprinta izračunat je i procentualni pad izvedbe sprinta. Rezultati istraživanja su pokazali značajan pad izvedbe ponavljanja sprinta kod obe grupe ispitanika. Brzina sprinta svih šest ponavljanja je bila statistički značajno viša kod fudbalera 1. lige, što pokazuju ostvarena vremena na distanci od 30 metara. Pored toga, fudbaleri 1. lige su imali i statistički značajno bolje ukupno i prosječno vrijeme sprinta u odnosu na fudbalere 3. lige ($p < 0.01$). Jedini parametar izvedbe u kome se fudbaleri različitog ranga takmičenja nisu razlikovali je bio procentualni pad izvedbe ($p > 0.05$). Zaključak je da profesionalni fudbaleri imaju bolje razvijenu sposobnost ponavljanja sprinta u odnosu na amatere, što potvrđuje ranije dokazanu ulogu ove sposobnosti u savremenom fudbalu.

Gljučne reči: sposobnost ponavljanja sprinta, fudbal, pad izvedbe.

Uvod

Vrhunski fudbal od igrača zahtijeva da tokom igre stalno ponavljaju aktivnosti različitih intenziteta i dužine trajanja. Aktivnosti maksimalnog ili približno maksimalnog intenziteta se stalno smijenjuju sa periodima niskog ili umjerenog intenziteta koji omogućuju djelimični ili potpuni oporavak organizma (Bradley i sar., 2009). Sposobnost igrača da se u kratkom periodu vremena brzo opo-

or complete recovery (Bradley et al., 2009). The ability of players to recover quickly from a previous sprint in a short period of time and perform each subsequent sprint without significantly reducing the running speed is an important predictor of quality performance in the game. This component is defined as repeated sprint ability and refers to sprints of short duration (less than 10 seconds) with recovery periods of less than 60 seconds (Gleister et al., 2005; Spencer et al., 2005). Research have shown that sprint accounts for 1-10% of the total distance covered during game, and it covers 1-3% of effective play time (Stolen et al., 2005; Buchheit et al., 2010). The ability to quickly recover during the performance of a sprint series has, in addition to the player's technical and tactical skills, been designated as an important component of quality player performance (Buchheit et al., 2010). A significant correlation was found between RSA and distance covered by high intensity running and sprint during professional football game (Rampinini et al., 2006). Also, RSA tests have been found to significantly discriminate professional and amateur players (Aziz et al., 2008; Impellizzeri et al., 2008; Rampinini et al., 2009). The fatigue that occurs during play is closely related to the ability to perform sprints (Krustrup et al., 2010). In addition, a significant decline in sprint running in the later stages of the game was found in top football players (Mohr et al., 2003). The same conclusions were drawn in a study conducted on a sample of professional football players (Krustrup et al., 2005). The aim of this research was to determine whether there is a difference in the performance of RSA between football players at different levels of competition and thus to confirm the role and importance of this ability as a predictor of top performance in modern football.

METHODS

Participants

Thirty male football players (15 amateurs and 15 professionals) participated in this research. Amateur football players were selected from a team that competed in the 3rd League of Bosnia and Herzegovina ($M = 23.3 \pm 3.2$ years), while professional football players were selected from a team that competed in the 1st (Premier) League of Bosnia and Herzegovina ($M = 22.4 \pm 3.4$ years). Participants were fully informed of the possible risk and discomfort associated with testing prior to giving written consent to participate in the study. Division 1 players had six training sessions per week and an official game, while Division 1 players had three training ses-

sions per week and an official game. The aim of this research was to determine whether there is a difference in the performance of RSA between football players at different levels of competition and thus to confirm the role and importance of this ability as a predictor of top performance in modern football.

rave od prethodnog sprints i da izvedu svaki sledeći sprint bez značajnog smanjenja brzine trčanja je važan prediktor kvalitetne izvedbe u igri. Ova komponenta je definisana kao sposobnost ponavljanja sprints (eng. repeated sprint ability) i odnosi se na sprinteve kratkog trajanja (manje od 10 sekundi) sa periodima oporavka kraćim od 60 sekundi (Gleister i sar., 2005; Spencer i sar., 2005). Analize su pokazale da sprint sačinjava 1-10% ukupne distance pokrivene tokom igre, odnosno da obuhvata 1-3% efektivnog vremena igre (Stolen i sar., 2005; Buchheit i sar., 2010).

Sposobnost brzog oporavka tokom izvođenja serije sprinteva je, pored tehničkih i taktičkih vještina igrača, označena kao važna komponenta kvalitetne izvedbe igrača (Buchheit i sar., 2010). Značajna povezanost je pronađena između sposobnosti ponavljanja sprints i distance pokrivene trčanjem visokim intenzitetom i sprintom tokom igre u profesionalnom fudbalu (Rampinini i sar., 2006). Takođe, utvrđeno je da testovi ponavljanja sprints značajno diskriminišu profesionalne i amaterske igrače (Aziz i sar., 2008; Impellizzeri i sar., 2008; Rampinini i sar., 2009). Zamor koji nastaje u toku igre usko je povezan sa sposobnošću izvođenja sprinteva (Krustrup i sar., 2010). Pored toga, utvrđeno je i značajno smanjenje trčanja u sprintu u kasnijim fazama utakmice kod vrhunskih fudbalera (Mohr i sar., 2003). Isti zaključci su izvedeni i u istraživanju koje je provedeno na uzorku profesionalnih fudbalerki (Krustrup i sar., 2005). Cilj ovog istraživanja je bio da se utvrdi da li postoji razlika u izvedbi ponavljanja sprints između fudbalera različitog ranga takmičenja i na taj način da se potvrdi uloga i važnost ove sposobnosti kao prediktora vrhunške izvedbe u savremenom fudbalu.

