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RELATIONSHIP BETWEEN REACTION TIME, MEDAL WINNING AND PERFORMANCE IN THE 60 m HURDLE INDOOR EVENT BEFORE AND AFTER THE CHANGE OF FALSE START RULE

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Summary: 60 m hurdles races are included in the World Indoor Athletics Championships and consist the shortest hurdle race distance. Thus, it is possible that the reaction time (RT) affects the finish time (t60mH) and the rank of the hurdlers. The aims of this research were: a) to examine the relationship between RT and t60mH, b) the possible differentiation of RT: c) between the hurdlers who won a medal in World Indoor Athletics Championships (WM) and those who did not (NMW), d) between hurdlers who competed before (BRC) and after (ARC) the change of the starting rules in 2009. Analysis included 70 performances (WM: n = 28; NMW: n = 42; BRC: n = 32; ARC, n = 38). The differences between WM and NMW and BRC and ARC were examined with independent samples T-test, while the possible relationship between RT and t60mH with Pearson's correlation. The results showed that RT was not significantly different ($p < .05$) between WM and NMW and between BRC and ARC. A weak, but significant, positive correlation ($r = .228$, $p = .016$) between RT and t60mH was observed. Results revealed that RT is a factor that affects t60mH. In conclusion, the essential focus on the reaction time at the starting blocks must be given during the training process.

Key-words: Track and field, hurdlers, reaction time, starting block, sprint.

Introduction

The 60 m hurdles race is part of the indoor track and field events and it is included in the World Indoor Championships program since their inauguration in at 1985. The rules of the 60 m hurdles are the same to those applied for the 110 m and 100 m hurdle race, for men and women respectively, of the outdoor track and field athletics. The differences between the indoor and

outdoor high hurdle events are that in the indoor race: a) athletes should clear only five, instead of ten, hurdles and, b) the distance from the last hurdle to the finish line is smaller by 3.30 m.

Quite similar to the pattern of the 110 m hurdle race (Tsiokanos et al. 2018), analysis revealed that, during the 60mH race, the speed of the athletes follows a consistent pattern (Panoutsakopoulos et al. 2020). In specific, there is a gradual increase of speed from the start till the 4th hurdle, followed by a second acceleration phase after the clearance of the 5th hurdle till the finish line (Kuitunen & Poon 2010). The structure of the 60mH performance is comprised by four main components: a) the start and the sprint to the first 1st hurdle, b) the clearance of the hurdles, c) the sprint of the intermediate distance between the hurdles, d) the sprint from the last hurdle to the finish line. Previous studies have shown that the most decisive factors for the performance are: a) the horizontal sprint velocity, b) the hurdle clearance time (Kuitunen & Poon 2010; Muller & Hommel 1997; Panoutsakopoulos et al. 2020). As for the latter, analysis of the technique index, namely the difference between the performance in a hurdle race and in a race of the same distance without hurdles (Stein 2000), is related with performance in 60mH (Kaisidou et al. 2021), thus indicating the importance of the fast hurdle clearance (Bedini 2016).

Concerning the first component of the race, there are some differences in the way that the hurdlers execute the start of the race compared to sprinters (Bezodis et al. 2019a), due to the presence of the 1st hurdle after 13.72 m from the start line. Furthermore, one of the important factors of this phase is the reaction time (RT) at the sound of the starter's gun. RT is considered the time between the sound signal of the start and the first motor response of the athlete. Although studies proved a significant correlation between RT and the result at the small sprinting distances (Delalija & Babic 2008; Gurses & Kamis 2019; Tønnessen et al. 2013), other studies claimed that there is no correlation between these two variables (Pilianidis et al. 2012a; Panoutsakopoulos et al. 2020). According to past research, the magnitude of RT increases as the running distance decreases (Collet 1999; Delalija & Babic 2008; Juhas et al. 2015). Based on this evidence, since the 60-m hurdle race is the smallest distance of the hurdle events, RT is more likely to be a deciding factor of 60mH performance, considering that a 20ms difference in RT could be translated as a 20 cm difference at the finish line in the 200 m sprint race (Mitašík et al. 2020).

