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Razlike u vremenu startne reakcije i postignutom rezultatu u sprinterskim disciplinama u finalu olimpijskih igara u Londonu

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Sažetak: U sprinterskim disciplinama vrlo važno mjesto zauzimaju start i startno ubrzanje koje u velikoj mjeri generiše konačni rezultat. U zavisnosti od odgovarajućih individualnih morfoloških dimenzija, a naročito motoričkih i funkcionalnih sposobnosti takmičara mogućnost dobre realizacije ovih parametara je izvjesnija. Međutim, i pored vrhunskih rezultata koje ostvaruju, razlike u ova dva parametra su evidentne, što u pogledu na konačni rezultat ima određenog efekta. Cilj ovog istraživanja je bio da se utvrde razlike u vremenu startne reakcije i rezultata u sprinterskim disciplinama finalista Olimpijskih igara u Londonu 2012. godine. Analizirani su rezultati finalista (24 muška) i 24 (ženska) takmičara koji su nastupili u finalnim trkama na 100m, 200m i 400m. Evaluacija vremena startne reakcije (ms) i rezultata u sprintu (s) bazirala se na izvještajima koje je službeno objavila Međunarodna atletska federacija (IAAF). Rezultati analize T-testa su pokazali statistički značajne razlike u vremenu reakcije kod ženskih takmičara u disciplinama trčanja 100m i 400m (t= -3,220; p<0,01) kao i za discipline 200m i 400m (t=-2,550; p<0,01), za razliku od muških finalista gdje nisu zabilježene statistički značajne razlike. Takođe, u istim disciplinama između polova nisu zabilježene statistički značajne razlike, dok su evidentne u postignutim rezultatima u disciplinama 100m (t=-2,842; p<0,05), 200m (t=-11,526; p<0,01) i 400m (t=-27,019; p<0,01).

Ključne riječi: sprinterske discipline, Olimpijske igre, vrijeme startne reakcije, razlike

Differences in Time of Start Reaction and Achieved Result in the Sprint Disciplines in the Finals of The Olympic Games in London

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Abstract: In the sprint events, a very important place has the start and start acceleration which is largely generated by the final score. Depending on the appropriate individual morphological dimension, especially motor and functional abilities of competitors, good possibility to implement these parameters is certain. However, despite the excellent results they achieve, differences in these two parameters are evident, which in terms of the final result has a certain effect. The aim of this study was to determine the differences in the starting reaction time and results in the sprint events of the finalists at the Olympic Games in London in 2012. The results from the finalists (24 male) and 24 (women) that participated in the final races in the 100m, 200m and 400m were analyzed. The evaluation of starting reaction time (ms) and results in a sprint (s) were based on the reports that were officially published by the International Association of Athletics Federations (IAAF). The results of the analysis of t-test showed statistically significant differences in response time for female athletes in the disciplines of running 100m and 400m (t=-3.220; p<0,01) as well as for the 200m and 400m events (t =-2.550; p<0,05) unlike male finalists for which there were no statistically significant differences. Also, in the same disciplines between the sexes there were no statistically significant differences, while they are evident in the results achieved in the disciplines of 100m (t= -2.842; p<0,05), 200 (t= -11.526; p<0,01) and 400 (t= -27.019; p<0,01).

Key words: sprint events, the Olympic Games, the time of start reaction, differences

Uvod

Startno ubrzanje je relevantno u svim sprinterskim atletskim disciplinama, kao i u mnogim drugim sportskim granama u kojima je potrebno razviti brzinu na relativno kratkoj udaljenosti (tenis, odbojka, rukomet, košarka, fudbal, itd). Međutim, u sprinterskim disciplinama start i startno ubrzanje, kao dvije bitne komponente u velikoj mjeri generišu konačni rezultat u trčanju na 60m, 100m, 200m i 400m (Čoh & Tomažin, 2008). Kaže se da je startno ubrzanje jedan od najkompleksnijih segmenata sprinterskog trčanja, u kome se može racionalizovati sprinterski kapacitet koji će se manifestovati tek u segmentu trčanja maksimalnom brzinom. Najčešeća dužina startnog ubrzanja jeste od 25-30m, pri kojoj vrhunski sprinteri u prvih 10m razviju 50 do 55% svoje maksimalne brzine, u drugih 10 (do 20m) 70-80% i u trećih deset (do 30m) 85-95% (Čoh, 2001). Između 50 i 80m postižu maksimalnu brzinu, a nakon 80-90 metara brzina opada. Upravo zbog toga, nije slučajnost da su mnogi autori ušli u biomehaničku analizu ove dvije faze kako bi objasnili fenomen sprinterske brzine i startnog ubrzanja koje se temelji na vremenu startne reakcije (Coppenolle, Delecluse, Goris, Diels, & Kraayenhof, 1990; Guissard, Duchateau, & Hainaut, 1992; Mc Clements, Sanders, & Gander 1996, Harland & Steele, 1997, Čoh, Peharec, & Bačić, 2007; Bračić, Peharec, Bačić & Čoh, 2010). Početak sprinta i startnog ubrzanja su prva dva faktora sprinterske brzine kojima sportista pokušava postići maksimalnu brzinu. Svojevremeno istraživanje Tom Telleza, trenera legendarnog Carla Lewisa je pokazalo da ove dvije faze čine čak 64% učešća u rezultatu sprinta na 100m (Téllez & Doolittle, 1984). Istraživanja nekih autora (Schot & Knutzen 1992; Harland & Steele, 1997; Wang, 2006; Pain & Hibbs, 2007; Babić, 2008; Babić & Čoh, 2010) su saglasna u tome, da rezultat u sprintu zavisi od položaja u startnom bloku, tj. položaja težišta tijela, vremena startne reakcije i startnog ubrzanja.

Optimalna koherentnost između početka sprinta i startnog ubrzanja predstavljaju specifične motoričke probleme koje sportista mora integrisati u pogledu vremenskih i prostornih parametara u jednopolarni pokret cikličnog karaktera. Startno ubrzanje je složen ciklični pokret definisan pretežno progresijom frekvencije i dužine koraka, trajanjem faze kontakta i faze leta i položaja težišta tijela u trenutku dodira s podlogom, propulzijom u fazi leta i silama koje se savladavaju u prvom koraku (Hunter, Marshall, & McNair, 2005). Svi ovi navedeni parametri su uslovljeni funkcionisanjem CNS-a, motoričkih sposobnosti, energetskih procesa, morfoloških obilježja i stukture mišića (Locatelli & Arsac, 1995; Young, McLe-

Introduction

Starting acceleration is relevant in all sprint athletic disciplines, as in many other branches of sports which require developing the speed in relatively short distance (tennis, volleyball, handball, basketball, soccer, etc.). However, in the sprint events start and starting acceleration, as the two major components largely generate the final result of running the 60m, 100m, 200m and 400m (Čoh & Tomažin, 2008). It is said that the starting acceleration is of one of the most complex segments of the sprint, in which sprint capacity can be rationalized that will be manifested only in the segment of maximal running speed. The most common length in start accelerating is from 25-30m, at which the top sprinters in the first 10m develop 50 to 55% of their maximum speed, and in other 10 (up to 20m) 70-80% in the third 10 (up to 30m) 85-95% (Čoh, 2001). Between 50 and 80m they achieve maximum speed, and after 80-90 meters the speed decreases. It is therefore no coincidence that many of the authors included the biomechanical analysis of these two phases in order to explain the phenomenon of sprint speed and start acceleration based on the time of the start reaction (Coppenolle, Delecluse, Goris, Diels, & Kraayenhof, 1990; Guissard, Duchateau, & Hainaut, 1992; Mc Clements, Sanders, & Gander, 1996, Harland & Steele, 1997, Coh, Peharec & Bacic, 2007; Bračić, Peharec Bacic & Coh, 2010). The start of the sprint and start acceleration are the first two factors of sprint speed with which athlete tries to achieve maximum speed. Earlier Tom Tellez study, of the legendary coach of Carl Lewis showed that these two phases are as much as 64% of participation in the sprint result at 100 m (Téllez & Doolittle, 1984). Studies by some other authors (Schot & Knutzen 1992; Harland & Steele, 1997; Wang, 2006; Pain & Hibbs, 2007; Babic, 2008; Babic & Coh, 2010) have agreed that the result in the sprint depends from the position in the start block that from the center of gravity of the body, start reaction time and from start accelerating.