METODE

Ispitanici

Trideset fudbalera muškog pola (15 amatera i 15 profesionalaca) je učestvovalo u ovom istraživanju. Fudbaleri amateri su izabrani iz ekipe koja se takmičila u 3. ligi Bosne i Hercegovine (prosječna starost ispitanika je bila 23.3 ± 3.2 godine), dok su fudbaleri profesionalci izabrani iz ekipe koja se takmičila u 1. (Premijer) ligi Bosne i Hercegovine (prosječna starost ispitanika je bila 22.4 ± 3.4 godine). Ispitanici su bili potpuno informisani o eventualnim rizicima i nelagodnostima povezanim sa testiranjem prije davanja pismene saglasnosti za učešće u istraživanju. Igrači iz 1. lige su imali treninge šest puta sedmično i zvaničnu utakmicu, dok su igrači 3. lige trenirali tri puta sedmično i učestvovali u zvaničnoj utakmici. Ispitanici su informisani da dan prije testiranje izbjegavaju intenzivnu fizičku aktivnost i da ne uzimaju napitke koji sadrže kofein.

sions per week and an official game. Participants were instructed that avoid intense physical activity and not take caffeine-containing beverages a day prior to testing.

Measurement procedures

Repeated sprint ability performance testing

Prior to the repeated sprint ability testing, all subjects performed a 10-15 minutes low-intensity warm-up consisting of functional mobility exercises (8–10 exercises, 10–12 repetitions of each exercise). Before warm up, the subjects were familiar with the RSA test protocol and the importance of performing each sprint at maximum intensity. The RSA test consisted of successive performance of 6 sprints at a distance of 30 meters with an active rest between two sprints of 20 seconds. Sprint time was measured using a photocell system (Globus Ergotester, Italy). Testing was carried out indoors in the morning on an artificial floor. The subjects started the test in a high stance behind the start line of 30 meters distance and after the sound signal they started in the maximum sprint. Players were required to maintain maximum running speed for the entire length of the course and to slow down only after passing through photocells at 30 meters. After that, the players jogged 20 seconds to the start line and prepare for the next sprint.

Total sprint time and average sprint time were calculated for all subjects in both groups. The total sprint time was calculated as a sum of all six sprints, while the average sprint time was obtained by dividing the total sprint time by the total number of sprints.

total sprint time = sprint 1 + sprint 2 + sprint 3 + sprint 4 + sprint 5 + sprint 6

average sprint time = (total sprint time) / number of sprints

In addition to the total and average sprint time, the percentage decline in sprint performance was calculated according to the following formula (Girard et al., 2011):

performance decline (%) = [((sprint 1 + sprint 2 + sprint 3 + sprint 4 + sprint 5 + sprint 6) / fastest sprint x number of sprints) - 1] x 100

Statistical analyzes

Statistical data processing was performed using the SPSS 20 for the Windows operating system. The first step in data analysis was to determine the normality of the distribution. Using the Wilks-Shapiro test, it was determined whether the test results deviated significantly from the normal distribution. The normality of the distribution was tested at a significance level of 0.05. Measures of central tendency and dispersion are represented by arithmetic means

Procedure mjerenja

Mjerenje izvedbe ponavljanja sprinta

Prije izvođenja testa ponavljanja sprinta svi ispitanici su proveli zagrijavanje niskog intenziteta trajanja 10-15 minuta koje je bilo sastavljeno od vježbi funkcionalne pokretljivosti u kretanju (8-10 vježbi, 10-12 ponavljanja svake vježbe). Prije zagrijavanja ispitanici su upoznati sa načinom izvođenja protokola testiranja ponavljanja sprinta i važnosti izvođenja svakog sprinta maksimalnim intenzitetom. Test ponavljanja sprinta se sastojao od uzastopnog izvođenja 6 sprinteva na distanci od 30 metara sa aktivnim odmorom između dva sprinta od 20 sekundi. Mjerenje vremena sprinta je izvršeno korištenjem sistema fotočelija (Globus Ergotester, Italija). Testiranje je provedeno u prijedpodnevnim satima u zatvorenom prostoru (sala) na vještačkoj podlozi (tartan). Ispitanici su početak testa čekali u visokom stavu iza linije starta distance od 30 metara i nakon zvučnog signala su startali u maksimalni sprint. Od ispitanika je zahtijevano da održe maksimalnu brzinu trčanja čitavom dužinom staze i da usporavaju tek nakon prolaska kroz fotočelije na 30 metara. Poslije toga, ispitanici su imali 20 sekundi da se u laganom trčanju vrate na start i da se pripreme za sledeći zvučni signal i sledeći sprint. Registrovano je vrijeme svih šest sprinteva i upisivano u unaprijed pripremljen obrazac radi kasnijeg izračunavanja parametara izvedbe sprinta.

Ukupno vrijeme sprinta i prosječno vrijeme sprinta su izračunati za sve ispitanike u obe grupe. Ukupno vrijeme sprinta je dobijeno sabiranjem ostvarenih vremena na svih šest sprinteva, dok je prosječno vrijeme sprinta dobijeno dijeljenjem ukupnog vremena sprinta sa ukupnim brojem sprinteva.

ukupno vrijeme sprinta = sprint1 + sprint2 + sprint 3 + sprint 4 + sprint 5 + sprint 6

prosječno vrijeme sprinta = (ukupno vrijeme sprinta) / broj sprinteva

Pored ukupnog i prosječnog vremena sprinta izračunat je i procentualni pad izvedbe sprinta prema sledećoj formuli (Girard i sar., 2011):

pad izvedbe (%) = [((sprint1+sprint2+sprint3+sprint4+sprint5+sprint6)/najbrži sprint x broj spinteva)-1] x 100

Statističke analize

Statistička obrada podataka izvršena je primjenom kompjuterskog programa SPSS 20 za operativni sistem Windows. Prvi korak u analizi podataka je bilo utvrđivanje normalnosti distribucije rezultata. Primjenom Vilks-Šapiro testa (Wilks-Shapiro test) je utvrđeno da li rezultati testiranja značajno odstupaju od normalne distribucije. Normalnost distribucije rezultata je testirana na nivou značajnosti od 0.05. Mjere centralne tendencije i disperzije rezultata su

and standard deviations. A ANOVA with repeated measurements with Bonferoni correction and post hoc comparison was used to test the statistical significance of the time differences of six sprints separately for the amateur soccer group and the professional soccer group. A t-test for independent samples was used to determine the significance of the arithmetic mean differences of each individual sprint and the arithmetic mean differences of the sprint performance between two groups of football players. The magnitude (power) of the difference determined by the t-test for independent samples is represented by Cohen's d (Cohen effect size). The criterion proposed by Hopkins (2004) was used to interpret the magnitude (power) of the differences. Based on the proposed criterion, the differences were interpreted as follows: <0.2 - trivial difference; 0.2-0.6 - small difference; 0.6-1.2 - moderate difference; 1.2-2.0 - large difference; > 2.0 - very large difference.

