An Observational Study on the Perceptive and Physiological Variables During a 10,000-m Race Walking Competition

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Abstract

Vernillo, G, Agnello, L, Drake, A, Padulo, J, Piacentini, MF, and Torre, AL. An observational study on the perceptive and physiological variables during a 10,000-m race walking competition. *J Strength Cond Res* 26(10): 2741–2747, 2012—In this study, we observed the variations on physiological and perceptual variables during a self-paced 10,000-m race walking (RW) event with the aim to trace a preliminary performance profile of the distance. In 14 male athletes, the heart rate (HR) was monitored continuously throughout the event. The rating of perceived exertion (RPE) was collected using the Borg's 6–20 RPE scale placed at each 1,000 m of an outdoor tartan track. Pacing data were retrieved from the official race results and presented as percent change compared with the first split time. The athletes spent 95.4% at 90–100% of the HRpeak, whereas the other work (4.6%) was negligible. During the race, a shift toward higher HR values was observed because % HRpeak increased by 3.6% in the last vs. the first 1,000-m sector ($p = 0.002$, effect size [ES] = 1.55 ± 0.68, large). The mean RPE reported by the athletes in the last 1,000 m was significantly higher than in the first 5 sectors ($p < 0.02$, ES = 1.93–2.96, large to very large). The mean percent change increased between the first 6 sectors and the last 1,000-m sector ($p < 0.01$, ES = 1.02–2.1, moderate to very large). The analysis of walking velocity at each 1,000-m sector suggested the adoption of a negative pacing. In conclusion, the RPE may be a valid marker of exercise intensity even in real settings. Match physiological and perceptual data with work rate are required to understand race-related regulatory processes. Pacing should be considered as a conscious behavior decided by the athletes based on the internal feedback during the race.

Key Words athlete, pacing strategy, perceived exertion, heart rate, performance

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Introduction

Race walking (RW) can be described as an endurance and technical discipline in which the gait employed is dictated by the rules governing this sport (6,7). In fact, to perform a legal technical action, rule 230 prescribed by the athletics governing body (i.e., the International Association of Athletics Federation) states that (a) an invisible (to the human eye) loss of contact occurs and (b) during the forward action, the advancing leg shall be straightened from the moment of the first contact with the ground until the vertical upright position. Thus, RW is a technical and athletic expression of fast walking, adhering to strict technique. Despite the fact that over the years its physiological determinants have been extensively investigated (14,34,40), to the best of our knowledge, no study provides evidence of exercise intensity experienced by race walkers in real settings during competitions.

Among the various methods available, heart rate (HR) monitoring is the most common method exploited for prescribing and quantifying the exercise intensity (20,21,31), providing important feedback about the training stimulus and the physiological load applied to the athletes (9,17). Moreover, the increased use of rating of perceived exertion (RPE) provides a practical and alternative method for quantifying the global exercise intensity in endurance (15,17), team (24), and technical sports, such as gymnastics (32).

Conversely, to obtain an insight into the physiological and regulatory processes during an RW event, the responses provided by the HR and RPE may be not sufficient because this information should be completed by the analysis of the pacing strategy. Pacing strategy is commonly defined as the distribution of work or pattern of energy expenditure throughout an exercise task to optimize the overall performance (2,11,37). Although numerous studies have been conducted to understand the influence of pacing strategy on athletic performance (1,16,18,23), no study has been carried out on 10,000-m RW, particularly in real settings.

Such competition is typically performed during the spring season (i.e., second third of the athletic season), between the athletes' general training period and the major outdoor competitions (i.e., 20 and 50 km), which are planned throughout the summer season. Thus, it represents an important test for both the athletes and coaches. This is because the feedback (e.g., HR, RPE, and pacing strategy) gathered can be used to (a) prescribe and quantify the sport-specific exercise intensity, (b) analyze critically the training done during the general training period, and (c) develop specific training strategies focused on summer competitions.

Accordingly, the aim of this study was to provide evidence of the effects on the HR and RPE during a self-paced 10,000-m RW competition.