Optimal coherence between the start of the sprint start and start acceleration represents specific motor problems that athletes must integrate in terms of time and spatial parameters in the unipolar movement of cyclic character. Start acceleration is a complex cyclic motion defined mainly by progression of frequency and step length, duration of the contact phase and the phase of flight and the position of the center of gravity of the body at the moment of contact with the ground, the propulsion in phase of the flight and the forces that are handled in the first step (Hunter, Marshall, & McNair, 2005). All these parameters are conditioned by the operation of CNS, motor skills, energy processes, morphological characteristics and structure of

an, Ardagna, 1995; Muller & Hommel 1997; Čoh, et al. 1998; Čoh, Tomažin, and Štuhec, 2006; Mero, Kuitunen, Harland, Kyrolainen, & Komi, 2006).

U modernoj atletici, vrijeme startne raeakcije dobija sve više na značaju u rezultatskoj uspješnosti. Radi se o vrhunskim sprinterima sa izuzetnim rezultatima u obje konkurencije, koji svoj put do uspjeha upravo baziraju na dobroj realizaciji ovog faktora. Dobrom realizacijom oni nastoje da u prvim metrima nakon pucnja steknu određenu prednost koju nastoje zadržati do kraja trke. Često se na velikim takmičenjima (Olimpijske igare, Svjetska i Evropska prvenstava, Dijamantske lige) uočavaju određene razlike u pogledu vremena startne reakcije između disciplina i u zavisnosti od pola. Međutim, te razlike nekada nisu velike, pa na primjer, često se dešava da sprinteri na 100m ostvare vrijeme reakcije skoro identično vremenu reakcije na 400m ili da između vremena reakcije na 100m, 200m ili 400m nema značajnih razlika, iako se radi o izvjesnim razlikama u dužini staze. Ove konstatacije su u suprotnosti sa činjenicom da je značaj startnog ubrzanja i vremena reakcije važniji u kraćim (Moravec, 1988) nego u dužim sprinterskim disciplinama. To navodi na zaključak da se radi o vrhunskim sportistima koji angažuju maksimalno svoje psihofizičke kapacitete bez obzira na dužinu staze. Takođe, određena istraživanja su dokazala da su određene karakteristike sprintera i vrijeme reakcije izuzetno dobri prediktori rezultata u sprintu. (Susanaka et al. 1998). Takođe (Martin & Buonchristiani, 1995), smatraju da je za konačan rezultat u sprintu (100m i 200m) važniji, dužina ubrzanja, postignuta maksimalna brzina i brzinska izdržljivost. Moravec, Ružička, Susanka, et al. (1988) su analizirajući sprinterske discipline na II Svjetskom prvenstvu u Rimu potvrdili rezultate istraživanja iz 1982. godine (Dostal) te naveli vremena reakcije na većim takmičenjima za žene i muškarce. Takođe su potvrdili da se rezultati vremena reakcije na Svjetskom prvenstvu 1987. godine značajno razlikuju od rezultata postignutih na velikim tamičenjima održanim od 1978. do 1986. godine. Duffy 2004, prema Smajlović i Kozić, 2006, u svom istraživanju vremena reakcije na uzorku 16 vrhunskih sprintera učesnika mitinga Zlatne lige Rim 2003, navode da je prosječno vrijeme reakcije iznosilo 153ms (±28ms) te da se prosječna vremena reakcije u polufinalnim i finalnim trkama discipline 100m za muškarce na Svjetskim prvenstvima od 1997 do 2003 se kreću od 120ms do 160ms, dok korelacija vremena reakcije i rezultata u trci iznosi .05. Pojedini autori (Smajlović i Kozić, 2006) su nastojali da utvrde efekte promjene atletskih pravila na vrijeme

muscle (Locatelli & Arsac, 1995; Young, McLean, Ardagna, 1995; Muller & Hommel, 1997; Coh, et al. 1998; Coh, Tomažin, and Štuhec, 2006; Mero, Kuitunen, Harland, Kyrolainen, & Komi, 2006).

In modern athletics, the time of the start reaction becomes more and more important in the result success. It is about the top sprinters with outstanding results in both categories, that their path to success is based on good implementation of this factor. By the good realization they tend to in the first meters of shooting acquire certain advantage that they want to keep until the end of the race. Often at the major events (Olympic Games, World and European Championships, Diamond League) some differences in the time of the start reaction between disciplines and depending on gender are observed. However, sometimes these differences are not large, so for example, often, the 100m sprinters achieve almost the identical reaction time compared to reaction time at 400m or between the reaction time in the 100m, 200m or 400m where there is no significant difference, although it is about some differences in the length of the track. These findings are in contrast to the fact that the importance of start acceleration and reaction time is more important at shorter (Moravec, et al. 1988) than in the longer sprint events. This suggests that these are elite athletes who engage most of their mental and physical capacity, regardless of the length of the track. Also, some studies have shown that certain characteristics of a sprinter and the response time were extremely good predictors of results in the sprint (Susanaka et al. 1998). Also (Martin & Buonchristiani, 1995), believe that for the final result in the sprint (100m and 200m) more important are the length of acceleration, maximum speed achieved and speed-endurance. Moravec, Ruzicka, Susanka, et al. (1988) analyzed the sprint events at the II World Championships in Rome and confirmed the results of the research in 1982 (Dostal) and gave reaction times at larger competitions for men and women. They also confirmed that the results of the reaction time at the World Championship in 1987 were significantly different from the results obtained at large competitions held from 1978 to 1986. Duffy 2004 according to Smajlović and Kozic, 2006, in his study of reaction time in 16 top sprinters sample of top sprinter participants of the meeting of the Golden League Rome 2003, the average response time was 153ms (± 28ms) and the average response time in the semi-final and final races of men discipline 100m at the World Championships from 1997 to 2003 range from 120ms to 160ms, while the correlation of reaction and results in the race is .05. Some authors (Smajlović and Kozic 2006) tried to determine the effects of change in athletic rules on time of start reaction

startne reakcije u sprinterskim disciplinama. Na uzorku vrhunskih atletičara i atletičarki učesnika Svjetskog prvenstva u Edmontonu 2001 i Parizu 2003 su dobijeni rezultati koji su potvrdili razlike u startnom vremenu reakcije između ova dva Svjetska prvenstva u disciplinama, 100m, 200m, 110m i 100m prepone za muškarce i žene, dok razlike po polu nisu utvrđene. Autori (Colet, 2000; Babić, 2008; Babić & Čoh, 2010; Theophilos Pilianidis, Kasabalis, Mantzouranis, & al. 2012; Pavlović i sar. 2013) su proučavali ovaj parametar sa aspekta sprinterskih disciplina nastojeći da da analiziraju vrijeme startne reakcije i rezultat trčanja u sprinterskim disiplinama na velikim takmičenjima, poput evropskih prvenstava i olimpijskih igara. Upravo zbog važnosti startnog ubrzanja u atletskim sprinterskim disciplinama, koje se temelji na vremenu startne reakcije se baziralo se i ovo istraživanje. Osnovni cilj istraživanja je bio da se utvrde i analiziraju razlike u vremenu startne reakcije finalista olimpijskih igara u Londonu 2012. godine. u sprinterskim disciplinama.

