ORIGINAL ARTICLE

Relationship between reaction time and performance in the 60 m hurdles at the 2022 World Indoor Championships

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Abstract

Previous studies indicate that there is a large influence of the starting reaction time (RT) on sprint performance, but also that some recent changes in athletic rules may affect this correlation. This study aimed to examine the relationship between RT and results in: men's (M60mH) and women's (W60mH) disciplines 60 m over hurdles, 60 m hurdles in the heptathlon (H), 60 m hurdles in the pentathlon (P) at the recently held World Indoor Championship 2022 (WIC). The aim was also to determine whether there are differences in RT between M60mH and W60mH, M60mH and H, W60mH, and P, and between H and P. The study included 170 competitors who competed at the WIC. Pearson's linear correlation coefficient (r) was used for correlation analysis, and the t-test for independent samples was used to examine differences between groups. A statistically significant correlation (r=0.23, N=72, p=0.05) was found between the results and RT in W60mH when observing the entire sample of participants (r^2 = 5.29). Considering that in H (r=0.42, N=10, p=0.23, r^2=0.18) and P (r=0.54, N=12, p=0.07, r^2=0.29), a much higher correlation was obtained between results and RT than in competitors in the 60 m hurdles event, we believe that this is a consequence of different athletic rules that refer to a false start. There are no significant differences between RT for M60mH and W60mH, M60mH and H, W60mH, and P, and between H and P. Coaches should pay attention to developing all parts of the sprint race, including the reaction time.

Keywords sprint • heptathlon • pentathlon • athletic rules.

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Introduction

A sprint is a short-distance race consisting of start reaction time (RT), acceleration, maximum speed, endurance speed, and finish (Widodo, 2023). The results in these disciplines are exact and represent the maximum individual capabilities in terms of technical, tactical, and motor-physiological potentials (Pavlović, 2021).

The RT is a relevant variable in areas such as sports and other activities of daily life (Sant'Ana et al., 2016). It can be defined as the time that elapses from when a stimulus appears until a response is given and is considered a good measure to assess the capacity of the cognitive system to process information (Kuang, 2017). The RT depends on the speed of the sensorimotor cycle, composed of the detection of the initial stimulus, transfer of the information through the afferent nerves, generation of the response from the central nervous system, and response of the effector (Greenhouse et al., 2017).

The RT is especially associated with the CNS processing times as measured from the onset of the stimulus to the onset of muscle activity (Janssen, 2015). For example, mechanical perturbations elicit goal-directed responses as little as 100 ms (Nashed et al., 2014). Although there is scientific evidence that a conscious (not reflexive) RT can be less than 100 ms, according to the International Association of Athletics Federations (IAAF) co-

mpetition rules, an RT under 100 ms is considered a false start.

According to today's athletic rules, a false start is not allowed. Previously (until January 1st, 2010), according to the athletic rules, one false start was allowed, after which none of the competitors was disqualified. A bad start is one of the factors that can be a disruptive factor in the overall ranking, and the fastest RT in the sprint was recorded by Tim Montgomery (0.104 s, which was achieved when one false start was allowed in the race according to the athletic rules) back in 2002 (Pavlović, 2021).

In the research of Tonnessen et al. (2013), the association of RT at the world championships from 2003 to 2009 was examined, and statistically significant correlations were obtained between RT and the results achieved in races. A shorter RT has a positive effect on the acceleration and continuity of speed in the 60 m sprint, which was confirmed by previous research (Gürses & Kamis, 2018). The RT of male sprinters is shorter than that of female sprinters in the disciplines 100, 200, and 400m among analyzed competitors from the world championships in athletics in the period from 2001 to 2019 (Pavlović, 2021).

This study aimed to examine the relationship between RT and results in: men's (M60mH) and women's (W60mH) disciplines 60 m over hurdles, 60 m hurdles in the heptathlon (H), 60 m hurdles in the pentathlon (P). Furthermore, the aim was also to determine whether there are differences in RT between M60mH and W60mH, M60mH and H, W60mH, and P, and between H and P.

Method

Participants

The study included 170 competitors (76 men and 72 women competing in the 60 m hurdles event, 10 heptathletes, and 12 pentathletes) who competed at the World Indoor Championships held in Belgrade in 2022. Their achieved results and RT were analyzed. The results and RT are taken from the official IAAF website https://worldathletics.org/competitions/world-athletics-indoor-championships/world-athletics-indoor-championships-7138985/timetable/bydiscipline.