Methods

Experimental Approach to the Problem

This study is an observational study aimed to investigate the effects on perceptive and physiological variables during a self-paced 10,000-m RW race. A second aim of this study was to analyze the impact of self-selected regulations of effort on the aforementioned variables. Such information could be important to trace a preliminary performance profile of the distance. Thus, in a cross-section design, 14 high-level male race walkers participated in this study. They were already familiarized with both the HR and RPE, because these are common devices used during their training sessions. To assess the physiological variable, during the race, the HR was recorded continuously using a short-range telemetry system. The maximal HR value found during the race was taken to be the highest HR achieved by the athletes. Subsequently, the HR was expressed relative to the maximum value (% HRpeak) of the athletes' observed value during the race. Moreover, to assess the perceptive variable, the Italian translation of Borg's 6–20 RPE scale was used throughout the race, placing 2 A1 international standard paper formats (ISO 216, 594·841 mm), corresponding to every 1,000-m split distance. However, the athletes' pacing strategies were retrieved from the official race results published by the organizers of the event and then presented as absolute speed every 1,000 m and as percent change compared with the first split time.

Subjects

During a 10,000-m RW race added to the Italian RW Challenge list, 14 male race walkers (mean ± *SD*: age 22.3 ± 5.6 years; height 177.9 ± 6.3 cm; body mass 62.9 ± 5.5 kg; 10,000-m personal best 43 minutes 26 seconds ± 02 minutes 51 seconds) of regional, national, and international levels, participated in this study. They were fully informed of the aims and the procedures of the study and received both verbal and written explanations. Moreover, they gave an informed consent in agreement with the Declaration of Helsinki on human experimentation. This study was approved by the local Ethics Committee. The subjective goal of the competition was primarily to win and second to attain the best performance based on individual characteristics and training background. All the athletes were already familiarized with the distance because it represents a common and important step during the training cycle focusing to the major RW events (i.e., 20- and 50-km races).

The race was performed during the second third of the season (April 2009). During this period, the athletes spent approximately 15% and approximately 85% of their training sessions at high intensity and low intensity (>4 and <4 $mmol \cdot L^{-1}$, respectively). The last high-intensity training was performed 3–5 days before the race, with a tapering strategy that consisted of 50% training reduction in both volume and intensity. On the race day, the subjects were asked to maintain their nutritional habits and were allowed to drink ad libitum; however, the hydration status was not controlled. Before the performance, the athletes performed a warm-up consisting of 20 minutes of slow RW and 10 minutes of technical drills. The race was performed on a certified 400-m outdoor tartan track (~21° C, 53% relative humidity, <0.3 $m \cdot s^{-1}$ wind, 138.5-m altitude).

During the entire event, the athletes were highly motivated because the event awarded points for the 3 best performances. These points were fundamental to success in the RW challenge list mentioned above. However, to constantly motivate the athletes, verbal encouragement was provided by the coaches throughout the race to ensure the best performance. The participants were only included in the study (i.e., a priori decision) if there was evidence that they completed the race without receiving, from experienced RW judges, >1 technical warning. This was because during an RW competition athletes can be disqualified when they do not comply with RW rules (as mentioned above) and after receiving 3 red cards. Consequently, the technical warnings might be considered as a constraint, negatively influencing the performance.

Procedures

Data Collection during the Race. All the athletes were already familiarized with both the HR and RPE, using these devices during their training sessions.

Heart Rate. During the race, the HR was recorded continuously using a short-range telemetry system (Polar S610 HR Monitor, Polar Electro Oy, Kempele, Finland). The maximal HR value found during the race was taken to be the highest HR achieved by the athletes. Therefore, for the rest of the article, the term HRpeak will be used when referring to maximal HR values. The decision was based on the small variance (±3.4 $b \cdot min^{-1}$) observed between the

HRpeak and maximal HR values obtained during an incremental and maximal field test (i.e., Conconi test), performed by the athletes during various portions of their training cycle as a normal function of monitoring training. Moreover, because our participants were professional race walkers, we took into consideration 85% of the HRpeak as the value that can be considered to be equivalent to 80% of peak oxygen uptake, corresponding to a vigorous activity (36).

