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DIFFERENCES IN THE TIME OF START REACTION AND ACHIEVED RESULTS IN THE SPRINT DISCIPLINES IN THE FINALS OF THE WORLD CHAMPIONSHIP IN MOSCOW

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Abstract. *In the sprint events the start and start acceleration play a very important role which is largely generated by the final score. Depending on the appropriate individual morphological dimension, especially the motor and functional abilities of competitors, the suitable conditions 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 World Championship in Moscow in 2013. The results from the finalists 24 (male) and 24 (female) participants that participated in the final races in the 100m, 200m and 400m were analyzed. The starting reaction time (ms) and results in the sprint (s) based on the reports that were officially published by the International Association of Athletics Federations (IAAF) were evaluated. The results of the t-test showed statistically significant differences in response time for the female athletes in the disciplines of the 100m and 400m run (t=-3.227**) as well as for the 200m and 400m events (t =-3.794**) unlike the male finalists for which there were no statistically significant differences. Also, in the same disciplines there were no statistically significant differences between the sexes, while they are evident in the results achieved in the disciplines of 100m (t=-14.860**), 200 (t=-18.331**) and 400 (t=-18.250 **).*

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

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INTRODUCTION

Starting acceleration is relevant in all sprint athletic disciplines, as in many other branches of sports which require developing speed over relatively short distances (tennis, volleyball, handball, basketball, soccer, etc.). However, in the sprint events, the start and starting acceleration, as the two major components largely generate the final result of the 60m, 100m, 200m and 400m run (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 that will be manifested only in the segment of maximal running speed can be rationalized. The most common length in start acceleration is from 25-30m, where the top sprinters in the first 10m develop 50 to 55% of their maximum speed, in the second 10 (up to 20m) 70-80%, and 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 carried out 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 (Mero, Luhtanen, & Komi, 1983; Moravec, Ruzicka, Susanka, & Nosek, 1988; Coppenolle & Delecluse, 1989; Coppenolle, Delecluse, Goris, Diels , & Kraayenhof, 1990; Brüggemann & Hunger, 1990; Mero & Komi, 1990; Guissard, Duchateau, & Hainaut, 1992; Delecluse, Coppenolle, Diels, & Goris, 1992; Schot & Knutzen, 1992; Mc Clements, Sanders, & Gander in 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 the athlete tries to achieve maximum speed. An earlier Tom Tellez study, of the legendary coach of Carl Lewis showed that these two phases make up 64% of the participation in the sprint result for the 100 m run (Téllez & Doolittle, 1984). Studies by some other authors (Coppenolle & Delecluse, 1990; Schot & Knutzen 1992, Korchemny, 1992; Guissard, Duchateau, & Hainaut, 1992; Harland & Steele, 1997; Wang, 2006; Pain & Hibbs, 2007; Babic, 2008; Babic & Coh, 2010) have agreed that the result in the sprint depends on the position on the start block that from the center of gravity of the body, start reaction time and start acceleration.

Optimal coherence between the start of the sprint start and start acceleration represent specific motor problems that athletes must integrate in terms of time and spatial parameters in the unipolar movement of a cyclic character. Start acceleration is a complex cyclic motion defined mainly by the 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 during the flight phase and the forces that are handled in the first step (Hunter, Marshall, & McNair, 2005; Bračić, Peharec Bacic & Coh, 2010). All these parameters are conditioned by the operation of the CNS, motor skills, energy processes, morphological characteristics and the structure of the muscle (Cavagna, Komárek, & Mazzoleni, 1971; Mann & Sprague, 1980; Mero, Kuitunen, Harland, Kyrolainen, & Komi, 2006 ; Moravec et al, 1988; Mero & Komi, 1990; Mero, Komi, & Gregor 1992, Locatelli & Arsac, 1995; Young, McLean, Ardagna, 1995; Muller & Hommel, 1997; Coh, et al. 1998; Coh, Tomažin & Štuhec, 2006).

