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An analysis of pacing profiles of world class race walkers

Original Investigation

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Abstract
Purpose: The aim of this study was to describe the pacing profiles used by race walkers competing in IAAF World Championships. *Methods:* The times for each 5 km segment were obtained for 225 men competing over 20 km, 214 women competing over 20 km, and 232 men competing over 50 km, of whom 49 did not finish. Athletes were grouped based on finishing position (for medallists) or finishing time. *Results:* Different pacing profiles were used by athletes grouped by finishing time, with 20 km medallists using negative pacing and those finishing within 5% of the winning time matching the medallists' early pace but failing to maintain it. Lower-placed 20 km athletes tended to start more quickly relative to personal best pace and experienced significant decreases in pace later. Across all competitions, the fastest finishers started the slowest relative to previous best performance. All 50 km athletes slowed towards the finish but lower-placed finishers tended to decrease pace earlier (with up to 60% of the race remaining). After halfway in the 50 km, 8 of the 15 athletes who had a 5 km split more than 15% slower than the previous split dropped out. *Conclusions:* The negative pacing profile used by 20 km medallists required the ability to start fast and maintain this pace and similarly paced training may be beneficial in race preparation. Over 50 km, the tactic of starting slower than personal best pace was generally less risky; nonetheless, any chosen pacing strategy should be based on individual strengths.

Keywords: Coaching, endurance training, fatigue, track and field, world championships

Introduction

Pacing profiles are an important component of endurance events with regard to achieving an individual's optimal performance.[1] Optimal pacing profiles are considered those which are the most physiologically efficient[2] in that they use all available energy stores before the end of the competition, but not so far from the end that meaningful slowing down occurs.[3] A number of different pacing profiles have been previously identified in a variety of endurance events[1,4]: positive pacing (where the athlete slows down over the course of the event); negative pacing (where the athlete speeds up); even pacing (a relatively constant speed is maintained); parabolic-shaped pacing (a relatively fast pace at the start and finish but a slower mid-section); and variable pacing (power output is varied due to external conditions[1] or as a competitive tactic[5]). It has been suggested that negative pacing is best suited to prolonged exercise due to reduced rates of carbohydrate depletion, lower excessive oxygen consumption, and lower blood lactate concentrations[1] but this pacing profile is not always adopted in practice. For example, faster marathon runners tend to exhibit little variation in pace[6,7] and Olympic distance runners have been found to follow the leaders' variable pace in attempting to optimize their chances of competitive success.[8] In addition, an individual athlete's pacing profile can be affected by their Rating of Perceived Exertion (RPE), how this compares with how they expected to feel, and how much distance is left to cover.[4,9-11] In particular, the knowledge that one is nearing the end of a race means that increases in pace often occur despite possible homeostatic disturbance and discomfort.[4]

Men and women compete in race walking events over 20 km at global competitions, while the men's 50 km race walk is the longest race in the athletics programme.[12] Elite race walkers therefore have similar physiological profiles to elite distance runners.[13,14] Little attention has been paid to the effects of fatigue in the shorter 20 km races, but it is widely believed by coaches that many 50 km race walkers start too quickly and slow significantly during the last third of the race.[15] These decreases in speed during a 50 km race could be due (as in other endurance events)[16] to a shift from glycogen to fat as the major energy source[17] and an increase in energy cost.[18] Minimising fatigue is especially important for elite race walkers because deteriorations in technique can lead to an increased risk of disqualification, particularly due to changes in knee contact angle, although this is more likely to occur over 50 km[19] than over 20 km.[20]

Previous research has not analyzed the pacing profiles utilized by elite race walkers competing over the two championship distances of 20 km and 50 km. An understanding of the pacing profiles used might provide race walkers and their coaches with insights into typically successful or unsuccessful approaches to pacing, leading to better informed training regimens and race tactics. The aim of this study was to describe the pacing profiles used by male and female race walkers competing in the IAAF World Championships.

