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INDIVIDUAL PERFORMANCES RELATIVE TO SEASON BESTS IN MAJOR TRACK RUNNING CHAMPIONSHIP RACES ARE DISTANCE-, POSITION- AND SEX-DEPENDENT

Arturo Casado [1]; Andrew Renfree [2]; Beatriz Maroto-Sánchez [1]; Brian Hanley [3]

1. Faculty of Health Sciences. Isabel I de Castilla International University, Spain.
2. Institute of Sport and Exercise Science. University of Worcester, United Kingdom.
3. Carnegie School of Sports. Leeds Beckett University, United Kingdom.

ABSTRACT

Objectives. To compare season's best times preceding major championships (SBprior) and times achieved in major championship flat track races. Material and methods. 2320 men's and 2312 women's finishing times over 100 m, 400 m, 800 m, 1500 m and 5000 m at the International Association of Athletics Federations (IAAF) World Championships and Olympic Games from 1999 to 2019, and their SBprior, were obtained via IAAF open-access website. Paired t-tests were used to compare major championship times and SBprior for groups across sex in each event. Repeated measures ANOVA was used to examine differences in the percentage of SBprior achieved in the major championship races (%SBprior) between groups and sexes. Results. Finishing time performances were generally slower than SBprior. The difference between SBprior and championship performances increased with distance run and across preliminary rounds and finals. Differences in %SBprior between sexes were found in non-medal finalists in the 800 m and 5000 m ($p < 0.001$, ES ≥ 0.72). Conclusions. 1500 m and 5000 m athletes competing at major championships should train and be physiologically prepared to sustain non-even paces and produce a fast endspurt to achieve an optimal performance.

Keywords: competition, performance, tactics, track and field, training

EL RENDIMIENTO EN LOS GRANDES CAMPEONATOS DE ATLETISMO EN CARRERAS DE PISTA EN RELACIÓN AL MEJOR TIEMPO DE LA TEMPORADA DEPENDE DE LA DISTANCIA DE LA PRUEBA, DE LA POSICIÓN Y DEL SEXO DEL ATLETA

RESUMEN

Objetivos: Comparar los mejores tiempos de la temporada alcanzados previamente al gran campeonato (SBprevio) con los tiempos alcanzados en grandes campeonatos en carreras de pista lisas. Material y métodos: se recopilaron desde la página web de acceso abierto de la Asociación Internacional de Federaciones de Atletismo (IAAF) 2320 tiempos finales de hombres y 2312 de mujeres en las pruebas de 100 m, 400 m, 800 m, 1500 m y 5000 m realizados en los Campeonatos del Mundo de la IAAF y Juegos Olímpicos desde 1999 hasta 2019, y sus SBprevio. Se utilizaron t-tests emparejados para comparar los tiempos alcanzados en los grandes campeonatos y los SBprevio entre grupos y sexo. Se utilizaron ANOVA de medidas repetidas para examinar las diferencias en el porcentaje de SBprevio alcanzado en las carreras de los grandes campeonatos (%SBprevio) entre grupos y sexo. Resultados: Los tiempos finales alcanzados en carreras de grandes campeonatos fueron generalmente mayores que SBprevio. La diferencia entre SBprior y rendimiento en los grandes campeonatos se incrementó con la distancia recorrida y disminuyó según avanzaban las rondas preliminares hasta la final. Se encontraron diferencias en %SBprevio entre sexos en finalistas no-medallistas en 800 m y 5000 m ($p < 0.001$, TE ≥ 0.72). Conclusiones: Los corredores de 1500 m y 5000 m que compiten en grandes campeonatos deben tanto estar fisiológicamente preparados como entrenar para mantener ritmos variables durante la carrera y ser capaces de acelerar al final de la carrera para poder alcanzar un rendimiento óptimo.