Pored osnovnog cilja, parcijalni su ciljevi sadržani u:

- utvrđivanju razlike u vremenu startne reakcije atletičara u disciplinama 100m, 200m, 400m
- utvrđivanju razlike u vremenu startne reakcije atletičarki u disciplinama 100m, 200m, 400m
- utvrđivanju razlike u vremenu startne reakcije između muških i ženskih finalista u disciplinama 100m, 200m, 400m.
- utvrđivanju razlike u postignutom rezultatu između muških i ženskih finalista u disciplinama 100m, 200m, 400m

Metod rada

Populacija koja je definisana istraživanjem obuhvatila je vrhunske atletičare i atletičarke u sprinterskim disciplinama XXX Olimpijskih igara u Londonu 2012. godine. Uzorak je obuhvatio ukupno 48 finalista (24 muška i 24 ženska takmičara), koji su nastupili u finalnim trkama sprinterskih disciplina (100m, 200m, 400m). Vrijeme startne reakcije (ms) i postignuti rezultat (s) su preuzeti iz zvaničnog službenog izvještaja Olimpijskih igara 2012. godine, izdatih od strane IAAF. Podaci dobijeni istraživanjem su obrađeni standardnim deskriptivnim postupcima, a razlike između grupa ispitanika-finalista testirane su pomoću Studentovog-T-testa za nezavisne uzorke. Statistička obrada podataka je izvršena statističkom programu Statistica 6.0.

in sprint events. In a sample of top athletes participants in the World Championships in Edmonton in 2001 and Paris in 2003, results were obtained that confirmed the differences in the starting reaction time between the two World Championships in events, 100m, 200m, 110m and 100m hurdles for men and women. Authors (Colet 2000; Babic, 2008; Babic & Coh, 2010; Theophilos Pilianidis, Kasabalis, Mantzouranis, & al. 2012; Pavlović et al. 2013) have studied this parameter in terms of sprint discipline trying to analyze the response time of start reaction and running result in sprint disciplines at major events, such as the European Championships and Olympic Games. This study is based on reasons precisely because of the importance of starting acceleration in athletic sprint events, based on the starting time of the start reaction. The main objective of this study was to identify and analyze the differences in the time of starting reaction of the finalist of Olympic Games in London 2012 in sprint events. In addition to its primary objective, partial objectives are contained in:

- determining the difference of time of starting reaction of male athletes in the 100m, 200m, 400m
- determining the difference in time of starting reaction of female athletes in the disciplines of 100m, 200m, 400m
- determining the difference in time of the starting reaction between male and female finalists for events 100m, 200m, 400m.
- determining the difference in achieved results between male and female finalists for events 100m, 200m, 400m

Method

The population defined in the research has included top male and female athletes in the sprint events of XXX Olympic Games in London 2012. The sample included a total of 48 finalists (24 male and 24 female competitors), who participated in the final races of sprint events (100m, 200m, 400m). Starting reaction time (ms) and achieved result (s) are taken from the official report of the Olympic Games of 2012, issued by the IAAF. Data obtained in the survey were analyzed by standard descriptive methods, and the differences between groups of respondents-finalists were tested using Student's t-test for independent samples. Statistical analysis was done using the statistical program Statistica 6.0.

Tabela 1. Rezultati trčanja na 100m-finale

Men			
Wind: 1,5m/s		**Time Reaction**	**Result**
1.	Usain Bolt	0.165	9.63
2.	Yohan Blake	0.179	9.75
3.	Justin Gatlin	0.178	9.79
4.	Tyson Gay	0.145	9.80
5.	Ryan Bailey	0.176	9.88
6.	Churandy Martina	0.139	9.94
7.	Richard Thompson	0.160	9.98
8.	Asafa Powell	0.155	11.99

Table 1. The results of running the 100m-finals

Women			
Wind: 1,5m/s		**Time Reaction**	**Rezultata**
1.	Shelly-Ann Fraser-Pryce	0.153	10.75
2.	Carmelita Jeter	0.153	10.78
3.	Veronica Campbell-Brown	0.143	10.81
4.	Tianna Madison	0.171	10.85
5.	Allyson Felix	0.176	10.89
6.	Kelly-Ann Baptiste	0.128	10.94
7.	Murielle Ahoure	0.156	11.00
8.	Blessing Okagbare	0.165	11.01

Tabela 2. Rezultati trčanja na 200m-finale

Men			
Wind: 0,4m/s		**Time Reaction**	**Result**
1.	Usain Bolt	0.180	19.32
2.	Yohan Blake	0.172	19.44
3.	Warren Weir	0.162	19.84
4.	Wallace Spearmon	0.165	19.90
5.	Churandy Martina	0.157	20.00
6.	Christophe Lemaitre	0.153	20.19
7.	Alex Quinonez	0.185	20.57
8.	Anaso Jobodwana	0.216	20.69

Table 2. The results of running the 200m-finals

Women			
Wind: 0,2m/s		**Time Reaction**	**Result**
1.	Allyson Felix	0.174	21.88
2.	Shelly-Ann Fraser-Pryce	0.169	22.09
3.	Carmelita Jeter	0.167	22.14
4.	Veronica C. Brown	0.176	22.38
5.	Sanya Richards-Ross	0.171	22.39
6.	Murielle Ahoure	0.161	22.57
7.	Myriam Soumare	0.157	22.63
8.	Semoy Hackett	0.15	22.87

Tabela 3. Rezultati trčanja na 400m-finale

Men			
Vind:---		**Time Reaction**	**Result**
1.	Kirani James	0.163	43.94
2.	Luguelin Santos	0.185	44.46
3.	Lalonde Gordon	0.159	44.52
4.	Chris Brown	0.166	44.79
5.	Kevin Borlee	0.151	44.81
6.	Jonathan Borlee	0.173	44.83
7.	Demetrius Pinder	0.153	44.98
8.	Steven Solomon	0.143	45.14

Table 3. The results of running the 400m-finals

Women			
Vind:---		**Time Reaction**	**Result**
1.	Sanya Richards-Ross	0.189	49.55
2.	Christine Ohuruogu	0.174	49.70
3.	Deedee Trotter	0.167	49.72
4.	Amantle Montsho	0.198	49.75
5.	Novlene Williams-Mills	0.258	50.11
6.	Antonina Krivoshapka	0.175	50.17
7.	Francena Mccorory	0.196	50.33
8.	Rosemarie Whyte	0.184	50.79

Rezultati

Tabela 4. Osnovni statistički parametri vremena startne reakcije (RT) atletičara i atletičarki

Disciplines	N	Mean RT (s)	Min	Max	Rang	SD	Skew.	Kurt.
100m M	8	0,162	0,139	0,179	0,040	0,152	-,338	-1,343
100m W	8	0,155	0,128	0,176	0,048	0,015	-,525	,148
200m M	8	0,174	0,153	0,216	0,063	0,203	1,396	2,177
200m W	8	0,165	0,151	0,176	0,025	0,009	-,627	-,691
400m M	8	0,161	0,143	0,185	0,042	0,133	,487	,081
400m W	8	0,192	0,167	0,258	0,091	0,028	2,042	4,829

Results

Table 4. Basic statistical parameters of the starting reaction time (RT) of men and women athletes

Slika 1. Srednje vrijeme reakcije muških i ženskih finalista

Legend: *N (number of subject; Mean (average value reaction time); Min (minimal result); Max (maximal result); Rang (range result); SD (standard deviation); Skew. (skewness), Kurt. (kurtosis)*

