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START REACTION TIME AND PERFORMANCE TIME IN WOMEN'S SPRINT AT THE WORLD CHAMPIONSHIPS IN ATHLETICS

Key words: sprint start, speed reaction, reaction time.

ABSTRACT

The purpose of this study was to assess relationships between the start reaction time and performance time in sprinters. The data for analysis came from the women's final events of 100 m (n = 53), 200 m (n = 53) and 100 m hurdles (n = 55) at the World Athletics Championships. The evaluation of both sprinters' start reaction time (ms) and performance time (s) were based on the IAAF Official Reports. The regression analysis revealed that the start reaction time was not associated with sprinting performance. The multiple comparisons for the female finalists reported a significantly faster start reaction time only in the 200 m race in Sydney 1997 in relation to Paris 2003 ($p < 0.05$) as well as significantly better performance in the 200 m event during the World Championships in Seville in 1999 in relation to the Edmonton championships in 2001 only ($p < 0.05$). Conclusively, in world-class female athletes the faster start reaction time did not bring any advantage at the finish line during sprint events.

INTRODUCTION

Being able to run fast is extremely important for success in a variety of sports. Speed in sports is the ability, via both motor control mechanisms and the neuro-muscular system, to achieve a fast reaction time as well as the highest running performance [1, 2]. In athletics, running speed is one of the most important factors for winning, especially in sprint events. A sprint race starts with the firing of the starter's gun followed by the action of the athlete after a time lapse known as the reaction time. This is the time taken to transfer the sound waves to nerve impulses that activate muscle fibres, and it naturally depends on the athlete's training level, functional state and fatigue during strong competition loads [3].

One of the first studies on reaction time [4] revealed that international level athletes appeared to perform better and attain more stable reaction times in comparison with novice athletes in all sprint events. Similarly, a later study confirmed that novice athletes who participated in 200 m races had their reaction times at the start as high as 300 ms, while world-class sprinters achieved reaction times below 150 ms in this event [5].

An interesting question is whether the start reaction time positively affects the athlete's competitive running performance. Reaction time is one of several factors determining success in sprint events. The overall race finish time is determined by a combination of quick start reaction time and both mobilizable and sustainable power [6, 7]. Since start reaction times were measured for the

first time at the Munich Olympic Games in 1972, less than 1% of athletes who participated in sprint events have yielded reaction times below 120 ms with the average recorded start reaction times in 100 m races of approximately 160 ms for men and 189 ms for women. Additionally, a comparison of the start reaction times of male athletes in particular events revealed that 100 m and 100 m hurdles sprinters achieved shorter reaction times than equal level athletes who participated in the 200 m event at the 1972 Olympics [8].

In assessing the impact of start reaction time upon sprinting performance it is important to mention the scientific summary of the 1987 IAAF World Championships in Athletics in Rome, which revealed that the longer the sprint distance, the longer the mean start reaction time was, and also that an outstanding start reaction time had little bearing on whether an athlete won the race or not [9]. In a more qualitative approach other researchers noted that a time of 200 ms represents only 2% of a 100 m sprint lasting 10.00 s, or 0.4% of a 400 m sprint lasting 45 s in top level athletes [10], while in international level female athletes the start reaction time was reported longer than in their male counterparts, however, statistically non-significant [11].

From the late 1990s sprinters like the Jamaican Merlene Ottey to the present-day generation of female athletes training excellence as well as sophisticated sports equipment have had a positive impact on sprinting performance. The purpose of this study was to identify the relationship between start reaction times of female sprinters who participated in the IAAF World Athletics Championships from 1997 to 2009 and their performance in sprint events.

METHODS

This study sample consisted of 161 female athletes ($n = 161$) who participated in the final sprint races of 100 m ($n = 53$), 200 m ($n = 53$) and 100 m hurdles ($n = 55$) in the IAAF World Athletics Championships in Sydney 1997, Seville 1999, Edmonton 2001, Paris 2003, Helsinki 2005, Osaka 2007 and Berlin 2009. Twelve sprinters ($n = 12$) in the final races who were disqualified or took a fair start but did not pass the finish line were excluded from the study. The start reaction times (ms) and the athletes' performance times (s) were

analyzed on the basis of the Official Reports published by the International Association Athletics Federation. Descriptive statistics with exploration and cross-tabulation were performed for all categorical variables. The differences in start reaction times between the three sprint events were assessed with the use of a paired samples t-test. Comparisons between continuous (reaction time and sprint performance) and fixed factors (IAAF World Athletics Championships) were performed with the use of Multi-Analysis of Variance (MANOVA, & *post hoc* Bonferroni comparisons). Linear regression analysis was applied in order to predict sprinters' performance from the reaction time at the start. The level of statistical significance was set at $p < 0.05$. All statistical calculations were carried out with the use of SPSS-PASW ver. 18.0 for Windows (SPSS, Inc., Chicago, IL).