Methods

Subjects. Overall race times and 5 km split times were obtained for competitors in the 20 km and 50 km race walk events at the seven IAAF World Championships in Athletics events held between 1999 and 2011. The athletes' personal best times at the time of competing were also obtained. These data were obtained from the IAAF's competition archive.[21] A total of 225 finishers were analyzed in the men's 20 km competitions and 214 finishers analyzed in the women's 20 km competitions. No performances of athletes who failed to complete the 20 km races were analyzed (23 male athletes and 29 female athletes dropped out over this distance). In the men's 50 km competitions, the performances of 183 finishers were analyzed as well as those of 49 athletes who dropped out after 30 km. No athletes who were disqualified (75 across the men's 50 km races; 45 across the men's 20 km; 52 across the women's 20 km) have been included for analysis. The total complement of split times was not available for 1 athlete in the men's 20 km races, 6 in the women's 20 km, and 6 in the men's 50 km and none of these competitors' data have been analyzed. The performance of one female 20 km athlete who competed as part of the IAAF's policy of allowing small member federations to enter unqualified athletes has not been included as it was more than 40 minutes slower than the winner.

Design and Methodology. The study was designed as observational research in describing pacing profiles. Competitors in each race were divided into four groups: (1) medallists; (2) non-medallists whose finishing times were less than 5% slower than the winner's time ('the 5% group'); (3) athletes whose finishing times were between 5 and 10% slower than the winner's time ('the 5 – 10% group'); and (4) those athletes whose finishing times were more than 10% slower than the winner's time ('the 10% group'). These divisions were used rather than actual finishing times in order to account for differences in racing conditions. The number and proportion of athletes per group for each of the three race categories are shown in Table 1. Each individual athlete's finishing time was also expressed as a percentage of their personal best. To calculate whether the athletes were ahead of or behind personal best pace as the race progressed, each 5 km split time was calculated as a percentage of the average 5 km time achieved during the personal best performance.

Statistical analysis. Repeated measures ANOVAs were conducted on the time split data recorded with repeated contrast tests conducted to establish significant changes between successive measurement points.[22] An alpha level of 5% was set for these tests with Greenhouse-Geisser correction used if Mauchly's test for sphericity was violated.

Results

20 km men. Figure 1 shows the average 5 km times for each group of athletes competing in the men's 20 km races. Mean finishing times for each group in each race category are shown in Table 2. Overall, the faster the group, the closer they finished to their personal best time. The medallists completed the opening 5 km slowest of all four groups relative to personal best pace (105.6% ± 3.9) in comparison with the 10% group who started at 103.5% (± 4.1) of their personal best pace. Seven of the 17 athletes who achieved a personal best (Table 2) completed the first 5 km faster than personal best pace, while 24 others who also started the race ahead of personal best pace ultimately failed to achieve a personal best time.

20 km women**.** Figure 2 shows the average 5 km times for each group of athletes competing in the women's 20 km races. In Table 2, it can be seen that the faster the athletes, the closer they finished to their personal best time. The medallists were the slowest starters over the first 5 km when compared with personal best pace (104.3% ± 2.7) while the 10% group were the fastest (101.5% ± 2.8). Seven of the 14 athletes who achieved a personal best (Table 2) completed the first 5 km faster than personal best pace, while 36 others who also started the race ahead of personal best pace failed to achieve a personal best time.

50 km men**.** Figure 3 shows the average 5 km times for each group of finishers in the men's 50 km races. The slowest starters relative to personal best pace (over the first 10 km) were the medallists (103.6% ± 2.7) whereas the 10% group started the fastest at 102.2% (± 2.7). In total, thirty-seven competitors achieved a personal best time (Table 2). The split times revealed that none of the medallists who achieved a personal best (or any medallists at all) were ahead of personal best pace by 10 km. Twelve athletes in the 10% group were ahead of personal best pace after the same distance but ultimately none of these athletes achieved a personal best time. Eleven of the 49 athletes who dropped out were ahead of personal best pace after 10 km. Thirteen of the 51 athletes who completed the first 10 km at personal best pace achieved a personal best finishing time.

