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Meso-pacing in Olympic and World Championship sprints and hurdles: Medallists save their best for the final

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ABSTRACT

The aim of this novel study was to analyse performance changes across qualifying heats, semi-finals and finals in world-class sprinters and hurdlers. Finalists' finishing positions, times and rankings at the Olympic Games and IAAF World Championships (2012–2019) were obtained. 78% of gold, 67% of silver and 38% of bronze medallists won their qualifying heat and semi-final, and in most events final placings were associated with finishing positions in the qualifying heats ($P \leq 0.006$), but not with finishing times. Medallists ran faster in each successive round ($P < 0.001$), whereas those finishing between 4th-6th did not improve on their semi-final times. Most athletes finishing last and second-last ran the final slower than both their semi-final and qualifying heats. The short hurdles events, with fixed barrier heights and distances, differed from the other races as the medallists were faster than most rivals in the qualifying rounds ($P < 0.05$), and their race times did not improve from the semi-final to the final. Coaches should note that the world's best athletes were able to conserve energy for the final within a meso-pacing strategy throughout the championships, which was more important in the short hurdles, and requires preparation within their training regimens.

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KEYWORDS
Elite-standard athletes; race tactics; speed; track and field; training

Introduction

The sprint and hurdle events at the Olympic Games and other major track and field championships comprise the 100 m, 200 m, 400 m, 100 m hurdles (women only), 110 m hurdles (men only) and 400 m hurdles. Athletes are allocated a lane that they must stay within and, for those events that start on a bend (200 m, 400 m and 400 m hurdles), the start line is staggered. Unlike in middle-distance championship racing (Hanley et al., 2019), seeding for lanes in the semi-finals and final is prioritised by finishing position, in that the top seeds are the winners of the heats in the preceding round (subsequently ranked by winning time), the next seeds are the runners-up, etc. (World Athletics, 2019). The benefits to winning the heat are thus that it ensures both avoiding other top seeds and a middle lane in the next round. The middle lanes are considered the most advantageous as, in races of 200 m and longer, those running in the outside lanes could find pacing themselves using other athletes more difficult (Renfree et al., 2014), whereas those in the inside lanes have a tighter bend to negotiate (Aftalion & Martinon, 2019), affecting horizontal propulsion (Judson et al., 2019). The championship structure filters the entrants down to eight finalists via a series of earlier rounds. Because the term "heats" is used to describe the first round of qualifying races and the races held within each round (e.g., "semi-final heats"), we have described the first round of competition as the "qualifying heats". The championship structure means 24 athletes progress from the qualifying heats to the semi-finals (comprising three heats of eight athletes), where the highest finishing athletes progress as automatic qualifiers alongside the fastest non-automatic qualifiers (World Athletics, 2019), often referred to as "fastest losers" (e.g., World Athletics, 2017). For the best athletes, planning a strategy that accounts for the multiple races that need negotiating can help plan for championship success.

Sprinters and hurdlers are considered to adopt "all-out" pacing profiles, running at or close to their maximum speed (Casado et al., 2020), and changes in pace that occur, such as the slowing that occurs at the end (Bissas et al., 2018), are not because of any specific strategy but through metabolic and mechanical fatigue (Morin et al., 2006). This suggests that the eventual finalists run as fast in the qualifying heats and semi-finals as they do in the final, or even that they slow in successive rounds because of accumulated fatigue. Indeed, in elite-standard short track skating, it was found that high-intensity race efforts affected performances in subsequent same-day races, although there was less of an effect when races were on successive days (Konings & Hettinga, 2018), and competitors in other multi-stage events, such as cycling grand tours, adopt long-term approaches to distribute their energy reserves (Foster et al., 2005). Given the eventual medallists are the fastest athletes in a specific championships, it follows that those athletes should consistently finish in the top positions in the earlier rounds. In the middle-distance events over 800 m

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and 1500 m, Hanley and Hettinga (2018) found that 70% of gold medallists, 36% of silver medallists and 19% of bronze medallists won both their qualifying races, even though lower qualifying positions would have been sufficient, and attributed some of this behaviour to ego orientation, where sportspeople use performances in competition to judge competence and feel successful when they have outperformed others (in contrast to mastery of tasks, for example) (Kavussanu & Ntoumanis, 2003). Although it might also be important to sprinters and hurdlers to win early rounds for ego orientation reasons (Pensgaard & Roberts, 2002), it is possible that a higher proportion of these medallists win both rounds because of the additional incentive of a high seeding and the all-out nature of pacing.