In modern athletics, the time of the start reaction becomes more and more important for result success. In the case of top sprinters with outstanding results in both categories, their path to success is based on the good implementation of this factor. In the good realization they tend to during the first meters of shooting acquire certain advantage that they want to keep until the end of the race. Often at 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, were observed. However, sometimes these differences are not extensive, so for example, often, the 100m sprinters achieve almost identical reaction time to the reaction time at the 400m run, or between the reaction time in the 100m, 200m or 400m run there is no significant difference, although there are some differences in the length of the track. These findings are in contrast with the fact that the importance of start acceleration and reaction time is more important at shorter (Moravec, 1988) than 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 (Brueggemann & Hunger, 1990; Buonchristiani & Martin, 1995; Ozolin, 1996; Susanaka et al. 1998). Also, Martin & Buonchristiani (1995), believe that for the final result in the sprint (100m and 200m) the length of acceleration, maximum speed achieved and speed-endurance are more important. Moravec, Ruzicka, Susanka, et al. (1988) analyzed the sprint events at the II World Championships in Rome and confirmed the results of the research from 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 during large competitions held from 1978 to 1986. Duffy (2004) according to Smajlović & Kozic (2006), in a study on the reaction time of a sample of 16 top sprinters, participants of the meeting of the Golden League in Rome 2003, indicate that the average response time was 153ms (± 28ms) and that the average response time in the semi-final and final races of the men's 100m discipline 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 & Kozic, 2006) tried to determine the effects of change in athletic rules on the time of start reaction in sprint events. In a sample of top athletes, participants in the World Championships in Edmonton in 2001 and Paris in 2003, the 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, while differences based on gender have not been established.

Authors (Colet 2000; Babic, 2008; Babic & Coh, 2010; Theophilos Pilianidis, Kasabalis, Mantzouranis, et al. 2012) have studied this parameter in terms of the sprint discipline trying to analyze the response time of the 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 World Championship in Moscow 2013 in the sprint events. In addition to its primary objective, partial objectives included

- determining the difference of the 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 the achieved result between male and female finalists for events 100m, 200m, 400m.

THE METHOD

The population defined in the research included top male and female athletes in the sprint events of the XIV World Championship in Moscow in 2013. 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 the achieved results (s) are taken from the official report of the World Championship of 2013, and the IAAF official site. The data obtained in the survey were analyzed by standard descriptive methods, and the differences between groups of respondents-finalists were tested using the Student's t-test for independent samples. The statistical analysis was done using the Statistica 6.0 statistical program.

Table 1 The results of running the 100m - finalists

Men				Women			
	Wind: -0,3m/s	Reaction Time	Result		Wind: -0,3m/s	Reaction Time	Result
1.	Usain Bolt	0.163	9.77	1.	S.A.Fraser-Pryce	0.174	10.71
2.	Justin Gatlin	0.163	9.85	2.	Murielle Ahoure	0.165	10.93
3.	Nesta Carter	0.157	9.95	3.	Carmelita Jeter	0.156	10.94
4.	Kemar Bailey-Cole	0.186	9.98	4.	English Gardner	0.151	10.97
5.	Nickel Ashmeade	0.142	9.98	5.	Kerron Stewart	0.229	10.97
6.	Mike Rodgers	0.158	10.04	6.	Blessing Okagbare	0.154	11.04
7.	Christophe Lemaitre	0.154	10.06	7.	Alexandria Anderson	0.159	11.10
8.	James Dasaolu	0.177	10.21	8.	Octavious Freeman	0.179	11.16

Table 2 The results of running the 200m - finalists

Men				Women			
	Wind: 0,0m/s	Reaction Time	Result		Wind: -0,3m/s	Reaction Time	Result
1.	Usain Bolt	0.177	19.66	1.	S.A.Fraser-Pryce	0.156	22.17
2.	Warren Weir	0.176	19.79	2.	Murielle Ahoure	0.180	22.32
3.	Curtis Mitchell	0.147	20.04	3.	Blessing Okagbare	0.154	22.32
4.	Nickel Ashmeade	0.145	20.05	4.	Shaunae Miller	0.146	22.74
5.	Adam Gemili	0.151	20.08	5.	Jeneba Tarmoh	0.161	22.78
6.	Anaso Jobodwana	0.172	20.14	6.	ChaRonda Williams	0.155	22.81
7.	Churandy Martina	0.138	20.35	7.	Mariya Ryemyen	0.197	22.84
8.	Jaysuma Saidy Ndure	0.145	20.37	8.	Allyson Felix	0.181	DNF