Palabras clave: competición, rendimiento, táctica, atletismo, entrenamiento

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Correspondence:
Arturo Casado Alda
Faculty of Health Sciences. Isabel I de Castilla International University. Burgos (Spain).
arturocasado1500@gmail.com
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INTRODUCTION

Performance peaking at the International Association of Athletics Federations (IAAF) World Championships and Olympic Games is paramount for most elite track and field athletes because these championships represent their main goal of the season. However, this goal can differ from non-championships races, where the goal is to achieve the lowest time possible over a specific race distance (e.g., to achieve the qualifying time for the championships). In championships themselves, the goal is to achieve the highest possible end position in the final, or a position during the preliminary rounds that allows athletes to qualify for the next round, where the actual time achieved might not be so important (Hanley & Hettinga, 2018). These circumstances might in fact negatively affect the performance times achieved, in the sense that, although athletes are presumably in their best physical condition during the major championships, they might not achieve their season's best times. Any differences between preceding season's best performances ("SBprior") and championship performances might themselves differ depending on the event's characteristics because of a number of factors. Accordingly, there are three main differences between sprint races (100 m to 400 m) and middle- and long-distance races (800 m, 1500 m and 5000 m): distance to complete; whether they run in separate lanes; and the number of participants in the race (which increases with distance run) (IAAF, 2017).

In the IAAF World Championships and the Olympic Games, rewarded positions (medallists and finalists) occur in the final race. Before the final, other qualifying races such as heats and semi-finals allow a predetermined number of athletes to participate in the next race based on either finishing in the highest positions, or by finishing time as a "fastest loser". The allocated number of qualifying rounds and the recovery time between them differ between events and are dictated by the event distance (IAAF, 2017). However, in non-championships races, additional previous races (that might affect final race performance in terms of recovery) are not held and athletes effectively run in a straight final. Similarly, the preliminary rounds at major championships are run at slower paces than the final, as the standard of competitors within any specific race increases through the successive qualifying rounds (Casado & Renfree, 2018; Hanley & Hettinga, 2018; Hanley, Stellingwerff, & Hettinga, 2019), but what precise intensity of SBprior is adopted per round is not established. The preparation needed for one-off non-championship performances (that typically involve aiming to achieve a fast time) might therefore differ from what is required to do well in championships that incorporate multiple rounds.

Previous research has found sex-based differences in pacing in the 800 m (Filipas, Ballati, Bonato, La Torre, & Piacentini, 2018), 5000 m and 10000 m

(Filipas, La Torre, & Hanley, 2018), marathon (Hanley, 2016) and ultra-distance races (Renfree, Crivoi do Carmo, & Martin, 2016). but whether there are differences between non-championships race performances and those in major championships in athletics have not been considered, but could reveal whether sex-based differences in race preparation are appropriate. Finishing time performance is obviously influenced by athletes' finishing positions in championships finals; consequently, medallists achieve a higher performance than non-medal finalists. All the aforementioned variables might influence the performance time of athletes running at major championships in track races. It was hypothesised that the longer the race distance, the slower the finishing times in major championships relative to SBprior because of increased race time. That is, middle- and long-distance running races in non-championships races are typically characterised by the presence of a pre-arranged pacemaker to maximise performance (Noakes, Lambert, & Hauman, 2009). By contrast, these pacemakers are not available at major championships, and different tactical approaches might be used as a result (Casado & Renfree, 2018; Renfree, Mytton, Skorski, & Clair Gibson, 2014). Thus, the purpose of this study was to compare SBprior and heat, semifinal and final race time performances across different distances for non-medal finalists and medallists, and to contrast these differences for sex at major championships in flat track races.

METHOD

The finishing time and the SBprior performances preceding each championship of each athlete who finished among the top eight finishing positions in men's and women's track finals were obtained for the finals, semi-finals and heats (before the semi-finals) over 100 m, 400 m, 800 m, 1500 m and 5000 m at the IAAF (International Association of Athletics Federations) World Championships and Olympic Games from 1999 to 2019, inclusive (16 championships in total), via the open-access World Athletics website (www.worldathletics.org). These times were recorded using official electronic timing devices, accurate to 1/1000 s (IAAF, 2015). A total of 2472 men's performances taken from the results achieved by 240 medallists and 382 non-medal finalists and 2463 women's performances taken from the results achieved by 240 medallists and 377 non-medal finalists were included in the analyses. Thirty-four athletes who were disqualified, 3 athletes who did not start and 6 athletes who did not finish the final were excluded. All individual finishing times were calculated relative to SBprior performance (%SBprior): (Race time / SBprior) x 100.