Those athletes who reach the final have already negotiated two rounds, with all three races typically held over four days. The 100 m sprint and 100 m hurdles events are held over two days, with semi-finals and finals on the same day. Apart from the men's and women's 400 m hurdles events, which are held over four days, the spread of races for the other events was between two and four days for championships held between 2011 and 2019 (World Athletics, 2020). World-class sprinters and hurdlers frequently compete in more than one event, as 100 m runners often also compete in the 200 m or 4 × 100 m relay, and 400 m sprinters and hurdlers frequently take part in the 4 × 400 m relay. The relay events comprise qualifying heats and a final, and although many nations' best runners appear only in the final, athletes might nonetheless compete many times over the course of a championships. For example, Usain Bolt (Jamaica) competed in seven races over seven days in the 2016 Olympic Games, winning all heats, semi-finals and finals he competed in (Almeida, 2016). Within these successive rounds, avoiding fatigue or possible injury as much as possible before the final is an important strategy for sprinters and hurdlers, especially given the subjective element involved in effort and fatigue perception that can mean athletes risk investing too much energy in qualifying (Schiphof-Godart & Hettinga, 2017). Success in championship racing, which comprises tasks known in advance, might therefore involve an element of longer-term meso-pacing throughout the championships, defined here as a strategy of athletes conserving energy across multiple races (over several days) by running slower in qualifying so that they save their best performance for the finals. However, for sprinters and hurdlers, the nature of their events poses a problem in this regard: the benefits of finishing in a high position in terms of seeding and the all-out nature of their events mean that running slower in the early rounds to conserve energy could be a risky strategy for that race, but could have later benefits.

How the world's best sprinters and hurdlers progress through the qualifying heats and semi-finals has not previously been studied as to whether they adopt meso-pacing, whether they use all-out pacing in each race, and whether there are differences between events. Coaches can benefit from this novel research as knowledge of how much effort is required to succeed across multiple races can help them plan for championship meso-pacing, rather than just for single, one-off events like in the Diamond League. The aim of this study was to analyse the performances of world-class sprinters and hurdlers across the qualifying heats, semi-finals and finals. As the all-out nature of these short races suggests a minimal impact of strategic or tactical considerations (Casado et al., 2020), it was hypothesised that there would be no difference in finishing times between the qualifying heats, semi-finals and finals. It was also hypothesised, given the likelihood of similar ego orientation to middle-distance runners and the added incentive of ensuring a high seeding position, that the proportion of eventual medallists who won their heat and semi-final would be higher than that found in middle-distance championship racing.

Methods

Participants

The study was approved by the School Research Ethics Committee. Finishing positions and times of the finalists in the men's and women's 100 m, 200 m, 400 m, 100 m hurdles, 110 m hurdles and 400 m hurdles events at the 2012 and 2016 Olympic Games and the 2013, 2015, 2017 and 2019 IAAF World Championships were obtained from the open-access World Athletics website (World Athletics, 2020). The finalists' finishing positions and times in the qualifying heats and semi-finals were also obtained. An extra preliminary round was held for the lowest ranked qualifiers in the men's 100 m at all championships analysed, and in the women's 100 m at the two Olympic Games analysed. No athlete who took part in the preliminary round reached the final. The finalists were classified as to whether they qualified for the next round as an automatic qualifier (based on position, having finished within those places guaranteeing qualification), a fastest loser (based on time, as one of the fastest athletes not to qualify automatically), or based on an appeal (which could mean more than eight competitors in a final). Any finalist who did not have a full complement of results from all three rounds was excluded (which included four who started but did not finish the final, two who did not start it, and one who progressed after an appeal). The performances of one woman who was injured during the 100 m final were also removed as her finishing time was more than 2.2 times the interquartile range from the median of the scores (Hoaglin & Iglewicz, 1987) and therefore an outlier.

