


Reaction Time and Performance in the Short Sprints

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ABSTRACT

Even though reaction time values are very small, they could differentiate final performance in short sprint races, where the margin of victory is often measured in thousandths of a second. The aim of this study was to examine the role of reaction time in performance in sprints at the elite level. Data on 60m and 100m races staged in the world's most important competitions from 1996 to 2012, including the IAAF World Indoor Championships, the IAAF World Championships in Athletics (outdoors) and the Olympic Games were gathered from official published results. The times of 565 60m athletes (334 men and 231 females) and 1,533 100m athletes (866 males and 667 female) were analysed. The results showed no significant differences in reaction time between men and women in the 60m, whereas reaction times were shorter for men in the 100m. The analysis revealed an important association between reaction time and performance in the 60m but not in the 100m. The author recommends that athletes, both men and women, and coaches who are looking for success in the 100m should emphasise parameters of their training strategy other than improving reaction time as the means to improve overall performance.

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Introduction

Reaction time in athletics has been defined as the time that elapses between the firing of the starter's gun and the moment that the athlete exerts a pre-determined amount of force on the starting blocks¹. MERO & KOMI² divided reaction time into pre-motor time (the time from the gun signal until the onset of activity in the skeletal muscles) and motor time, (the delay between the onset of electrical activity and the force production by the muscles). There are claims that, even though reaction time values are very small, they could differentiate final performance in the short sprint races, such as the 60m and the 100m, where the margin of victory is often measured in thousandths of a second⁴.

MARTIN & BUONCRISTIANI³ reported the reaction times 171 ± 26 ms and 179 ± 27 ms for men and women respectively for the 1994 European Athletics Championships 100m races. MORAVEC et al.⁵ analysed the reaction time for the 100m finals at the 1987 IAAF World Cham-

pionships in Athletics (175 ± 45 ms and 196 ± 35 ms for men ($n = 8$) and women ($n = 8$) respectively) and concluded that there was no significant correlation between reaction time and final performance. Similar results reported by BRÜGGEMANN & GLAD⁶, who analysed the reaction times in the 100m races at the 1988 Olympic Games (153 ± 21 ms and 152 ± 16 ms for men and women respectively). However, MARTIN & BUONCRISTIANI³ analysed the reaction times of 206 men and 191 women in the 100m (1993 IAAF World Championships in Athletics and 1994 European Athletics Championships) and found significant relationship between reaction time and final performance ($P < 0.001$), but they did not provide any correlation coefficient.

In the case of the 60m, there are no data regarding the correlation between reaction time and performance. Therefore, in order to have a conclusive answer to this issue further research is needed.

The aim of this study was to examine the relationship between reaction time and final performance in elite sprinters in both the 60m and

100m in order to compare men and women and to determine if a short reaction time provides such an advantage that the mastering of techniques to minimise it should be emphasised in training.

Methods

In order to examine the relationship between reaction time and final performance data on sprint races staged in the world's most important competitions from 1996 – 2012, including the IAAF World Indoor Championships, the IAAF World Championships in Athletics (outdoors) and the Olympic Games were gathered from the official published results. The IAAF approved the timing systems used in all the events studied. The times of 565 60m athletes (334 men and 231 females) and 1,533 100m athletes (866 males and 667 female) were analysed (Table 1). The data analysed for both the performance (time of 60m and 100m) and reaction time were obtained from the electronic timing systems at the corresponding events and the best performance of each athlete was included for analysis.

Table 1: Number of participants in the competitions studied

Event	Men	Women
OG Atlanta 1996	104	49
OG Sidney 2000	95	80
OG Athens 2004	80	57
OG Beijing 2008	79	82
IAAF WCA Seville 1999	74	49
IAAF WCA Edmonton 2001	77	53
IAAF WCA Paris 2003	72	56
IAAF WCA Helsinki 2005	58	55
IAAF WCA Osaka 2007	66	70
IAAF WCA Berlin 2009	89	60
IAAF WCA Daegu 2011	72	56
IAAF Indoor WC Birmingham 2003	56	32
IAAF Indoor WC Budapest 2004	58	35
IAAF Indoor WC Moscow 2006	54	33
IAAF Indoor WC Valencia 2008	57	35
IAAF Indoor WC Doha 2010	52	34
IAAF Indoor WC Istanbul 2012	57	62

An independent t-test was used to examine differences between the sexes and a Pearson correlation coefficient was used to establish any significant relationship between the time performance and reaction time. The significance level for the tests was set at $P < 0.05$.