Finishing times from three races per championship were analysed in the 100 m, 400 m, 800 m and 1500 m, and from two races per championship in the 5000 m. In the 100 m, there were two rounds of heats (the "heats" and “quarter-finals”) until 2009 for all competitors. However, after 2009, athletes who achieved the qualifying time for major championships did not have to participate in the preliminary round (which is held for “unqualified” athletes). Accordingly, the first round of heats (by whatever name it was called) was removed from the analysis of all championships. In the 400 m, athletes contested a round of heats, semi-finals and final from 2001 onwards and, therefore, results from the first round of heats (before a quarter-final round) in 1999 and 2000 were also removed from the analysis. Although three rounds were conducted in the 800 m and the 1500 m from 1999 to 2017, heats were not held in 1999, 2005 and 2008 in the women’s 1500 m. Two rounds were always conducted in the 5000 m (i.e., the heats and final).

Time differences between races across events were also assessed (from the beginning of the first race of a round to the beginning of the first race of the next round). The time from the first to second round of heats in the 100 m up to and including 1999 was 7.5 ± 2.2 h. The time from the second round of heats to the semi-finals, and from the semi-finals to the final, in the 100 m were 25.35 ± 3.43 h and 2.27 ± 0.48 h, respectively. The time from the heats to the semi-finals, and from the semi-finals to the final, in the 400 m were 30 ± 4.34 h and 29.5 ± 9.81 h, respectively. The time from the heats to the semi-finals, and from the semi-finals to the final, in the 800 m were 28.43 ± 4.89 h and 48.34 ± 1.82 h, respectively. The time from the heats to the semi-finals, and from the semi-finals to the final, in the 1500 m were 43.58 ± 13.23 h and 48.07 ± 1.77 h, respectively. The time from the semi-finals to the final in the 5000 m was 75.78 ± 11.31 h.

Statistical analyses were performed using the Statistical Package for the Social Sciences 24.0 (IBM, Armonk, NY, USA). Data were checked for normality of distribution and sphericity assumptions as appropriate. When the sphericity assumption was violated, Greenhouse-Geisser corrections were employed. Descriptive statistics (mean ± standard deviation (SD)) for SBprior time and race times for each participant were calculated for medallists and non-medal finalists in each event (of both sexes). Paired t-tests were used to compare race times and SBprior times for medallists and non-medal finalists across both sexes in each event for the finals, semi-finals and heats (before semi-finals). Effect sizes (ES) between race times and SBprior times were calculated using Cohen’s *d* for medallists, finalists and non-medal finalists of each sex in each event, and considered to be either small (0.21 – 0.50), moderate (0.51 – 0.80) or large (> 0.80) (Cohen, 1988). Additionally, time differences between SBprior and finishing times of each race in terms of %SBprior were also calculated along with the percentage of mean differences (MD (%)). To examine differences in %SBprior between medallists and non-medal finalists between sexes and across events for each type of race, two-way (sex x events) repeated measures ANOVA were used. Where appropriate, post-hoc pairwise comparisons were made with Bonferroni corrections. Statistical significance was set at $p < 0.05$. ES were calculated using partial eta-squared (η_p^2) for the ANOVA tests and Cohen´s d for the post-hoc analysis.

RESULTS

Regarding the eventual medallists, in the men's finals (Table 1) there were no differences between final time and SBprior in the 100 m and 800 m events, whereas finishing times were faster than SBprior in the 400 m, and slower in the 1500 m and 5000 m (both differences had large effect sizes) (Table 1). In the semi-finals, there were at least moderate effect sizes in all events, being large in the 100 m, 800 m, 1500 m and 5000 m. SBprior was always faster than finishing times. In the heats, all events displayed a large effect size with SBprior always faster than finishing times. In the women's events, there were no differences between final time and SBprior in the 100 m, whereas final time was faster than SBprior in the 400 m and the 800 m. In the 1500 m and 5000 m, final times were slower than SBprior. In the semi-finals, finishing times were slower than SBprior. Differences with large effect sizes were found at the 800 m, 1500 m and 5000 m. In the heats, finishing times were slower than SBprior, and all events showed at least moderate effect sizes, being large in the 400 m, 800 m and 1500 m (Table 1).

TABLE 1
Male and female medalists' season best times (SBprior), times in the finals, semi-finals and heats before the semi-finals (Heats) (mean ± SD), paired t-tests, effect sizes (ESrace-SB) and percentage of mean differences (MD (%)) between SBprior times and times achieved at major championships.