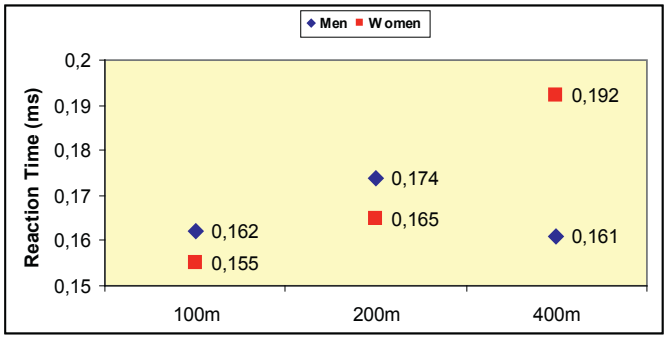


Figure 1. Mean reaction time of male and female finalists

Legend: *N (number of subject; Mean RT (average value reaction time); Min (minimal result); Max (maximal result); Rang (range result); SD (standard deviation); Skew. (skewness), Kurt. (kurtosis)*

U Tabeli 4. prikazani su osnovni statistički parametri vremena startne reakcije (RT) muških i ženskih finalista korištenih u ovom radu. Uvidom u Tabelu 4. uglavnom se uočava normalnost distribucije. Manja homogenost se manifestuje u disciplini 400m za žene, sa većom vrijednosti kurtosisa, pa se zaključuje da se radi o većem rasponu ostvarenog vremena reakcije u ovoj disciplini koje su zabilježili ženski finalisti. Takođe povećana vrijednost skjunisa je potvrda da se radi o većoj vrijednosti reakcionog vremena u istoj disciplini. U trčanju 200m za muškarce zabilježene su povećane mjere varijabilnosti u oba parametra ali ipak nešto manje od prethodnog slučaja. Inspekcijom Tabele 4. može se zaključiti da je srednje, (numerički najmanje) vrijeme reakcije u disciplini 100m kod žena (0,155s) sa najmanjim (najbržim) vremenom reakcije od 0,128s. od svih disciplina u obje konkurencije. Kao najslabije prosječno i pojedinačno startno reakciono vrijeme je takođe kod ženskih finalista u disciplini 400m (0,192sec.), odnosno (Max.=0,258sec.). Raspon od najboljeg vremena startne reakcije do najslabijeg vremena u obje konkurencije iznosi 0,130 sec. što i nije neka velika razlika ako se uzme u obzir različitost dužine staze (100mW:400mW). Da bi se utvrdile eventualne razlike u startnom vremenu reakcije po disciplinama za muške i ženske finaliste, te razlike vremena reakcije između polova primjenjen je T-test za nezavisne uzorke.

Table 4 presents the basic statistical parameters of the starting reaction time (RT) of male and female finalists used in this work. Looking at Table 4, normality of distribution can be mainly observed. Less homogeneity manifests itself in the discipline 400m for women, with higher values of kurtosis, and we conclude that it is about a greater range of achieved reaction time in this discipline that female finalists achieved. Also increased value of skewness confirms that it is a large value of reaction time in the same event. In the men's 200m running increased measures of variability in both parameters were observed, but slightly less than the previous case. By inspection of Table 4 it can be concluded that the medium, (the least numerically) reaction time in the discipline of women's 100m (0,155 s) with the lowest (fastest) reaction time of 0.128 s. from all disciplines in both categories. The lowest average and individually starting reaction time is also in the female finalists in the 400m discipline (0.192 sec.) that is (Max. = 0.258 sec.). The range of the best time of starting reaction to the weakest time in both competitions is 0.130 sec. which does not make a big difference if you take into account the different lengths of track. In order to identify any differences in the starting reaction time in each discipline for male and female finalists and differences of reaction time between the sexes t-test for independent samples has been applied.

Tabela 5. Razlike u vremenu startne reakcije ženskih finalista

Legend: Mean (average value), standard deviation (SD), coefficient of t-test value(T-value), significance level (Sig.**p<0,01; * p<0,05)

Disciplines	Reaction Time (s) Women (N=24)		
	Mean±SD	t-value	p-level
100m	0,155±0,015	-1,583	0,136
200m	0,165±0,009		
100m	0,155±0,015	-3,220	0,006**
400m	0,192±0,028		
200m	0,165±0,009	-2,550	0,023*
400m	0,192±0,028		

Table 5. Differences in the starting reaction time of female finalists

Legend: Mean (average value), standard deviation (SD), coefficient of t-test value(T-value), significance level (Sig.**p<0,01; * p<0,05)

U Tabeli 5. prezentovane su razlike u vremenu startne reakcije ženskih finalista u disciplinama 100m, 200m i 400m. Uvidom u Tabelu 5, razlike između disciplina su evidentne, međutim ostvarene razlike nisu i statistički značajne. Od ukupno tri discipline, utvrđene su značajne razlike u dvije. Statistički značajna razlika nije utvrđena između disciplina 100m i 200m (p<0,136). U preostale dvije discipline razlika je statistički značajna, i to između disciplina 200m i 400m (t= -2,550*) i između 100m i 400m (t=-3,220**).

Table 5 presents the differences in the starting reaction time of the finalist in the women's events: 100m, 200m and 400m. Looking at the Table 5, the differences between the disciplines are evident; however, realized differences are not statistically significant. Of the three disciplines, significant differences were found in two. A statistically significant difference was not found between 100m and 200m disciplines (p <0.136). In the other two disciplines difference is statistically significant, between 200m and 400m disciplines (t=-2,550*) and between 100m and 400m (t=-3,220**).

Tabela 6. Razlike u vremenu startne reakcije muških finalista

Legend: Mean (average value), standard deviation (SD), coefficient of t-test value(T-value), significance level (Sig.**p<0,01; * p<0,05)

Disciplines	Reaction Time (s) Men (24)		
	Mean±SD	t-value	p-level
100m	0,162±0,152	-1,297	0,216
200m	0,174±0,203		
100m	0,162±0,152	0,070	0,945
400m	0,161±0,133		
200m	0,174±0,203	1,414	0,179
400m	0,161±0,133		

Table 6. Differences in the starting reaction time of male finalists

Legend: Mean (average value), standard deviation (SD), coefficient of t-test value (T-value), significance level (Sig.**p<0,01; * p<0,05)

Tabela 6. sadrži numeričke parametre razlika u vremenu startne reakcije muških finalista u sprinterskim disciplinama. Uvidom u Tabelu 6. evidentirane su manje razlike u vremenu reakcije između disciplina ali, one nisu tolike da bi se pokazale statistički značajnim. Najveća razlika aritmetičkih sredina koja nije statistički značajna je između discipline 200m i 400m (p<0,179). Ovakva distribucija rezultata može se potvrditi velikim značajem startnog vremena reakcije, bez obzira o kojoj se dužini staze radi. Takođe ovi rezultati finalnih trka odbacuju ranije tvrdnje da je vrijeme reakcije sporije na kraćim stazama, a da sa dužinom staze gubi na značaju (Moravec, 1988), takođe i da sa dužinom staze linerano se povećava i vrijeme reakcije (Baumann, 1980; Babić & Delalija, 2009**).**

Table 6 contains numerical parameters of the differences in time of starting reaction of male finalists in the sprint events. Looking at Table 6 minor differences in reaction time between the disciplines are evident, but they are not so large to be statistically significant. The largest difference of arithmetic mean that is not statistically significant is between the 200m and 400m events (p<0.179). This distribution of results can be confirmed by the great importance of the starting reaction time, regardless of the length of the track work. Also, these results of final races dismiss earlier claims that the response time is slower in the short tracks, and that with the length of the track it loses its significance (Moravec, et al. 1988), also that with the length of tracks the reaction time also increases linearly (Baumann, 1980; Babic & Delalija, 2009).