RESULTS

Both groups of players performed a RSA test that consisted of 6 repeated sprints over a distance of 30 meters, with an active rest between sprints (20 seconds). A decline in running speed with the each subsequent sprint was evident in both groups of players (Figure 1). A statistically significant decline in sprint time was found between the first and second sprint in both groups of players ($p < 0.01$). The third sprint running speed was statistically significantly lower than the second sprint running speed ($p < 0.01$). Running speed continued to decline in both groups of players during the fourth sprint compared to the third sprint ($p < 0.01$). The difference between the time of the fourth and fifth sprints was not statistically significant ($p > 0.05$), while the decline in running speed was the smallest between the fifth and sixth sprint ($p > 0.05$).

Differences of each individual sprint between amateur and professional football players were analyzed, as well as differences in total and average sprint time as indicators of performance quality. In addition, the differences in the percentage decline in sprint performance and the magnitude of fatigue during the RSA test were analyzed (Tables 1 and 2). Professional football players had significantly better performance on all six sprints compare to amateur football players (Figure 2). The difference was particularly pronounced for the first, third and fifth sprints ($p < 0.01$), while for the second, fourth and sixth sprints the difference was slightly smaller ($p < 0.05$). The difference between the two groups of football players was also statistically significant considering the fastest and slowest sprint times ($p < 0.01$).

predstavljene aritmetičkim sredinama i standardnim devijacijama. Analiza varijanse ponovljenih mjerenja sa Bonferoni korekcijom i post hoc poređenjem je korištena za testiranje statističke značajnosti razlika vremena šest sprinteva odvojeno za grupu fudbalera amatera i za grupu fudbalera profesionalaca. Za utvrđivanje značajnosti razlika aritmetičkih sredina vremena svakog pojedinačnog sprinta i parametara izvedbe sprinta između dvije grupe fudbalera korišten je t-test za nezavisne uzorke. Veličina (snaga) razlike utvrđene t-testom za nezavisne uzorke je predstavljena Koenvim d (Cohen effect size). Za interpretaciju veličine (snage) razlika korišten je kriterijum predložen od strane Hopkinsa (2004). Na osnovu predloženog kriterijuma razlike su interpretirane na sledeći način: <0.2 – trivijalna razlika; 0.2-0.6 – mala razlika; 0.6-1.2 – umjerena razlika; 1.2-2.0 – velika razlika; >2.0 – veoma velika razlika.

REZULTATI

Obe grupe ispitanika, fudbaleri 1. lige i fudbaleri 3. lige, su izveli test koji se sastojao od ponavljanja 6 sprinteva na distanci od 30 metara, sa aktivnim odmorom između sprinteva (lagano trčanje od 20 sekundi). Pad brzine trčanja je evidentan kod obe grupe ispitanika, sa ponavljanjem svakog narednog sprinta (Slika 1). Statistički značajno duže vrijeme sprinta je utvrđeno između prvog i drugog sprinta kod obe grupe fudbalera ($p < 0.01$). Brzina trčanja tokom izvođenja trećeg sprinta je bila statistički značajno manja nego kod izvedbe drugog sprinta ($p < 0.01$). Brzina trčanja se i dalje smanjivala, pa su obe grupe fudbalera postigle statistički značajno lošije vrijeme tokom izvedbe četvrtog sprinta, u odnosu na treći sprint ($p < 0.01$). Razlika između vremena četvrtog i petog sprinta nije bila statistički značajna ($p > 0.05$) kod obe grupe ispitanika, dok je pad brzine trčanja bio najmanji između petog i šestog sprinta ($p > 0.05$).

Poslije analize izvedbe ponavljanja sprinta posebno za svaku grupu ispitanika, trebalo je dati odgovor na pitanje da li se fudbaleri različitog nivoa kvaliteta razlikuju u sposobnosti ponavljanja sprinta. Analizirane su razlike svakog pojedinačnog sprinta između amatera i profesionalaca, kao i razlike u ukupnom i prosječnom vremenu sprinta kao pokazateljima kvaliteta izvedbe. Pored toga, analizirane su i razlike u procentualnom padu izvedbe ponavljanja sprinta, odnosno stepenu pojave zamora tokom izvođenja serije sprinteva (Tabele 1 i 2). Fudbaleri profesionalci su imali značajno bolja vremena svih šest sprinteva u odnosu na fudbalere amatere (Slika 2). Razlika je bila naročito izražena kod prvog, trećeg i petog sprinta ($p < 0.01$), dok je kod drugog, četvrtog i šestog sprinta razlika bila nešto manja ($p < 0.05$). Razlika između dvije grupe fudbalera je bila i statistički značajna kad su u obzir uzeta vremena najbržeg i najsporijeg sprinta ($p < 0.01$).