Results

The overall mean reaction time and final performance for the 60m races studied was 185 ± 64 ms and 6.90 ± 0.30 sec respectively for men and 189 ± 59 ms and 7.52 ± 0.42 sec respectively for women (Table 2). The statistical analysis revealed no significant differences in reaction time between men and women. Further analysis of each competition examining the differences in sex in terms of the mean of all the participants in each competition (M_CompT) and in terms of the mean of the participants in the finals (M_FinalT) revealed no significant differences except for the 2010 IAAF World Indoor Championships, where M_CompT of men showed lower reaction times ($P < 0.05$) and at the 2012 IAAF World Indoor Championships, where M_FinalT of men produced slower reaction times compared to women (Table 2). On the other hand performance in 60m was statistically faster for men than in women when the sample was analysed overall, as M_CompT and as M_FinalT (Table 2).

The overall mean reaction time and final performance for the 100m races studied was 166 ± 29 ms and 10.59 ± 0.55 sec respectively for men

and 178 ± 35 ms and 11.85 ± 0.85 sec respectively for women (Table 3).

The statistical analysis revealed significant differences in reaction times between men and women ($P < 0.05$). Further analysis of each competition examining the differences in sex in terms of M_CompT and in terms of M_FinalT revealed that in seven out of eleven competitions the M_CompT of men showed shorter reaction times than women (Table 3), whereas in only three competitions M_FinalT of men showed shorter reaction times (in the 2008 Olympic Games, 2003 IAAF World Championships in Athletics and 2009 IAAF World Championships in Athletics). On the other hand performance in the 100m was statistically faster for men than for women when the sample was analysed overall, as M_CompT and as M_FinalT (Table 3).

The progression of the 60m performances and the reaction times in terms of the best performance of the competition (B_FinalT), M_COMPT and M_FINALT from 2003 to 2012 are shown in Figure 1 and Figure 2 for men and in Figure 3 and Figure 4 for women. Analysing Figure 1 and Figure 3 it is clear that even though BPC and M_FINALT for men and women were constant throughout the years, the M_COMPT in the 60m has worsened. In term of reaction time, both BPC and M_COMPT reaction times worsened throughout the years, whereas M_FINALT remains constant.

Table 2: Reaction time and final time in the 60m races at the IAAF World Indoor Championships (mean \pm SD)

Event	Men		Women	
	RT (ms)	Time (sec)	RT (ms)	Time (sec)
IAAF Indoor WC Birmingham 2003	153 \pm 24	6.84 \pm 0.28*	154 \pm 27	7.33 \pm 0.22
IAAF Indoor WC Budapest 2004	150 \pm 23	6.81 \pm 0.23*	157 \pm 23	7.39 \pm 0.26
IAAF Indoor WC Moscow 2006	176 \pm 50	6.83 \pm 0.23*	180 \pm 47	7.50 \pm 0.37
IAAF Indoor WC Valencia 2008	207 \pm 66	6.93 \pm 0.31*	197 \pm 53	7.48 \pm 0.40
IAAF Indoor WC Doha 2010	181 \pm 47*	6.92 \pm 0.33*	208 \pm 73	7.50 \pm 0.40
IAAF Indoor WC Istanbul 2012	240 \pm 89	7.06 \pm 0.37*	214 \pm 69	7.72 \pm 0.54

* = Significantly shorter than women, as determined by Student's T-test for independent samples ($P < 0.05$)

Table 3: Reaction time and final time in the 100m races at the Olympic Games and IAAF World Championships in Athletics (mean ± SD)