Men (n = 48 per event)	100 m	400 m	800 m	1500 m	5000 m
SB_{prior} (s)	9.90 ± 0.09	44.4 ± 0.42	104.07 ± 1.07	211.56 ± 3.01	780.39 ± 10.8
Finals (s)	9.89 ± 0.12	44.24 ± 0.49	104.4 ± 1.33	214.91 ± 4.61	800.31 ± 18.42
$ES_{Final-SB}$	0.12	0.35†	0.27	0.86§	1.32§
MD (%)	−0.12 ± 0.71	−0.36 ± 0.91	0.32 ± 1.16	1.59 ± 2.26	2.56 ± 2.43
Semi-finals (s)	9.99 ± 0.09	44.63 ± 0.44	104.97 ± 0.76	219.01 ± 2.95	807.71 ± 9.04
$ES_{Semi-final-SB}$	1§	0.55†	0.97§	2.5§	2.74§
MD (%)	0.93 ± 0.71	0.54 ± 1.09	0.87 ± 1.11	3.54 ± 1.9	3.52 ±1.71
Heats (s)	10.04 ± 0.1	45.11 ± 0.35	106.41 ± 1.25	219.4 ± 2.74	
$ES_{Heat-SB}$	1.48§	1.83§	2§	2.72§	
MD (%)	1.42 ± 1.12	1.62 ± 1.18	2.25 ± 1.54	3.72 ± 1.94	
Women (n = 48 per event)	100 m	400 m	800 m	1500 m	5000 m
SB_{prior} (s)	10.91 ± 0.16	49.99 ± 0.64	117.85 ± 1.43	240.62 ± 3.45	875.12 ± 18.34
Finals (s)	10.90 ± 0.12	49.61 ± 0.41	117.32 ± 1.26	242.85 ± 4.47	890.01 ± 20.08
$ES_{Final-SB}$	0.1	0.72§	0.39*	0.56*	0.77§
MD (%)	−0.11 ± 1.24	−0.76 ± 1	−0.44 ± 1.27	0.95 ± 2.58	1.73 ± 2.63
Semi-finals (s)	10.95 ± 0.11	50.06 ± 0.3	118.98 ± 1.28	246.58 ± 3.67	908.05 ± 14.62
$ES_{Semi-final-SB}$	0.39*	0.14	0.83†	1.67§	1.99§
MD (%)	0.41 ± 1.35	0.15 ± 1.33	0.97 ± 1.82	2.5 ± 2.21	3.8 ± 2.48
Heats (s)	11.02 ± 0.17	50.91 ± 0.44	120.61 ± 1.32	248.31 ± 2.98	
$ES_{Heat-SB}$	0.64†	1.69§	2,01§	2.38§	
MD (%)	0.98 ± 1.77	1.87 ± 1.7	2.36 ± 1.63	3.48 ± 1.46	

*Significant differences were set at p < 0.05 (*p < 0.05, †p < 0.01, §p < 0.001).*

In all men's events, non-medal finalists' finishing times were slower than SBprior in the final. (Table 2). In the semi-finals, moderate or larger effect sizes were found in all events except the 400 m, with finishing times always slower than SBprior. This was also the case in the heats, where effect sizes were always large in all events. The situation was similar in the women's events, with final time performances also slower than SBprior in all events. Additionally, moderate or larger effect sizes were found in all events except the 800 m.

SBprior was also faster than semi-finals times, showing moderate o large effect sizes in all events except the 400 m. Heat finishing times were always slower than SBprior, with larger effect sizes found in all events (Table 2).

TABLE 2
Male and female non-medal finalists' season best times (SBprior), times in the finals, semi-finals and heats before the semi-finals (Heats) (mean ± SD), paired t-tests, effect sizes ($ES_{race-SB}$) and percentage of mean differences (MD (%)) between SBprior and times achieved at major championships.