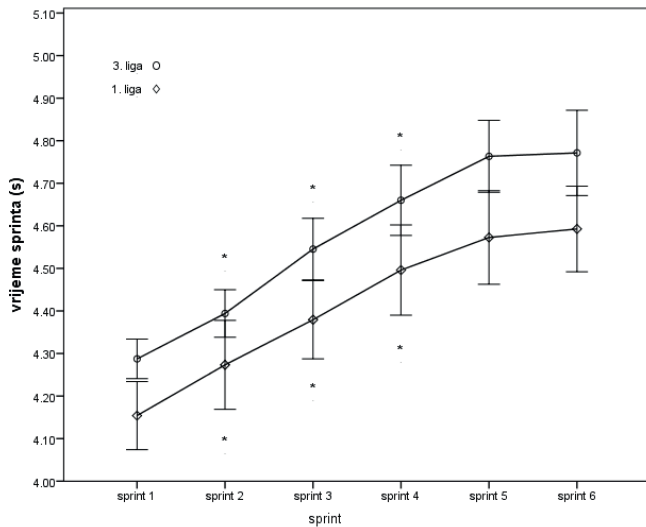
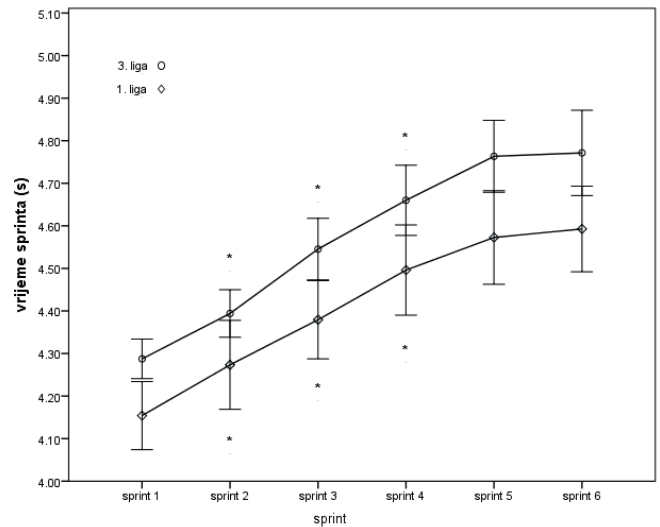


Figure 1. Speed decline in 6x30m RSA test, separately for a sub-sample of Division 3 and Division 1 players. The circles represent the group of Division 3 players, and the squares represent the group of Division 1 players. The results are presented as arithmetic means and standard deviations ($M \pm SD$). (*) represents a statistically significant difference between two sprints at a significance level of 0.01 within the same group of players



Slika 1. Pad brzine trčanje kod izvedbe sprinta 6x30 m, odvojeno za subuzorak fudbalera 3. lige i fudbalera 1. lige. Krugovi (○) prikazuju grupu fudbalera 3. lige, a rombovi (◇) grupu fudbalera 1. lige. Rezultati su prikazani kao aritmetičke sredine i standardne devijacije ($M \pm SD$). (*) predstavlja statistički značajnu razliku između dva sprinta na nivou značajnosti od 0.01 unutar iste grupe ispitanika

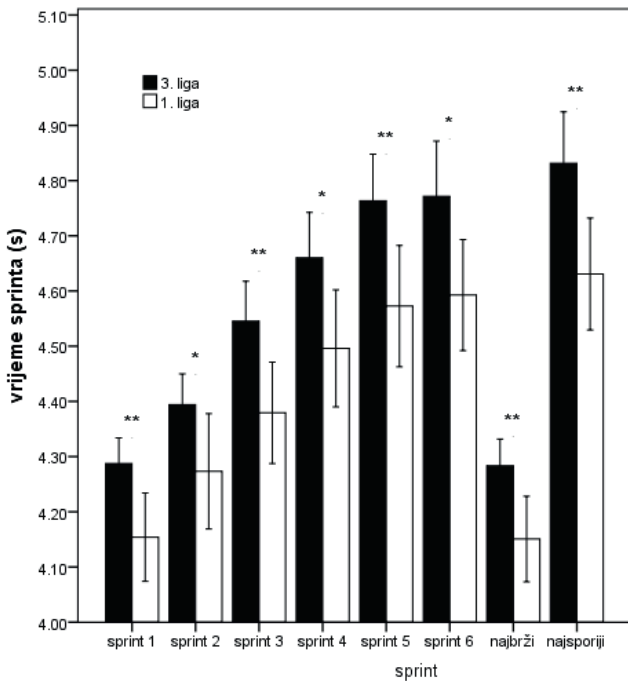
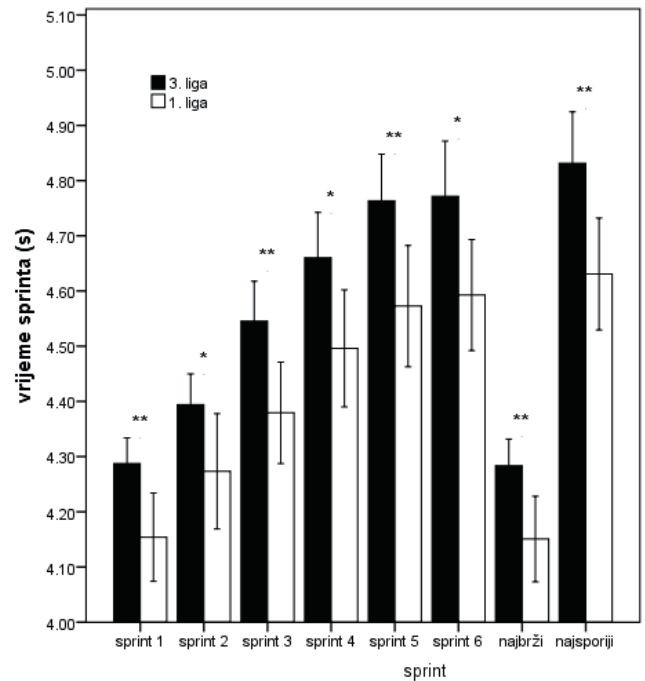


Figure 2. Differences between groups of Division 3 players and Division 1 players in RSA test (6x30m). The closed columns represent the results of Division 3 football players, the open columns represent the results of Division 1 football players. All results are presented as arithmetic means and standard deviations ($M \pm SD$). (*) shows statistically significant difference at significance level of 0.05, (**) shows statistically significant difference at significance level of 0.01.



Slika 2. Razlike između grupa fudbalera 3. lige i fudbalera 1. lige u izvedbi ponavljanja sprinta (6x30m). Zatvoreni stupci prikazuju rezultate fudbalera 3. lige, otvoreni stupci prikazuju rezultate fudbalera 1. lige. Svi rezultati su prikazani kao aritmetičke sredine i standardne devijacije ($M \pm SD$). (*) prikazuje statistički značajnu razliku na nivou značajnosti od 0.05, (**) prikazuje statistički značajnu razliku na nivou značajnosti od 0.01.