RESULTS

The statistics for the start reaction time and performance time (mean \pm 95% CI, minimum/maximum) in women final races at 100 m, 200 m and 100 m hurdles at the 7th IAAF World Athletics Championships from Sydney 1997 to Berlin 2009 are presented in Table 1. The multiple comparisons for the female sprinters who participated in these championships showed significantly faster start reaction times only in the 200 m final race in Sydney 1997 in relation to Paris 2003 ($F_{1,6} = 3.47$, $p < 0.05$), as well as significantly better running performance in the 200 m event during the Seville championships 1999 in relation only to the Edmonton 2001 Championship [$F_{(1,6)} = 2.97$, $p < 0.05$]. Similarly to the above results, at the 1997 championships in Sydney significantly faster reaction times at the 100 m hurdles start were recorded than both in Paris 2003 and in Helsinki 2005 [$F_{(1,6)} = 3.64$, $p < 0.05$].

The paired samples t-test showed significant differences in the start reaction time between sprint events. In this study, the female athletes' mean reaction times at the sprint start at the level of statistical significance were:

- 100 m (149 ± 23 ms) and 200 m (169 ± 31): $t = -4.43$, $df 52$, $p < 0.001$;
- 100 m (149 ± 23 ms) and 100 m hurdles (140 ± 15 ms): $t = 2.334$, $df 51$, $p < 0.05$;
- 100 m hurdles (140 ± 15 ms) and 200 m (169 ± 31): $t = 6.36$, $df 51$, $p < 0.001$.

Table 1. Start reaction times and performance times at the women's 100 m, 200 m, and 100 m hurdles final races (mean (95% CI, fastest/slowest) of IAAF World Athletics Championships; * $p < 0.05$)

Mean (95%CI) fastest- -slowest	100 m		200 m		100 m Hurdles	
	Reaction Time (ms)	Time (s)	Reaction Time (ms)	Time (s)	Reaction Time (ms)	Time (s)
Sydney 1997	142 (120-165) 110-180	11.06 (10.89-11.22) 10.83-11.29	142 (125-160)* 120-180	22.50 (22.36-22.63) 22.32-22.73	127 (116-137)* 110-140	12.73 (12.56-12.89) 12.50-12.98
Seville 1999	134 (120-147) 116-162	10.92 (10.80-11.05) 10.70-11.16	157 (116-199) 124-277	22.29 (22.08-22.51) 21.77-22.64	138 (122-154) 107-155	12.64 (12.45-12.83) 12.37-12.97
Edmonton 2001	149 (125-172) 123-189	11.02 (10.88-11.15) 10.82-11.17	161 (148-173) 140-176	22.89 (22.67-23.12) 22.52-23.15	138 (126-149) 123-153	12.59 (12.46-12.71) 12.42-12.79
Paris 2003	169 (138-200) 133-219	11.03 (10.97-11.08) 10.93-11.11	201 (174-228)* 144-230	22.75 (22.50-23.00) 22.38-23.00	154 (148-159)* 146-161	12.74 (12.65-12.83) 12.57-12.87
Helsinki 2005	139 (124-153) 113-165	11.04 (10.98-11.10) 10.93-11.13	169 (156-181) 144-190	22.55 (22.30-22.80) 22.16-23.00	150 (140-159)* 138-174	12.79 (12.67-12.92) 12.53-12.97
Osaka 2007	162 (147-177) 141-189	11.07 (11.00-11.14) 11.01-11.26	187 (161-212) 136-239	22.61 (22.28-22.94) 21.81-23.08	131 (117-146) 105-161	12.55 (12.48-12.61) 12.46-12.66
Berlin 2009	151 (137-164) 130-173	10.95 (10.82-11.07) 10.73-11.16	170 (159-181) 141-184	22.59 (22.29-22.87) 22.02-23.05	144 (133-155) 128-164	13.01 (12.15-13.86) 12.51-15.53

The regression analysis was applied in order to evaluate possible prediction of each sprint event performance at the finish line from the start reaction time. The standardized value of start reaction time for 100 m performance with the multiple $R = 0.02$, did not permit to predict female athletes' performance at 100 m sprint event from the reaction time at the start ($F_{1,51} = 0.941$, $p < 0 = 0.337$). Similarly to the 100 m final races at the IAAF World Athletics Championships, in the 200 m sprint event the regression results showed that the multiple R was close to zero ($R^2 = 0.03$) making it impossible to predict the sprinters' performance at 200 m from the start reaction time ($F_{1,51} = 1.626$, $p < 0 = 0.208$). Finally, in the regression coefficients of the linear equation in order to predict the finalists in IAAF World Athletics Championships, the 100 m hurdles races results revealed multiple R as low as 0.038, i.e. the start reaction time was not associated with performance time in this women's sprint event ($F_{1,53} = 2.084$, $p = 0.155$).