The HR recordings were averaged for every 5 seconds and expressed relative to the maximum value (% HRpeak) of the athletes observed during the race. To provide a measure of relative intensity, 5 HR zones were assessed according to Edwards, briefly: HR1 = 50–60% of the HRpeak, HR2 = 60–70% of the HRpeak, HR3 = 70–80% of the HRpeak, HR4 = 80–90% of the HRpeak, and HR5 = 90–100% of the HRpeak (12).

Rating of Perceived Exertion. The Italian translation of the Borg's 6–20 RPE scale (5) was used. According to Impellizzeri et al., this scale was modified to better reflect the American idiomatic English (24). The use of this scale was based on the linear relationship observed between perceptual data and HR (4,5,22). Before the race, standardized instructions on how to implement the scale during the performance were provided (5). It was emphasized that the overall sensation of exertion would be reported during the race. Borg's 6–20 RPE scale was in full view of the participants, using 2 A1 international standard paper formats (ISO 216, 594·841 mm), placed corresponding to every 1,000-m split distance. Fifty meters before each 1,000 m, an operator recalled to the participants to report the sensation of exertion to another operator situated close to the paper format.

Pacing Strategy. Pacing strategies and the list of technical warnings inflicted were retrieved for each athlete from the official race results published by the organizers of the event. Race distance and walking speed were expressed in 'actual units' and according to the International System of Units (meters and meters per second, respectively). Pacing strategy was presented as the absolute speed every 1,000 m and as percent change compared with the first split time.

Statistical Analyses

Data are presented as the mean ± *SD* and primarily accomplished using simple descriptive statistics. The 1,000-m split distances were used to determine the test-retest reliability of % HRpeak, RPE, and % change in walking speed by means of intraclass correlation coefficient (ICC) and *SEM* expressed as a coefficient of variation (CV) (39).

Subsequently, the results were tested for normal distribution using the Shapiro-Wilk *W* test. All data met the assumption of normal distribution with the exception of % HRpeak. A log transformation was applied to this measure to reduce bias caused by nonuniformity of error. Then, the alterations in % HRpeak, RPE, and walking speed among the ten 1,000-m split distances were determined using a 1-way analysis of variance for repeated measures, with the Bonferroni post hoc test. The magnitude of the changes was assessed using effect size (ES) statistic with 90% confidence intervals and percentage change (3). The ESs were classified according to Hopkins (http://www.sportsci.org. Accessed October 2011): <0.2 = trivial, 0.2–0.6 = small, 0.6–1.2 = moderate, 1.2–2.0 large, >2.0 = very large. The alpha level set for significance was $p < 0.01$. The statistical analyses were performed using the software IBM® SPSS® Statistics (version 18.0.0, IBM Corporation, Somers, NY, USA).

Results

All the athletes ($n = 14$) received not more than 1 technical warning. Consequently, according to the a priori decision mentioned above, the whole group was taken into consideration in the analysis. The mean final time of the race was 44 minutes 16 seconds ± 2 minutes 27 seconds, 06 minutes 23 seconds (i.e., −17%) slower than the 10,000-m RW World Record (i.e., 37 minutes 53 seconds performed by Spanish Francisco Javier Fernández on July 2008).

The HRmean recorded was 181.7 ± 10.7 b·min^{-1} corresponding to 96.2 ± 3.4% of the mean HRpeak observed throughout the event (i.e., 189.0 ± 6.6 b·min^{-1}). On analyzing the mean distribution of the HR during the performance, narrow ranges of intensity were observed. In fact, the athletes spent 95.4% (42 minutes 13 seconds) at HR5 (i.e., 90–100% of the HRpeak), whereas the other work (4.6%, 02 minutes 03 seconds) was negligible because the athletes performed 0, 15, 15 seconds, and 1 minute 30 seconds to intensities corresponding to HR1, HR2, HR3, and HR4, respectively. A detailed description of the HR response expressed relative to the % HRpeak is illustrated in Figure 1 and described in Table 1. During the race, a shift toward

