Pacing Ability in Elite Runners with Intellectual Impairment

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ABSTRACT

VAN BIESEN, D., F. J. HETTINGA, K. MCCULLOCH, and Y. C. VANLANDEWIJCK. Pacing Ability in Elite Runners with Intellectual Impairment. *Med. Sci. Sports Exerc.*, Vol. 49, No. 3, pp. 588–594, 2017. **Purpose**: To understand how athletes invest their energy over a race, differences in pacing ability between athletes with and without intellectual impairment (II) were explored using a novel field test. **Methods**: Well-trained runners (n = 67) participated in this study, including 34 runners with II (age = 24.4 ± 4.5 yr; IQ = 63.1 ± 7.7) and 33 runners without II (age = 31.4 ± 11.2 yr). The ability to perform at a preplanned submaximal pace was assessed. Two 400-m running trials were performed on an athletics track, with an individually standardized velocity. In the first trial, the speed was imposed by auditory signals given in 20–40 m intervals, in combination with coach feedback during the initial 200 m. The participant was instructed to maintain this velocity without any feedback during the final 200 m. In trial 2, no coach feedback was permitted. **Results**: Repeated-measures analyses revealed a significant between-group effect. II runners deviated more from the target time than runners without II. The significant trial–group interaction effect (F = 4.15, P < 0.05) revealed that the ability to self-regulate the pace during the final 200 m improved for runners without II (trial 1, 1.7 ± 1.0 s; trial 2, 0.9 ± 0.8 s), whereas the II runners deviated even more in trial 2 (4.4 ± 4.3 s) than that in trial 1 (3.2 ± 3.9 s). **Conclusion**: Our findings support the assumption that intellectual capacity is involved in pacing. It is demonstrated that II runners have difficulties maintaining a preplanned submaximal velocity, and this study contributes to understanding problems II exercisers might experience when exercising. With this field test, we can assess the effect of II on pacing and performance in individual athletes which will lead to a fair Paralympic classification procedure. **Key Words:** RUNNING, ATHLETICS, TRACK AND FIELD, INTELLIGENCE

For optimal athletic performance, athletes must regulate their exercise intensity (1) and decide how and when to invest their energy related to the goal they would like to achieve (25). Poor regulation of exercise intensity is associated with competition failures (7,29), thereby stressing the importance for athletes to adequately pace their races through the use of pacing strategies. Previous research has addressed the complexity of pacing (1,18,26), and this important skill has been associated with a combination of interoceptive (i.e., physiological, psychological, and/or biomechanical) and exteroceptive (i.e., environmental) factors (25). There is growing consensus in the literature about pacing being linked to the brain (1,6,9,10,21–23,25,26,28,31,32). Factors related to intellectual capacity, such as using previous experiences, knowledge of future physiological requirements, understanding of self-physiology, perceived exertion, deductive reasoning, and interactions with external factors all influence this process. However, up until now, the majority of pacing studies have focused on individuals with excellent pacing abilities (elite athletes), whereas only few studies specifically addressed pacing in relationship with intellectual impairment (II). Previous research on cognitive development (11) and how it affects pacing strategies and motor skills highlights that there is some link; however, the specific relationship between cognition and pacing remains unknown (33). Knowing that pacing ability is at least partly influenced by an intellectual component, evidenced by a definite relationship between cognitive development and selecting appropriate pacing strategies in schoolchildren (15), we can assume that this ability is affected in athletes with II, but there is a general lack of evidence, and more thorough investigation is required. The in-depth understanding of the role cognition plays in regulating exercise intensity (and therefore the balance between exhaustion and successful performance) is of high importance to improve our understanding of the potential problems that exercisers with II might experience when exercising, particularly during middle distance/longer distance running events. Therefore, the goal of this study is to enhance our understanding regarding pacing in elite runners with II.

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Several elements are crucial within pacing, such as the ability to think in advance how to organize the race and also how to respond to opponents and to correctly judge and react (or not react) to the actions of your opponents (13,19,30) and to interpret the signals of fatigue within your own body (7,16,27). This study is the first to actually assess one of the core elements of pacing ability, i.e., the ability to maintain a preplanned submaximal velocity. This is particularly relevant for the middle- and long-distance runners with II, and we will focus specifically on the 400-, 800-, 1500-, and 5000-m runners. The principal research question is whether there are differences in this ability to maintain a preplanned submaximal running velocity in well-trained athletes with and without II. The hypotheses are as follows:

1. Well-trained runners with II are able to run at an imposed submaximal velocity making use of external auditory and visual cues.
2. Runners with II have more problems than equally well-trained runners without II to maintain an imposed submaximal running speed making use of internal information (self-regulation).
3. Well-trained athletes with and without II improve their performance between the first and the second trials (learning effect).