DISCUSSION

The analysis of relationships in start reaction times between the 100 m, 200 m and 100 m hurdles races at the IAAF World Athletics Championships showed that in the 200 m final race in Sydney 1997

the mean start reaction time was the best. In the final 200 m race in Sydney 1997 a statistically significant faster start reaction time (142 ms) was recorded, while a longer start reaction time was reported at the Paris 2003 Championship (201 ms). Similar to the 200 m race, the start reaction time in 100 m hurdles in Sydney 1997 was the shortest of all Championships. Additionally, significantly better start reaction times were recorded only in the 100 m hurdles event in Sydney 1997 (127 ms) as compared with the Paris 2003 (154 ms) and Helsinki 2005 (150 ms) Championships. The above findings can be interpreted as a result of the IAAF change concerning the false start rule from March 2003, according to which the athlete is disqualified at the 2nd false start [12]. With an approximate delay of 13 ms in mean start reaction times in all sprint events after the Paris 2003 Championship, the longer recorded reaction times in sprint start in Paris 2003 and in Helsinki 2005 seem to be related to the new IAAF false start rule [13].

With regard to the progressive distance of sprint events (100 m, 100 m hurdles, 200 m) at all IAAF World Athletics Championships, the mean start reaction times became significantly and linearly longer. Outstanding start reaction times were reported in 100 m hurdles (140 ms), while the start reaction times in 100 m and in 200 m sprint events were excellent: 149 ms and 169 ms,

respectively. This confirms the findings of earlier studies which reported that the increase of race length causes a significant linear increase in the mean start reaction times [14, 15]. A possible explanation for this is that sprinters realize that the start reaction time comprises little contribution to their total performance at the finish [5]. Concerning the evaluation of start reaction time as a component of sprint performance, this study confirms, in accordance with previous studies, that the reaction time at the sprint start is not related to female sprinters' performance [9, 16].

Considering the quality assessment of the winners of women's sprint events of 100 m, 200 m and 100 m hurdles at the IAAF World Athletics Championships, it is apparent that the majority of the above sprinters achieved both outstanding performance times and excellent start reaction times (Tables 2, 3, 4). It is also important to note that Michelle Perry representing the USA, winner of the 100 m hurdles final race at the Osaka 2007 Championships, had a 105 ms start reaction time, the fastest of all winners of IAAF Championships, from Sydney 1997 to Berlin (Table 4).

Table 2. Start reaction time (ms) and performance time (s) of winners of women's final races of 100 m. 1997-2009 International Association of Athletics Federations – IAAF Official Reports©

Championship	Athlete	Country	Time (s)	Start reaction time (ms)
Sydney 1997	Jones Marion	USA	10.83	160
Seville 1999	Jones Marion	USA	10.70	120
Edmonton 2001	Pintusevitch-Block Zhanna	UKR	10.82	123
Paris 2003	Edwards Torri	USA	10.93	133
Helsinki 2005	Williams Lauryn	USA	10.93	146
Osaka 2007	Campbell Veronica	JAM	11.01	167
Berlin 2009	Frasher Ann-Shelly	JAM	10.73	146

Table 3. Start reaction time (ms) and performance time (s) of winners of women's final races of 200 m. 1997-2009 International Association of Athletics Federations – IAAF Official Reports©

Championship	Athlete	Country	Time (s)	Start reaction time (ms)
Sydney 1997	Pintusevitch Zhanna	UKR	22.32	120
Seville 1999	Miller Inger	USA	21.77	124
Edmonton 2001	Ferguson Debbie	BAH	22.52	176
Paris 2003	Kapachinskaya Anastasiya	RUS	22.38	222
Helsinki 2005	Felix Allyson	USA	22.16	180
Osaka 2007	Felix Allyson	USA	21.81	172
Berlin 2009	Felix Allyson	USA	22.02	173

Table 4. Start reaction time (ms) and performance time (s) of winners of women's final races of 100 m hurdles. 1997-2009 International Association of Athletics Federations – IAAF Official Reports©

Championship	Athlete	Country	Time (s)	Start reaction time (ms)
Sydney 1997	Enquist Ludmila	SWE	12.50	120
Seville 1999	Devers Gail	USA	12.37	113
Edmonton 2001	Kirkland Anjanette	USA	12.42	123
Paris 2003	Felicien Perdita	CAN	12.53	147
Helsinki 2005	Perry Michelle	USA	12.66	149
Osaka 2007	Perry Michelle	USA	12.46	105
Berlin 2009	Hylton-Foster Brigitte	JAM	12.51	157

Additionally, Zhanna Pintusevitch from Ukraine in 100 m at Edmonton 2001 and in 200 m at Sydney 1997 won the final races with start reaction times of 120 ms and 123 ms, respectively (Tables 2, 3). Finally, from this qualitative point of view the average reaction times at the sprint start tend to be longer in all final sprint races after the false start rule was first applied at the Paris 2003 IAAF World Athletics Championship.

It can be concluded that the start reaction time does not exert a significant impact on the sprinting performance. This means that a faster start reaction could not produce any advantage at the finish line in women's sprint events. Evaluating the IAAF new false start rule applied from March 2003, it is obvious that it has a negative effect on female top-level athletes' start reaction time improvement in both winners and finalists in sprint events of the IAAF World Athletics Championships from 2003 onwards.

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