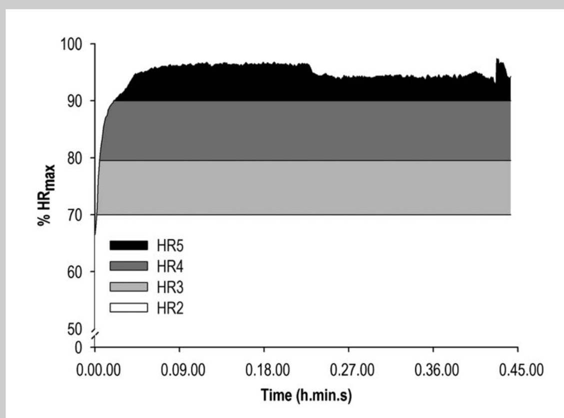

Figure 1. Athletes' heart rate profile (expressed as mean % HRpeak) during the 10,000-m RW event. HR2 = 60–70% of the HRpeak, HR3 = 70–80% of the HRpeak, HR4 = 80–90% of the HRpeak, and HR5 = 90–100% of the HRpeak.

TABLE 1. Mean (*SD*) of the perceptive and physiological variables provided by the athletes over the event.*

Distance (m)	RPE	HR (b·min^{-1})	% HRpeak
1,000	11 (1.5)	180.1 (11.3)	94.6 (2.6)
2,000	12 (1.5)	183.4 (12.0)	96.3 (2.4)
3,000	13 (1.5)	183.9 (13.1)	96.5 (2.4)
4,000	13.5 (2.0)	181.3 (13.5)	95.2 (3.5)
5,000	14 (1.5)	183.4 (13.9)	96.3 (2.2)
6,000	14.5 (1.5)	183.9 (14.4)	96.5 (1.7)
7,000	14.5 (2.0)	185.1 (14.4)	97.2 (1.2)
8,000	15 (2.0)	184.6 (15.0)	96.9 (0.7)
9,000	15.5 (2.0)	184.5 (15.6)	96.9 (0.9)
10,000	16 (2.0)	186.5 (16.1)	97.9 (1.2)

*RPE = rating of perceived exertion (rounded to the nearest 0.5 value); HR = heart rate (absolute value); % HRpeak = heart rate expressed relative to the maximum value observed during the race (relative value).

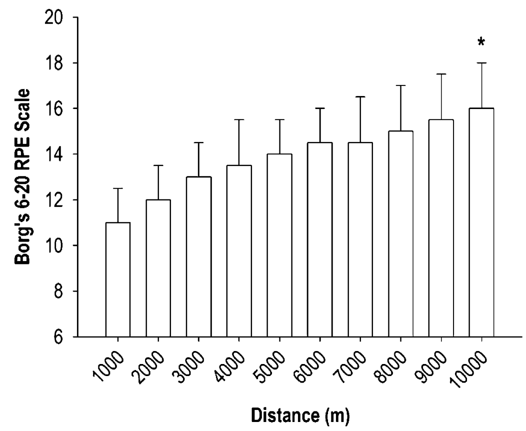

Figure 3. Mean (±*SD*) of the athletes' perceived exertion (using Borg's 6–20 RPE scale) across the ten 1,000-m sectors. *Significantly different compared with the first five 1,000-m sectors ($p < 0.02$).

higher HR values was observed. In fact the % HRpeak (ICC = 0.87; *SEM* as a CV = 1.5%) increased by 3.6% in the last vs. the first 1,000-m sector ($p = 0.002$, ES = 1.55 ± 0.68, large) (Figure 2).

The mean RPE reported by the athletes (rounded to the nearest 0.5 arbitrary unit) during the race was 14 ± 1.5, corresponding to a 'somewhat hard' intensity on the Borg's 6–20 RPE scale. Table 1 provides the detailed description of the athletes' perceived exertion throughout the competition. Data ranged from 11.5 ± 1.5 to 16 ± 2 at the first and last 1,000-m split distances, respectively. The mean RPE increased by 43% in the last vs. the first 1,000-m sector ($p < 0.001$, ES = 2.96 ± 0.67, very large). Moreover, the mean RPE (ICC = 0.64; *SEM* as a CV = 5.8%) in the last 1,000 m was significantly higher than in the first 5 sectors ($p < 0.02$, ES = 1.93–2.96, large to very large) (Figure 3).

