Original Article

Changes in the start reaction times of male and female sprinters in world athletic championships

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Abstract:

Reaction time is an important component of the structure of sports performance in sprint disciplines. In our observation, we focused on the men's and women's 100 metres discipline at the World Championships (World Championships) in two periods. The first in 1999 - 2009 and the second in 2011 - 2019. This division was conditioned by the change in the false start rule, which states that any competitor who makes a false start, except in multicontest, will be disqualified (effective from 1 January 2010). This change affected the speed of the sprinter's reaction. The monitored group were finalists of the 100 m runs at the World Championships, a total of 11 events. We used basic mathematical-statistical characteristics and assessed changes in reaction times using parametric and nonparametric t-test. We compared reaction time in both periods in the heats (statistically insignificant in both categories) and in the finals we found a statistically significant difference ($p < 0.05$) only in women's category. By comparing the speed of reactions in the heats with the speed of reactions in the finals in each period, we noticed statistically significant differences – in the first period in both categories at the level of $p < 0.01$ and in the second period at the level of $p < 0.05$. We also assessed the reaction time values in terms of the percentage of total performance, which was different for men compared to women. When comparing men and women, the results showed an increase in reaction time in finals during the second period compared to the first. In men's category, we found an increase by 4.17 % (0.144 s in 1999 - 2009 finals and 0.150 s in 2011 - 2019 finals) and in women's category by 7.95 % (0.151 s in 1999 - 2019 finals and 0.163 s in 2011 - 2019 finals).

Keywords: reaction time, World Athletics Championships, men's, and woman's 100 m run, heats, finals, IAAF (WA)

Introduction:

Short-distance runs are cyclical in nature, with maximum intensity in order to overcome a given distance in the shortest possible time. As reaction time is an essential part of these disciplines, we are aware of its important position in the effort to achieve the best possible sports performance. Kampmiller and Košťál (1986), Sedláček (1992) already included reaction ability into the first factor level in the structure of youth sports performance in sprinting disciplines (14.2 % share in the total performance). It usually concentrates all the indicators that are the immediate components of sports performance in the 100 m run. Limiting factors in achieving performance in athletic smooth sprint disciplines include maximum running speed and the ability to maintain speed during exercise – referred to as endurance in speed (Kampmiller and Košťál, 1986). According to Choutek (1976), reaction speed is promoted in relation to sports performance from the second-factor level. In an empirical model of the structure of men's sports performance in the 100 m run, he perceives it as a mediated link through acceleration speed.

Several factors influence the speed of the reaction: age, gender, physiological and psychological abilities, fatigue, warm-up, sports age, intelligence, anticipation (Štulrajter, 1989; Schweitzer, 2001; Luchies et al., 2002; Barral and Debu 2004; Van den Berg and Neely, 2006; Kohen et al., 2008; Zemková, 2011).

Although the share of reaction time in sports performance is getting smaller with increasing running distance, it is important to realise that the result is often decided by hundredths of seconds (Delalija and Babić 2008). Their research also focused on reaction time as the first factor in the time sequence of the sprint. The sample included 250 women and 360 men from the 2004 Olympic Games in Athens. The research aimed to determine the influence of reaction time on the result of the sprint. A statistically significant correlation between reaction time and achieved performance was proved in the women's 100 m hurdles and the men's 100 m run and 110 m hurdles. We believe that a factor such as reaction speed must be approached as responsibly and with sufficient emphasis as the development of other skills. The speed of the reaction could also be influenced by the rules of athletics about start in short distances (rule no. 162). Changes in the number of false starts and tightening of the criteria for excluding an athlete could have affected the speed of the sprinter's reaction. The 2009 rule

(effective from 1 January 2010) stipulated that the reaction rate should not be below 0.10 s. Since then, any competitor who makes a false start (except for multicontest) will be disqualified. After taking the final start position, the competitor must not start moving before the gun is fired. If in the opinion of the starter or a deputy – starter assistant, the athlete starts the movement earlier, it is considered a false start (IAAF Rules of Athletics 2018 - 2019).

The goal

The aim of the paper was the empirical collection of data on the start reactions of men and women, finalists of the World Championships in 100 m run in the years from 1999 to 2019. The criterion for comparing the speed of reaction in the monitored groups (1999 - 2009, resp. 2011 - 2019) was the rule tightening on the exclusion of an athlete at the start.

Hypotheses

H1 We assume a statistically significant improvement of the start reactions in the finals in comparison with the heats in the group of men and women in the individual World Championships.

H2 We assume, due to rule change of a false start, we will find a statistically significant deterioration of the start reactions in the World Championships at the period of 2011 - 2019 in comparison with the period of 1999 - 2009 at the heats and at the finals of men and women.

H3 We assume statistically significant better values of start reactions of men and women in the finals in comparison with the heats at the World Championships in the first and second period, too.