Data analysis

The study was designed as observational research in describing race performances across successive competition rounds (qualifying heats, semi-finals and finals). The number of qualifying heats across all events and championships ranged from four to 10. There were three semi-finals in each competition apart from the men's 110 m hurdles and the women's 400 m hurdles in 2013, when two semi-finals were held. Competitors in each event were divided into three groups based on finishing position: medallists (N = 18 per event), non-medallists finishing in 4^{th} to 6^{th} positions ("4^{th} – 6^{th}", N = 18 per event), and those athletes finishing in 7^{th} to 8^{th} ("7^{th} – 8^{th}", 12 in the men's 100 m and 200 m and women's 400 m and 400 m hurdles; 11 in the men's 400 m and 400 m hurdles, women's 100 m, 200 m and 100 m hurdles; and 10 in the men's 110 m hurdles). On the two occasions where there were more than eight finalists, one was disqualified (in the 110 m hurdles) and the other has been included in the 7^{th} – 8^{th} group (in the men's 100 m). The total number of performances analysed was 474. Athletes' performances were measured using three outcome variables: their finishing time; their finishing position; and their overall ranking in that round (based on all competitors' finishing times). Because the number of starters per event varied between championships and event, each athlete's ranking was expressed as a percentile based on the number of starters in that round. For the final, the ranking used was finishing position.

To validate the model ensuing from these analyses, we analysed retrospectively the results from the 2011 IAAF World Championships (World Athletics, 2020), the only other global championships with a similar qualifying structure to the main sample. The 2011 finalists therefore acted as a sub-group of athletes to determine how well they predicted the results of the reserved sample (i.e., the global finalists from 2012 to 2019). This sub-sample comprised eight finalists from all events except the men's 100 m (one athlete disqualified), men's 200 m and women's 100 m hurdles (one athlete did not finish in each), and men's 110 m hurdles (one athlete disqualified and another did not finish).

Statistical analysis

Means and standard deviations (SD) were calculated for each group of athletes in their event for each round of competition. One-way repeated measures analysis of variance (ANOVA) was conducted on the qualifying heat, semi-final and final finishing times, with repeated contrast tests conducted to identify changes between successive rounds (Field, 2009). Greenhouse-Geisser corrections were used if Mauchly's test for sphericity was violated. In addition, one-way ANOVA with Tukey's post-hoc tests were conducted to compare finishing times between groups (Field, 2009). Statistical significance was accepted as $P < 0.05$. Effect sizes for differences between successive rounds, and between groups for each round, were calculated using Cohen's d (Cohen, 1988) and considered to be either trivial ($d < 0.20$), small (0.21–0.60), moderate (0.61–1.20), large (1.21–2.00), very large (2.01–4.00), or nearly perfect (> 4.00) (Hopkins et al., 2009). Differences between successive splits, and differences between groups during each round, have been included when d was moderate or larger only. Kendall's tau-b (τ_b) correlations were used to determine the relationships between finishing position in the final ("final position") with qualification round positional, rank and finishing time data; Bonferroni corrections were used to help avoid Type I errors.

Results

Across all races, 78% of gold medallists, 67% of silver medallists and 38% of bronze medallists won both their qualifying heat and semi-final (Table 1). The mean percentile ranking of each group in each qualifying round is also shown in Table 1. Finishing time in the qualifying heats was only correlated with final position in the two short hurdles races (Table 2), although finishing position in the qualifying heats was correlated with final position in most events. Table 2 also shows that semi-final position, finishing time and ranking were correlated with final position in most events, with the exception of the men's 400 m hurdles. Nearly all finalists (98%) were automatic qualifiers from the heats and no fastest loser from the heats won a medal. There were no fastest losers from the heats in the finals of the women's 200 m, men's and women's 400 m or women's 100 m hurdles. There was one fastest loser from the heats in the finals of the women's 100 m, men's 200 m, men's 110 m hurdles, two in the men's and women's 400 m hurdles, and three in the men's 100 m. Six men and four women who were fastest losers in the semi-finals went on to win a medal, representing 5.6% of all medallists. No gold medallist was a fastest loser in either the qualifying heats or semi-finals.

There were no differences between groups for finishing time in the qualifying heats in any men's or women's sprint race, but medallists were the only group to run faster in each successive round (Figure 1(a-f)). The pattern in the hurdles races was different, as the medallists in the short hurdles were faster than both the 4^{th}-6^{th} and 7^{th}-8^{th} groups in the semi-finals (and in the qualifying heats in the men's 110 m hurdles event), but the medallists did not run faster in the final than in the semi-final (Figure 2(a–d)). In the men's 400 m hurdles, all three groups had the same mean finishing time in the heats and semi-finals, with a difference between them occurring in the final only. In the women's 400 m hurdles, by contrast, the medallists were faster than the other two groups from the semi-final round onwards. Apart from the short hurdles races, a consistent pattern of the medallists improving in each round was found, whereas the 4^{th}-6^{th} group maintained their running times from the semi-final to the final, and the 7^{th}-8^{th} group was slower in the final than in the semi-final (Figures 1(a-f) and Figures 2(a-d)). Indeed, 53% of athletes in the 7^{th}-8^{th} group across all events ran slower in the final than in the qualifying heats.

