Are experienced and high-level race walking athletes able to match pre-programmed with executed pacing?

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Abstract

The objective of this study was to verify the agreement between pre-programmed and executed pacing during race walking and whether level of the athletes experience and performance influenced this relationship. Twenty-nine national and international race walkers participated in this study (14 males, 24.0 ± 7.1 years old, and 15 females, 23.3 ± 7.3 years old). Pre-programmed pacing for 10- and 20-km official walking races was self-selected via demonstrative pacing charts prior to races, while executed pacing was analyzed by a specialist investigator via an individual plot of current velocity versus distance. There was no agreement between pre-programmed and executed pacing (P=0.674). There was no association between the ability to match the pre-programmed pace with the executed pace and race walking experience or level of performance. Low- and high-performance athletes pre-programmed a similar pacing profile (P=0.635); however, high-performance athletes generally executed an even pacing strategy, while low-performance athletes generally adopted a positive pacing strategy (P=0.013).

Race walkers did not faithfully match their pre-programmed with their executed pacing, and this seemed to be independent of previous experience and level of performance. High-performance athletes, however, tended to execute an even pacing strategy, even though this had not been pre-programmed.

Key words: Aerobic evaluation; Performance; Sport; Elite athlete; Physiology

Introduction

Pacing is defined as the alterations in power output or velocity that occur throughout a race, in order to reach the endpoint in the shortest possible time (1–4). This is an important determinant of performance in endurance sports such as cycling, speed skating, kayaking, running, and race walking (5–9). In particular, for race walking ranging from 10 to 20 km, a negative pacing (i.e., a slower start followed by a progressive increase in velocity as the race progresses) seems to be the most used pacing strategy (10–12). However, athletes may individually choose other pacing profiles, such as even (maintaining a constant velocity), positive (gradually decreasing the velocity over the distance), parabolic (starting with high velocities, slowing down during mid-race and increasing at the end), and variable (there is no clearly defined pattern for velocity distribution) (1,2,13,14). However, it is currently unknown whether the athletes follow a pre-programmed pacing profile or they “unconsciously” execute a given pacing during race walking.

Pacing may be influenced by learning and experience (3,15–17). For example, Hopkins and Hewson (18) reported that variations in end times for different running distances (3000 m to marathon) tend to be smaller for experienced than for inexperienced athletes. Foster et al. (19) also verified the effect of learning on performance during 3-km cycling and 2-km rowing time trials and reported a progressive increase in power output during the initial and middle phases of the race as individuals were repeating the trials. Together, these studies suggest that previous experience with endurance events is essential for determining optimal pacing and ultimately maximizing overall performance. Experience may be more important in sports demanding more technical skills as race walking; more experienced athletes may have a lower deterioration in

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Received February 9, 2019 | Accepted April 22, 2019
walking technique and consequently a lower number of
warnings (11,12,20–22). Thus, experience in race walking
might have an impact on the ability of the athlete to execute
a given pre-programmed pacing profile.

Another important factor that might impact pacing is
the level of performance. It has been demonstrated that
medalists in the 20- and 50-km races of the 7th World
Race Walking Cups started the race at velocities lower
than their best personal mark, while non-medalists started
the race at velocities higher than their best personal mark
(12). However, it is not known whether level of perfor-
ance influences pacing by allowing athletes to execute
precisely a pre-programmed pacing profile or by enabling
them to react more efficiently to unpredictable challenges
demanding a momentary pacing alteration during races
(e.g., opponent scrape).

Understanding whether an actual pacing profile differs
from the pre-programmed profile by the athlete and whether
different levels of experience and performance influence
the ability to execute a pre-established pacing strategy
can provide insights into how pacing is regulated during
race walking. Therefore, the objective of this study was to
verify the agreement between pre-programmed and exe-
cuted pacing during official 10- and 20-km race walking,
as well as to verify whether prior experience and level
of performance of the athletes influenced this relation-
ship. We hypothesized that more experienced and high-
performance athletes better matched a pre-programmed
pacing with their executed pacing compared with the less
experienced and low-performance racing competitors.