Tabela 7. Razlike u vremenu startne reakcije između muških i ženskih finalista

Legend: Mean (average value), standard deviation (SD), coefficient of t-test value(T-value), significance level (Sig.**p<0,01; * p<0,05)

Disciplines	Reaction Time (s) Women-Men		
	Mean±SD	t-value	p-level
100m W 100m M	0,155±0,015 0,162±0,152	-1,297	0,838
200m W 200m M	0,165±0,009 0,174±0,203	-1,172	0,832
400m W 400m M	0,192±0,028 0,161±0,133	1,411	0,269

Table 7. The differences in the time of the starting reaction between male and female finalists

Razlike po polovima su uvijek zanimljive za analize bez obzira o kojim se disciplinama radi. U ovom slučaju je interesantno i značajno za praksu utvrditi razlike u vremenu startne reakcije istih disciplina između muškaraca i žena, finalista Olimpijskih igara. Inspekcijom Tabele 7. uočavaju se manje vrijednosti razlika aritmetičkih sredina vremena reakcije u disciplinama 100m (W155ms:M162ms) i 200m (W165ms:M174ms) u korist ženskih finalista. Razlika u korist muških finalista je ostvarena u disciplini 400m (161ms) u odnosu na žene (192ms). Međutim važno je istaći da ove razlike nisu toliko velike i nisu ostvarile statističku značajnost, tako da razlike po polovima nisu evidentirane.

Differences by gender are always interesting for analysis regardless of the disciplines. In this case it is interesting and important for the practice to determine the differences in the starting reaction time of the same disciplines between men and women finalists of the Olympics. By inspecting Table 7, lower values of differences of arithmetic means of reaction time were observed in the disciplines of 100m (W155ms: M162ms) and 200 (W165ms: M174ms) in favor of women's finalists. The difference in favor of male finalists was achieved in the discipline 400m (161ms) in relation to women (192ms). However, it is important that these differences are not as large and did not achieve statistical significance, so the differences by gender were not evident.

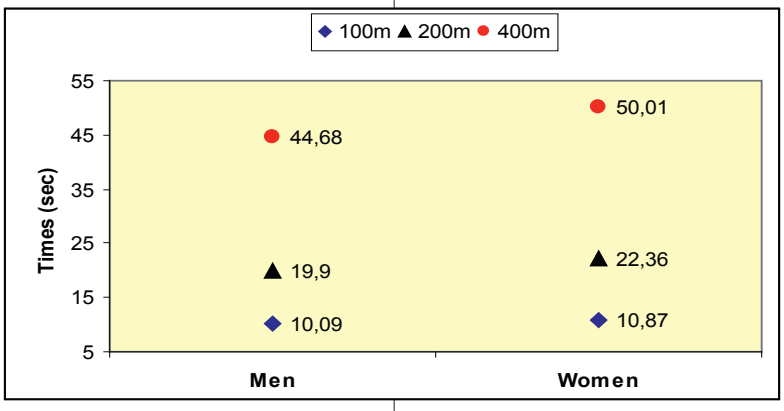
Tabela 8. Razlike u postignutom rezultatu muških i ženskih finalista

Legend: Mean (average value), standard deviation (SD), coefficient of t-test value(T-value), significance level (Sig.**p<0,01; * p<0,05)

Disciplines	Time (s) Mean±SD		t-value	p-level
100m	M	10,09±0,774	-2,842	0,013*
	W	10,87±0,989		
200m	M	19,99±0,485	-11,526	0,000**
	W	22,36±0,323		
400m	M	44,68±0,373	-27,019	0,000**
	W	50,01±0,415		

Table 8. The differences in achieved results of male and female finalists

Legend: Mean (average value), standard deviation (SD), coefficient of t-test value (T-value), significance level (Sig.**p<0,01; * p<0,05)



Slika 2. Srednje vrijednosti ostvarenih rezultata muških i ženskih finalista

Figure 2. Mean in achieved results of male and female finalists

Tabela 8. sadrži rezultate koji negativnim vrijednostima t-testa jasno diferenciraju muške i ženske finaliste po postignutom rezultatu. Najmanja razlika je ostvarena u disciplini 100m gdje su žene ostvarile srednju vrijednost postignutog rezultata od 10,87sec (±0,989) za razliku od muških finalista 10,09sec (±0,774). Dobijena razlika je potvrđena t-testom na nivou (p<0,013). Značajno veće razlike su ispoljene u disciplini 200m (t=-11,526; p<0,000) i 400m (t=-27,019; p<0,000). Ovi rezultati potvrđuju jasne polne razlike, koje su u sprinterskim disciplinama jasno izražene, ne toliko u 100m koliko u disciplinama 200m i 400m.

Table 8 contains the results that by negative values of t-test clearly differentiated male and female finalists by the results achieved. The smallest difference was achieved in the 100m discipline where women achieved the mean value of result of 10,87 sec (± 0,989) unlike the male finalists 10,09 sec (± 0,774). The achieved difference was confirmed by t-test at the level (p <0,013). Significantly larger differences are manifested in the 200m discipline (t=-11,526, p <0,000) and 400 (t= -27,019, p<0,000). These results confirm clear gender differences, in the sprint events clearly expressed, not so much in the 100m 200m and 400m events.

Diskusija

Startno ubrzanje je jedan od najkompleksnijih segmenata sprinterskog trčanja, u kome se može racionalizovati sprinterski kapacitet koji će se manifestovati tek u segmentu trčanja maksimalnom brzinom. Naime, izgubljeno vrijeme zbog loše startne reakcije, loše izvedenog starta, neefikasne startne progresije i kasnog dostizanja brzine, teško je ili nemoguće nadoknaditi u preostalom dijelu trke (Smajlović & Kozić, 2006). Međutim, u novije vrijeme dešava se i, da loše izveden start, sa slabijom startnom reakcijom, ne mora značiti i neuspjeh tokom trke, odnosno slabiji plasman. Ovoj konstataciji ide u prilog i najbrži čovjek planete, Usain Bolt, koji je u finalu Olimpijskih igara u Londonu ostvario peto vrijeme startne reakcije (160ms) na 100m i šesto vrijeme na 200m (180ms) a ipak zauzeo prva mjesta. Ovi navodi potvrđuju ranija istraživanja koja tvrde da su za konačan rezultat u sprintu (100m i 200m) važniji dužina ubrzanja, postignuta maksimalna brzina i brzinska izdržljivost (Martin & Buonchristiani, 1995). Smatra se da je izvršenje faze kontakta nakon starta i tokom trke jedan od najvažnijih generatora uspjeha u realizaciji sprinterske brzine (Lehmann & Voss, 1997). Kontaktna faza mora biti što je moguće kraća s optimalnim odnosom faze odraza i faze leta, dok frekvencija koraka zavisi od funcionisnja CNS-a i genetski je određena, veća frekvencija koraka, kraći korak i obrnuto (Mero, Komi, i Gregor, 1992). Vrhunske performanse sprintera su rezultat kompleksne mješavine mnogih faktora kao što su genetski potencijal, trening i zdravstveno stanje sportiste. Sa antropološke tačke gledišta, vrijeme reakcije je sposobnost da se brzo odgovori na nadražaj.Veća brzina reakcije daje i bolje vrijeme reakcije koje je samo jedan od nekoliko faktora koji utiču na uspjeh u modernoj atletici (Dick, 1987; Brüggemann & Glad, 1990; Pain & Hibbs, 2007). U sprinterskim disciplinama početak vremena reakcije je vremenski interval (ms) signala pištolja i pokreta sportiste kada će izvršiti pritisak na startne blokove. Steinbach i Tholl (1969) su svojevremeno objavili studiju u kojoj navode da elitni sportisti imaju bržu i stabilniju reakciju od početnika sportista. Osim toga, brzina reakcije pokazuje pad rezultata kad sportista nije trenirao (Doherty, 1985), tako da početno vrijeme reakcije utiče oko 1 do 2% na ukupan rezultat sprintera (Baumann, 1980; Helmick, 2003). Suprotno navedenome, vrijeme reakcije u sprintu ne može predvidjeti završno vrijeme na 200m, u odnosu na 100 i 110m prepone, zbog dužeg trčanja na ciljnoj ravnini (Collet, 2000, Komi, Ishikawa, & Jukka, 2009). Vrijeme od 200ms predstavlja samo 2% od 100m sprinta u trajanju 10,00s, ili 0,4% od 400m sprinta koji traje oko