Men (n = 48 per event)	100 m	400 m	800 m	1500 m	5000 m
N	73	72	77	80	85
SB_{prior} (s)	9.99 ± 0.1	44.82 ± 0.5	104.31 ± 0.81	213.08 ± 2.07	785.72 ± 10.2
Finals (s)	10.1 ± 0.27	45.01 ± 0.41	105.63 ± 1.37	216.55 ± 4.18	805.32 ± 16.45
$ES_{Final-SB}$	0.53†	0.41†	1.18§	1.05§	1.43§
MD (%)	1.08 ± 2.9	0.43 ± 1.22	1.28 ± 1.37	1.64 ± 2.17	2.5 ± 2.14
Semi-finals (s)	10.05 ± 0.09	44.86 ± 0.4	105.43 ± 2.05	219.3 ± 3.68	808.29 ± 8.55
$ES_{Semi-final-SB}$	0.65§	0.1	0.72§	2.08§	2.4§
MD (%)	0.6 ± 0.85	0.11 ± 1.16	1.08 ± 2.14	2.93 ± 1.93	2.89 ± 1.64
Heats (s)	10.1 ± 0.1	45.16 ± 0.34	106.43 ± 1.02	219.77 ± 2.58	
$ES_{Heat-SB}$	1.12§	0.8§	2.31§	2.87§	
MD (%)	1.1 ± 1.16	0.77 ± 1.15	2.04 ± 1.26	3.15 ± 1.55	
Women (n = 48 per event)	100 m	400 m	800 m	1500 m	5000 m
N	74	73	71	79	80
SB_{prior} (s)	10.97 ± 0.14	50.33 ± 0.5	118.86 ± 1.32	242.49 ± 3.2	892.87 ± 17.28
Finals (s)	11.06 ± 0.1	50.65 ± 0.61	119.24 ± 1.58	245.53 ± 4.62	900.17 ± 18.7
$ES_{Final-SB}$	0.73§	0.61§	0.26	0.76§	0.4†
MD (%)	0.82 ± 1.37	0.65 ± 1.36	0.32 ± 1.5	1.27 ± 2.23	0.85 ± 2.58
Semi-finals (s)	11.06 ± 0.11	50.43 ± 0.38	119.46 ± 1	246.78 ± 3.63	910.67 ± 14.5
$ES_{Semi-final-SB}$	0.68§	0.23	0.51†	1.25§	1.12§
MD (%)	0.81 ± 1.46	0.21 ± 1.03	0.51 ± 1.33	1.79 ± 1.89	2.03 ± 2.25
Heats (s)	11.11 ± 0.09	51 ± 0.38	121.29 ± 1.71	248.63 ± 2.48	
$ES_{Heat-SB}$	1.15§	1.53§	1.59§	2.14§	
MD (%)	1.22 ± 1.36	1.35 ± 1.11	2.07 ± 1.88	2.6 ± 1.54	

Significant differences were set at $p < 0.05$ ($p < 0.05$, †$p < 0.01$, §$p < 0.001$).*

In terms of differences in relative performances (%SBprior) achieved by medallists in the final, there were differences between events (F (2.46, 115.62) = 32,9, $p < 0.001$, $\eta_p^2 = 0.412$). Post-hoc analysis showed that %SBprior differed between the 100 m and 5000 m ($p < 0.001$, ES = 1.15), 100 m and 1500 m ($p < 0.001$, ES = 0.75), 400 m and 1500 m ($p < 0.001$, ES = 0.98), 800 m and 1500 m ($p = 0.002$, ES = 0.7), 400 m and 5000 m ($p < 0.001$, ES = 1.37) and 800 m and 5000 m ($p < 0.001$, ES = 1.09). Therefore, medallists in the 1500 m and 5000 m recorded finishing times representing a greater percentage of %SBprior than did medallists in the shorter events. Again, mean %SBprior was different across sex (F (1, 47) = 17.99, $p < 0.001$, $\eta_p^2 = 0.277$), being higher in the men than women in 800 m ($p = 0.002$, ES = 0.64) (see Figure 1A).

When comparing %SBprior achieved by medallists in the semi-finals, differences between events were found (F (3.48, 162.94) = 83.37, $p < 0.001$, $\eta_p^2 = 0.639$). Post-hoc analysis showed that %SBprior differed between the 100 m and 5000 m ($p < 0.001$, ES = 1.58), 100 m and 1500 m ($p < 0.001$, ES = 1.26), 400 m and 1500 m ($p < 0.001$, ES = 1.58), 800 m and 1500 m ($p < 0.001$, ES = 1.21), 400 m and 5000 m ($p < 0.001$, ES = 1.92) and 800 m and 5000 m ($p < 0.001$, ES = 1.53). Differences between the 800 m and 5000 m and the shorter events were greater than in the final. However, no differences between sexes were found (Figure 1C). Comparisons between medallists' %SBprior in the heats showed differences between events (F (3, 114) = 32.78, $p < 0.001$, $\eta_p^2 = 0.463$). Post-hoc analysis showed that there were differences between the 100 m and 800 m ($p = 0.003$, ES = 0.73), 100 m and 1500 m ($p < 0.001$, ES = 1.54), 400 m and 1500 m ($p < 0.001$, ES = 1.17) and 800 m and 1500 m ($p < 0.001$, ES = 0.83). Again, differences existed between 1500 m and the shorter events, with the latter always having a lower %SBprior. No differences were found between sexes (Figure 1E).