Of the 24 athletes whose pace slowed by between 10 and 15% between any two successive 5 km segments, 18 continued to finish. Half of these athletes finished 10% behind the winner's time and none were medallists. Eight of the 15 athletes experiencing more than 15% slowing between segments managed to complete the race, with 7 finishing in the 10% group. All 3 athletes who slowed by more than 15% between 30 and 35 km dropped out, while 4 of the 6 who slowed by the same amount between 35 and 40 km dropped out. None of the 4 who slowed by more than 15% between 40 and 45 km failed to finish. Two finishers slowed dramatically between 45 km and 50 km, with one individual suffering a 40.7% decrease in pace.

Discussion

The aim of this study was to describe the pacing profiles used by high-level race walkers. Although all competitors analyzed were elite race walkers who qualified for and competed at the IAAF World Championships, pacing profiles were not uniform across groups based on finishing time. Instead, it appeared that most athletes adopted profiles where they tried to follow the early pace set by the leaders and maintain this pace for as long as possible, as has been found in endurance running.[8] There is a sound rationale in adopting a fast early pace to keep up with the leaders as it places the athlete in a strong position to be competitively successful. Furthermore, being part of a group has advantages similar to those found in other endurance events (e.g. decreases in wind resistance).[8] More specifically to race walking, there is an added benefit is avoiding becoming isolated as it reduces the chances of attracting the judges' attention. However, athletes must judge whether the early lead pace is too fast and if holding back is a better option.

In the 20 km races, it was noticeable that the most successful athletes started slowest with respect to their personal best times and appeared to have planned negative pacing profiles in advance, where they intentionally walked the early stages much slower than personal best pace. This might have increased their chances of success given previous research on negative pacing in endurance exercise has found physiological benefits such as reduced carbohydrate depletion and lower blood lactate profiles.[1] In contrast, athletes who completed the early part of the race faster than personal best pace tended to finish slower. In particular, only 14 of the 91 race walkers competing over 20 km who began faster than personal best pace ultimately achieved a personal best time. 20 km athletes are therefore recommended to try to adopt negative pacing with an opening 5 km slightly slower (about 105%) than personal best pace. Athletes with aspirations of winning championship medals should attempt similar negative pacing in training, for not only will this develop their ability to adopt a negative pacing profile in competition, but experience of such training also allows the athlete to develop a sense of pace perception at varied speeds.[23]

The general profile for all 50 km athletes was a relatively slow start, followed by an increase in pace, which was maintained for some time, and then followed by a progressive decrease in pace. This gave the patterns the look of parabolic pacing, except unlike in previous studies on shorter competitions,[1,24] the faster sections were in the middle rather than at the beginning and end. Like their 20 km counterparts, the medallists in the 50 km race adopted a negative pacing profile for most of the race (which may have helped to spare glycogen),[1] but the race's duration meant that significant decreases in pace occurred towards the finish. These pace decreases might be inevitable considering the conversion from glycogen to fat as the major energy source. With regard to some of the lower-placed athletes, the results showed that a significant number were slowing down for between 50 and 60% of the race, rather than just in the last third as previously noted by coaches.[15] All 50 km athletes might need to consider a different pacing profile (e.g. starting even more slowly) especially if the weather or other relevant conditions (e.g. elevation compared with sea level) are not conducive to good finishing times.[25]

While it is not possible to analyze the athletes' pacing profiles with regard to several pertinent factors (e.g. prior training, or consumption of carbohydrate during the race), it was noticeable from the overall profiles that approximately 25% of the 50 km walkers ahead of personal best pace at 10 km achieved a personal best time. However, athletes starting off faster than personal best pace were in general more likely to end up either dropping out or finishing more than 10% slower than the winning time. There is thus a risk in adopting this pacing profile, but as it paid off for a quarter of the competitors analyzed some coaches and athletes might feel that it is worth the risk considering the potential gains. It should be noted though that the majority of athletes who achieved a personal best time (65%) were not ahead of personal best pace after 10 km and this included 8 medallists. The best pacing profile for any given athlete is determined by their individual strengths and weaknesses and these should be considered in advance of any major competition when deciding on the race pace deemed most likely to result in personal success.