Table 3 The results of running the 400m - finalists

Men			Women		
Wind: 0,4m/s	Reaction Time	Result	Wind:-0,2m/s	Reaction Time	Result
1. LaShawn Merritt	0.256	43.74	1. Christine Ohuruogu	0.247	49.41
2. Tony McQuay	0.155	44.40	2. Amantle Montsho	0.273	49.41
3. Luguelín Santos	0.350	44.52	3. Antonina Krivoshapka	0.209	49.78
4. Jonathan Borlée	0.224	44.54	4. Stephanie McPherson	0.198	49.99
5. Pavel Maslák	0.169	44.91	5. Natasha Hastings	0.163	50.30
6. Yousef Ahmed Masrahi	0.162	44.97	6. Francena McCorory	0.241	50.68
7. Kirani James	0.186	44.99	7. Kseniya Ryzhova	0.195	50.98
8. Anderson Henriques	0.157	45.03	8. Novlene Williams-Mills	0.276	51.49

RESULTS

Table 4 The basic statistical parameters of the starting reaction time (RT) of male and female athletes

Disciplines	N	Mean RT (s)	Min	Max	Rang	SD	Skew.	Kurt.
100m M	8	0,163	0,142	0,186	0,044	0,014	,489	,343
100m W	8	0,171	0,151	0,229	0,078	0,025	2,072	4,696
200m M	8	0,156	0,138	0,177	0,039	0,016	,476	-1,971
200m W	8	0,166	0,146	0,197	0,051	0,018	,770	-,640
400m M	8	0,207	0,155	0,350	0,195	0,068	1,577	2,207
400m W	8	0,225	0,163	0,276	0,113	0,040	-,115	-1,187

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

Table 4 presents the basic statistical parameters of the starting reaction time (RT) of male and female finalists included in this study. Looking at Table 4 we can determine the normality of distribution. Less homogeneity manifests itself in the discipline 100m for women, with higher values of kurtosis, and we conclude that the greater range of achieved reaction time in this discipline was achieved by female finalists. In addition, the increased value of skewness confirms that it is a large value of reaction time in the same event. In the men's 200m run increased measures of variability in both parameters were observed, but slightly less than the previous case. By analyzing Table 4, it can be concluded that the medium, (the smallest number) the reaction time in the discipline of the men's 200m run (0,156 s) with the lowest (fastest) reaction time of 0,138s of all the disciplines in both categories. As the lowest average and individually starting reaction time is also among the female finalists in the 400m discipline (0,225s) and the weakest singles starting reaction time among the male finalist was 400m (Max. = 0,350s). The range of the best time of starting reaction to the weakest time in both competitions is 0,212s. (200mM:400mM) which does not make a big difference if you take into account the different lengths of the 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 genders, the t-test for independent samples was used.

Table 5 Differences in the starting reaction time of female finalists

Disciplines	Reaction Time (s) Women (N=24)		
	Mean±SD	t-value	p-level
100m	0,171±0,025	,423	0,679
200m	0,166±0,018		
100m	0,171±0,025	-3,227	0,006**
400m	0,225±0,040		
200m	0,166±0,018	-3,794	0,002**
400m	0,225±0,040		

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

Table 5 presents the differences in the starting reaction time of the finalist in the women's events: 100m, 200m and 400m run. Looking at Table 5, the differences between the disciplines are evident. However, the realized differences are not statistically significant. Of the three disciplines, significant differences were determined for two. A statistically significant difference was not found between the 100m and 200m disciplines (p <0,679). In the other two disciplines, the difference is statistically significant between the 100m and 400m disciplines (t = -3,227**) and between the 200m and 400m (t = -3,794**).

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

Disciplines	Reaction Time (s) Men (24)		
	Mean±SD	t-value	p-level
100m	0,163±0,014	,827	0,422
200m	0,156±0,016		
100m	0,163±0,014	-1,833	0,088
400m	0,207±0,068		
200m	0,156±0,016	-2,069	0,058
400m	0,207±0,068		

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

Table 6 contains numerical parameters of the differences in time of starting reaction of the male finalists in the sprint events. Looking at Table 6 we can note minor differences in reaction time between the disciplines but they are not so large as to be statistically significant. The largest difference of arithmetic means that is not statistically significant is between the 200m and 400m events (p<0,058). This distribution of the 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 the final races dismiss earlier claims that the response time is slower in the short tracks, and with the length of the track it loses its significance (Moravec, 1988), also with the length of the tracks the reaction time also increases linearly (Baumann, 1980; Babic & Delalija, 2009).