Within the analysed sub-group from the 2011 World Championships, every gold medallist, 50% of silver medallists and 20% of bronze medallists won both their qualifying heat and semi-final. Seventy-nine of the 80 finalists (99%) were automatic qualifiers from the qualifying heats; the single fastest loser competed in the men's 110 m hurdles, and did not win a medal. Only one of the 30 medals (a bronze) was won by a fastest loser from the semi-finals, also in the men's 110 m hurdles. Most athletes improved finishing time from the heats to the semi-finals (70% of medallists, 77% of those finishing 4^{th}-6^{th}, and 80% of the 7^{th}-8^{th} group). By contrast, whereas most medallists (87%) ran faster in the final than the semi-final, only 40% of those finishing 4^{th}-6^{th}, and 13% of those finishing 7^{th}-8^{th}, did likewise; 60% of athletes in the 7^{th}-8^{th} group ran slower in the final than in the qualifying heats.

Discussion

The aim of this novel study was to analyse the performances of world-class sprinters and hurdlers across the qualifying heats, semi-finals and finals. The hypothesis that there would be no difference in finishing times between the qualifying heats, semi-finals and finals was mostly rejected, as one pattern

Table 1. The number of medallists who won both their heat and semi-final ("Heat and Semi"), won their heat only ("Heat only"), won their semi-final only ("Semi only") or won neither qualification race ("Neither") in the 100 m, 200 m, 400 m, 100 m hurdles, 110 m hurdles and 400 m hurdles events. The values in brackets are the mean ranking (percentile) of those athletes in the qualification rounds (heats/semi-finals).

	Heat and Semi	Heat only	Semi only	Neither
		Men's 100 m		
Gold	5 (9/9)	1 (14/25)	0	0
Silver	5 (3/10)	1 (7/25)	0	0
Bronze	1 (4/4)	4 (10/18)	1 (22/17)	0
		Women's 100 m		
Gold	6 (10/8)	0	0	0
Silver	5 (6/9)	1 (22/13)	0	0
Bronze	3 (3/10)	1 (5/13)	1 (26/8)	1 (15/21)
		Men's 200 m		
Gold	5 (20/13)	0	1 (22/5)	0
Silver	5 (8/14)	1 (9/29)	0	0
Bronze	2 (13/10)	3 (6/13)	0	1 (20/17)
		Women's 200 m		
Gold	5 (9/11)	0	0	1 (13/13)
Silver	5 (8/9)	1 (17/17)	0	0
Bronze	2 (4/8)	3 (15/19)	0	1 (32/17)
		Men's 400 m		
Gold	5 (22/9)	1 (16/22)	0	0
Silver	3 (6/8)	2 (13/17)	0	1 (63/25)
Bronze	1 (23/8)	2 (24/30)	2 (24/8)	1 (31/33)
		Women's 400 m		
Gold	4 (13/9)	1 (7/17)	1 (4/17)	0
Silver	5 (11/6)	0	0	1 (8/29)
Bronze	1 (30/8)	3 (32/13)	0	2 (9/13)
		Men's 110 m Hurdles		
Gold	4 (4/5)	1 (3/13)	1 (12/8)	0
Silver	2 (11/16)	3 (16/19)	0	1 (37/13)
Bronze	3 (4/10)	0	2 (10/14)	1 (9/16)
		Women's 100 m Hurdles		
Gold	5 (5/5)	1 (11/8)	0	0
Silver	3 (9/13)	1 (16/25)	2 (15/8)	0
Bronze	4 (7/10)	0	0	2 (16/15)
		Men's 400 m Hurdles		
Gold	3 (17/6)	1 (2/33)	1 (34/4)	1 (26/8)
Silver	4 (11/18)	1 (3/25)	0	1 (19/42)
Bronze	2 (12/6)	2 (27/24)	0	2 (6/27)
		Women's 400 m Hurdles		
Gold	5 (9/5)	1 (8/17)	0	0
Silver	3 (6/13)	2 (6/14)	0	1 (65/33)
Bronze	4 (9/13)	1 (5/8)	0	1 (9/25)