Past research showed that false start regulations may have an effect on elite athletes' RT (Haugen et al. 2013). The current competition rules state that the athletes' RT should surpass the 100 ms threshold to be considered legal (rule 16.6; World Athletics 2019). In addition, with the

exception of the combined events, once an athlete makes a false start, he/she does not have a second opportunity to compete as is immediately disqualified (rule 16.8; World Athletics 2019). This strict start rules regarding the inability to execute a false start is implemented since 2010. This stricter false start rule could have an impact on athletes starting performance, since their caution for not being disqualified due to a false start could be translated as a delay in their RT and, eventually, in larger official time (Collet 1999). Previous studies regarding this topic revealed larger RT in elite male sprinters after the introduction of the stricter false start rules (Haugen et al. 2013; Mitašík et al. 2020 Pilianidis et al. 2012b). Since the importance of RT for the final performance is increased when the distance of the race is shorter, sprinters try to decrease RT (Collet 1999). Thus, it is of interest to examine the effect of the change of start rules in the RT exhibited by elite 60mH hurdlers, as the indoor 60mH is the shortest hurdle event.

Aim of Study

The purpose of this present study was to examine the relationship between RT and performance of elite male athletes who competed on major indoor events in the 60 m hurdle race. Furthermore, additional aims were to examine the possible differentiation of RT: a) over time, b) between the hurdlers who won a medal in a major indoor event and those who did not, and c) between hurdlers competed before and after the change of the false start rule. It was hypothesized that:

1. Medal winners will exhibit a lower RT,
2. RT will be improved over time,
3. RT will be larger after the change of the false start rule in 2009, and
4. RT and performance in the 60-m hurdle race will be related.

Methods

Study design

For the purposes of the study, the official performances (t60mH) of the hurdlers who competed at the finals of the 60 m hurdle race in the World Athletics Indoor Championships were recorded. The exclusion of the data from the previous rounds was based on the concept of increased ecological validity, as athletes were found to exhibit lower RT in the final of an event rather than in the qualifying rounds (Collet 1999; Tønnessen et al. 2013). In addition, data were retrieved from

9 events that were held from 2003 to 2018. This range was selected because there were also changes in the false start rules in 2003. The collected performance data were classified depending on: a) if the athlete won a medal or not in 60 m hurdle race, b) if the event took place from 2003 to 2009 or from 2010 to 2018.

Sample

The final sample included 70 performance cases. From those, 28 cases were from athletes that won a medal (WM; n = 28) and 42 from athletes who didn't win a medal (NMW; n = 42). Also, 32 of the cases were retrieved before the change of the rules (BRC; n = 32) and 38 after (ARC; n = 38). The study was conducted in accordance with the recommendations of the Declaration of Helsinki and the ethical standards of the Institutional Research Committee Guidelines. Nevertheless, there was an exception, as no informed consent was obtained, since the data were acquired from publicly available resources.

Procedure

Performance data of the 60 m hurdle event in the World Indoor Championships held from 2003 to 2018 were obtained from Wikipedia (https://en.wikipedia.org/wiki/0000_IAAF_World_Indoor_Championships_%E2%80%93_Men%27s_60_metres_hurdles where 0000 is the year of the competition) after checking the validity of the presented information with the official results published in the public databases of the World Athletics (https://www.worldathletics.org/competitions/world-athletics-indoor-championships/history/). The criteria considered in order to include a performance in the analysis were: a) the athlete was not banned for doping for the period which his performance was documented, b) t60mH was provided in the publicly available resource, and c) RT was also available.

Statistical analysis

Normality of distribution was assessed using the Kolmogorov - Smirnov test (p > .05). Since the results showed that the variables were normally distributed, separate independent samples T–tests were used to examine the possible differences in RT and t60mH between WM and NMW and between BRC and ARC. In addition, the relationship between RT and t60mH was tested with Pearson's correlation. The differentiation RT and t60mH among championships was checked with repeated-measures ANOVA with Bonferroni adjustments. Significant differences were followed up with Scheffe post hoc analysis. For all tests, the IBM SPSS Statistics v.25 software

(International Business Machines Corp., Armonk, NY) was used, with the level of significance set at $a = 0.05$.