Although it is a particularly gruelling competition, the majority of 50 km athletes do actually complete the race. Nonetheless, there is still considerable attrition in 50 km competition and this might be due to injury, pain, or illness. Another cause could be a sudden decline in performance due to fatigue and an expectation of being unable to recover any time losses. It might be useful for coaches and athletes to know the level of decrease in performance which indicates that race completion is unlikely, so that unnecessary fatigue is avoided and recovery prior to the next competition or heavy training load is easier. Athletes who suffered particularly dramatic decreases in pace (> 15% between 5 km segments) tended to drop out if there were 10 km or more of the race left. By comparison, most athletes with smaller decreases in pace, or those whose pace decreased dramatically only in the last 10 km, continued to the finish. This suggests that the psychological boost of approaching the finish has a beneficial effect in overcoming fatigue and discomfort[4] even in very long exercise durations.

Practical implications

In both men and women's 20 km races, the medallists had negative pacing profiles and the ability to start quickly and continue at this pace (or increase it) is a requirement which needs appropriate practice in training. Not all athletes aim as high as winning a medal but instead simply aim to achieve a personal best time. However, the results of this study showed that achieving a personal best performance was less likely to occur if the athlete started faster than personal best pace as this tended to result in a positive pacing profile instead. While final race position was ultimately decided in the latter stages, significant decreases in pace were caused by starting too fast. All competitors must therefore take care in planning a sensible pacing profile based on prior results and current training status, and which is practiced beforehand and monitored by the coach.

The needs of the 50 km race walker are quite different from those of the 20 km competitor. In particular, the duration of the 50 km race is possibly too long and arduous for maintaining and replacing glycogen in even the best competitors. It was not unexpected that pace slowed in the last third of the race[15] due to physiological changes[16,26] but it was surprising that significant decreases in pace occurred at approximately halfway in the slower athletes. While many of these athletes (and those who dropped out) showed signs of starting too quickly, it is also possible that they did not have the background training or endurance ability to complete the 50 km distance at pre-planned pace. Individual race walkers and their coaches need to measure any decreases in pace during long distance training sessions so that they can evaluate competitive readiness. While many athletes will analyze their own race performance in terms of 5 km split times, they should note the findings of this study on a large number of elite competitors when considering their pacing profile, particularly in terms of starting pace and its relation to personal best time.

Conclusion

The ability to start at a fast pace and maintain or increase it was what differentiated successful 20 km race walkers from those who were less successful. Slower 20 km race walkers began at a much faster pace (when compared with personal best time) which they could not maintain and slowed considerably towards the end. In the much longer 50 km race, all athletes slowed as the race progressed but those who did best slowed less and at a later stage than their competitors. It is imperative that all elite race walkers accurately evaluate their race preparedness prior to competing and plan their pacing tactics accordingly.

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Table 1 Number of finishers per group (and as a percentage of the total number) across the three race categories.

	Medallists	Within 5%	5 – 10%	More than 10%
Men’s 20 km	21 (9.3%)	83 (36.9%)	75 (33.3%)	46 (20.4%)
Women’s 20 km	21 (9.8%)	57 (26.6%)	73 (34.1%)	63 (29.4%)
Men’s 50 km	21 (11.5%)	44 (24.0%)	76 (41.5%)	42 (23.0%)

Table 2 Mean finishing time (± SD) for each group of athletes across the three race categories, expressed both as absolute time and percentage of personal best time. The number of athletes achieving a personal best time in each category is also shown.