The mean walking speed throughout the event was 3.78 ± 0.20 m·s^{-1}. The first and the last 1,000 m were walked at a mean speed of 3.76 ± 0.20 m·s^{-1} (0%) and 3.80 ± 0.22 m·s^{-1} (4.16 ± 2.7%), respectively, with the middle 8,000 m performed at 3.78 ± 0.20 m·s^{-1} (1.87 ± 0.9%). Comparing the pacing strategy every 1,000 m as the percent change of the first split time, the walking speed increased over the duration of the event. In fact, the mean percent change (ICC =

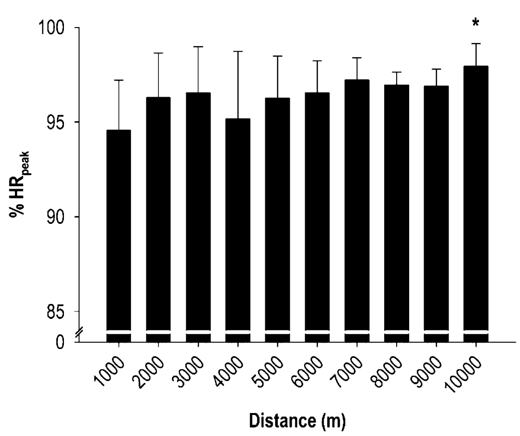

Figure 2. Mean (±*SD*) of the athletes' heart rate (expressed as a percentage of the HRpeak) across the ten 1,000-m sectors. *Significantly different compared with the first 1,000-m sector ($p = 0.002$).

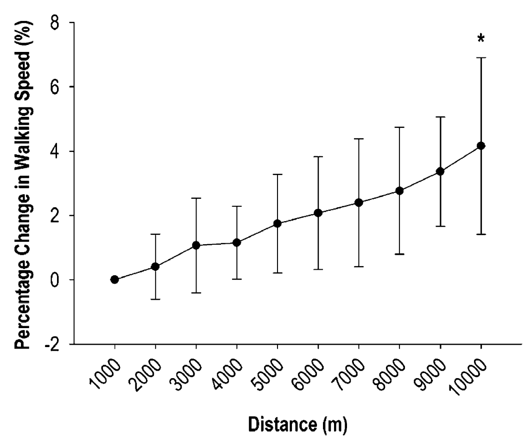

Figure 4. A plot of the athlete's walking speed (expressed as percentage change compared with the first split time) during the race in relation to the distance (1,000 m) completed. *Significantly different compared with the first six 1,000-m sectors ($p < 0.01$).

0.71; *SEM* as a CV = 0.2%) increased between the first 6 sectors and the last 1,000-m sector ($p < 0.01$, ES = 1.02–2.1, moderate to very large) (Figure 4).

Discussion

To the best of our knowledge, this study was the first attempt to quantify the perceptual and physiological variables during a self-paced 10,000-m RW race.

Primarily, the athletes' HRmean corresponded to 96.2 ± 3.4% of the mean HRpeak observed throughout the event. This value exceeded 85% of the HRpeak set according to Stachenfeld et al. (36), arguing that the pattern of exercise intensity during this event shows a high-intensity profile. In fact, almost all the exercise (95.4%) was performed to an HR5 (i.e., 90–100% of HRpeak). The work performed inside the other ranges was negligible because HR1 was not measured, whereas HR2, HR3, and HR4 (4.6%, 120 seconds) were mainly observed during the initial phases of the race (Figure 1). This consideration is in line with that of a previous study that showed that the HR of trained endurance athletes increased around 90 seconds from the start of the race (18). During the competition, the athletes' % HRpeak increased by 3.6% in the last vs. the first 1,000-m sector ($p = 0.002$, ES = 1.55 ± 0.68, large) (Figure 2). This would suggest an increase in the HR to maintain a nearly constant cardiac output until the end of the race (Figure 1). This growth in cardiovascular responses at a certain walking intensity is probably related to avoiding the so-called phenomenon 'cardiovascular drift' (CV drift) (13), which is a time-dependent change (i.e., decrement) in some cardiovascular responses such as stroke volume (10,19). Moreover, the weather conditions (~21° C, 53% relative humidity, <0.3 $m \cdot s^{-1}$ wind) did not exacerbate this phenomenon, given that the CV drift during prolonged submaximal exercise would be greater in a hot (e.g., 35° C) than in a cool environment (e.g., 22° C) (25).