Table 1. Arithmetic mean differences of six individual sprints of 30 m (6x30m) between Division 3 players (amateurs) and Division 1 players (professionals), with t-test results for independent samples and effect size estimation

	III liga / Division 3		I liga / Division 1		Cohen-ovo d / Cohen's d	95% CI	veličina razlike / magnitude of difference	p vrijednost / p value
	M ₁	SD ₁	M ₂	SD ₂				
sprint 1 / sprint 1	4.29	0.08	4.15	0.14	1.13	(0.36, 1.90)	umjerena / moderate	0.005**
sprint 2 / sprint 2	4.39	0.1	4.27	0.19	0.8	(0.05, 1.54)	umjerena / moderate	0.04*
sprint 3 / sprint 3	4.54	0.13	4.38	0.16	1.11	(0.34, 1.88)	umjerena / moderate	0.005**
sprint 4 / sprint 4	4.66	0.15	4.5	0.19	0.96	(0.20, 1.71)	umjerena / moderate	0.014*
sprint 5 / sprint 5	4.76	0.15	4.57	0.2	1.07	(0.31, 1.84)	umjerena / moderate	0.006**
sprint 6 / sprint 6	4.77	0.18	4.59	0.18	0.98	(0.23, 1.74)	umjerena / moderate	0.012*
najbrži sprint / fastest sprint	4.28	0.09	4.15	0.14	1.14	(0.36, 1.90)	umjerena / moderate	0.005**
najsporiji sprint / slowest sprint	4.83	0.17	4.63	0.18	1.14	0.37, 1.91)	umjerena / moderate	0.004**

Tabela 1. Razlike aritmetičkih sredina vremena šest pojedinačnih sprinteva dužine 30 m (6x30m) između igrača 3. lige (amateri) i igrača 1.lige (profesionalci), sa rezultatima t-testa za nezavisne uzorke i procjenom veličine razlike (effect size)

Table 2. Differences in arithmetic means of sprint performance parameters between Division 3 players (amateurs) and Division 1 players (professionals), with results - test for independent samples and effect size estimation

	III liga / Division 3		I liga / Division 1		Cohen-ovo d / Cohen's d	95% CI	veličina razlike / magnitude of difference	p vrijednost / p value
	M ₁	SD ₁	M ₂	SD ₂				
prosječno vrijeme / average time	4.5702	0.11036	4.4113	0.16804	1.12	(0.35, 1.88)	umjerena / moderate	0.005**
ukupno vrijeme / total time	27.4213	0.66216	26.468	1.00823	1.12	(0.35, 1.89)	umjerena / moderate	0.005**
pad izvedbe (%) / performance decline (%)	6.7047	1.86	6.2709	1.22432	0.28	(-0.44, 0.99)	mala / small	0.457

Tabela 2. Razlike aritmetičkih sredina parametara izvedbe sprinta između igrača 3. lige (amateri) i igrača 1. lige (profesionalci), sa rezultatima t-testa za nezavisne uzorke i procjenom veličine razlike (effect size)

Legend: M₁ ± SD₁ - arithmetic means and standard deviations of sprint performance parameters (amateurs), M₂ ± SD₂ - arithmetic means and standard deviations of sprint performance parameters (professionals), Cohen's d - difference size parameter (<0.2 - trivial; 0.2 - 0.6 small; 0.6 - 1.2 moderate; 1.2 - 2.0 large; 2.0 - 4.0 very large; > 4.0 - extremely large; according to Hopkins, 2004), p - significance level, ** - statistically significant at the 0.01 level; * - statistically significant at the 0.05 level

The results showed that Division 1 football players had significantly better results in all six sprints compared to League 3 players. The magnitude of the difference is expressed by the Cohen's d (effect size) parameter with recommendations for interpreting this parameter proposed by Hopkins (2004). The difference between the two groups of players was most pronounced in the first, third, and fifth sprint. In addition, the significance level of t statistics was less than 0.01. The arithmetic mean of the first sprint time for professional soccer players was lower than for amateur players (4.15 ± 0.14 vs 4.29 ± 0.08). The magnitude of the difference was indicated as moderate (d = 1.13), while the obtained t statistic was significant at the level of 0.01 (p =

Legenda: M₁±SD₁ - aritmetičke sredine i standardne devijacije parametara izvedbe sprinta (amateri), M₂±SD₂ - aritmetičke sredine i standardne devijacije parametara izvedbe sprinta (profesionalci), Cohen-ovo d - parametar veličine razlike (<0.2 - razlika trivijalna; 0.2 - 0.6 razlika mala; 0.6 - 1.2 razlika umjerena; 1.2 - 2.0 razlika velika; 2.0 - 4.0 razlika vrlo velika; >4.0 - razlika ekstremno velika; prema Hopkinsu, 2004), p - nivo značajnosti t statistika, ** - statistički značajno na nivou 0.01; * - statistički značajno na nivou 0.05

Rezultati su pokazali da su fudbaleri 1. lige imali statistički značajno bolja vremena na svih šest sprinteva u odnosu na fudbalere 3. lige. Veličina razlike je izražena parametrom Cohen d (effect size) sa preporukama za tumačenje ovog parametra koje je predložio Hopkins (2004). Razlika između dvije grupe ispitanika je bila najizraženija kod izvedbe prvog, trećeg i petog sprinta, jer su vrijednosti Koenovog d bile najveće. Pored toga, ostvareni nivo značajnosti testiranja statističke značajnosti t statistika je bio manji od 0.01. Aritmetička sredina vremena prvog sprinta kod fudbalera profesionalaca je bila manja nego kod amatera (4.15±0.14 vs 4.29±0.08). Veličina razlike je označena kao umjerena (d=1.13), dok je dobijeni t statistik bio značajan na