For the realization of the research, the results and RT achieved by all participants, participants in the qualifying, semi-final, and final races in the discipline of running 60 m over hurdles for men and women were used. Also, the results and RT achieved in running 60 m over hurdles for heptathletes and pentathletes were used.

Statistical procedures

The results were processed using standard descriptive, correlational, and comparative statistical procedures. Central and dispersion parameters were calculated from descriptive statistics for each variable: arithmetic mean (A) and standard deviation (SD). Data distribution was done using the Kolmogorov-Smirnov test ($p>0.05$). Pearson's linear correlation coefficient (r) was used for correlation analysis. Before using the r, preliminary analyses were performed to examine the normality and linearity of variance. The extreme points were determined by a rectangular diagram (boxplot). Values of r in the ranges from 0.10 to 0.29 were considered low, from 0.30 to 0.49 moderate, and above 0.50 high. (Cohen, 1988). To determine how much of the variance of the two variables is shared, the coefficient of determination (r^2) was calculated. The r^2 was also calculated when no statistically significant correlation was obtained if $r>0.29$ (according to Cohen 1988, correlation coefficient values of 0.30 are considered moderate correlations). Given that in some groups the number of athletes is small (final groups or the total number of participants in the pentathlon is 12 athletes), a statistically significant correlation was not obtained even when $r=0.54$. Differences between the RT of M60mH and W60mH, M60mH and H, W60mH, and P, and between H and P were determined using the t-test for independent samples. Statistical processing was performed in the program (SPSS 21.0; Chicago, IL).

Results

The number of subjects (N), A, SD, minimum (Min), and maximum (Max) of the RT values are shown in Table 1.

Table 1. Descriptive statistics of the RT (presented in seconds) in the disciplines of 60 m hurdles for M60mH, W60mH, H, P

Variable	Men					Women				
	N	A	SD	Min	Max	N	A	SD	Min	Max
60 m H all	76	0.14	0.02	0.11	0.21	72	0.14	0.02	0.11	0.19
60 m H qual	44	0.14	0.02	0.11	0.18	41	0.14	0.02	0.11	0.19
60 m H sfin_fin	32	0.14	0.02	0.12	0.21	31	0.14	0.02	0.11	0.17
Heptathlon	10	0.14	0.02	0.12	0.18					
Pentathlon						12	0.14	0.03	0.11	0.21

Note: 60 m H all: all competitors who participated in the men's/women's competition in the discipline of 60 m hurdles; 60 m H qual: competitors who participated in the qualifying men's/women's 60 m hurdles races; 60 m H sfin_fin: competitors who participated in the semi-final and final men's/women's 60 m hurdles races

In the finals of the 60 m hurdles race, the gold medal was won by Grant Holloway, who achieved the second RT time in the final race, which was 151 ms, the fastest RT was 142 ms, and the slowest was 207 ms. In the women's competition, the gold medal was won by Cyréna Samba-Mayela, and in the final race, she also achieved the second RT time in the value of 119 ms. The fastest RT was 108 ms, and the slowest was 169 ms. Among the pentathletes, Noor Vidts had the best result in the 60 m hurdles with an RT of 127 ms. The fastest RT time among pentathletes was 108 ms, and the slowest was 209 ms. Damian Warner had the best result in the 60 m hurdles with an RT of 133 ms in heptathletes. The fastest RT was 122 ms, and the slowest was 177 ms.

Table 2. Descriptive statistics of the results (presented in seconds) in the disciplines of 60 m hurdles for M60mH, W60mH, H, P

Variable	Men					Women				
	N	A	SD	Min	Max	N	A	SD	Min	Max
60 m H all	76	7.67	0.14	7.29	8.07	72	8.09	0.15	7.78	8.65
60 m H qual	44	7.74	0.13	7.40	8.07	41	8.15	0.15	7.91	8.65
60 m H sfin_fin	32	7.59	0.09	7.29	7.75	31	8.02	0.13	7.78	8.22
Heptathlon	10	8.04	0.26	7.61	8.41					
Pentathlon						12	8.40	0.20	8.15	8.76

Note: 60 m H all: all competitors who participated in the men's/women's competition in the discipline of 60 m hurdles; 60 m H qual: competitors who participated in the qualifying men's/women's 60 m hurdles races; 60 m H sfin_fin: competitors who participated in the semi-final and final men's/women's 60 m hurdles races

Table 3 shows the r between the results and RT of all competitors in the male or female categories, competitors in the qualifying, semi-final, and final races in the 60 m hurdles, and the heptathlon and pentathlon categories.