Discussion

Starting acceleration is one of the most complex segments of the sprint, in which sprint capacity can be rationalized that will be manifested only in the segment of maximal running speed. The time lost due to poor start reaction, poor start and, ineffective start progression and late reaching speed is difficult or impossible to make up in the rest of the race (Smajlović and Kozić, 2006). However, recently it also happens that a poor start, starting with a lower reaction does not necessarily mean the failure of the race, and weaker result. This conclusion is supported by the planet's fastest man, Usain Bolt, who in the finals of the Olympic Games in London achieved the fifth time of starting reaction (160ms) in the 100m and sixth in the 200m (180ms) and still took first place. These remarks confirm earlier studies which claim that for the final score in the sprints (100m and 200m) length of acceleration, reached maximum speed and speed-endurance are more important (Martin & Buonchristiani, 1995). It is believed that the execution of the contact phase after the start and during the race are one of the most important generators of success in the implementation of sprint speed (Lehmann & Voss, 1997). Contact phase should be as short as possible with an optimal phase of reflection and phase of flight, while step frequency depends on the functioning of the CNS and is genetically determined, increased step frequency, shorter step and vice versa (Mero, Komi and Gregor, 1992). The high performance of sprinters is the result of a complex mixture of many factors such as genetic potential, training and health of athlete. From the anthropological point of view, the reaction time is the ability to quickly respond to stimulation. Higher reaction rate gives better response time, which is only one of several factors that influence the success of modern athletics (Dick, 1987; Brüggemann & Glad, 1990; Pain & Hibbs, 2007). In the sprint events, start reaction time is the time interval (ms) of pistol signal and movement of athlete when he will put pressure on the starting blocks. Steinbach and Tholl (1969) once published a study stating that elite athletes have a faster and more stable response from novice athletes. In addition, the reaction speed shows decreased result when athlete did not train (Doherty, 1985), so the initial reaction time affects about 1 to 2% of the total score of sprinter (Helmick, 2003). Contrary to the above, the reaction time in the sprint cannot predict the final time in the 200m, compared to the 100 and 110m hurdles, because of the long run at the finish line (Collet, 2000, Komi, Ishikawa, & Jukka, 2009). Time of 200ms represents only 2% of the 100m sprint in 10.00 s duration, or 0.4% of the 400m sprint, which takes about 45 seconds (Martin, & Buonchristiani 1995). However, re-

45sec. (Martin & Buoncristiani, 1995). Međutim, istraživanja (Stevenson, 1997, Michel, i Jarver, 2002; Henson, Cooper, i Perry, 2002) su dokazala da sportisti s boljim vremenom reakcije u početku sprinta su imali psihološku prednost nad svojim protivnicima, koja u mnogim trkama može biti važna na ciljnoj ravni.

Rezultati prezentovani u Tabeli 4. pokazuju da povećanjem dužine staze raste i prosječno vrijeme reakcije kod ženskih finalista, za razliku od muških finalista gdje ne važi ovo ‘’nazovimo’’ pravilo, pa je prosječno vrijeme reakcije na 100m slabije nego na 400m (0,162:0,161).

Poredeći rezultate ovog istraživanja sa rezultatima prethodnih (Moravec, et al. 1987; Colet, 2000; Duffy, 2004, Smajlović i Kozić, 2006; Babić, 2008) može se zaključiti da se radi o ostvarenim rezultatima skoro istog nivoa u svim disciplinama. U istraživanju Theopilos Pilianidis, et al. (2012), utvrđeno je da su i muškarci i žene bili značajno bolji u disciplini trčanje na 100m u Pekingu 2008. godine nego u Sydneyu 2000. godine. Isto tako, vremena startne reakcije u disciplinama trčanje na 100/110m s preponama bila su statistički značajno bolja u Atini 2004. godine nego u Sydneyu 2000. godine. I na kraju, u muškoj finalnoj trci na 100m u Pekingu 2008. godine i vrijeme startne reakcije i ukupan rezultat trčanja bili su bolji nego rezultati takmičara koji su nastupili u Atini 2004. i Sydneyu 2000. godine. Takođe rezultati ovog istraživanja u disciplini 100m su malo slabiji od rezultata mitinga Zlatne lige Rim 2003.godine. Prosječno vrijeme reakcije finalista u Rimu 2003. godine je iznosilo 153ms (±28ms) naspram 162ms (±0,152ms). Poredeći rezultate Olimpijskih igara u Londonu sa rezultatima Svjetskog prvenstva u Edmontonu 2001. i Parizu 2003. može se zaključiti da su dobijeni rezultati koji su potvrdili razlike u startnom vremenu reakcije između ovih takmičenja. Prosječno ostvareno vrijeme muških finalista u disciplini 100m na SP u Edmontonu 2001. godine je 10,19 sec, sa vremenom rekcije 145ms, a u finalu SP u Parizu 2003. 10,20 sec sa vremenom reakcije 159ms. Na Olimpijskim igrama u Londonu 2012. prosječno vrijeme u finalnoj trci bilo je 10,09 sec. sa vremenom rekacije 162 ms. U ženskoj konkurenciji SP Edmontonu ostvareno je srednje vrijeme 11,15 sec sa reakcionim vremenom od 146ms i SP Parizu 2003. 11,13sec sa vremenom reakcije 157ms. Žensko finale u Londonu je završeno sa prosječnim vremenom od 10,87 sec i vremenom reakcije 155ms.

Raniji rezultati su pokazali da na Olimpijskim igrama sa produžavanjem dionice, linearno se povećava i vrijeme startne reakcije u sprintera svjetske klase (Baumann, 1980; Babić & Delalija, 2009). Isto tako u pojedinim istraživanjima je potvrđeno da vrijeme reakcije

search (Stevenson, 1997, Michel and Järvere, 2002; Henson, Cooper, and Perry, 2002) has shown that athletes with better response time at the beginning of the sprint had the psychological edge over their opponents, which in many races may be important on the target plane.

The results presented in Table 4 show that increasing the length of track increases also the average response time in the female finalists unlike male finalists where this so called rule is not valid, and an average response time on 100m is weaker than on 400m (0,162:0,161).

Comparing the results of this study with previous one, (Colet 2000; Duffy, 2004 Smajlović and Kozić 2006; Babic, 2008) it can be concluded that these are the results achieved almost at the same level in all disciplines. The study Theopilos Pilianidis, et al. 2012 found that both men and women were significantly better in the discipline of running 100m in Beijing in 2008 than in Sydney in 2000. Similarly, the times of starting reaction in the disciplines of running 100/110m hurdles were significantly better in Athens in 2004 than in Sydney in 2000. Finally, in the men’s 100m final race at Beijing in 2008, both the time of start reaction and overall score of running’s were better than the results of competitors that participated in Athens in 2004 and in Sydney in 2000. Also the results of this research in the discipline of 100m are slightly weaker from the results of the Rome Golden League meeting in 2003.

Average response finalist time in Rome 2003 amounted to 153ms (± 28ms) versus 162ms (± 0.152 ms). Comparing the results of the London Olympics with the results of the World Championships in Edmonton in 2001 and Paris 2003 it can be concluded that the results obtained have confirmed the differences in starting reaction time between these competitions. Average achieved time during the men’s 100m finalists in the discipline at the World Championships in Edmonton in 2001 was 10.19 sec, with a response time 145ms, and in World Cup final in Paris in 2003 10.20 sec with a response time 159ms. At the Olympic Games in London in 2012, average time in the final race was 10.09 sec. with reaction time 162 ms. In the women’s World Cup in Edmonton the mean time was 11.15 sec with a reaction time of 146ms and at WC in Paris in 2003 11.13 sec with a response time 157ms. Female Finals in London has been completed with an average time of 10.87 seconds and response time 155ms.