0.005). The magnitude of the difference in the arithmetic means of the second sprint time was also classified as moderate ($d = 0.8$) and the difference in the arithmetic means was slightly smaller compare to first sprint (4.27 ± 0.19 vs 4.39 ± 0.1). The t-statistic was also statistically significant, but at the 0.05 level ($p = 0.04$). In the third sprint, the Division 1 players had again better sprint times than the Division 3 players (4.38 ± 0.16 vs 4.54 ± 0.13). The magnitude of the difference was indicated as moderate ($d = 1.11$), and the t-test showed that the difference of arithmetic means was statistically significant at the 0.01 level ($p = 0.005$). The arithmetic mean of the fourth sprint time of professionals and amateurs differed significantly at the 0.05 level ($p = 0.014$; 4.5 ± 0.19 vs 4.66 ± 0.15). The value of Cohen's d was 0.96, so the difference was again marked as moderate. The fifth sprint performance was better in the group of Division 1 players (4.57 ± 0.2 vs 4.76 ± 0.15), the value of Cohen's d was 1.07 which classified the obtained difference as moderate. The difference in arithmetic mean was statistically significant, as the t-statistic was statistically significant at the 0.01 level ($p = 0.006$). Cohen's d value at the sixth sprint was 0.98 (moderate difference), and the t-statistic was statistically significant at the 0.05 level ($p = 0.012$). The arithmetic mean of the sixth sprint time of professional football players was lower compared to amateur football players (4.59 ± 0.18 vs 4.77 ± 0.18). The repeated sprint ability is estimated based on the values of performance parameters, total sprint time, average sprint time, and percentage decline in sprint performance. Division 1 football players had a significantly better total and average sprint time compared to Division 3 football players. The magnitude of the difference in the arithmetic means of the total sprint time between the two groups of football players was moderate, the value of Cohen's d was 1.12. The difference of arithmetic means was statistically significant at the 0.01 level ($p = 0.005$; 4.41 ± 0.17 vs 4.57 ± 0.11). As for the average sprint time, the same values of Cohen's d ($d = 1.12$) were obtained and the difference was also indicated as moderate. The arithmetic mean of the average sprint time of Division 1 players (4.41 ± 0.17) was significantly smaller than the arithmetic mean of the average sprint time of Division 3 players (4.57 ± 0.11 ; $p = 0.005$). The percentage decline in sprint performance did not differ significantly between the two groups of football players. The level of significance of the differences in the arithmetic means of the percentage decline in sprint performance was above the threshold value of 0.05 (t statistic not statistically significant). The arithmetic mean of the decline in sprint performance in professionals was slightly smaller than the arithmetic mean of the decline in sprint performance in amateurs (6.27 ± 1.22 vs 6.70 ± 1.80). The dif-

nivou od 0.01 ($p=0.005$). Veličina razlike aritmetičkih sredina vremena drugog sprinta je takođe klasifikovana kao umjerena ($d=0.8$), s tim da je razlika aritmetičkih sredina u ovom slučaju bila nešto manja u odnosu na prvi sprint (4.27 ± 0.19 vs 4.39 ± 0.1). T- statistik je takođe bio statistički značajan, ali na nivou 0.05 ($p=0.04$). Kod izvedbe trećeg sprinta, fudbaleri 1. lige su ponovo postizali bolja vremena u odnosu na fudbalere 3. lige (4.38 ± 0.16 vs 4.54 ± 0.13). Veličina razlike je označena kao umjerena ($d=1.11$), a t-test je pokazao da je razlika aritmetičkih sredina statistički značajna na nivou 0.01 ($p=0.005$). Aritmetičke sredine vremena četvrtog sprinta profesionalaca i amatera su se statistički značajno razlikovale na nivou 0.05 ($p=0.014$; 4.5 ± 0.19 vs 4.66 ± 0.15). Vrijednost Koenovog d je iznosila 0.96, pa je razlika ponovo označena kao umjerena. Izvedba petog sprinta u seriji je bila bolja kod grupe fudbalera 1. lige (4.57 ± 0.2 vs 4.76 ± 0.15), vrijednost Koenovog d je bila 1.07 što je dobijenu razliku klasifikovalo kao umjerenu. Razlika aritmetičkih sredina je bila statistički značajna, jer je t-statistik bio statistički značajan na nivou 0.01 ($p= 0.006$). Vrijednost Koenovog d kod šestog sprinta je bila 0.98 (umjerena razlika), a t-statistik je bio statistički značajan na nivou 0.05 ($p=0.012$). Aritmetička sredina vremena šestog sprinta fudbalera profesionalaca je bila manja nego kod fudbalera amatera (4.59 ± 0.18 vs 4.77 ± 0.18). Nivo sposobnosti ponavljanja sprinta se procjenjuje na osnovu vrijednosti parametara izvebe, ukupnog vremena sprinta, prosječnog vremena sprinta i procentualnog pada izvebe. Fudbaleri 1. lige su imali statistički značajno bolje ukupno i prosječno vrijeme sprinta u odnosu na fudbalere 3. lige. Niže vrijednosti ovih parametara znače bolju izvedbu ponavljanja sprinta. Veličina razlike aritmetičkih sredina ukupnog vremena sprinta između dvije grupe fudbalera je bila umjerena, vrijednost Koenovog d je bila 1.12. Razlika aritmetičkih sredina je bila statistički značajna na nivou 0.01 ($p=0.005$; 4.41 ± 0.17 vs 4.57 ± 0.11). Kad je u pitanju prosječno vrijeme sprinta dobijene su iste vrijednosti Koenovog d ($d=1.12$) i razlika je takođe označena kao umjerena. Aritmetička sredina prosječnog vremena sprinta fudbalera 1. lige (4.41 ± 0.17) je bila statistički značajno manja od aritmetičke sredine prosječnog vremena sprinta fudbalera 3. lige (4.57 ± 0.11 ; $p=0.005$). Procentualni pad izvedbe ponavljanja sprinta se nije značajno razlikovao između dvije grupe fudbalera. Ostvareni nivo značajnosti razlika aritmetičkih sredina procentualnog pada izvedbe je bio iznad granične vrijednosti od 0.05 i iznosio je 0.457 (t statistik nije statistički značajan). Aritmetička sredina pada izvedbe uzorka profesionalaca je bila neznatno manja od aritmetičke sredine pada izvedbe amatera (6.27 ± 1.22 vs 6.70 ± 1.80). Veličina razlike je označena kao mala, jer je d parametar iznosio 0.28 (Cohen effect size).

ference size was labeled small because the *d* parameter was 0.28 (Cohen effect size).