Event	Men		Women	
	RT (ms)	Time (sec)	RT (ms)	Time (sec)
OG Atlanta 1996	171 ± 21	10.55 ± 0.21*	177 ± 20	11.54 ± 0.49
OG Sidney 2000	193 ± 36*	10.56 ± 0.38*	212 ± 35	11.79 ± 0.64
OG Athens 2004	164 ± 24*	10.50 ± 0.44*	187 ± 29	11.65 ± 0.71
OG Beijing 2008	162 ± 20*	10.54 ± 0.51*	190 ± 30	11.99 ± 0.89
IAAF Outdoor WC Seville 1999	154 ± 39	10.51 ± 0.51*	166 ± 48	11.66 ± 0.87
IAAF Outdoor WC Edmonton 2001	165 ± 20	10.60 ± 0.65*	170 ± 30	11.92 ± 0.94
IAAF Outdoor WC Paris 2003	158 ± 28*	10.58 ± 0.49*	172 ± 28	12.07 ± 0.98
IAAF Outdoor WC Helsinki 2005	154 ± 23*	10.62 ± 0.56*	166 ± 26	12.00 ± 0.91
IAAF Outdoor WC Osaka 2007	159 ± 19*	10.70 ± 0.67*	167 ± 27	12.02 ± 1.06
IAAF Outdoor WC Berlin 2009	155 ± 20*	10.62 ± 0.56*	163 ± 25	11.99 ± 0.98
IAAF Outdoor WC Daegu 2011	177 ± 27	10.77 ± 0.81*	188 ± 43	11.62 ± 0.52

* = Significantly shorter than women, as determined by Student's T-test for independent samples (P < 0.05)

The progressions of the 100m performance and reaction time in terms of BPC, M_COMPT and M_FINALT from 1996 until 2011 are shown in Figure 5 and Figure 6 for men and in Figure 7 and Figure 8 for women. Analysing Figure 5 and Figure 6 it can be seen that all three indices for both reaction time and 100m performance for men show fluctuations, and during

the last years they have worsened. However, in term of women, the M_COMPT has shown an improving trend over the last years, even though BPC and M_FINALT have worsened (Figure 7). Finally, reaction time progression in the women's 100m has shown very large fluctuation throughout the years (Figure 8).

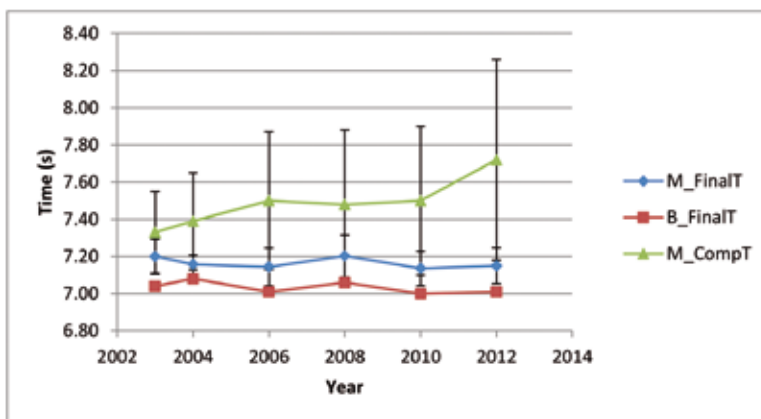


Figure 1: Progression of men's 60m performance in terms of the best performance of the competition (B_FinalT), mean of all the participants of the competition (M_Compt) and mean of the participants in the finals (M_FinalT)

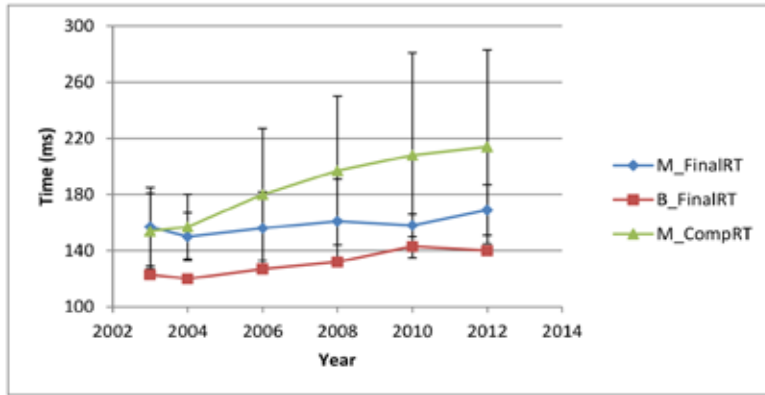


Figure 2: Progression of men's 60m reaction times in terms of the best performance of the competition (B_FinalT), mean of all the participants of the competition (M_CompT) and mean of the participants in the finals (M_FinalT)