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

Disciplines	Reaction Time (s) Women-Men		
	Mean±SD	t-value	p-level
100m M	0,163±0,014	-,820	0,426
100m W	0,171±0,025		
200m M	0,156±0,016	-1,177	0,259
200m W	0,166±0,018		
400m M	0,207±0,068	-,640	0,532
400m W	0,225±0,040		

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

Differences in gender are always interesting for analysis, regardless of the disciplines. In this case it is interesting and important for practice to determine the differences in the starting reaction time of the same disciplines between men and women finalists of the World Championship. By analyzing Table 7, lower values of differences of arithmetic means of reaction time were observed in the disciplines of 100m (W163ms:M171ms), 200m (W156ms: M166ms) and 400m run (M207ms:W225ms) in favor of the men finalists. However, it is important that these differences are not as large and did not achieve statistical significance, so the differences based on gender were not noted.

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

Disciplines		Time (s) Mean±SD	t-value	p-level
100m	M	9,98±0,134	-14,860	0,000**
	W	10,98±0,135		
200m	M	20,06±0,245	-18,331	0,000**
	W	22,57±0,285		
400m	M	44,64±0,439	-18,250	0,000**
	W	50,26±0,752		

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

Table 8 contains the results that based on the negative values of the t-test clearly indicate differences between male and female finalists based on the results achieved. The smallest difference was achieved in the 100m discipline where the women achieved a mean result value 10,98 sec (± 0,135) unlike the male finalists 9,98sec (± 0,134). The achieved difference was confirmed by the t-test at the level (p <0,000**). Significantly larger differences are manifested in the 200m discipline (t = -18,331, p <0,000**) and 400 (t = -18,250, p <0,000**). These results confirm a clear gender difference, clearly expressed in the sprint events, not so much in the 100m 200m and 400m events.

DISCUSSION

Starting acceleration is one of the most complex segments of the sprint, in which sprint capacity that will be manifested only in the segment of maximal running speed can be rationalized. The time lost due to poor start reaction, poor start and, ineffective start progression and achieving speed late, it is difficult or impossible to make up for it in the rest of the race (Smajlović and Shrimp, 2006). However, in recent times, it also happens that a poor start, or starting with a lower reaction, does not necessarily mean the failure of the race, and weaker results. 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 places. These remarks confirm earlier studies which claim that for the final score in the sprints (100m and 200m) the length of acceleration, reached maximum speed and speed-endurance are more important (Buonchristiani & Martin, 1995). It is believed that the execution of the contact phase after the start and during the race is one of the most important generators of success in the implementation of sprint speed (Lehmann & Voss, 1997). The 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, & Gregor, 1992). The high performance of sprinters are the result of a complex mixture of many factors such as genetic potential, training and health of the athlete. From the anthropological point of view, reaction time is the ability to quickly respond to stimulation. A higher reaction rate gives better response time, which is only one of several factors that influence the success of modern athletes (Dick, 1987; Brüggemann & Hunger, 1990; Pain & Hibbs, 2007). In the sprint events, start reaction time is the time interval (ms) between the pistol signal and the movement of the 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 than novice athletes. In addition, the reaction speed shows a decreased result when the athlete did not train (Doherty, 1985), so the initial reaction time affects about 1 to 2% of the total score of the sprinter (Baumann, 1980; Helmick, 2003). Contrary to the abovementioned, 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). The time of the 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 (Buoncristiani & Martin, 1995). However, research (Stevenson, 1997, Michel and Järvere, 2002 Henson, Cooper, & Perry, 2002) has shown that athletes with a better response time at the beginning of the sprint had a psychological advantage over their opponents, which in many races may be important on the target plane.

The results presented in Table 1 show that increasing the length of the track also increases the average response time in the female finalists, unlike the male finalists where this so-called rule is not valid, and an average response time on the 100m run is weaker than on the 400m (0,162:0,161).