familiar to all races except the short hurdles was that the medallists ran faster in each successive round, the 4th-6th group ran faster in the semi-final than in the qualifying heats but did not run faster (or slower) in the final than the semi-final, and the 7th-8th group ran faster in the semi-finals than in the qualifying heats (except in the men's 100 m), but were then slower in the final. Indeed, 53% of all those in the 7th-8th group ran slower in the finals than in the qualifying heats, and therefore had their worst performance in the most important race. It is possible that those who finished in the last two positions ran worse times because of accumulated fatigue during the competition or, in some cases, realised soon after starting that their chances of a top finishing position were low and became demotivated; however, this latter reason is probably less likely given how short the races are, and therefore managing recovery from fatigue between rounds is a key factor for successful athletes. The applied implications of these results is that coaches should develop meso-pacing strategies as part of championship preparation so that their athletes peak in their most important races.

In all sprint events and the 400 m hurdles, the top athletes did not go all-out in winning the qualifying rounds, in that they were not faster than the other finalists in the qualifying heats, and not faster than the 4th-6th group in the semi-finals. In these races, there was also no correlation between qualifying heat finishing time and finishing position in the final, and no correlation between qualifying heat ranking and finishing position in the final in six of the 10 events. There is thus no need for the most capable athletes to run all-out in the earlier rounds and accumulate unnecessary fatigue, unlike in sports where times are aggregated across heats, such as in some winter sports (IBSF, 2021) and which has tempted athletes to dope to help recover sufficiently between races (Rodchenkov, 2020). However, a different pattern emerged in the short hurdles, where the eventual medallists were already faster than the 7th-8th group in the heats in the women's event, and faster than both groups of non-medallists in the men's race. Additionally, the short hurdles were the only events where the medallists did not run faster in the final than in the semi-final, and were also the only events where finishing position in

Table 2. Correlations (τ_b) between final position with positional, rank and finishing time data in the preceding qualifying heats and semi-finals ("heat" and "semi", respectively).

	Heat position	Heat time	Heat ranking	Semi position	Semi time	Semi ranking
Men's 100 m	$\tau_b = 0.42$ $P < 0.001$	$\tau_b = 0.24$ $P = 0.023$	$\tau_b = 0.31$ $P = 0.004$	$\tau_b = 0.53$ $P < 0.001$	$\tau_b = 0.32$ $P = 0.002$	$\tau_b = 0.47$ $P < 0.001$
Women's 100 m	$\tau_b = 0.32$ $P = 0.010$	$\tau_b = 0.25$ $P = 0.022$	$\tau_b = 0.22$ $P = 0.039$	$\tau_b = 0.56$ $P < 0.001$	$\tau_b = 0.49$ $P < 0.001$	$\tau_b = 0.59$ $P < 0.001$
Men's 200 m	$\tau_b = 0.30$ $P = 0.016$	$\tau_b = 0.03$ $P = 0.781$	$\tau_b = 0.01$ $P = 0.907$	$\tau_b = 0.41$ $P = 0.001$	$\tau_b = 0.32$ $P = 0.003$	$\tau_b = 0.37$ $P = 0.001$
Women's 200 m	$\tau_b = 0.34$ $P = 0.006$	$\tau_b = 0.09$ $P = 0.389$	$\tau_b = 0.11$ $P = 0.330$	$\tau_b = 0.56$ $P < 0.001$	$\tau_b = 0.37$ $P = 0.001$	$\tau_b = 0.55$ $P < 0.001$
Men's 400 m	$\tau_b = 0.12$ $P = 0.338$	$\tau_b = -0.05$ $P = 0.650$	$\tau_b = -0.08$ $P = 0.453$	$\tau_b = 0.40$ $P = 0.001$	$\tau_b = 0.26$ $P = 0.014$	$\tau_b = 0.41$ $P < 0.001$
Women's 400 m	$\tau_b = 0.35$ $P = 0.005$	$\tau_b = 0.10$ $P = 0.365$	$\tau_b = 0.12$ $P = 0.254$	$\tau_b = 0.46$ $P < 0.001$	$\tau_b = 0.49$ $P < 0.001$	$\tau_b = 0.54$ $P < 0.001$
Men's 110 m hurdles	$\tau_b = 0.38$ $P = 0.002$	$\tau_b = 0.36$ $P = 0.001$	$\tau_b = 0.35$ $P = 0.001$	$\tau_b = 0.44$ $P < 0.001$	$\tau_b = 0.48$ $P < 0.001$	$\tau_b = 0.54$ $P < 0.001$
Women's 100 m hurdles	$\tau_b = 0.41$ $P = 0.001$	$\tau_b = 0.39$ $P < 0.001$	$\tau_b = 0.43$ $P < 0.001$	$\tau_b = 0.45$ $P < 0.001$	$\tau_b = 0.47$ $P < 0.001$	$\tau_b = 0.57$ $P < 0.001$
Men's 400 m hurdles	$\tau_b = 0.31$ $P = 0.009$	$\tau_b = 0.08$ $P = 0.470$	$\tau_b = 0.13$ $P = 0.228$	$\tau_b = 0.29$ $P = 0.016$	$\tau_b = 0.15$ $P = 0.171$	$\tau_b = 0.20$ $P = 0.070$
Women's 400 m hurdles	$\tau_b = 0.45$ $P < 0.001$	$\tau_b = 0.25$ $P = 0.017$	$\tau_b = 0.38$ $P < 0.001$	$\tau_b = 0.48$ $P < 0.001$	$\tau_b = 0.37$ $P = 0.001$	$\tau_b = 0.47$ $P < 0.001$