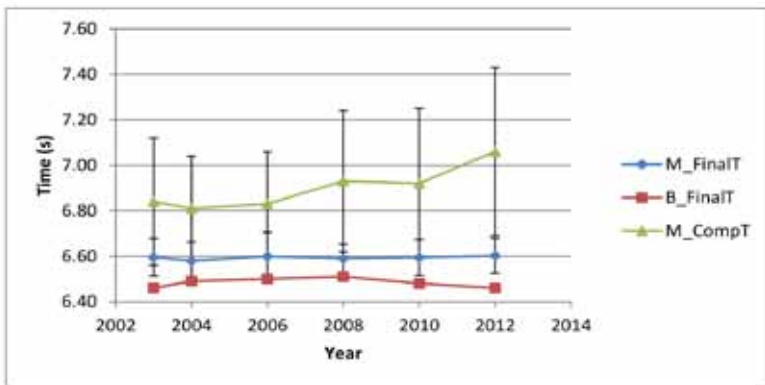


Figure 3: Progression of women's 60m performances in terms of the best performance of the competition (B_FinalT), mean of all the participants of the competition (M_CompT) and mean of the participants in the finals (M_FinalT)

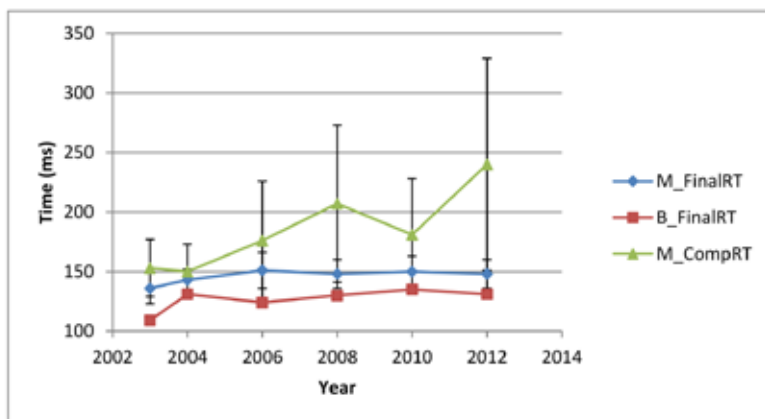


Figure 4: Progression of women's 60m reaction times in terms of the best performance of the competition (B_FinalT), mean of all the participants of the competition (M_CompT) and mean of the participants in the finals (M_FinalT)

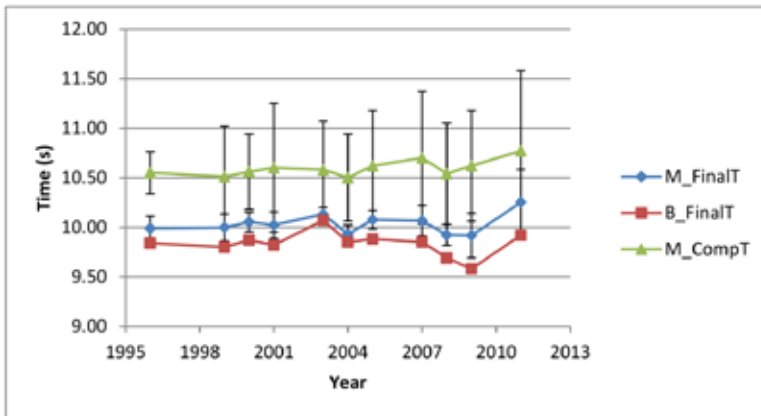


Figure 5: Progression of men's 100m performances in terms of the best performance of the competition (B_FinalT), mean of all the participants of the competition (M_CompT) and mean of the participants in the finals (M_FinalT)

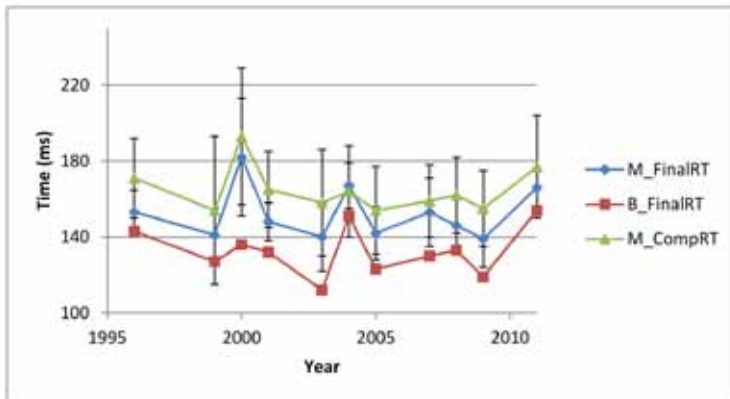


Figure 6: Progression of men's 100m reaction times in terms of the best performance of the competition (B_FinalRT), mean of all the participants of the competition (M_CompRT) and mean of the participants in the finals (M_FinalRT)