In terms of differences in relative performances (%SBprior) in non-medal finalists in the final, there were neither differences between events nor sex (Figure 1B). When comparing %SBprior achieved by non-medal finalists in the semi-finals, differences between events were found (F (3.02, 172.13) = 48.86, $p < 0.001$, $\eta_p^2 = 0.462$). Again, post-hoc analysis showed that %SBprior differed between the 100 m and 5000 m ($p < 0.001$, ES = 0.95), 100 m and 1500 m ($p < 0.001$, ES = 0.94), 400 m and 1500 m ($p < 0.001$, ES = 1.36), 800 m and 1500 m ($p < 0.001$, ES = 0.96), 400 m and 5000 m ($p < 0.001$, ES = 1.37) and 800 m and 5000 m ($p < 0.001$, ES = 0.97). Differences between sexes were also found (F (1, 53) = 10.64, $p = 0.002$, $\eta_p^2 = 0.157$). %SBprior values were lower in the women in the 5000 m ($p = 0.03$, ES = 0.31) (Figure 1D). Event differences between non-medal finalists' %SBprior in the heats were found (F (1.54, 72.13) = 16.73, $p < 0.001$, $\eta_p^2 = 0.263$). Post-hoc analysis showed that there were differences between the 100 m and 1500 m ($p < 0.001$, ES = 1.14) and 400 m and 1500 m ($p < 0.001$, ES = 1.27). No differences were found between sexes (Figure 1F).

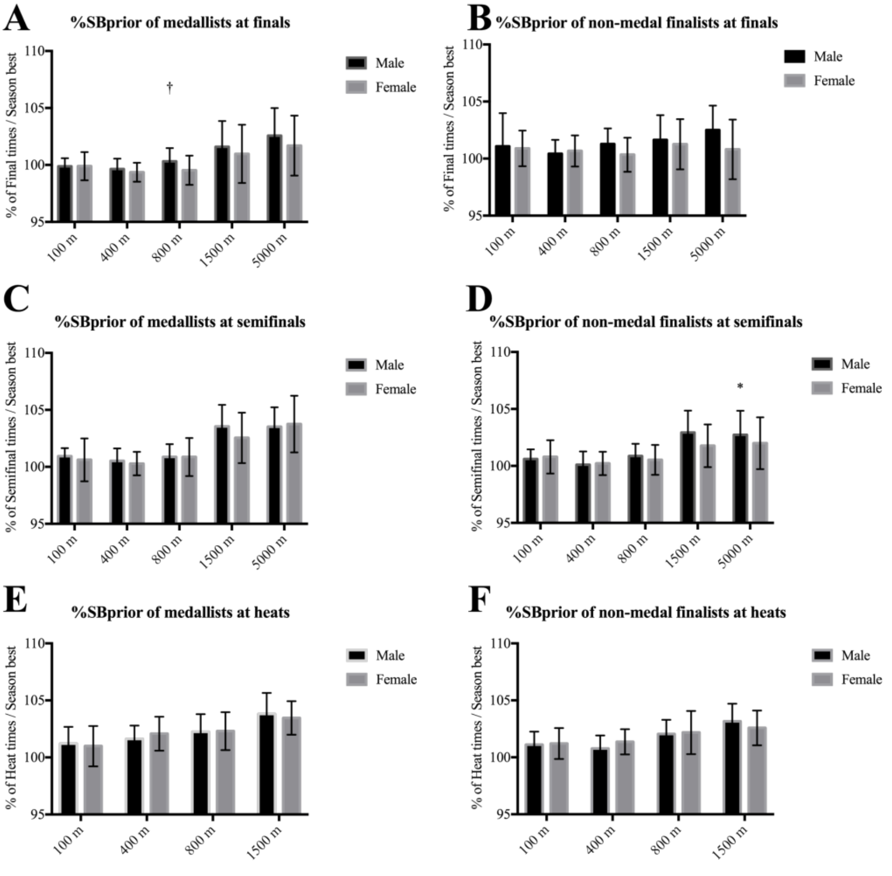

FIGURE 1A-F: Differences of mean %SBprior by events and sex between medallists at finals (A), semi-finals (C), heats (E), and non-medal finalists at finals (B), semi-finals (D) and heats (F). Significant differences were set at $p < 0.05$ (*$p < 0.05$, †$p < 0.01$, §$p < 0.001$).