Material and Methods

Participants

Twenty-nine race walkers of national and international
experience levels participated in this study (14 males and
15 females, 24.0 ± 7.1 and 23.3 ± 7.3 years old, respec-
tively). Athletes were in the under 20 (4 males and 7
females) and adult (10 males and 8 females) categories,
and participated in 10- and 20-km races, respectively.
Athletes at the national level had participated in state and
national competitions, while athletes at the international
level had participated in competitions such as the Olympic
Games, South American/Pan American Championships,
IAAF World Race Walking Cup, and competitions hosted
in other countries in the last four years before the study.
One athlete ranked third in the 2017 IAAF World Cham-
ionships and was among the top 10 race walking athletes
in the world. All participants received a verbal explana-
tion about the potential benefits, risks, and discomfort
associated with this study. Each was asked to give written
informed consent before participating in the study.

This study was approved by the Ethics Committee of
Universidade Federal de Juiz de Fora (1.047.279) and
was performed in accordance with the ethical standards
established by the Declaration of Helsinki (23).

Experimental design

The data were collected during the 10- and 20-km
races of the largest Brazilian race walking competition,
which was organized by the Brazilian Athletics Confed-
eration (CBAt) and followed the rules established by the
International Association of Athletics Federations (IAAF).
The races were performed on a 1-km flat street circuit
(altitude 17.0 ± 3.0 m). The time recorded for each lap of 1
km was provided by the official organizer (CBAt).

Instruments and procedures

A dashboard with the most common pacing profiles
during race walking (i.e., even, positive, negative, para-
bolic, or variable) was prepared and showed to each
athlete before the competition. The dashboard was created
based on a previous study that described various types of
pacing strategy in athletic competitions (1). The pacing
profiles were displayed as velocity (km/h) for each 10%
of the total distance. Athletes were familiarized prior to
responding to the questionnaire through examples of pacing
strategy performed in previous competitions of endurance
sports. In addition, verbal explanations were provided on
how to interpret figures and then the participants indicated
which strategy they would use in that competition. The
pacing profiles were explained as: a) even pacing, where
the athlete maintains (or changes minimally) the velocity
during the race; b) positive pacing, where the athlete starts
at a high velocity and decreases gradually during the race;
c) negative pacing, where the athlete starts at low velocity
and gradually increases during the race; d) parabolic
pacing, where the athlete starts at high velocity, decreases
during the race, and increases at the end; and e) variable
pacing, where there is no defined pattern for velocity
distribution (Figure 1).

After athletes had indicated their pre-programmed
pacing strategy, they warmed up for approximately 40 min
before speed walking their respective races. For the exe-
cuted pacing, the velocity for each lap (km/h) was plotted
against each 10% of the total distance and displayed in
graphs. A specialist investigator, who was an expert in race
walking and not aware of the pre-programmed pacing
strategy of the athletes, classified each executed pacing
profile as one of the five possible patterns.

The experience was measured by recording how long
(in months) he/she had been practicing race walking up to
the day of competition. Then, the sample was split into two
groups using the 50th percentile, one group with less
experience (5–48 months) and the other group with more
experience (49–240 months). The level of performance
was evaluated similarly by dividing the athletes into
two groups using the 50th percentile, one with high
(1st to 5th place) and another with low (>6th place) level of performance in the race.

**Statistical analysis**

Data are reported as means ± SD and frequency. The data normality assumption was evaluated by the Shapiro-Wilk test. The level of agreement between pre-programmed and executed pacing was verified using the Kappa agreement test. In order to test the relationship between experience/level of performance with the agreement of pre-programmed and executed pacing, a nominal variable was created to classify athletes as performing or not the pre-programmed pacing during the event. For athletes who did not match the pre-programmed pacing with their executed pacing, code 1 was assigned. Those for whom agreement was obtained, code 2 was assigned. The association of experience and level of performance with agreement in pacing strategy was tested with Fisher’s exact test. The association of experience and level of performance with pre-programmed and executed pacing was tested with the chi-squared test. All analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 20.0 (IBM Corp., USA). Statistical significance was considered when P < 0.05.
Results

The average velocity was 10.59 ± 0.74 km/h in 10-km and 11.09 ± 1.59 km/h in 20-km races. The frequency of pre-programmed and executed pacing strategies is shown in Table 1. The most frequent pre-programmed pacing strategy was the negative (n=16, 55.2%), followed by the even (n=10, 34.4%), positive (n=2, 6.8%), and parabolic (n=1, 3.4%). The most frequently executed pacing strategy was the positive (n=14, 48.2%), followed by the even (n=12, 41.3%), parabolic (n=2, 6.9%), and negative (n=1, 3.4%). None of the participants pre-programmed or executed the variable pacing strategy. The agreement analysis indicated that there was no significant association between pre-programmed and executed pacing (k=–0.074; P=0.307; n=29).