Previous results have shown that the Olympics with extending tracks increase linearly also the time of the starting reaction in world-class sprinters (Baumann, 1980; Babic & Delalija, 2009). Also, in some studies it was confirmed that the time reaction of male sprinters is better than women. However, the results of this study are in contrast

muških sprintera bolje nego kod ženskih. Međutim, rezultati ovog istraživanja su u suprotnosti sa istraživanjima koja su potvrdila da nema razlike u vremenu startne reakcije između muških i ženskih sprinetra (Martin & Buonchristiani, 1995). Kada su u pitanju razlike vremena reakcije po polu, rezultati u ovom istraživanju to nisu potvrdili (Tabela 7). Skoro identične rezultate su dobili Smajlović i Kozić 2006. u svom istraživanju svjetskih prvenstva Edmonton 2001 i Pariz 2003. godine. Dobijeni rezultati upućuju na zaključak da se radi o vrhunskim atletičarima, dobrih performansi pa su razlike skoro i nemoguće ili minimalne. Razlike su evidentne ne samo u vremenu reakcije, već i u nekim psihofizičkim sposobnostima samo u slučajevima ako se radi o selekcionisanim i ne selekcionisanim kategorijama. Ovome ide u prilog da samo dobra selekcija, tehnologija trenažnog procesa uz naravno genetske predispozicije su garant upjeha (Meckel, Atterborm, Grodjinovsky, Ben-Sira, & Rotsteina, 1995). Značajan uticaj na vrijeme startne reakcije u sprintu i realizacija startnog ubrzanja je u zavisnosti od manifestacije sile izometrijske i izotoničke mišićne kontrakcije na startne blokove, položaja i uglova u koljenom zglobu, horizontalnog i vertikalnog impulsa (Young, McLean, & Ardagna 1995; Hunter, Marshall, & McNair, 2005). U svojoj studiji (Čoh, Tomažin, and Štuhec, 2006) analiziraju i identifikuju glavne kinematičke parametre u fazi sprinta i startnog ubrzanja koji utiču na ukupan rezultat. Istraživanje je pokazalo da su optimalna udaljenost blokova, brzina napuštanja startnih blokova, dužina prvog koraka, visina težišta tijela u prva tri metra ubrzanja, optimalan odnos između dužine i frekvencije koraka ključni faktori uspjeha u dvije faze sprinterskog trčanja.

Istraživanja (Dostal, 1982 prema Smajlović i Kozić, 2006; Moravec et al. 1988) su potvrdila, da startno vrijeme reakcije u sprintu nije u direktnoj korelaciji sa završnim rezultatom ni kod muških ni kod ženskih spintera. Slično istraživanje na deset vodećih sprintera su sproveli Paradisis et al. 2006 i dobili suprotne rezultate. Oni su utvrdili da je vrijeme početka reakcija usko povezano s rezultatom u sprintu. To je itekako značajno, s obzirom da su u finalnoj trci u Londonu 2012. muškarci ostvarili srednje vrijeme startne reakcije od 162ms i ukupni rezultat od 10,09 sec. Takođe, u finalu Olimpijskih igara u Pekingu 2008. godine, muški sprinteri su imali prosječno vrijeme startne reakcije (146ms) a ostvareni ukupni rezultat od 9,89 sec. i bili su bolji u odnosu na finalne trke OI-a u Atini 2004 i Sydney 2000. godine. Na svjetskom prvenstvu u Berlinu 2009. godine došlo, može se reći, do prave eksplozije rezultata. 2009. prosječno vrijeme reakcije muških finalista je bilo bolje nego i u Pekingu (138ms sa ostvarenim rezultatom

to studies that have confirmed that there is no difference in the time of the starting reaction between male and female sprinters. When it comes to response time differences by gender, the results in this study did not confirm that (Table 7). Almost identical results were obtained by Smajlović and Kozic in 2006 in their study of world championships in Edmonton in 2001 and in Paris in 2003. The results indicate that it is about superb athletes, with good performances and the differences are almost impossible or minimal. The differences are evident not only in the reaction time, but also in some mental and physical abilities only in cases if it is about selected and non-selected categories. Also with this goes that only a good selection, the technology of the training process, with of course natural predisposition there could be success (Meckel, Atterborm, Grodjinovsky, Ben-Sira, & Rotstein, 1995). Significant impact on the response time in sprint and the implementation of starting acceleration is in dependence of the force manifestation of isometric and isotonic muscle contraction on the starting blocks, the position and angle of the knee joint, the horizontal and vertical impulses (Young, McLean, & Ardagna 1995; Hunter, Marshall, & McNair, 2005). In their study, Coh, Tomažin, and Štuhec, 2006 analyze and identify the main kinematic parameters in the phase of the sprint and starting acceleration that affect the overall result. The research has shown that the optimum distance of blocks, the speed of leaving the starting blocks, the length of the first step, height of center of gravity of the body in the first three meters of acceleration, the optimal ratio between length and step frequency are key success factors in the two-stage sprint.

Researches (Dostal, 1982 by Smajlović and Kozić 2006; Moravec et al. 1988) have confirmed that the starting time of the reaction in the sprint is not directly correlated to the final result neither in male nor in female sprinters. Similar research in ten leading sprinters conducted Paradisis et al. in 2006 and obtained conflicting results. They found that the time of starting reaction is closely related to the results in the sprint. This is particularly important, given that in the final race in London in 2012 men achieved a mean time of starting reaction 162ms and a total score of 10.09 sec. Also, in the final of the Beijing Olympics in 2008, male sprinters had an average response time of starting reaction (146ms) and achieved a total score of 9.89 sec. and they were better than in the final race of the OG in Athens in 2004 and in Sydney in 2000. At the World Championship in Berlin in 2009 there has been, so to speak, an explosion of the results. In 2009, the average reaction time of male finalists was better than in Beijing (138ms with the achieved

9,91 sec.). Možda i prisutvo Jamajčanina, Usain Bolta, u svim finalima, s vremenima reakcije od 165ms i vrijeme svjetskog rekorda 9,69sec. u Pekingu, zatim 146ms i 9,58 sec. u Berlinu i najzad 165ms i 9,63 sec. u Londonu 2012. imao snažan uticaj u sve tri startne reakcije i performanse ovih finalnih trka. Takođe ista formula se može navesti i za ženske finaliste gdje je prvoplasirana S.A. Fraser-Pryce ostvarila vrijeme reakcije od 153ms i rezultat 10,75sec., a drugoplasirana C. Jeter 153ms i 10,78sec. Takođe, konstatacija da vrijeme reakcije linerano raste sa produžavanjem dionice (Baumann, 1980; Babić 2008; Babić & Delalija, 2009) se ne može u potpunosti prihvatiti. Kao protiv argument ovoj konstataciji jesu manje srednje vrijednosti vremena reakcije ostvarenih u finalu 400m u Londonu kod muškaraca (161ms) u odnosu na 100m (162ms) i 200m (174ms).

Rezultati ovog istraživanja pokazuju da su se u modernoj atletici, vrijeme startne reakcije i ukupno vrijeme trčanja jednako poboljšali, da nema razlike po polovima i da nisu evidentne statistički značajne razlike po disciplinama. Rezultati su u suprotnosti sa istraživanjem nekih autora koji navode da je vrijeme rakcije sprinterki sporije od sprintera, te da se ono povećava sa povećanjem dužine dionice. Takođe ovi rezultati istraživanja su u suprotnosti sa rezultatima Babić, (2008) koja je analizirala učesnike kvalifikacionih grupa, polufinalnih i finalnih na Olimpijskim igrama u Atini 2004. u sprinterskim i preponskim disciplinama za žene, gdje je dobila rezultate da je u skoro svim disciplinama ostverene statistički značajne razlike. Generalno, posmatrano ovi rezultati djelomično potvrđuju rezultate prethodnih istraživanja u sprinterskim disciplinama koja se tiču Svjetskih prvenstava u Rimu, 1987 (Susanaka et al.1988), u Štutgartu 1993 (Martin, & Buonchristiani, 1995), u Edmontonu, 2001. i Parizu, 2003 (Smajlović & Kozić, 2006) kao i Olimpijskih igara u Seulu 1988 (Brueggemann, & Glad, 1988) i Atini, 2004 (Smajlović i Kozić, 2006; Theophilos Pilianidis et al. 2012), Svjetskog prvenstva u Moskvi (Pavlović i sar. 2013).