Comparing the results of this study with previous ones (Moravec et al. 1987, Colet 2000; Duffy, 2004 Smajlović & Skins, 2006; Babic, 2008) it can be concluded that these results are almost of the same level in all the disciplines. The study carried out by Theopilos Pilianidis, et al. (2012) found that both men and women were significantly better in the discipline of running on the 100m in Beijing in 2008 than in Sydney in 2000. Similarly, the times of starting reaction in the disciplines of the 100/110m run with hurdles were significantly better in Athens in 2004 than in Sydney in 2000, and finally, in the men's 100m final race in Beijing in 2008. Both the time of start reaction and overall score of the runs were better than the results of competitors that participated in Athens in 2004 and in Sydney in 2000. Also the results of this study in the discipline of the 100m run are slightly weaker than the results of the Rome Golden League meeting in 2003.

The average response time finalist in Rome in 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 finals in the discipline at the World Championships in Edmonton in 2001 was 10.19 sec, with a response time of 145ms, and in the World Cup final in Paris in 2003 10.20 sec with a response time of159ms. At the Olympic Games in London in 2012, the average time in the final race was 10.09 s with reaction time of 162 ms. In the women's World Cup in Edmonton the mean time was 11.15 s with a reaction time of 146ms and at the WC in Paris in 2003 11.13 s with a response time of 157ms. The female Finals in London were completed with an average time of 10.87 seconds and response time 155ms.

Previous results have shown that in the Olympic disciplines with extending tracks, the time of the starting reaction in world-class sprinters also increases linearly (Baumann, 1980; Babic & Delalija, 2009). Also, in some studies it was confirmed that the time reaction of male sprinters is better than that of women. However, the results of this study are in contrast with studies that have confirmed that there is no difference in the time of the starting reaction between male and female sprinters (Buonchristiani & Martin, 1995). When it comes to response time, differences in terms of gender, the results in this study did not confirm that (Table 4). Almost identical results were obtained by Smajlović & Kozic in 2006 in their study of the World Championship in Edmonton in 2001 and in Paris in 2003. The results indicate that about the sample consisted of 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 of selected, and non-selected categories. In addition, only a good selection, the technology of the training process, with of course natural predisposition, could 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 depends on the force manifestation of isometric and isotonic muscle contractions 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, & 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 the blocks, the speed of leaving the starting blocks, the length of the first step, height of the 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.

Studies (Dostal, 1982; Smajlović & Skins 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. A similar study including ten leading sprinters was carried out by Paradisis et al. in 2006 and obtained conflicting results. They found that the time of starting reaction is closely related to sprint results. This is particularly important, given that in the final race in London in 2012 men achieved a mean time of starting reaction of 162ms and a total score of 10.09 s. 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 9.89s 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 2009, there was, so to speak, an explosion of the results. In 2009, the average reaction time of the male finalists was better than in Beijing (138ms with an achieved result of 9.91 s). Perhaps the presence of the Jamaican Usain Bolt in all the finals, with a reaction times of 165ms and a world record time of 9.69 s in Beijing, then 146ms and 9.58 s in Berlin, and finally 165ms and 9.63 s in London in 2012 had a strong influence in all three starting reactions and performances of these final races.

The results of this study indicate that in the modern track and field, the time of starting reaction and total running time were equally improved, there was no difference by gender and there are no evident statistically significant differences in terms of disciplines. The results are in contrast to the research of some authors who state that the time of reaction among female sprinters' response is slower than in male sprinters, and that it increases with the length of the section. In addition, the research findings are not consistent 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 results that in almost all the disciplines achieved statistically significant differences. In general, these results partially confirm the results of previous studies 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, & Hunger, 1988) and Athens 2004 (Smajlović & Kozic 2006; Theophilos Pilianidis et al. 2012).

One possible explanation for this distribution of research results 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, that is, they were the best at the moment and so they did not corroborate earlier research.

In short, this study showed that no difference was determined between the genders in the time of starting reaction. 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.

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 at determining the 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 than those of previous studies including superb athletes. The probability distribution of slightly better results in this research lies in the fact that it is a final competition where only the best in both categories performed.