DISCUSSION

Muscle fatigue occurs when sprints are repeated, which causes a decline in sprint performance. In this study, the aim was to determine how muscle fatigue is associated with decline in sprint performance. In addition, the study compared the performance of sprint between players of different level of competition to determine whether higher-ranked football players have a better repeated sprint ability and whether muscle fatigue is lower in group of Division 1 football players. In addition, the aim was to confirm the association of RSA with match performance by comparing differences in sprint performance between players of different quality. The results of the study showed a significant decline in sprint performance in both groups of players. These results are consistent with those of other studies (Rampinini et al., 2009; Bishop & Edge, 2006; Bishop et al., 2003; Aziz et al., 2008). Repeating sprints at a distance of 30 meters, with an active pause of 20 seconds, led to muscle fatigue as the sprint speed decreased with each subsequent sprint. The difference in all six sprints were significant for both groups of players ($p = 0.001$). After the fourth sprint, there was a stabilization of the running speed, so the decline in the sprint speed from the fourth to the sixth sprint was smaller than at the beginning of the test. Professional football players had significantly better sprint times compared to amateur football players ($p < 0.01$; $p < 0.05$). The sprint speed of all six reps was significantly higher for Division 1 players. In addition, Division 1 football players had a significantly better total and average sprint time compared to Division 3 players ($p < 0.01$). The only performance parameter in which the players of different competition rank did not differ was the percentage decline in sprint performance ($p > 0.05$). Certain authors find it more appropriate to use total sprint time as an indicator of the RSA performance than the percentage decline in performance (Gabbett, 2010; Fitzsimons et al., 1993; Gleister et al., 2007). It is very important that the fatigue indicator during the series of sprints (percentage decline in performance) is not taken as the only parameter of performance quality, since large / small fatigue does not in any case mean worse / better performance (Mohr et al. 2007; Racinais et al. 2010). The time of the first sprint can significantly affect the values of the fatigue index (percentage decline in performance) and can thus lead to an incorrect interpretation of the quality of the sprint performance. Research has shown that first sprint time can correlate significantly with performance decline during sprint repetition (Mendez-Villanueva et al., 2008; Bishop et al., 2003;

DISKUSIJA

Tokom ponavljanja sprinta dolazi do pojave mišićnog zamora koji uzrokuje pad izvedbe sprinta, pa je i u ovom istraživanju cilj bio da se utvrdi u kojoj mjeri dolazi do razvoja mišićnog zamora i sa njim povezanog pada izvedbe. Dodatno, u istraživanju je poređena izvedba ponavljanja sprinta između fudbalera 1. i 3. lige kako bi se utvrdilo da li fudbaleri višeg ranga takmičenja imaju bolje razvijenu sposobnost ponavljanja sprinta, i da li je stepen mišićnog zamora manji kod kvalitetnijih fudbalera. Pored toga, cilj je bio da se poređenjem razlika izvedbe ponavljanja sprinta između fudbalera različitog kvaliteta potvrdi povezanost sposobnosti ponavljanja sprinta sa boljom izvedom u toku fudbalske igre. Rezultati istraživanja su pokazali značajan pad izvedbe ponavljanja sprinta kod obe grupe ispitanika. Ovi rezultati su u skladu sa rezultatima drugih studija (Rampinini i saradnici, 2009; Bishop & Edge, 2006; Bishop i saradnici, 2003; Aziz i saradnici, 2008). Ponavljanje sprinteva na distanci od 30 metara, sa aktivnom pauzom od 20 sekundi, dovelo je do pojave mišićnog zamora jer je brzina sprinta opadala svakim narednim sprintom. Vremena šest sprinteva su se statistički značajno razlikovala kod obe grupe fudbalera ($p=0.001$), s tim da pad brzine trčanja poslije četvrtog sprinta više nije bio statistički značajan. Poslije četvrtog sprinta je došlo do stabilizacije brzine trčanja, tako da je pad brzine trčanja od četvrtog do šestog sprinta bio manji nego na početku testa. Fudbaleri profesionalci su imali statistički značajno bolja vremena sprinta u odnosu na fudbalere amatere ($p < 0.01$; $p < 0.05$). Brzina sprinta svih šest ponavljanja je bila statistički značajno viša kod fudbalera 1. lige, što pokazuju ostvarena vremena na distanci od 30 metara. Pored toga, fudbaleri 1. lige su imali i statistički značajno bolje ukupno i prosječno vrijeme sprinta u odnosu na fudbalere 3. lige ($p < 0.01$). Jedini parametar izvedbe u kome se fudbaleri različitog ranga takmičenja nisu razlikovali je bio procentualni pad izvedbe ($p > 0.05$). Određeni autori smatraju da je primjerenije koristiti ukupno vrijeme sprinta, kao pokazatelj kvaliteta izvedbe ponavljanja sprinta, nego procentualni pad izvedbe (Gabbett, 2010; Fitzsimons i saradnici, 1993; Gleister i saradnici, 2007). Veoma je važno da se pokazatelj zamora tokom ponavljanja sprinta (procentualni pad izvedbe) ne uzima kao jedini parametar kvaliteta izvedbe, jer veći/manji zamor ne znači u svakom slučaju lošiju/bolju izvedbu (Mohr i saradnici, 2007; Racinais i saradnici, 2010). Vrijeme prvog sprinta može značajno uticati na vrijednosti indeksa zamora (procentualni pad izvedbe) i tako može dovesti do netačne interpretacije kvaliteta ponavljanja sprinta. Istraživanja su pokazala da vrijeme prvog sprinta može značajno korelirati sa padom izvedbe tokom ponavljanja sprinta (Mendez-Villanueva i saradnici, 2008; Bishop i saradnici, 2003; Yanagiya i saradnici, 2003). Ovo je vjerovat-