	Men’s 20 km	Women’s 20 km	Men’s 50 km
Medallists	1:20:32 (± 2:05)	1:29:04 (± 1:32)	3:42:30 (± 3:51)
	103.0% (± 2.6)	101.9% (± 1.4)	101.2% (± 1.5)
	3 personal bests	3 personal bests	8 personal bests
5% group	1:22:39 (± 2:07)	1:31:38 (± 1:35)	3:48:25 (± 4:32)
	103.9% (± 2.8)	102.9% (± 2.2)	101.7% (± 2.0)
	11 personal bests	6 personal bests	19 personal bests
5 – 10% group	1:25:22 (± 2:12)	1:34:39 (± 1:57)	4:00:07 (± 4:30)
	105.0% (± 3.1)	104.3% (± 2.7)	103.2% (± 2.5)
	2 personal bests	3 personal bests	10 personal bests
10% group	1:29:59 (± 2:51)	1:40:06 (± 3:19)	4:11:40 (± 7:42)
	109.0% (± 4.7)	106.8% (± 3.9)	107.6% (± 3.6)
	1 personal best	2 personal bests	0 personal bests

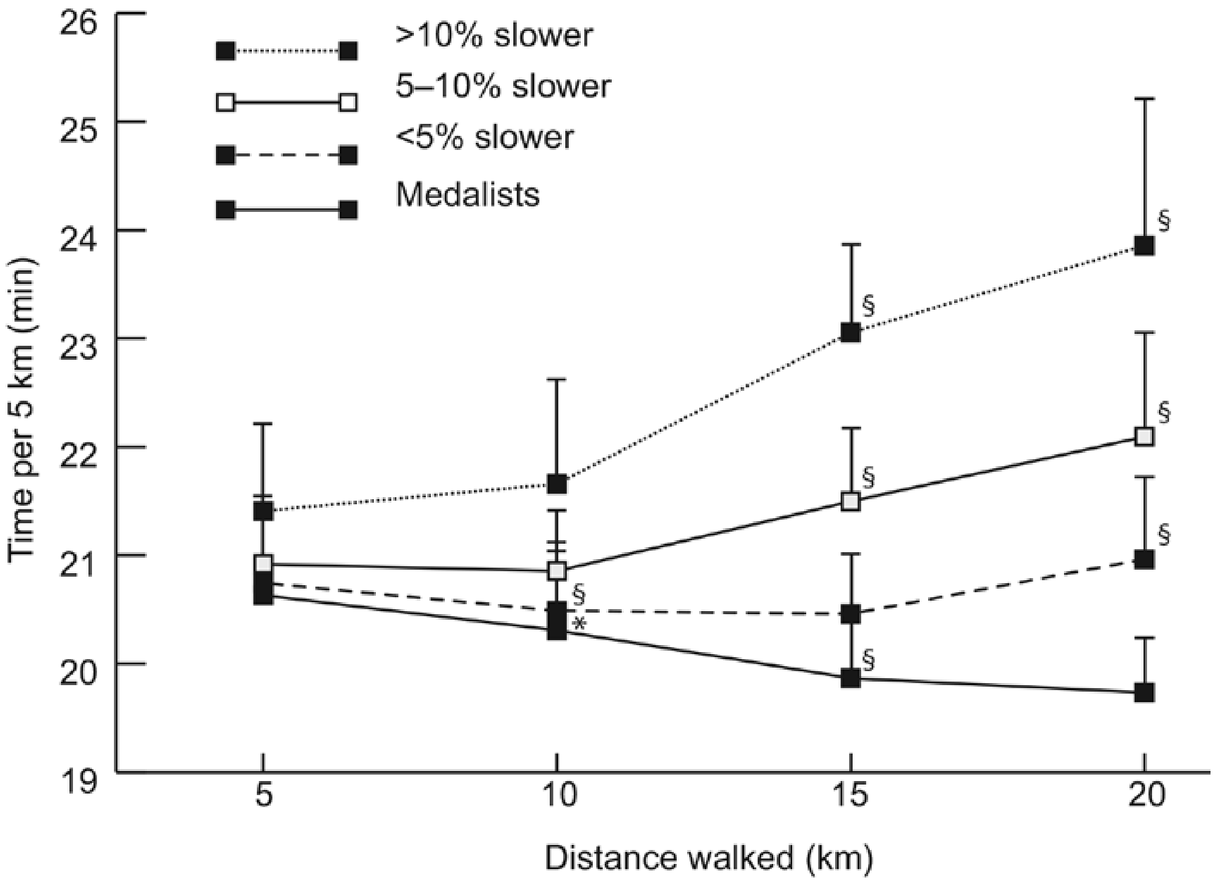

Figure 1. Mean (+ SD) times for each 5-km segment for each group of athletes competing in the men's 20 km. Differences between successive 5-km segments are shown as either *P* < .01 (*) or *P* < .001 (§).