Table 3. Correlation of results and RT in M60mH, W60mH, H, P

Results		Reaction time							
		M all	M qual	M sfin_fin	W all	W qual	W sfin_fin	H	P
M all	r	0.02							
	p	0.87							
M qual	r		0.23						
	p		0.14						
M sfin_fin	r			0.05					
	p			0.78					
W all	r				0.23*				
	p				0.05				
W qual	r					0.29			
	p					0.06			
W sfin_fin	r						0.14		
	p						0.44		
H	r							0.42	
	p							0.23	
P	r								0.54
	p								0.07

Note. M all/W all: all competitors who participated in the men's/women's competition in the 60 m hurdles races; M qual/W qual: competitors who participated in the qualifying men's/women's 60 m hurdles races; M sfin_fin/W sfin_fin: competitors who participated in the semi-final and final men's/women's 60 m hurdles races; H: 60 m hurdles in heptathlon; P: 60 m hurdles in pentathlon; r: linear Pearson correlation coefficient; p: value; *: level of statistical significance $p<0.05$.

Table 3 shows a statistically significant correlation ($r=0.23$, $p<0.05$) between the results and RT in women when observing the entire sample of participants in the 60 m hurdles event. The r^2 is 5.29, which means that the RT explains 5.29 percent of the variance of the achieved result for all participants in the 60 m hurdles event. There is no significant correlation when examining the correlation between results and RT in the qualifying or semi-final and final groups of women and all groups of men. In H, $r^2=18$ was obtained, and in P, $r^2=29$, which means that the RT explains 18 percent (heptathletes) and 29 percent (pentathletes) of the variance of the achieved result.

Table 4 and Table 5 show the results of the t-test for independent samples and the effect size (ETA) values.

Table 4. Independent samples t-test results between M60mH and H, W60mH and P

	Disciplines	t	p	ETA
Results	W 60 m H all Pentathlon	6.13	0.00	0.31
Reaction time	W 60 m H all Pentathlon	0.41	0.69	/
Results	M 60 m H all Heptathlon	4.45	0.001	0.19
Reaction time	M 60 m H all Heptathlon	0.35	0.73	/

Note: M 60 m H all / W 60 m H all: all competitors who participated in the men's/women's competition in the 60 m hurdles races; p: if the value of $p<0.05$, there is a statistically significant difference in the RT; ETA: effect size (0.01 small impact; 0.06 medium impact; 0.14 large impact).

Table 4 shows significant differences in the result between H and the M 60 m H all and between P and W 60 m H all. However, the differences between RT in the mentioned groups of athletes are not significant ($p>0.05$).

Table 5. Results of the t-test for independent samples between M60mH and W60mH, and between H and P in the 60 m hurdles event

Group	Gender	t	p	ETA
60 m H all	Women Men	-0.045	0.964	/
60 m H qual	Women Men	-1.199	0.234	/
60 m H sfin_fin	Women Men	1.259	0.213	/
All-Around Athletes	Women Men	0.142	0.888	/

Note: Note. 60 m H all: all competitors who participated in the men's/women's competition in the discipline of 60 m hurdles; 60 m H qual: competitors who participated in the qualifying men's/women's 60 m hurdles races; 60 m H sfin_fin: competitors who participated in the semi-final and final men's/women's 60 m hurdles races; All-Around Athletes: the difference between heptathlon and pentathlon; p: if the value of $p<0.05$ there is a statistically significant difference in the RT; ETA: effect size (0.01 small impact; 0.06 medium impact; 0.14 large impact)

Table 5 shows no significant differences between RT in women and men.

Discussion

Previous research (Ntolaptsis & Panoutsakopoulos, 2021; Pavlović, 2021) have shown uneven findings regarding the relationship between the achieved result and RT. There is also an inconsistency in previous research on the differences between RT in men and women. Helmick (2003) suggests that a good RT affects sprinter performance by 1–2%. According to the authors Ntolaptsis and Panoutsakopoulos (2021), RT represents approximately 2.1% of the total performance in the 60 m hurdles. In our study, RT accounted for approximately 5.3 percent of the variance when considering the entire female sample competing in the 60 m hurdles event. A minor percentage influence of RT on the result is given by authors Mitašík et al. (2020), who believe that a difference of 20 ms in RT can be translated as a difference of 20 cm in the finish in the 200 m sprint race. In elite sprinters, RT is very important during world championships, especially when performance differences are minimal (Gutiérrez-Dávila et al., 2006). A slow RT negatively affects the rest of the race and impairs the athlete's ability to maximize performance (Gürses & Kamis, 2018).