Jedno od mogućih objašnjenja za ovakvu distribuciju rezultata ovog istraživanja jeste činjenica da su istraživanjem obuhvaćeni samo finalisti Olimpijskih igara u Londonu, koji su imali najbrže vrijeme reakcije i ukupni rezultat, odnosno bili su najbolji u tom momentu pa su tako negirali ranija istraživanja.

Ukratko ovo istraživanje je pokazalo da nema razlika između polova u vremenu startne reakcije, da ukoliko je vrijeme reakcije bolje, pretpostavka je da će i performanse trčanja biti bolje, te se potvrdilo da je reakciono vrijeme važan segment u postizanju ukupnog rezultata.

result 9.91 sec.). Perhaps the presence of Jamaican Usain Bolt in all the finals, with the reaction times of 165ms and a world record time of 9.69 sec. in Beijing, then 146ms and 9.58 sec. in Berlin, and finally 165ms and 9.63 sec. in London in 2012 had a strong influence in all three starting reactions and performances of these final races. Also, the same formula can be given for women's finalists, where the first-placed SA Fraser-Pryce made the response time of 153ms and the result of 10.75 sec. and second-placed C. Jeter 153ms and 10.78 sec. Also, the observation that the response time is linearly increasing with the lengthening of the section (Baumann, 1980; Babic 2008; Babic & Delalija, 2009) cannot be fully accepted. As an argument against this conclusion are less average values of response time achieved in the final 400m in London for men (161ms) compared to 100m (162ms) and 200 (174ms).

The results of this study indicate that in the modern track and field, the time of starting reaction and total running time are equally improved, that there is no difference by gender and there are no evident statistically significant differences by the disciplines. The results are in contrast to research of some authors who state that the time of reaction in female sprinters response is slower than in male sprinters, and that it increases with the length of the section. Also research findings are inconsistent with the results of Babic (2008) who analyzed the participants of qualification groups, the semi-final and final at the Athens Olympics in 2004 in sprint events and hurdles for women, where she received the results that in almost all disciplines had statistically significant differences. In general, these results partially confirm the results of previous researches in the sprint events related to the World Championships in Rome, 1987 (Susanaka et al.1988), Stuttgart, 1993 (Martin & Buonchristiani, 1995), in Edmonton, 2001 and Paris 2003 (Smajlović & Kozic, 2006) and the Olympic Games in Seoul in 1988 (Brueggemann, & Glad, 1988) and Athens 2004 (Smajlović and Kozic 2006; Theophilos Pilianidis et al. 2012), World Championship in Moscow 2013 (Pavlović et al. 2013).

One possible explanation for this distribution of results of this research is the fact that the survey covers only the finalists of the Olympic Games in London, who had the fastest response time and overall score, i.e. they were the best at the moment and so they denied earlier research.

In short, this study showed that there is no difference between the sexes in the time of starting reaction, that if the reaction time is better, the assumption is that the running performances will be better, and it was confirmed that the reaction time is an important segment in achieving the overall results.

Zaključak

Uzorak je obuhvatio ukupno 48 (24 muških i 24 ženskih) atletičara koji su nastupili u finalu Olimpijskih igara u disciplinama 100m, 200m, 400m. Istraživanje je imalo za cilj da utvrdi eventualne statistički značajne razlike u startnom vremenu reakcije i postignutom rezultatu sprinterskih disciplina na Olimpijskim igarama u Londonu 2012. Rezultati vremena reakcije i rezultatskog ostvarenja koja su postigli finalisti su na istom i na većem nivou rezultata dosadašnjih istraživanja na vrhunskim atletičarima. Vjerovatnost distribucije nešto boljih rezultata ovog istraživanja je u činjenici da se radi o finalnom takmičenju gdje su nastupili samo najbolji u obje konkurencije.

U skladu sa rezultatima istraživanja može se zaključiti da su utvrđene i da postoje statistički značajne razlike u vremenu reakcije kod ženskih finalista u disciplinama trčanja 100m i 400m ($t=-3,220$; $p<0,006$) kao i za discipline 200m i 400m ($t=-2,550$; $p<0,023$). Takođe ostvarene su statistički značajne razlike između polova u disciplinama 100m ($t=-2,842$; $p<0,013$), 200m ($t=-11,526$; $p<0,000$) i 400m ($t=-27,019$; $p<0,000$).

Rezultati istraživanja nisu potvrdili postojanje statistički značajnih razlika u vremenu reakcije kod muških finalista po disciplinama i razlika u istim disciplinama između polova.

Dobijeni rezultati su potvrdili ranija istraživanja kada su u pitanju razlike u postignutom rezultatu između suprotnih polova, što je i očekivano. Potvrđena su neka istraživanja koja nisu zabilježila značajne razlike u vremenu startne reakcije između polova. Takođe i brže vrijeme reakcije u kraćim distancama je potvrđeno kod ženskih za razliku od muških finalista.

Rezultati su pokazali da je trenažna tehnologija na visokom nivou, da su potencijali vrhunskih sprintera sve bolji, da su sve manje ili da uopšte ne postoje razlike u vremenu reakcije bez obzira na dužinu staze. To se pokazalo i u ovom istraživanju gdje su muški finalisti na 100m imali sporije vrijeme reakcije nego u disicplini 400m. Rezultati ovog istraživanja mogu poslužiti kao realna osnova za buduća istraživanja sa ovom problematikom ali npr. samo na finalnim takmičenjima Svjetskih i Evropskih prvenstava ili Olimpijskih igara.

Izjava autora
Autori pridonijeli jednako.

Konflikt interesa
Mi izjavljujemo da nemamo konflikt interesa.

Conclusion

The sample included a total of 48 (24 male and 24 female) athletes who took part in the final of the Olympic Games in the disciplines of 100m, 200m and 400m. The study was aimed to determine possible statistically significant differences in the starting time of the reaction and in the results achieved in the Olympic sprint disciplines of the Games in London in 2012. The results of reaction time and the result achievement that they have achieved are at the same or at a higher level of previous studies in the case of superb athletes. The probability of distribution of lightly better results of this research lies in the fact that it is a final competition where only the best in both categories were analyzed.

In accordance with the results of this research it can be concluded that the research showed that there were statistically significant differences in reaction time in female finalist in the disciplines of running 100m and 400m ($t = -3.220$; $p<0.006$) as well as for the 200m and 400m events ($t=-2.550$; $p<0.023$). Also there have been statistically significant differences between the sexes in the disciplines of 100m ($t=-2.842$; $p<0.013$), 200 ($t=-11.526$; $p<0.000$) and 400 ($t = -27.019$; $p<0.000$).

The research results did not confirm the existence of statistically significant differences in reaction time in male finalists by disciplines and differences in the same disciplines between sexes. The results obtained confirmed earlier studies in terms of the difference in the result achieved between the sexes, as expected. Some studies have confirmed no significant differences in time of starting reaction between the sexes. Also, the faster response time for short distances was confirmed in female as opposed to male finalists.

The results showed that the training technology is at a high level, that the potentials of top sprinters are getting better, that they are getting smaller or even there are no differences in response time regardless of the length of the track. In this study, it was also demonstrated that the male finalists in the 100m had slower reaction time than in the discipline of 400m. The results of this study can serve as a realistic basis for future research of these issues but, for example, only in the final competitions of the World and European Championships or Olympic Games.

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The authors have contributed equally.

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We declare that we have no confl icts of interest.

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