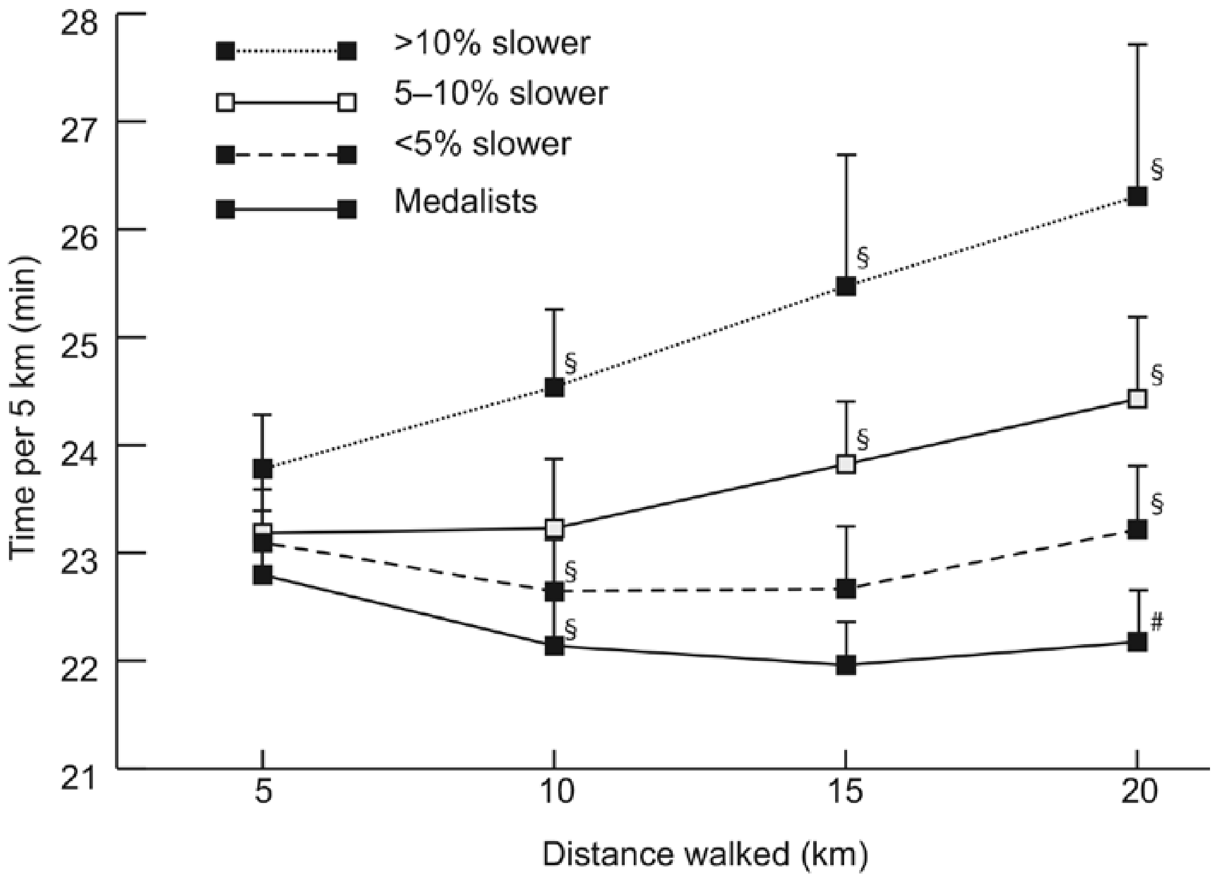

Figure 2. Mean (+ SD) times for each 5-km segment for each group of athletes competing in the women's 20 km. Differences between successive 5-km segments are shown as either $P < .05$ (#) or $P < .001$ (§).