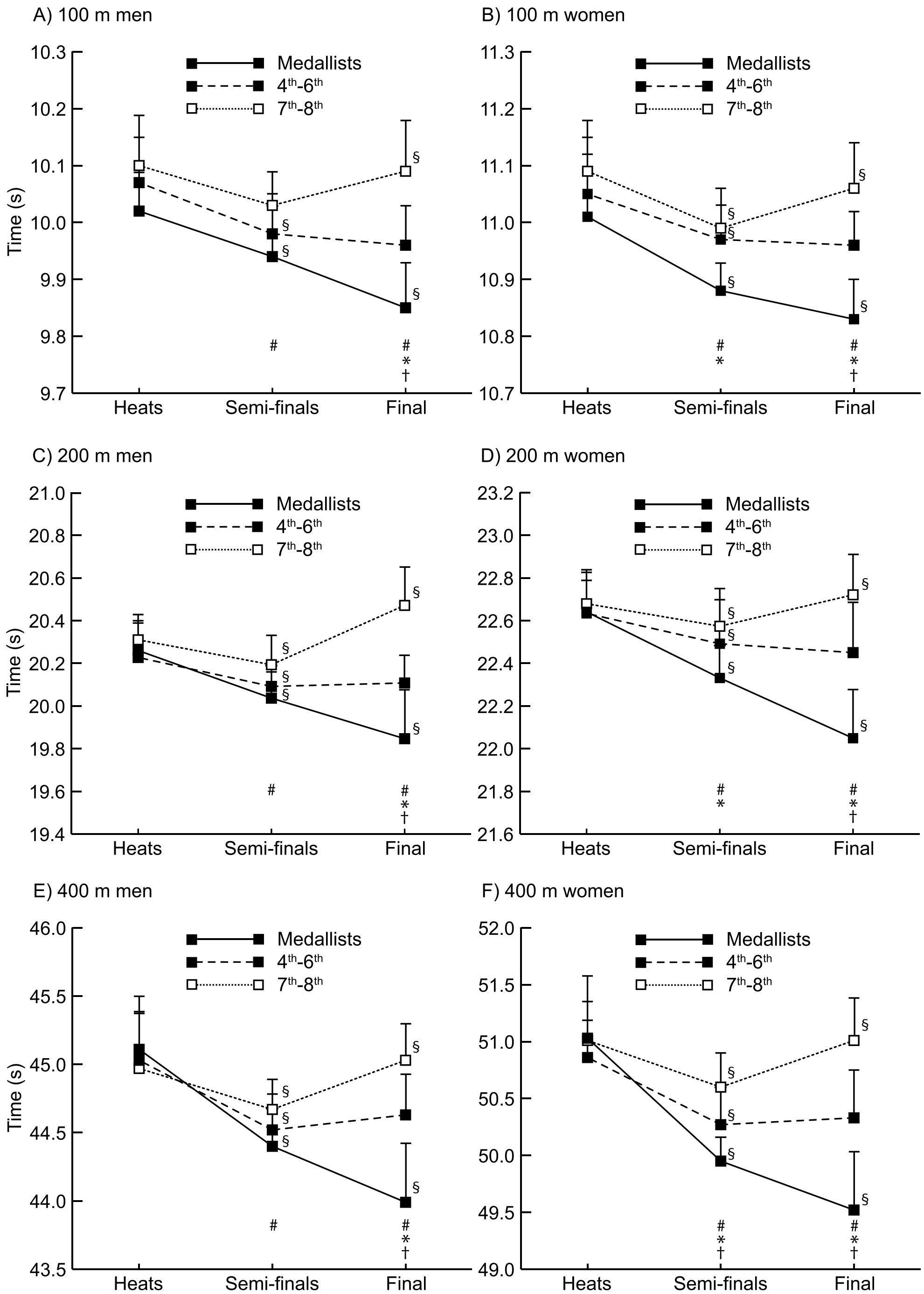

Figure 1. (a-f) The mean (+ SD) finishing time for each group of sprinters for all three rounds in each event. Differences between successive segments with a moderate or larger effect size are annotated as $P < 0.05$ (§). Differences ($P < 0.05$) with a moderate or larger effect size between medallists and the 4th-6th group (*), between medallists and the 7th-8th group (#), and between the 4th-6th group and the 7th-8th group (†) are also annotated.

the final was correlated with time achieved in the heats; ranking and position in the heats were also correlated with final position. These findings, many of which were exclusive to the short hurdles, show that the fixed height of the hurdles and the distance between them requires even the world's best athletes to run their fastest in qualifying so that their normal hurdling rhythm is adopted. As in speed skating, where the anticlockwise direction taken in each race dictates that the right leg needs to be in position to take the corners (Hettinga et al., 2016), the use of a three step pattern in the short hurdles to ensure the same lead hurdling leg means that hurdlers' options to vary pace are much more restrained. Coaches of sprint hurdlers should thus note that recovery strategies between rounds might be more important than for sprinters, and require a different approach in training before and during a championship campaign.

The results showed that the medallists in most events did not run truly all-out in the qualifying heats and semi-finals, and this shows that the very best athletes did adopt some form of meso-pacing across the championships that helped them peak for the final. However, this does not mean that they ran so slowly as to risk not qualifying; in fact, 98% of finalists finished