Tasks

1. Find and evaluate start reaction data from the official website of the IAAF (WA - World Athletics) from the World Championships 1999 - 2019.
2. Analyse, compare, and statistically prove changes in start reactions in individual disciplines.

Material & methods

Participants

We carried out the research on men and women sprinters in the 100 m runs, who took part in the finals at the World Championships in Athletics in the years 1999 - 2019. The group consisted of 350 athletes (176 men and 174 women).

Procedure

We obtained the values of the start reactions of sprinters from the mentioned period from the official website of the IAAF (WA). We calculated their percentage of performance and included runners in performance standards.

Statistical analysis

In the calculations, we used the basic statistical characteristics (Table 1): arithmetic mean ($\bar{x}$), standard deviation (s), minimum value ($x_{\min}$), maximum value ($x_{\max}$) and variation range (vr). We determined the statistical significance of changes (heats vs. finals at individual World Championships) using the Wilcoxon t-test. We used parametric paired and parametric unpaired t-test to compare the differences in the reaction speed in the monitored periods.

Tab. 1 Basic statistical characteristics of men (M) and women (F) in heats and the finals in the 100 m run at the World Championships 1999 - 2019

Category and period	$\bar{x}$	Me	s	$x_{\min}$	$x_{\max}$	vr
M heats 1999 - 2009 (n=48)	0,156	0,158	0,017	0,120	0,194	0,074
M heats 2011 - 2019 (n=40)	0,154	0,156	0,030	0,126	0,196	0,070
M finals 1999 - 2009 (n=48)	0,144	0,144	0,015	0,112	0,180	0,068
M finals 2011 - 2019 (n=40)	0,150	0,154	0,032	0,117	0,224	0,107
F heats 1999 - 2009 (n=46)	0,175	0,164	0,053	0,123	0,443	0,320
F heats 2011 - 2019 (n=40)	0,173	0,167	0,030	0,122	0,264	0,142
F finals 1999 - 2009 (n=46)	0,151	0,146	0,023	0,113	0,219	0,106
F finals 2011 - 2019 (n=40)	0,163	0,156	0,037	0,117	0,234	0,117

Legend: Me – Median, $\bar{x}$ – arithmetic mean, s – standard deviation, $x_{\min}$ – minimum value, $x_{\max}$ – maximum value, vr – variation range

Results

The first hypothesis was the assumption that in each observed period, both men and women achieve faster start reactions in the finals runs compared to the heats (Fig. 1, Fig. 2).

Legend: * $p < 0.05$; ** $p < 0.01$; s.i. – statistically insignificant

Fig. 1 Comparison of the average values of men's start reactions ($n = 8$) in the 100 m run from 1999 to 2019 at the World Athletics Championships.

Fig. 1 shows that men achieved on average faster start reactions in the finals at almost all World Championships, except for 2005. The average improvement in the start reaction in the finals was 8.05 %. We assume that this improvement was due to a higher concentration of sprinters. The start and its perfect implementation are an important factor that can affect the final rank of an athlete.

Legend: * $p < 0.05$; ** $p < 0.01$; s.i. – statistically insignificant

Fig. 2 Comparison of the average values of women's start reactions ($n = 8$) in the 100 m run from 1999 to 2019 at the World Athletics Championships.

Fig. 2 shows that women also had on average faster start reactions in the finals. We recorded a deterioration in the average start reactions in the finals at three World Championships, in 2003, 2007 and 2017. The average value of the improvement of the start reaction was 19.09 %, but this high improvement was caused by the year 1999 when athletes had a very slow start reaction. Based on these results, we did not confirm H1.

Tab. 2 Statistical significance of differences in reaction times in heats and the finals of the 100 m men's and women's run at the World Championships in Athletics

Period	1999 - 2009	t-test	2011 - 2019	1999 - 2009	t-test	2011 - 2019
M	Heats	s.i.	Heats	Finals	s.i.	Finals
F	Heats	s.i.	Heats	Finals	$p < 0,05$	Finals

In hypothesis H2, we assumed statistically significant differences in the reaction speed of men and women between heats and finals in individual periods (tab. 2). We found that the average value of the reaction time in women's heats worsened by 1.17 % and in men's, it improved by 1.28 %. However, these differences were not significant in either case.

In 2011 – 2019 finals the reaction speed deteriorated (men by 4.17 %) compared to 1999 - 2009. However, this deterioration was not statistically significant either in the heats or in the finals. Similarly, among women, we also observed a worsening of the reaction speed (by 7.95 %) in the finals, which was statistically significant ($p < 0.05$). These results did not confirm hypothesis H2.

In H3, we assumed that in each period (1999 - 2009, respectively 2011 - 2019), both men and women would achieve faster start reactions in the finals than in the heats (Tab. 3).