As shown in Figure 2, level of experience was not significantly related to the agreement between pre-programmed and executed pacing (P=0.99). In addition, more experienced athletes did not have a clear preferable pre-programmed or executed strategy for pacing nor did they differ from less experienced athletes (pre-programmed $\chi^2(3)=3.370, P=0.338$; executed $\chi^2(3)=4.447, P=0.217$, Table 2).

As shown in Figure 3, the level of performance was also not related to the match between pre-programmed and executed pacing (P=0.606). In addition, high-performance athletes did not have a clear preferable pre-programmed pacing strategy, and thus did not differ from low-performance athletes (pre-programmed $\chi^2(3)=1.708, P=0.635$). However, high-performance athletes predominantly used even pacing, while low-performance athletes predominantly used positive pacing (executed $\chi^2(3)=10.709, P=0.013$, Table 3).

Discussion

This is the first study investigating the agreement between pre-programmed and executed pacing in race walking, and whether experience and level of performance influenced this relationship. Our findings indicated that the majority of athletes pre-programmed the negative (55.2%) or even (34.4%) pacing strategy; however, they were unable to follow this pre-programmed pacing strategy and executed either the positive (48.2%) or even (41.3%) pacing style. Only four athletes (13.8%) matched their executed strategy with their pre-programmed pacing. The ability to match executed and pre-programmed pacing strategy seems not to be related to the athlete’s experience or level of performance. However, high-performance athletes predominantly performed even pacing, while low-performance athletes performed predominantly positive pacing. Interestingly, this difference could not be predicted from the pre-programmed pacing analysis. Together, these findings suggested that a higher performance during race walking might be related to the ability to keep a constant velocity throughout the race, rather than to try to follow the pre-programmed pacing.

In the present study, there was no agreement between pre-programmed and executed pacing. Likewise, a study with cyclists and ultramarathon runners observed many discrepancies between pre-programmed and executed pacing, mainly at the beginning and end sections of the race (24). Cyclists started a 5-km time trial more slowly and finished faster than their prediction. In contrast, during a 100-km head-to-head competition, ultramarathon runners started faster and finished more slowly than their prediction (24). This might indicate that the presence of competitors probably “enforces” a faster start (25). In fact, the presence of an opponent is an important issue during

Table 1. Number and percentage of pre-programmed vs executed pacing.

| Pre-programmed pacing | Even | Positive | Negative | Parabolic |
|-----------------------|------|----------|----------|----------|
| Even (n=10)           | 3 (10.3%) | 6 (20.7%) | 1 (3.4%) | 0 (0%)   |
| Positive (n=2)        | 1 (3.4%) | 1 (3.4%) | 0 (0%) | 0 (0%)   |
| Negative (n=16)       | 8 (27.6%) | 6 (20.7%) | 0 (0%) | 2 (6.9%) |
| Parabolic (n=1)       | 0 (0%) | 1 (3.4%) | 0 (0%) | 0 (0%)   |

Statistical test: Kappa (k=–0.074; P=0.307; n=29).

![Figure 2. Agreement between pre-programmed and executed pacing in less and more experienced race walkers (Fisher’s exact test, P=0.99).](image-url)
a mass-start event (25), leading to greater velocities at the beginning of a race (26,27). It has been suggested that the pacing template lacks accuracy, indicating greater reliance on momentary pacing decisions rather than pre-planned strategy (24). In the present study, race walkers switched from a pre-programmed negative (slow start) to positive (fast start) pacing, which suggests that the opponents, rather than the pre-programmed strategy, dictated the rhythms at the beginning of the race. Therefore, controlling the velocity at the beginning by prior instruction may be important to preserve a better overall performance and avoid early competitor-induced fatigue.