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 for the female finalist in the disciplines of the 100m and 400m run ($t = -3.220$, $p < 0.006$) as well as for the 200m and 400m events ($t = - 2.550$, $p < 0.023$). Also, statistically significant differences have been achieved between the genders in the disciplines of 100m ($t = -2.842$, $p < 0.013$), 200 ($t = -11.526$, $p < 0.000$) and 400m run ($t = -27.019$, $p < 0.000$).

The research results did not confirm the existence of statistically significant differences in the reaction time in male finalists based on disciplines and differences in the same disciplines between the genders. The obtained results confirmed earlier studies in terms of the difference in the result achieved between the genders, as expected. Some studies have been confirmed that did not record significant differences in the time of starting reaction between the genders. Also, the faster response time for short distances was confirmed in the female as opposed to male finalists.

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

REFERENCES

Baumann, W. (1980). Kinematic and dynamic characteristics of the sprint start. In P.V. Komi (Ed.), *Biomechanics V-B. International Series on Biomechanics, Vol.1B* (34- 47). Baltimore, MD: University Park Press.

Babić, V. (2005).Utjecaj motoričkih sposobnosti i morfoloških obilježja na sprintersko trčanje. [Influence of motor abilities and morphological properties on sprint running. In Croation]. Doktorska disertacija. Zagreb: Kineziološki fakultet Sveučilišta u Zagrebu.

Babić, V. (2008). Reaction time and sprint results in athletics. In M. Čoh (Ed.), *Biomechanical diagnostic methods in athletic training* (183-193). University of Ljubljana

Babic, V., & Delalija, A. (2009). Reaction time trends in the women's sprint and hurdle events at the 2004 Olympic Games. *New Studies in Athletics*, *24*(1), 49-57.

Babić, V, & Čoh, M. (2010). Karakteristike razvoja brzine i sprinterskog trčanja. In I. Jukić et al. (Ed.), *8. godišnja međunarodna onferencija Kondicijska priprema sportaša* (83-98). Sveučilište u Zagrebu & Udruga kondicijksih trenera Hrvatske.

Bruggemann, G.P., & Glad, W. (1990). Biomechanical analyses of the jumping events; time analysis of the sprint and hurdle events: *IAAF Scientific Research Project at the Games of XXXIV Olympiad-Seoul 1988*: Final Report. Monaco: IAAF.

Bračić, M., Peharec, S., Bačić, P, & Čoh, M. (2010). Biomehanička dijagnostika starta najboljih slovenskih sprintera. In I. Jukić et al. (Ed.), *8. godišnja međunarodna onferencija Kondicijska priprema sportaša (177-183)*. Sveučilište u Zagrebu & Udruga kondicijksih trenera Hrvatske.

Cavagna, G.A., Komárek, L, & Mazzoleni, S. (1971). The mechanics of sprint running. *Journal of Physiology*, 217, 709-721.

Coppenolle, H, & Delecluse, C. (1989). Technology and development of speed. *Journal of Physiology,* 217, 709-721

Coppenolle, H., Delecluse, C., Goris, M., Diels, R, & Kraayenhof, H. (1990). An evaluation of the starting action of world class female sprinters. *Track Technique, 90*, 3581-3582.

Collet, C. (2000). Strategic aspects of reaction time in world class sprinters. *Track Coach*, *152*, 486.

Čoh, M., Jošt, B., Škof, B., Tomažin, K. and Dolenec, A. (1998). Kinematic and kinetic parameters of the sprint start and start acceleration model of top sprinters. *Gymnica* 28, 33-42.

Čoh, M. (2001). Biomehanics of athletics. Ljubljana: Fakultet za šport.

Čoh, M., Tomažin, K. and Štuhec, S. (2006) The biomechanical model of the sprint start and block acceleration. *Facta Universitatis- Series Physical Education and Sport* 4, (2), 103-114.

Čoh, M., Peharec, S., Bačić, P. (2007). The Sprint Start: Biomechanical Analysis of Kinematic, Dynamic and Electromyographic Parameters. *New Studies in Athletics*, 22 (3), 29-38.

Čoh, M, & Tomažin, K .(2008). Biodynamic characteristics of female sprinters during the acceleration phase and maximum speed phase. In M. Čoh (Ed.), *Biomehanical diagnostic methods in athletic training* (125-133). University of Ljubljana.

Doherty, K. (1985). *Track and Field Omnibook*, 4 Ed. Tafnews Press: Los Altos.