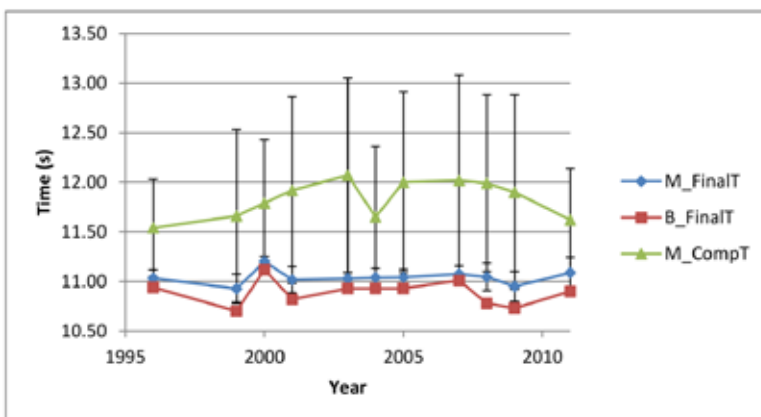


Figure 7: Progression of women's 100m performances in terms of the best performance of the competition (B_FinalT), mean of all the participants of the competition (M_CompT) and mean of the participants in the finals (M_FinalT)

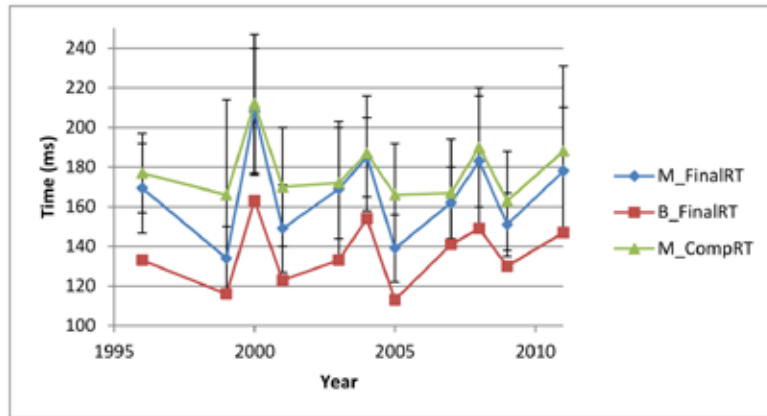


Figure 8: Progression of women's 100m reaction times in terms of the best performance of the competition (B_FinalT), mean of all the participants of the competition (M_CompT) and mean of the participants in the finals (M_FinalT)

The correlation coefficient between reaction time and performance in the 60m races overall was $r = 0.450$, $P < 0.05$: for the men it was $r = 0.550$, $P < 0.05$ ($y = 2.642x + 6.411$) and for the women it was $r = 0.601$, $P < 0.05$ ($y = 4.288x + 6.706$). The correlation coefficients for each of the championships studied appear in Table 4.

The correlation coefficient between reaction time and performance in the 100m races overall was $r = 0.393$; $P < 0.05$, for the men it was $r = 0.349$, $P < 0.05$ ($y = 6.546x + 9.503$) and for the women it was $r = 0.351$, $P < 0.05$ ($y = 8.564x + 10.315$). The correlation coefficients for each of the championships studied appear in Table 5.

Table 4: Correlation coefficients between the reaction time and performance in 60m races (* = $P < 0.05$)

Event	Men	Women
IAAF Indoor WC Birmingham 2003	0.212	-0.009
IAAF Indoor WC Budapest 2004	0.312*	0.236
IAAF Indoor WC Moscow 2006	0.462*	0.459*
IAAF Indoor WC Valencia 2008	0.646*	0.637*
IAAF Indoor WC Doha 2010	0.445*	0.702*
IAAF Indoor WC Istanbul 2012	0.615*	0.597*

Table 5. Correlation coefficients between the reaction time and performance in 100m races (* = $P < 0.05$)