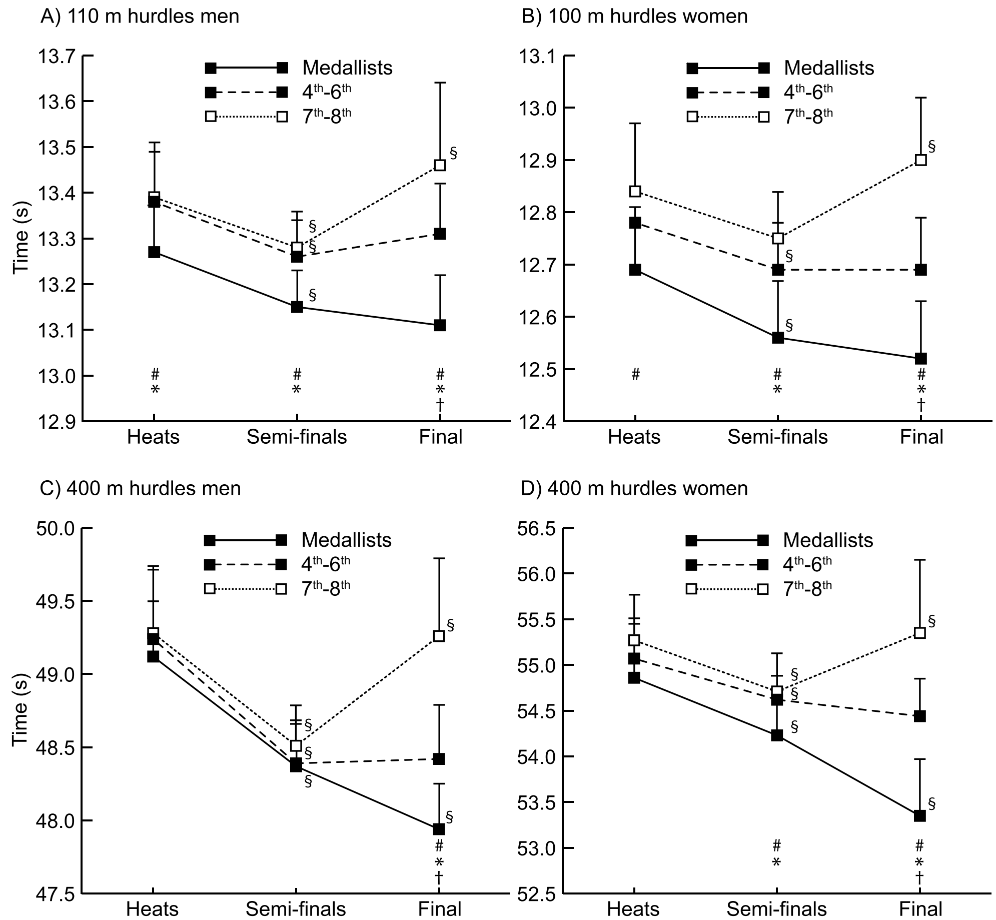

Figure 2. (a-d) The mean (+ SD) finishing time for each group of hurdlers for all three rounds in each event. Differences between successive segments with a moderate or larger effect size are annotated as $P < 0.05$ (§). Differences ($P < 0.05$) with a moderate or larger effect size between medallists and the 4th-6th group (*), between medallists and the 7th-8th group (#), and between the 4th-6th group and the 7th-8th group (†) are also annotated.

in the automatic qualifying positions in the qualifying heats and, equally, no fastest loser from the qualifying heats won a medal. Although it is plausible that higher-performing athletes recover better than athletes with less ability (Casado et al., 2020), it is also the case that the medallists did not run as close to their best (i.e., their final times) in the previous rounds as the other finalists, meaning there was less relative exertion to recover from. It would appear from the results that is not possible for world-class sprinters and hurdlers to race all-out throughout a championships: the eventual medallists run slower in the early rounds to prevent fatigue, whereas the lower-finishing athletes run all-out in earlier rounds to ensure qualification and cannot recover sufficiently to peak in the final. Coaches should note that meso-pacing strategies at major championships are thus important for all athletes in terms of recovering between races, and could be practised at lesser competitions or in structured training regimens that replicate factors such as running effort, time between efforts and rest protocols.

The second hypothesis that the proportion of eventual medallists who won their heat and semi-final would be higher than that found in middle-distance championship racing was supported. In the sprint and hurdle events, 78% of gold, 67% of silver and 38% of bronze medallists won both their qualifying heat and semi-final, more than the proportions found amongst middle-distance medallists of 70%, 36% and 19%, respectively. Previous research on the middle-distance events showed that ego orientation can help explain how the best athletes win races they do not need to (Hanley & Hettinga, 2018), and although the results of this study suggest that this could also be a factor in the winning rates of medallists in sprint events, the fact that lane draw is also affected means the percentage is higher. The best athletes won their heats in general, ensuring middle lanes, which are considered better as they mean a better curvature for events of 200 m and 400 m (Aftalion & Martinon, 2019), but without being isolated in the outside lanes (Renfree et al., 2014). Winning the heat is therefore more