Dick, W.F. (1987). Developing sprinting speed. *Athletics Coach*, *21*(4), 4-5.

Delecluse, C., Coppenolle, H., Diels, R., & Goris, M. (1992). The F.A.S.T. project –A scientific follow-up sprinting abilities. *New Studies in Athletics,* 11 (2-3), 141-143.

Guissard, N., Duchateau, J, & Hainaut, K. (1992). EMG and mechanical changes during sprint start at different front block obliquites. *Medicine and Science in Sport and Exercise*, 24 (11), 1257-1263.

Harland, M, & Steele, J. (1997). Biomechanics of the Sprint Start. *Sports Medicine*, 23 (1), 11-20.

Henson, P., Cooper, J., & Perry, T. (2002). A wider look at the sprint start. *Track and Field Coaches Review*, *75*(4), 19-21.

Helmick, K. (2003). Biomechanical analysis of sprint start positioning. *Track Coach*, *163*, 5209-5214.

Hunter, P. J., Marshall, N, R; McNair, J P (2005) Relationships Between Ground Reaction Force Impulse and Kinematics of Sprint-Running Acceleration. *Journal of Applied Biomechanics,* 21, 31-43. Human Kinetics Publishers, Inc.

Korchemny, R. (1992). A new concept for sprint start and acceleration training. *New Studies in Athletics*, 7 (4), 65-72.

Komi, V.P., Ishikawa, M., & Jukka, S. (2009). IAAF Sprint Start Research Project: Is the 100ms limit still valid? *New Studies in Athletics*, *24*(1), 37- 47.

Locatelli, E., & Arsac, L. (1995). The mechanics and energetic of the 100m sprint. *New Studies in Athletics*, *10*(1), 81-87.

Lehmann, F, & Voss, G. (1997). Innovationen fur den Sprint und Sprung: "ziehende" Gestaltung der st tzphasen-Tiel 1. *Leistungssport*, 6:20-25.

Martin, D, & Buonchristiani, J. (1995). Influence of reaction time on athletics performance. *New Studies in Athletics*, 10 (1), 67-69

Mann, R, & Sprague, P. (1980). A kinetic analysis of the ground leg during sprint running. Research Quarterly for exercise and sport, 51:334-348

Moravec, P., Ruzicka, J., Susanka, P., Dostal, E., Kodejs, M., & Nozek, M. (1988). The 1987 International Athletic Foundation/IAAF Scientif ic Project Report: Time analysis of the 100 metres events at the II World Championships in Athletics. *New Studies in Athletics*, *3*, 61-96.

Meckel, Y. Atterbom,H., Grodjinovsky, A.,Ben- Sira, D., & Rotstein, A. (1995). Physiological characteristics of female 100 metre sprinters of different performance levels. *Journal of sports medicine and physical fitness*. 35 (3), 169-175.

Michel, S., & Jarver, J. (2002). The start is (almost) everything in sprint performance. *Track Coach*, *160*, 5121.

Mero, A., Luhtanen, P., & Komi, P. (1983). A biomechanical study of the sprint start. *Scandinavian Journal of Sport Science*. 5 (1), 20-28.

Mero, A, & Komi, P. (1990). Reaction time and electromyographic activity during a sprint start. *European Journal Applied Physiology*, 61:73-80

Mero, A., Kuitunen, S., Harland, M., Kyrolainen, H, & Komi, P. (2006). Effect of muscle-tendon length on joint movement and during sprint starts. *Journal of Sport Science*, 24 (2), 165-173.

McClements, J., Sanders, L., & Gander. (1996). Kinetic and kinematic factors related to sprint starting as measured by Saskatchewan Sprint Start Team. *New Studies in Athletics*, 11 (2-3), 133-135.

Mero, A., Komi, P.V. i Gregor, R.J. (1992). Biomechanics of sprinting running. *Sport medicine*. 13 (6), 376 – 392.

Muller, H., & Hommel, H. (1997). Biomechanical Research Project at the VI. World Championship in Athletics, Athens 1997. *New Studies in Athletics*, 12 (3), 43-73

Ozolin, E.S. (1996). Sprinterskij beg. Fiskultura i sport. Moskva

Paradisis, G., Zacharogiannis, E., Smirniotou, A., Tziortzis, S., & Kritharakis, A. (2006). Correlation of reaction time and performance in 100m sprint running. *Medicine and Science in Sports and Exercise*, 38 (5), S518.