In the present study, we found no influence of the athletes’ previous experience on their ability to match pre-programmed with executed pacing. However, an interesting finding was that high-performance athletes adopted mostly an even pacing, while low-performance athletes adopted more aggressive pacing at the beginning (i.e., positive pacing), even though this was not pre-programmed. Previous studies have shown that athletes with a high performance level tend to establish distinct pacing from those of lower level (4,12). Only one study compared level of performance in race walking and found that medalists have the ability to start faster and maintain velocity throughout the race, when compared to non-medalist athletes (12). Our results suggested that during a mass-start event, low-performance athletes changed from even or negative pre-programmed pacing to a more aggressive, positive pacing strategy, perhaps trying to follow the leaders. The effect of this reduces wind resistance and the chances of attracting the judges’ attention for possible disqualification (12,29). This seems to be unsustainable for the entire race and velocity will likely decrease as the race progresses. High-performance athletes, on the other hand, were able to control their start, probably because they employed high velocities at the beginning and sustained them throughout the race.

The strategy to evaluate pre-programmed and executed pacing was inexpensive and easy to apply. Our analyses, however, were based on data from athletes (pre-programmed) and a researcher (executed) using visual identification. It is improbable that this had a strong impact on our results as the athletes had been instructed and familiarized with the five patterns of pacing; the same experience was true for the investigator, who was unaware of the pre-programmed pacing, and classified all executed pacing. Previous studies have demonstrated that pacing during endurance events can be classified only into the five types used in the present study (1,14). In addition, we recruited males and females, and young and

Table 2. Pre-programmed and executed pacing in less and more experienced race walkers.

|                     | Pre-programmed pacing |          | Executed pacing |          |
|---------------------|-----------------------|----------|-----------------|----------|
|                     | Less                  | More     | Less            | More     |
| Even                | 4 (26.7%)             | 6 (42.9%)| 5 (33.3%)       | 7 (50.0%)|
| Positive            | 2 (13.3%)             | 0 (0%)   | 9 (60.0%)       | 5 (35.7%)|
| Negative            | 8 (53.3%)             | 8 (57.1%)| 1 (6.7%)        | 0 (0%)   |
| Parabolic           | 1 (6.7%)              | 0 (0%)   | 0 (0%)          | 2 (14.3%)|

Statistical test: chi-squared (pre-programmed $\chi^2$(3)=3.370, P=0.338; executed $\chi^2$(3)=4.447, P=0.217).
older athletes, where both sex and age might have an influence on the capacity to match pre-programmed and executed pacing (18,30). Even with these recognized limitations, this was the first experimental study using highly competitive athletes in real competitions. Thus, our results might be useful to help coaches and athletes to understand the difficulty of matching pre-programmed and executed pacing, and to determine the most efficient pacing strategy for the best performance.

In summary, race walkers did not match their pre-programmed and executed pacing, and this seems to be independent of previous experience and performance level. However, high-performance athletes tended to execute an even pacing regardless if this had or had not been pre-programmed.

Acknowledgments

This study was financed in part by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, Brasil (CAPES, Finance Code 001). The authors thank all athletes for their participation in this research. The English text of this paper has been revised by Sidney Pratt, Canadian, MAT (The Johns Hopkins University), RSAdip - TESL (Cambridge University).

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Table 3. Pre-programmed and executed pacing in low- and high-performance race walkers.

|                     | Pre-programmed pacing | Executed pacing |
|---------------------|-----------------------|-----------------|
|                     | Low (38.5%)           | High (31.2%)    |
| Even                | 5 (38.5%)             | 5 (31.2%)       |
| Positive            | 1 (7.7%)              | 1 (6.3%)        |
| Negative            | 6 (46.1%)             | 10 (62.5%)      |
| Parabolic           | 1 (7.7%)              | 0 (0%)          |

Statistical test: chi-squared (pre-programmed $\chi^2(3)=1.708$, P=0.635; executed $\chi^2(3)=10.709$, P=0.013).

*Significantly different from low-performance athletes for executed pacing (P=0.013).
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