important than achieving a fast time *per se*; for example, the bronze medallist in the 2017 World Championship women's 400 m, Allison Felix, was only 29th fastest of 49 starters in the qualifying heats, but because she won her heat, she was seeded 6th of the 24 starters in the semi-finals and thus allocated a middle lane (World Athletics, 2020). Although doing well enough to win in qualifying is the aim of the best athletes, their higher win percentage (than middle-distance runners) might also be partly because the shorter race duration affects their ability to evaluate their position in the race, and thus reducing effort in the longer sprint and hurdles races (in particular) is not recommended until near the end of the home straight. Because our analyses were based only on finishing race times and positions, it was not possible to evaluate pacing profiles or their contribution to athlete performances. The world-class nature of the cohort studied meant that the sample sizes per group were small, especially with regard to the number of athletes allocated to the 7th-8th group. However, the athletes analysed were competing in the highest standard of competition available and thus the results have high ecological validity and were further supported by the results of our retrospective analysis of the subgroup from 2011, and are useful for coaches to consider when planning for long-term and competition-based practices.

Conclusions

This study examined the qualification profiles of World Championship and Olympic finalists in the men's and women's sprints and hurdles events. A clear difference therefore emerged between the world's fastest runners, who could reserve their best performances for the final, and those finishing in the lower positions who needed to peak merely to reach the final. The exception to this occurred in the short hurdles events, where the fixed height and distance of the barriers demanded performances closer to the maximal speed possible throughout the championships. Elite hurdlers therefore need specific training in terms of recovering between rounds, although all speed athletes and their coaches need to consider their resting and meso-pacing strategies over the course of a championship, particularly if competing in multiple events. Most gold and silver medallists had won their heat in both of their previous qualifying rounds, despite few correlations with finishing times, showing that the world's best athletes were able to race slow enough not to endure unnecessary fatigue but also fast enough to ensure a favourable lane draw in the next round.

Disclosure statement

The authors report no conflicts of interest.

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