Pavlović (2021) states that in the last few years, it is evident that slower RT does not mean that the athlete will be ranked worse than the other competitors. As an argument for this statement, he states that in the final of the Olympic Games in London, Usain Bolt achieved the fifth start reaction time (160 ms) at 100 m and the sixth time at 200 m (180 ms) and won first place. In the analyzed results of the 60 m hurdles for men and women, it can be seen that the gold medal winners (males or females) had the second fastest RT in the final races. Perhaps the association between RT and performance is less in the 100 m compared to the 60 m hurdles should be investigated in future research. The percentage impact of RT on the result in the 100 m race is probably smaller due to the longer distance compared to the 60 m. This agrees with Freeman (2015), who states that since the 60 m race is the shortest discipline in athletic events, the RT of athletes is of the utmost importance. Acceleration, maximum speed, and finish also affect the result in the 60 m hurdles discipline in addition to RT.

In this study, a statistically significant correlation was obtained only when examining the correlation between RT and the results ($r=0.23$, $p<0.05$) of all female competitors in the 60 m hurdles race, which is in agreement with the authors Tønnessen et al., (2013) and authors Gürses and Kamis (2018). Compared to our results, a stronger correlation was obtained by Ntolaptsis and Panoutsakopoulos (2021), who found a correlation between RT and results in all subjects ($r=0.44$, $p<0.016$). In all other examined groups, no statistically significant correlation was

obtained between RT and results, which is in accordance with the authors of Pilianidis et al. (2012).

A study (Haugen et al., 2012) showed that false start regulations could affect RT. Current competition rules state that an athlete's RT should be greater than 100 ms for a start to be considered legal. The change in the athletic rules led the runners to use at the start a little more conservative strategy in reaction time to avoid disqualification (Brosnan et al., 2017). By comparing all-rounders athletes (in which one incorrect start is allowed according to the athletic rules) and sprinters in the 60 m hurdles discipline (in which one incorrect start is not allowed according to the athletic rules), it was examined whether there is a significant impact of the change in athletic rules from 2010 for sprinters, according to which if even one incorrect start is made, the competitor is disqualified. In our study, it was found that there is no significant difference in RT between all-rounders athletes and sprinters, but there is a difference in the result. Although there were no differences in RT between sprinters and heptathletes, as well as between sprinters and pentathletes, we believe that the difference in athletic rules affects better concentration (Collet, 1999 believes that concentration is very important for good RT) in all-rounders athletes and less tension (fear of disqualification). According to Tønnessen et al. (2013), increased tension can inhibit the ability to react quickly after a shot, i.e., affect slower RT. Considering that in heptathletes and pentathletes, a much higher correlation was obtained between results and RT than in competitors in the 60 m hurdles event, we believe that this is a consequence of different athletic rules that refer to a false start. This is supported by the fact that the heptathlete's hurdle race is the fifth discipline in the competition, which leads to fatigue to a certain extent. The results show that the average RT is 142 ms, while for the entire sample is 140 ms.

Our study showed no significant difference in RT between men and women in sprinters and all-around competitors. These results are in agreement with the results of studies by Collet (1999), Martin and Buoncristiani (1995), and Pavlović et al. (2013), and in contrast to Der and Deary (2006), Babić and Delalija (2009), who showed that male athletes have better RT than female athletes. We believe that women have poorer RT, given that researchers Winter and Brookes (1991) found that women have a longer electromechanical delay after the stimulus than men. Whether the lack of a significant difference in RT between men and women was influenced by insufficient concentration, fear of possible transgression or something else should be investigated in future research.

Coaches should spend a large part of training on developing all potential sprint performance because research showed that athletes with a shorter reaction time had a significant psychological advantage over their opponents, which can be significant for success in the competition (Michael & Jarver, 2002; Stevenson, 1997).

Conclusion

RT is one of the components of the 60 m hurdles race and can significantly affect the placing of competitors. Although a statistically significant correlation between RT and results was obtained in only one group in this research, a positive trend was obtained in most of the other investigated groups.
It should be investigated whether there is a difference in RT between competitors who competed when the athletic rules allowed one false start compared to competitors who competed according to the rules, according to which no false start was allowed in the 60 m hurdles event.

For now, the possibility of reducing the threshold values of 100 ms for a correct start and returning one allowed incorrect start is unofficially proposed and commented on only within the referee athletic organizations. We hope that the IAAF will soon officially address and publish new rules on the number of false starts allowed and the start reaction time allowed. We believe that the minimum allowed reaction time of 100 ms should be solved by new scientific research. Current valid athletic rules related to a proper start were defined based on neurophysiological research from thirty years ago.

Conflict of interest

The authors declare no conflict of interest related to this manuscript.

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