DISCUSSION

The present study examined the influence of race distance and sex on finishing time performance in the heats, semi-finals and finals of medallists and non-medallists in major athletics championships. We found that absolute performances were generally slower than SBprior achieved before the championships across the heats, semi-finals and finals. This finding differs from that found by Konings & Hettinga (2018), who reported that the importance of competition might influence performance positively (i.e., decrease finishing times) in short track speed skaters. However, the use of pacemakers at non-championships races might explain these differences, which were especially high in the longer events such as 1500 m and 5000 m. In this sense, race distance influenced finishing times proportionally and negatively in non-medal finalists and medallists.

Aspects such as having to prepare for running a certain number of races in a short time period, in contrast to running just one race, might also differentiate the kind of optimal preparation for these competitions. The most important difference amongst both medallists and non-medal finalists was found in comparing finishing time performances in the 1500 m and 5000 m with the shorter events (100 m, 400 m and 800 m). In this sense, it is noteworthy that by contrast to longer races in which medallists achieved a significantly slower final finishing time than their SBprior, 400 m and female 800 m medallists significantly improved their respective SBprior in the final race. This finding agrees with Thiel, Foster, Banzer, & de Koning (2012), who studied the pacing strategies and performances of middle- and long-distance runners at the 2008 Olympics. Those authors reported that athletes displayed a stochastic tactical approach with constant microvariations in pace that preceded a fast endspurt. Furthermore, the best performance in each event differed by 4 – 5 % from the World Record (Thiel et al., 2012). However, as shown in our study, performances were relatively slower than those found in the shorter events, and this might be partially explained by the high number of microvariations in pace that occur during these longer events. Nonetheless, this assertion is not absolutely clear because pacing data from the races included in this study were not available, although it has been established that even paces, rather than variable ones, lead to better finishing time performances in marathon world records (Díaz, Fernández-Ozcorta, & Santos-Concejero, 2018). On average, women's 100 m, 400 m and 800 m medallists and men's 100 m and 400 m medallists recorded better performance in the finals than their previous SBprior performance, suggesting it very likely these sprinters peaked correctly at their major championships as part of a long-term training approach and preparation (Inigo Mujika, Halson, Burke, Balagué, & Farrow, 2018).

Differences between SBprior and finishing times in major championships races did decrease as athletes progressed through the qualifying rounds up to the final. In this regard, the largest differences were found in the heats. This trend was shown in every event amongst medallists and non-medal finalists, except in non-medal finalists in the 400 m and female 100 m, where a larger difference between SBprior and finishing time was found in the final than in the semi-final (Tables 1 and 2). These results suggest a tactical conservation of energy stores during the different qualification races in the championships to reduce fatigue as much as possible before the final for the very best athletes (Hanley et al., 2019). However, it is probable that the non-medal finalists in the

400 m had peaked by the semi-finals and could not replicate those performances in the final. The worst finishing times by non-medal finalist sprinters are therefore also possibly linked with the high volume of races (three or four races in two days for 100 m runners) or psychological factors related to facing an important competition (Neil, Hanton, Mellalieu, & Fletcher, 2011).