Results

The descriptive statistics concerning RT and t60mH in the examined championships are presented in Table 1. t60mH was not differentiated through time ($F_{8,61} = .695$, $p = .694$). However, RT ($F_{8,61} = 4.602$, $p < .001$) was different in the 2008 World Athletics Indoor Championship compared to the earlier events.

Table 1

Descriptive statistics for reaction time (RT) and official 60 m hurdle race performance (t60mH) in each examined event

Parameter	RT				t60mH			
Event	**mean**	**SD**	**min**	**max**	**mean**	**SD**	**min**	**max**
2003 ($n = 8$)	0.142*	0.015	0.116	0.163	7.57	0.077	7.47	7.67
2004 ($n = 8$)	0.138*	0.010	0.116	0.149	7.57	0.174	7.36	7.87
2006 ($n = 8$)	0.145*	0.021	0.124	0.186	7.53	0.066	7.43	7.62
2008 ($n = 8$)	0.196	0.040	0.136	0.249	7.63	0.129	7.46	7.91
2010 ($n = 8$)	0.157	0.022	0.134	0.196	7.53	0.157	7.34	7.81
2012 ($n = 8$)	0.157	0.020	0.135	0.202	7.58	0.100	7.44	7.74
2014 ($n = 7$)	0.152	0.024	0.143	0.174	7.51	0.058	7.45	7.60
2016 ($n = 8$)	0.152	0.024	0.127	0.200	7.51	0.162	7.41	7.88
2018 ($n = 7$)	0.154	0.017	0.129	0.176	7.59	0.121	7.46	7.77

NOTE: *: $p < .05$ compared to 2008

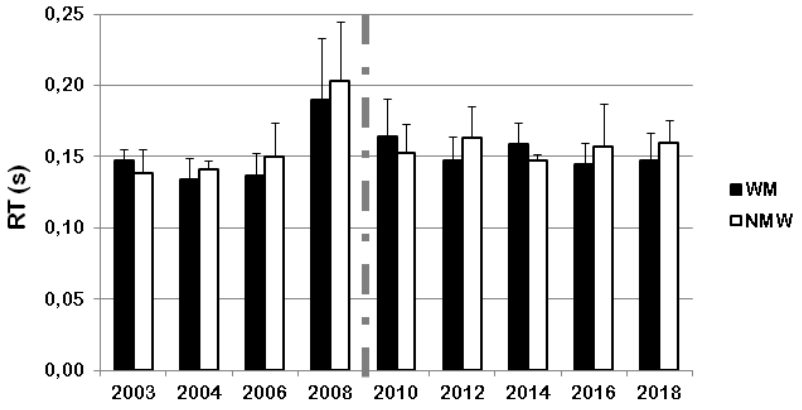

Figure 1

Results for reaction time (RT) observed in medal winners (WM) and no-medal winners (NMW) at each examined World Athletics Indoor Championship. The gray dashed line indicates the year that the false start rule changed.

Additional results concerning the respective descriptive statistics for WM and NMW are depicted in Figures 1 and 2.

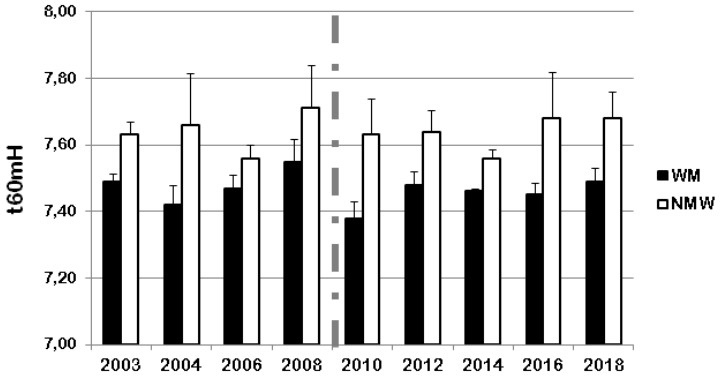

Figure 2

Results for the official 60 m hurdle race performance (t60mH) of the medal winners (WM) and no-medal winners (NMW) at each examined World Athletics Indoor Championship. The gray dashed line indicates the year that the false start rule changed

According to the results of the T-tests, RT was not significantly ($p > .05$) different in both comparisons (Table 2). As for t60mH, WM were significantly ($p < .05$) faster than NMW. On the opposite, t60mH was not significantly ($p > .05$) different between BRC and ARC.