Event	Men	Women
OG Atlanta 1996	0.348*	0.248
OG Sidney 2000	0.276*	0.406*
OG Athens 2004	0.527*	0.471*
OG Beijing 2008	0.433*	0.614*
IAAF WCA Seville 1999	0.409*	0.406*
IAAF WCA Edmonton 2001	0.539*	0.711*
IAAF WCA Paris 2003	0.414*	0.378*
IAAF WCA Helsinki 2005	0.429*	0.582*
IAAF WCA Osaka 2007	0.434*	0.314*
IAAF WCA Berlin 2009	0.341*	0.409*
IAAF WCA Daegu 2011	0.538*	0.401*

For the six analysed 60m competitions we note the following:

- in two cases the first man in the final had one of the three fastest reaction times,
- in five cases the second man had one of the three fastest reaction times,
- in four cases the third man had one of the three fastest reaction times,
- in three cases the first woman in the final had one of the three fastest reaction times,
- in two cases the second woman had one of the three fastest reaction times,
- in two cases the third woman had one of the three fastest reaction times.

For the 11 analysed 100m competitions we note the following:

- in three cases the first man in the final had one of the three fastest reaction times,
- in six cases the second man had one of the three fastest reaction times,
- in four cases the third man had one of the three fastest reaction times,
- in three cases the first woman in the final had one of the three fastest reaction times,
- in three cases the second woman had one of the three fastest reaction times,
- in five cases the third woman had one of the three fastest reaction times.

Discussion

General trends

The analysis of the progression of the 60m for men and women revealed that even though the best performance in the finals remained about the same over the years the average values for the competitions of both reaction time and final time showed increasing trends. This is rather surprising, as one would expect better performance as a result of improved training knowledge and methods. Similar results can be observed in the 100m progression for both men and women. However, further research is needed in order to identify any physiological or/and sociological parameters that could explain this observation.

Sex differences

It is a common belief that men have shorter reaction times than women⁴. Data from studies that examined sex differences in reaction time in response to auditory stimulus in large populations (1,265 and 7,130 accordingly), support the difference in reaction times in favour of men^{7,8}. However, others^{9,10} using small populations (140 and 22 accordingly), did not identify any sex differences in reaction time, even though WINTER & BROOKES¹⁰ did find differences in the Electromechanical Delay (the time interval between the change in EMG and movement). The biological reason for the sex difference in reaction time is not known, but it has been hypothesised that either neurological⁸, or mechanical factors are responsible¹⁰.

Interestingly, the results of this study revealed that there was significant difference in reaction time between the men's and women's 60m races at only two of the events studied even though overall performance for 60m was significantly faster for in men ($P < 0.05$). This approximation of parity in reaction time between the sexes is rather unexpected.

In contrast, in the 100m races studied the men did have significantly shorter reaction times than the women, as well as better overall performances ($P < 0.05$). BABIC & DELALIJA⁴ showed that reaction times of women in the 100m were statistically longer than those of men at the 2004 Olympic Games. MORAVEC et al.⁵ reported trends of longer reaction times for the women 100m runners at the 1987 IAAF World Championships in Athletics, but these were not statistically significant. In the 1988 Olympic Games, the men's reaction times did not differ from that of women's; in fact, M_FINALT of women showed shorter values⁶. MARTIN & BUONCRISTIANI³ reported a trend for shorter men's reaction times compared to women's in both 1993 IAAF World Championships in Athletics and the 1994 European Athletics Championships but, again, these trends were not significantly different.

To summarise, although there is conflicting data from the literature about the 60m, the data regarding the reaction time in the 100m supports the general belief regarding sex differences.

Reaction time and final performance

The results of this study showed that there is a significant association between reaction time and final performance; however the correlation coefficient between reaction time and performance in 60m races is greater in women than men. It looks like reaction time is an important factor in the final performance in the 60m at the elite level.

In contrast, the association between reaction time and final performance in the 100m is rather small except in some isolate cases (Table 5), supporting previous findings. It looks like reaction time does not play an important role in final performance in 100m races at the elite level.

Conclusions

The results of this study revealed no significant differences in reaction time between elite men and women in the 60m, whereas reaction times are significantly shorter for elite men in the 100m.

Additionally, the analysis revealed important associations between reaction time and final performance in the 60m but not in the 100m. Therefore, athletes, both men and women, and their coaches who are looking for success in the 100m should emphasise parameters of their training strategy other than improving reaction time as the means to improve overall performance.

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