Second, the mean RPE in the last 1,000 m was significantly higher than in the first 5 sectors ($p < 0.02$, ES = 1.93–2.96, large to very large). This would suggest that during the competition, a significant increase in the athletes' perceived exertion occurred (Figure 3). With RPE, an athlete uses subjective feelings to assign a numerical rating estimating global effort. Accordingly, there was a trend for greater values with increased duration (Figure 3), which incidentally corresponds to the time-dependent drifts for acute measures of intensity observed in Figure 2. Thus, the increment in the exercise intensity observed with the HR is also supported by the analysis of the mean perceived exertion. This would suggest that the RPE could be considered a simple and valid method for quantifying the global exercise intensity during RW-specific event.

Third, the pacing strategy adopted by the athletes during this kind of event shows that the first and the last 1,000 m were performed in the slowest and fastest times, respectively. Particularly, walking speed increased between the first 6 sectors and the last 1,000-m sector ($p < 0.01$, ES = 1.02–2.1, moderate to very large) (Figure 4). These improvements in walking speed are extremely important for an athlete, to complete the task required in the faster time when compared with the opponents. These results suggest the adoption of a 'negative' pacing strategy, commonly defined as an increment in the speed observed over the duration of the event (1). Van Ingen Schenau et al. suggested that in prolonged competitions, the start represents a much smaller portion of the total race time (38). Thus, the athletes presented in this study may have spontaneously chosen a lower starting strategy based on their previous experiences of the duration of the remaining effort required (2,30). This more conservative strategy aimed to minimize the accumulation of fatigue early in the task, preserving both the rate of carbohydrate depletion and oxygen uptake to be able to improve the speed during the event (29,35). Moreover, this strategy is in a good agreement with those of several studies that showed, during middle-distance events, how the speed increased toward the end of both simulated and actual time-trial events (16,33). However, the latter consideration was refereed to endurance runners and can only be take into consideration in RW. This is because athletes and coaches must pay attention to the important effects of technical constraints. In fact, it is much harder for race walkers to increase the pace in the last few minutes of a race because they must keep within the technical rules governing this discipline and not simply 'sprint for the line.'

Finally, taken together, the above-mentioned considerations support the concept of the combination between HR data, RPE data, and pacing strategy to gain a better insight into the underlying physiological, perceptual, and regulatory processes of a 10,000-m RW event. Accordingly, the HR responses and the perceptual data at each 1,000-m sector reflected a progressive increment of the exercise intensity (Figures 2 and 3). However, despite the increased effort, the pacing strategy adopted by the athletes revealed a linear increment (Figure 4). This means that the athletes were still able to perform an effort very close to the high-intensity range during the race at increased speed. This consideration is probably related to the athletes' perception of effort, that is, 'a conscious awareness of the central motor commands to the locomotor and respiratory muscles' (26). Consequently, the athletes' perceived exertions were probably lower than the maximum effort set to succeed in the exercise task (28), giving the athletes the opportunity to increase the walking speed throughout, maintaining it under volitional-maximum effort. These considerations may confirm the hypothesis that an exercise performance would be regulated by the conscious brain 'on the basis of the maximum effort a person is willing to exert to satisfy a motive and perceived exertion' (27). Furthermore, the conscious awareness of the end point offers a reference point that may allow the athletes to regulate the work rate to economize the power output. This is with the aim of preserving the energy stores available to face the several race-dependent tactical situations, such as a final end spurt, which occurred when a task was 90% complete, despite the duration of the task (8).

Practical Applications

The physiological and perceptual patterns assessed during a 10,000-m RW race showed a high-intensity profile. Such information may be used by the athletes and coaches to trace a performance profile of this kind of competition. This is with aim to prescribe a more accurate training periodization over the entire athlete's competitive season.

The findings of this study also suggest that the use of physiological and perceptual data, matched with the regulation of the physiologic strain, would be important to understand the regulatory processes during a 10,000-m RW event. Moreover, the RPE may be a valid marker of global exercise intensity in athletes who undertake high-intensity endurance exercise.

Finally, this study suggests that pacing strategy may be a conscious behavior that is decided by the athletes themselves according to the internal feedback during the race.

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