Table 2

Results (mean ± standard deviation) for reaction time (RT) and official 60-m hurdle race performance (t60mH)

Parameters	**WM (*n*=28)**			**NMW (*n*=42)**			***t***	***p***	**BRC (*n*=32)**			**ARC (*n*=38)**			***t***	***p***
RT (s)	0.153	±	.027	0.156	±	.027	.352	.726	0.156	±	.034	0.155	±	.019	.069	.945
t60mH (s)	7.47	±	.062	7.64	±	.102*	8.869	<.001	7.57	±	.119	7.56	±	.125	.379	.706

NOTE: WM: cases of performances won a medal; NMW: cases of performances not winning a medal; BRC: cases of performances before the change of the starting rules; ARC: cases of performances after the change of the starting rules.; *: $p < .05$.

Table 3

Pearson correlation coefficients (r) of the relationship between reaction time and official 60-m hurdle race performance

Cases	***r***	***p***
All cases (n = 70)	.23*	.016
WM (n = 28)	.18	.367
NMW (n = 42)	.44**	.003
BRC (n = 32)	.31	.085
ARC (n = 38)	.29	.081

NOTE: WM: cases of performances won a medal; NMW: cases of performances not winning a medal; BRC: cases of performances before the change of the starting rules; ARC: cases of performances after the change of the starting; * p < .5; **: p < .01.

The Pearson's correlation analysis revealed that there was a weak, but statistically significant (r = .44, p = .016) positive correlation between RT and t60mH (Table 3). In further detail, a positive moderate correlation was found between RT and t60mH for NMW (r = .23, p = .003). On the other hand, in the other examined subgroups (WM, ARC and BRC), no significant ($p < 0.05$) correlations were observed.

Discussion

Due to the short distance of the 60 m hurdle race, it was assumed that the reaction time may affect the final performance and the rank of the athletes. The results showed that reaction time was not different between the hurdlers who won medal and to those who did not, between those who competed before and after the change of the rules at 2009 and it was not decreased over the examined period of time. Regarding the relationship between reaction time and 60 m hurdle performance, a weak, yet significant positive correlation was observed, thus partly confirming the hypotheses of the study.

Compared to the latest event, namely the 2018 World Athletics Indoor Championships, where the average reaction time was .154 s (Walker et al. 2019), the data in the present study showed an almost equal average (.155 s and .156 s for ARC and BRC, respectively). A similar finding was observed concerning the 60 m hurdle performance, where the average value for the athletes who competed at the final of the 2018 Championship was 7.59 s (Walker et al. 2019), thus slightly above the average performance of the sample examined in the present study (7.57 s). The reaction time observed accounted for approximately 2.1% of the total 60 m hurdle performance. This is in reasonable agreement with the notion that the total start can account for approximately 5% of the overall race time (Harland & Steele 1997).

Past research concerning the 2003 false start rule change showed that it had an effect on the reaction time in the 100/110 m hurdle race (Ditrolo & Kilding 2004). This is not in agreement with the present findings, as the change to the current false start rule did not alter the reaction time in the finals of the men's 60 m hurdles races held at World Athletics Indoor Championships. This finding confirms previous findings for the 200 m race (Mitašík et al., 2020). This can attributed to the fact that the hurdlers participating in the final of a major competition are the top, experienced and highly skilled athletes in the event and thus master the sprint start performance (Tønnessen et al. 2013). On the other hand, the correlation revealed for between reaction time and 60 m hurdle

performance may be a result of the short distance of the event, as found in previous studies (Delalija & Babic 2008, Gurses & Kamis 2019, Tønnessen et al. 2013). The shorter the race, the more reaction time is important for the final performance. Thus, since winning or losing is decided at hundredths of seconds, the factors that affect the final performance play a considerable larger role. So, it is important that practitioners should emphasize on the necessary monitoring of the reaction time in the training process (Mitašík et al. 2020).