Yanagiya et al., 2003). This is probably related to the fact that athletes with better sprint performance in the series have greater changes in muscle metabolites, which is a consequence of a higher anaerobic energy provision for muscle work, which may ultimately be associated with a greater decline in performance (Gaitanos et al. 1993). Subjects with lower reserves of anaerobic power relied less on anaerobic metabolism, resulting in a smaller decline in performance during sprint repetition (nominally less fatigue). It is important to emphasize that the ability to repeat a sprint should not only be viewed through a relative decline in performance, a fall in speed relative to the fastest sprint. An important component of this ability is the fastest sprint, because as important as the sprint speed is to decrease as little as possible, it is also important that the fastest sprint benchmark be as good as possible. This underscores the importance of quality sprint performance, and the importance of developing quality of individual sprint. If we take the total sprint time as a valid indicator of the RSA, then higher level football players had better results. This data underscores the importance of sprinting ability in modern football, because excellent performance in sprint tests is significantly associated with certain parameters of the game, such as the distance covered by high-intensity running (Rampinini, 2007). In addition, it has been confirmed that football players from top-level clubs show better performance of high intensity intermittent activities (Bangsbo et al., 2008; Mohr et al., 2003) as well as repeated sprint performance (Impellizzeri et al., 2008). Studies of the validity of RSA tests have shown that this ability separates professional and amateur football players and this ability is valid predictor of good match performance in modern football (Aziz et al., 2008). The same conclusions can be drawn from our research, higher ranked football players had better individual sprint performance, so they had better times in all six sprints. Secondly, it has also been shown in this study that the percentage decline in performance (index of fatigue) cannot serve as a reliable parameter for evaluation of repeated sprint ability. Third, a difference was found in favor of the professionals, which confirms the previously proven role of this ability in modern football.

CONCLUSION

Research has shown that players of different levels of competition differ significantly in the repeated sprint performance. Professional players had better total sprint time and average sprint time compared to amateur players. This confirms the importance of this ability in modern football, as it differentiates players of different levels of quality. The ability to repeat a sprint is an important predictor of quality

no povezano sa činjenicom da sportisti sa boljom izvedbom prvog sprinta u seriji imaju veće promjene mišićnih metabolita, što je posljedica većeg anaerobnog udjela u dobijanju energije za mišićni rad, što na kraju može biti povezano i sa većim padom izvedbe (Gaitanos i saradnici, 1993). Ispitanici sa manjim rezervama anaerobne snage se manje oslanjaju na anaerobni metabolizam, što rezultira manjim padom izvedbe tokom ponavljanja sprinta (nominalno manji zamor). Važno je naglasiti da sposobnost ponavljanja sprinta ne treba posmatrati samo preko relativnog pada izvedbe, pada brzine u odnosu na najbrži sprint. Važna komponenta ove sposobnosti je upravo parametar najbržeg sprinta, jer koliko je važno da brzina sprinta opada što manje, isto tako je važno i da referentna vrijednost najbržeg sprinta bude što bolja. To naglašava važnost kvalitetne izvedbe pojedinačnog sprinta, odnosno važnost razvijanja brzine pojedinačnog sprinta. Ako uzmemo pokazatelj ukupnog vremena sprinta, kao validan pokazatelj sposobnosti ponavljanja sprinta, onda su fudbaleri višeg nivoa takmičenja imali bolje rezultate. Ovaj podatak naglašava važnost sposobnosti ponavljanja sprinta u vrhunskom fudbalu, jer je upravo kvalitetan rezultat na testovima ponavljanja sprinta kod fudbalera visokog standarda značajno povezan sa određenim parametrima igre, kao što je distanca pokrivena trčanjem visokog intenziteta (Rampinini, 2007). Pored toga, potvrđeno je da fudbaleri višeg kvaliteta takmičenja pokazuju bolju izvedbu intermitentnih aktivnosti visokog intenziteta (Bangsbo i saradnici, 2008; Mohr i saradnici, 2003), kao i izvedbu ponavljanja sprinta (Impellizzeri i saradnici, 2008). Studije validnosti testova ponavljanja sprinta su pokazale da ova sposobnost razdvaja fudbalere višeg nivoa takmičenja i fudbalere nižeg nivoa takmičenja, što pokazuje koliko je sposobnost intermitentnog izvođenja sprinteva važna determinanta uspjeha u savremenom fudbalu (Aziz i saradnici, 2008). Isti zaključci se mogu izvesti i iz našeg istraživanja, fudbaleri višeg ranga takmičenja su imali kvalitetniju izvedbu pojedinačnog sprinta pa su na svih šest sprinteva imali bolja vremena. Drugo, i u ovom istraživanju se pokazalo da procentualni pad izvedbe (indeks) zamora ne može služiti kao pouzdani parametar za procjenu sposobnosti ponavljanja sprinta. Treće, utvrđena je razlika u korist profesionalca, što potvrđuje ranije dokazanu ulogu ove sposobnosti u savremenom fudbalu.

ZAKLJUČAK

Provedeno istraživanje je pokazalo da se igrači različitog nivoa takmičenja značajno razlikuju u izvedbi ponavljanja sprinta. Igrači višeg ranga takmičenja su imali bolje ukupno vrijeme sprinta i prosječno vrijeme sprinta u poređenju sa igračima nižeg ranga takmičenja. To potvrđuje važnost ove sposobnosti u modernom fudbalu, jer razlikuje igrače

performance in football. Soccer training must include exercises to improve this ability. In addition, research has shown that the percentage decline in sprint performance cannot be taken as a reliable parameter for evaluating RSA because it is related to the performance of the first sprint in the series.

različitog nivoa kvaliteta. Sposobnost ponavljanja sprinta je važan prediktor kvalitetne izvedbe u fudbalu. Trening fudbalera mora uključivati vježbe za poboljšanje ove sposobnosti. Pored toga, istraživanje je pokazalo da se procentualni pad izvedbe ne može uzeti kao pouzdan parametar za procjenu sposobnosti ponavljanja sprinta jer je povezan sa izvedbom prvog sprinta u seriji.

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Primljen: 18. oktobar 2019. / Received: Oktober 18, 2019
Prihvaćen: 19. novembar 2019. / Accepted: November 19, 2019