This study showed that in the shorter events (100 m and 400 m), medallists performed much closer to their SBprior times in the final than non-medal finalists did. However, this is not the case in the longer events such as the 1500 m and 5000 m, as both medallists and non-medal finalists showed either a similar difference between them or even 5000 m non-medal finalist displayed a smaller difference. Although the underpinning mechanisms that are involved in this phenomenon are not entirely clear, the different characteristics of these shorter and longer events at major championships might account for this difference in the performances of non-medal finalists in the final. Although all athletes across the track events have the same goal (achieving the highest possible position in the final), the only way to reach that goal in the shorter events is by obtaining the fastest finishing time performance through an "all-out" pacing strategy (similar to non-championships races), and no substantial tactical issues in terms of deliberate variation of race pace are involved. It means that sprinters who set a higher pace than their rivals from the beginning of the race and maintained or only slightly reduced it subsequently became medallists. Additionally, sprinters cannot benefit from drafting as they are allocated in separate lanes throughout the race. Similarly, better %SBprior achieved by medallists than non-medallists at major championships were also found in swimmers (Iñigo Mujika, Villanueva, Welvaert, & Pyne, 2019) who are also restricted to separate lanes. By contrast, it appears that the absence of pacemakers (to set a fast pace), and the benefits of drafting that exist in middle- and long-distance races (Casado, Moreno-Pérez, Larrosa, & Renfree, 2019) might allow non-medal finalists in those events to adopt an early non-excessive pace at the beginning (Hanley et al., 2019) and eventually achieve a similar %SBprior to the medallists. Although this statement is not entirely substantiated because of the lack of pacing data, these might be the reasons why considerably higher effect sizes were shown in the differences between final and SBprior times in non-medal finalists in the shorter events than in the longer ones (see Table 2). Accordingly, this pacing strategy was also found in four major championships by Filipas, La Torre, et al. (2018) in the 5000 m, and by Hanley et al. (2019) in the 1500 m, who also found that these races were terminated with a fast endspurt, an eventuality that distance runners aiming to do well in a championship should practise for. According to the present results, elite middle- and long-distance runners aiming for being competitive at major championships have to be ready to run a fast race prior to these championships in order to be able to participate at them, and at the same time to generate a fast endspurt during a slower championship race. These requests have some training implications which are along with recent research which found important relationships between performance and the use of easy and tempo runs for developing a huge aerobic base, and short interval training to be able to produce a fast endpurt during slow races in world-class long-distance runners (Casado, Hanley, Santos-Concejero, & Ruiz-Pérez, 2019). Additionally, it has been found that world-class Kenyan long-distance runners accumulated more training volume during their sport careers as tempo runs and short interval training than elite Spanish long-distance runners (Casado, Hanley, & Ruiz-Pérez, 2019).

Medallists in the women's 800 m final and non-medal finalists in the women's 5000 m semifinal ran faster relative to their SBprior than men. These results might be explained by other research that found that elite female athletes set more even paces than male athletes in the 800 m when achieving their SBprior due to women's relatively slower second 200 m segment than men (Filipas, Ballati, et al., 2018). In addition, pacing differences among sex were also found in 5000 m major championships (Filipas, La Torre, et al., 2018) and in marathon major championships (Hanley, 2016). Women's more even paces might have occurred, among other factors, because women possess proportionately larger areas of slow twitch (type I) muscle fibres that resist fatigue better (Hunter, 2014). However, two previous studies did not find any difference in pacing between men and women in IAAF World Championships in the half marathon (Hanley, 2015) or cross country (Hanley, 2018). According to these results, and especially the results from the studies that researched 5000 m runners pacing during major championships finals, this more even pace might be also adopted by the women in our study that might lead them to a better overall time performance than men. Additionally, Filipas, La Torre, et al. (2018) suggested that this more even pace might be explained by the observed lower density of runners in the leading group earlier in the race compared with men's races.

CONCLUSIONS

Runners' finishing times in track flat races during major championships in athletics are higher than SBprior performance. The difference between SBprior and championship finishing time performances increases with distance run, i.e., 1500 m and 5000 m events were run at a slower relative pace to SBprior than shorter events were. The present results are useful for athletes and coaches because they represent the mean differences between the times achieved by athletes in major championship races and the best times conducted before major championships during the season. Most importantly, combined results on pacing strategies displayed at major championships from current literature (Casado & Renfree, 2018; Filipas, La Torre, et al., 2018; Hanley & Hettinga, 2018; Hanley et al., 2019) and from the present study, which showed that 1500 m and 5000 m events were run slower than when athletes achieved their season's best times, suggest that training for major championships races in these events should focus differently from training for non-championships races, where the goal might be to achieve a qualifying time, regardless of position achieved. Thus, in addition to being ready for an even-paced and overall fast race, athletes must develop their sprinting ability during training to be able to run a very fast endspurt in major championship races. Furthermore, athletes who aim to become a finalist or medallist at major championships must conserve their energy stores as much as possible throughout the championships by racing just to finish in the qualifying positions during the preliminary rounds, rather than obtaining the fastest time possible. In this way, performance is more likely to be optimised during the final, rather than earlier in the championships.

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