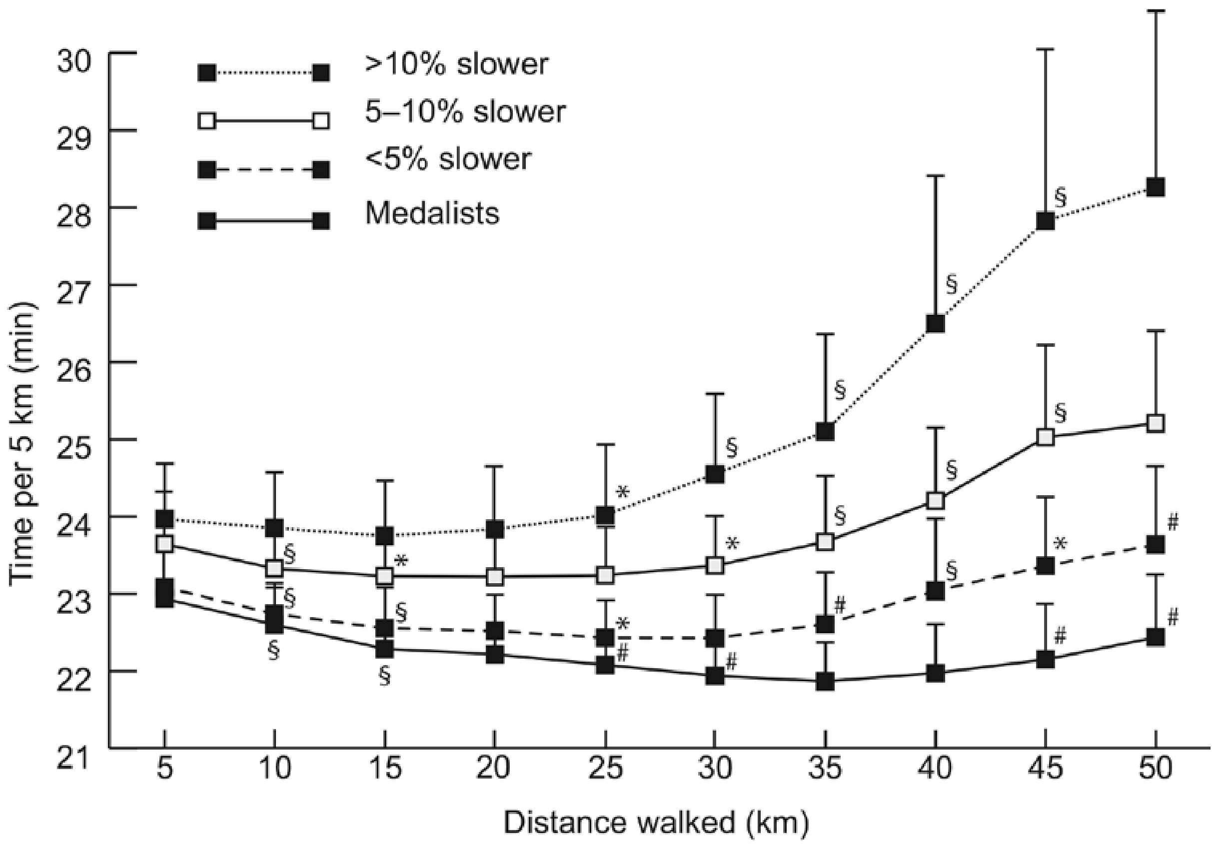

Figure 3. Mean (+ SD) times for each 5-km segment for each group of athletes competing in the men's 50 km. Differences between successive 5-km segments are shown as either *P* < .05 (#), *P* < .01 (*) or *P* < .001 (§).