Pain, M.T.G., & Hibbs, A. (2007). Sprint starts and the minimum auditory reaction time. *Journal of Sport Sciences*, 25 (1), 79-86.

Steinbach, M., & Tholl, R. (1969). Uber die Reaktionszeit. [About the reaction time. In German.] *Die Lehre der Leichtathletik*, *20*, 33.

Schot, P. K. & K. M. Knutzen (1992). A Biomechanical Analysis of Four Sprint Start Positions. *Research Quarterly for Exercise and Sport*, 63(2), 137– 147.

Stevenson, M. (1997). The sprint start: save as many split-seconds as you can on the start and you'll be in pretty good shape at the finish. *Coach and Athletic Director*. *66* (8), 18-20.

Susanaka et al. (1998).The 1987 IAF/IAAF Scientific project report: time analyses of the 100 meters events at the II world championship in athletics. *New studies in Athletics* (3), 61-96

Stein, N. (1999). Speed training in sport. In B. Elliot (Ed.), *Training in sport: applying sport science*. Chichester: Wiley.

Smajlović, N, & Kozić, V. (2006). Efekti promjene atletskih pravila na vrijeme startne reakcije u sprinterskim disciplinama. *HomoSporticus*, 9 (2), 21-27.

Tellez, T. i D. Doolittle (1984). Sprinting from Start to Finish. *Track Technique*, 88, 2802 – 2805.

Theophilos Pilianidis, T., Kasabalis, A., Mantzouranis, N., Mavvidis, A. (2012) Vrijeme startne reakcije i rezultat trčanja u sprinterskim disciplinama na olimpijskim igrama. *Kinesiology*, 44 (1), 67-72.

Young W, McLean B, Ardagna J (1995) Relationship between strength qualities and sprinting performance. *The Journal of Sports Medicine and Physical Fitness,* 35 (1), 13-19.

Wang, J. (2006). Dynamic analysis of velocity of elite world 100m runners. *Journal of Wuhan Institute of Physical Education*, 40 (5), 89-92.

http://msn.foxsports.com/olympics/track

http://www.iaaf.org/competitions/iaaf-world-championships/14th-iaaf-world-championships-4873/timetable/bydiscipline.

RAZLIKE U VREMENU POTREBNOM ZA STARTNU REAKCIJU I POSTIGNUTE REZULTATE U FINALU DISCIPLINE SPRINT NA SVETSKOM PRVENSTVU U MOSKVI

U sprint disciplinama, start i početak ubrzanja igraju jako važnu ulogu koju definiše krajnji rezultat. U zavisnosti od odgovarajućih pojedinačnih morfoloških dimenzija, naročito u pogledu motoričkih i funkcionalnih sposobnosti učesnika, neophodni je utvrditi uslove za primenu ovih parametara. Uprkos tome, odlični rezultati koji se postižu, i razlike u ovim parametrima su očigledne, što ima uticaj i na krajnji ishod. Cilj ovog istraživanja bio je da se utvrde razlike u vremenu starta u finalu discipline sprint na Svetskom prvenstvu održanom u Moskvi 2013. Rezultati finalista 24 (muškaraca) i 24 (žena) koji su učestvovali u finalu u disciplinama sprint na 100m, 200m i 400m su analizirani. Početno vreme (ms) i rezultati (s) bazirani su na zvaničnim podacima objavljenim za sajtu organizacije (IAAF) su analizirani. Rezultati t-testa pokazali su da postoje statistički značajne razlike u vremenu odgovora na startu kod ispitanica u disciplinama 100m i 400m run ($t=-3.227^{**}$) kao i 200m i 400m ($t=-3.794^{**}$), za razliku od ispitanika kod kojih nisu utvrđene statistički značajne razlike. Takođe, u istim disciplinama nisu utvrđene statistički značajne razlike između polova, dok su se one utvrdile za discipline 100m ($t=-14.860^{**}$), 200 ($t=-18.331^{**}$) i 400 ($t=-18.250^{**}$).

Ključne reči: *sprint, Olimpijske igre, reakcija na startu, razlike.*