In general, several factors have an impact on reaction time. Among them is the effect of the distance between the starting gun and the athlete (Majumdar & Robergs 2011) and of the running lane (Brown et al. 2008). Other contributing factors are the age, training, performance level and experience of the athletes (Tønnessen et al. 2013, Bezodis et al. 2019b). In addition, reaction time is affected by gender (Babic & Delalija 2009, Lipps et al. 2011, Mitašík et al., 2020), various psychomotor parameters (Collet 1999, Ille et al. 2013, Stadler et al. 2020) and the false start measurement technology (Haugen & Buchheit 2016, Milloz et al. 2021). As for the psychological factors, concentration is of importance for a fast reaction time (Collet 1999). However, increased external pressure results in slower reaction time (Tønnessen et al. 2013). In the case of the false start rule, the fear of disqualification may inhibit the ability to perform a fast reaction time at the sprint start (Tønnessen et al. 2013). The above indicate the importance of implementing training drills that improve the reaction skills in a regular and systematic manner.

Unlike the 100 m race, where a decreasing trend is observed in the start reaction in the 2010s (Zhang et al. 2021), there were no significant changes in average reaction time in the indoor 60 m hurdles race. This can attributed to the differences between hurdlers and sprinters concerning the start and the initial acceleration after the exit from the starting blocks. A recent study in elite athletes showed that hurdlers use a starting block arrangement with larger inter-block distance and with the front block placed closer to the start line (Bezodis et al. 2019a). In the same study, a higher body center of mass position while in the starting blocks was recorded for the hurdlers than the sprinters. These alterations possible change the neuromechanics of the sprint start movement that have an effect on exit velocity (Mero et al. 2006; Schot & Knutzen 1992). In addition, hurdlers use to get out of the blocks in an upright trunk position as, besides accelerating, hurdlers have to cover the first meters of the race regulating their step parameters aiming to negotiate the clearance of the first hurdle (Panteli et al. 2020). Thus, a specific step pattern is adopted (González-Frutos et al. 20019, 2020). It was found that the vast majority of hurdlers, after the false start rule change in

2009, use a 7-step approach to the first hurdle (López del Amo et al. 2018). This fact changes the selection of the front leg in the starting blocks, as, with this arrangement, the rear leg is the push-off leg for the clearance of the first hurdle. Normally, at the rear starting block, less resultant mean force is applied (Nagahara et al. 2020). In the case of a 7-step approach, the impulse in the front block, which is larger than the rear, is generated from the swing/lead rather than the push-off/trail leg for the hurdle clearance. This might have a negative effect on the effectiveness of the sprint start.

As for the limitations of the study, one of the factors that weren't taken under consideration was the effect of contacting the hurdle during its clearance. Contacting the hurdle affects the final performance with various ways, since it is translated: a) as an increase at the hurdle clearance time, b) as a loss of rhythm at the approach of the next hurdle, and c) as an overall loss of athlete's horizontal velocity, one of the most decisive factors of performance (Iwasaki et al. 2020). Despite the above, the 100 ms threshold itself is questionable and it is suggested to be either lower (80 – 85 ms according to Komi et al. 2009, Pain & Hibbs 2007) or higher (115 ms according to Brosnan et al. 2017, Lipps et al. 2011). Nevertheless, future research on the effect of the false start rule change on sprint start reaction time should consider all disciplines at various performance levels in relation with the performance structure of the event.

Conclusion

Reaction time was not different before and after the change of the rules at 2009 in the shortest hurdle race event, the indoor 60 m hurdle race in particular. However, performance was affected by the reaction time at the start. The results of the present study showed that there was a weak, but significant correlation between reaction time and the finish time. Thus, the exit from the blocks, especially in racing events with short distance, not only matter regarding the finish time of the athletes, but also as a factor which could be decisive for the outcome of the race. Based on this, it is suggested that, during the training process, the essential focus must be given on the exit from the blocks and the reaction time to the stimulus of the starter's gun.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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