Tab. 3 Statistical significance of differences in reaction times in heats and in the finals of the World Championships in Athletics

Period	1999 - 2009			2011 - 2019		
M	Heats	$p < 0,01$	Finals	Heats	$p < 0,05$	Finals
F	Heats	$p < 0,01$	Finals	Heats	$p < 0,05$	Finals

Tab. 3 shows that in the first period, this difference was statistically significant at the level of $p < 0.01$ and after tightening the rule at the level of $p < 0.05$. The importance of the reaction rate is confirmed by its percentage share in the sprinters' final time (Tab. 4).

Tab. 4 Reaction times and their percentage share of the achieved power in the 100 m run in the period 1999 - 2009 and 2011 - 2019.

Period	Male				Female			
	Heats		Finals		Heats		Finals	
	RT [s]	% share	RT [s]	% share	RT [s]	% share	RT [s]	% share
1999 - 2009	0,156	1,52	0,144	1,43	0,180	1,58	0,150	1,45
2011 - 2019	0,158	1,57	0,154	1,53	0,173	1,56	0,159	1,45

Legend: RT – reaction time

Based on the analysis of runs ($n = 2133$ in the men's and 1725 runs in the women's category), Gavařa (2002) proposed a 5-level scale for assessing the level of reaction time for both men and women (Tab. 5). Most of the finalists we watched in the mentioned periods of the World Championships were at the level of "very good, to average".

Tab. 5 Number of runners in individual stages of evaluation of runners' reaction times per 100 m at the World Championships (according to Gavařa, 2002).

Gender Rating	Male		Female	
	Heats	Finals	Heats	Finals
Excellent (0,100 - 0,120 ms)	1	4	0	4
Very good (0,121 - 0,150 ms)	31	47	20	34
Average (0,151- 0,175 ms)	43	28	32	28
Below average (0,176 - 0,205 ms)	10	5	21	13
Unsatisfactory (>206 ms)	0	1	10	4
Overall	85	85	83	83

Discussion

The first hypothesis about the improvement of start reactions in the finals was not confirmed. Men at one World Championships (2005) and women at three World Championships (2003, 2007, 2017) achieved worse reaction times in the finals. In the second hypothesis, we assumed statistically significant differences in the speed of reaction in the heats and the finals in the first (1999 - 2009) and the second (2011 - 2019) period. Our assumption was confirmed ($p < 0.05$) only in the women group in the comparison of the finals. We confirmed the third hypothesis, with better reaction times in the finals in each period. By tightening the false start rule on the exclusion of the sprinter, the statistical significance was reduced from $p < 0.01$ to $p < 0.05$. We assume that the new rule has reduced the competitors' efforts to "fall into the start shot".

Reaction abilities can be improved by regular and systematic training, so it is necessary to pay attention to them in the training process and focus on their monitoring and subsequent improvement (Englert and Bertrams, 2014). An example is Shelly-Ann Fraser-Pryce (Jamaica), who had a reaction rate of 187 ms in the start (11.41 s), semifinals (10.79 s) and finals (10.73 s) in 2009; 156 ms and 146 ms (1st place). After 10 years in 2019, she had reaction times in individual runs: 173 ms (final time 10.80 s); 133 ms (10.81 s) and 134 ms (10.71 s, 1st place). The reaction time values some of top athletes are characterised by a high degree of stability, e.g. Usain Bolt (mean 14 reaction times on MS was 157 ms), Justin Gatlin (159 ms from 12 runs). Among women, for example, Chandra Sturup (average 163 ms from 12 runs) and Veronica Campbell-Brown (165 ms from 15 runs at the World Championships).

The reaction time values can be influenced to some extent. A study by Englert and Bertrams (2014), on the sample of 37 runners, showed that the strength of self-control of athletes influences the value of reaction

time. The result depends on the level of difficulty of the tasks performed by the athlete before the start. Pilianidis, Mantzouranis, Kasabalis (2012) conducted research on a sample of 161 athletes from the indoor athletics World Championships, where they also showed that the 2003 rule negatively affected running performance in the finals. In the group of men and women, we noticed a worsening of reaction times after the change of the rule about a false start. Men had an increase of 4.17 % and women by 7.95 %.

In the studied periods (1999 - 2009 and 2011 - 2019) we confirmed the results of other authors (Barral, Debu, 2004) that women have slower start reactions compared to men. At heats in the first period, women had an average reaction time of 171 ms, men 156 ms (difference 8.77 %); in the second period, 173 ms respectively 154 ms (difference 10.98 %). In the finals in the first period, the values of women were 151 ms, and men 144 ms (difference 4.64 %); in the second period 163 ms and 150 ms, respectively (difference 7.98 %).

Conflicts of interest – The authors declare that there are no conflicts of interest.

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