METHODS

Participants. A total sample of 67 middle- and long-distance runners participated in this study: 34 elite runners with mild II (22 males and 12 females; age = 24.4 ± 4.5 yr; IQ = 63.1 ± 7.7) and a comparison group of 33 runners without impairment (27 males and 6 females; age = 31.4 ± 11.2 yr). The runners with II competed at the 2014 Open European Championship Athletics, in Bergen Op Zoom, The Netherlands, organized by the International Federation for Para-Athletes with Intellectual Impairment (INAS). From here on, the sample will be called the II runners. The II runners were recruited via personal contact with the coaches before and during the championship based on the following criteria: competing in long sprint and/or middle and long-distance races (400, 800, 1500, and 5000 m) and meeting the criteria for diagnosis of an intellectual disability as set by the American Association on Intellectual and Developmental Disabilities (2): IQ ≤ 75, significant deficits in adaptive behavior and manifested before the age of 18 yr. None of the participants had severe or moderate II or a chromosomal disorder (e.g., Down syndrome). The participants represented 13 countries: 11 European and 2 Asian.

The selection of the comparison group was based on their principal sport and comparable running experience (9.3 ± 7.4 yr) and training volume (8.3 ± 4.0 $h \cdot wk^{-1}$) similar to the II runners (9.6 ± 4.8 yr of experience and 9.4 ± 4.0 $h \cdot wk^{-1}$ training volume). They were recruited by contacting local (Belgian) athletics clubs via e-mail, phone, or a personal visit and by posters in the main sport facilities of Leuven's University Sports Center. IQ scores were not available for the comparison group; however, having an II was ruled out by including participants who, at minimum, had graduated from secondary education. All participants and/or their legal guardians signed a written informed consent form before participation. The study was approved by the local ethics committee (Commissie Medische Ethiek, KU Leuven).

Procedure. Each participant performed a running test to assess pacing ability on an official 400-m athletics track. The II runners were tested at the INAS European Athletics Championships track before competition (June 2014). Test sessions of the comparison group took place in and around Leuven, Belgium, between September and December 2014. The study has a cross-sectional design.

Before the start of the test, 11 cones were placed on the 400-m track at marked distances (20, 40, 60, 80, 120, 160, 200, 250, 300, 350, and 400 m) as indicated in Figure 1. The target pace for each participant was calculated as 80% of their personal best time (PR) on a 1500-m distance using the following formula: [(PR 1500 m/0.8)/1500] × 400. When no PR on 1500-m distance was available, it was predicted from the PR on the athlete's preferred distance using the following conversion formulas:

1. Lap time = (PR of a certain distance/distance of the PR) × 400.
2. Predicted PR on 1500-m distance = [(lap time world record 1500 m + (lap time PR preferred distance − lap time world record preferred distance))/400] × 1500.

This approach was used to extrapolate the use of the pacing test, which was originally developed for 1500-m runners to other distances. The formula was adapted to gender by using the male/female world records accordingly.

After warming up, the test instructions and demonstration were given to the participant. Every test was conducted by two test instructors. Every participant performed two trials of 400 m on the track. The required velocity was imposed during the first 200 m, and the task was to maintain this velocity during the last 200 m of the 400-m lap without any external feedback. During the first trial, the required velocity was imposed using auditory signals (whistle blows) combined with additional feedback of the athlete's personal coach. The first test instructor (T1 in Fig. 1) blew the

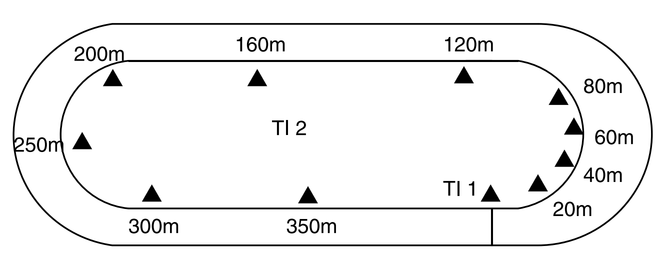

FIGURE 1—Test setup for the execution of the pacing test. TI 1, test instructor 1; TI 2, test instructor 2. Distances associated with 11 split time points.

whistle every time the athlete had to pass one of the cones. Hearing the whistle signal before reaching the cone implies the need to speed up. Hearing the whistle signal after having already passed the cone implies the need to slow down. A 5-m "run-up" to the start line was foreseen to overcome a velocity of zero and allowing the participant to build up speed to the start line. After the first trial, at least a 5-min recovery time was foreseen before executing the second trial. In between trials, no quantitative feedback was given regarding the performance of the athlete, only qualitative feedback about how the athlete followed the instructions during the first 200 m part. In the second trial, again, the same required velocity was imposed during the first 200 m using auditory signals (whistle blows), but this time without additional feedback from the coach. The second test instructor (T2 in Fig. 1) was standing in the middle of the infield and used a digital stop watch to register total lap time and split times each time the participant passed a cone. The total duration of the test was approximately 15 min.

After each trial of the pacing test, the recorded split times were registered and rounded up to one hundredth of a second. The deviation score for each time point was calculated. The deviation score is the difference between the actual time run until that measure point and the imposed target time for that measure point, which is calculated from the formula mentioned earlier. Positive deviation scores indicate that the athletes ran too slow, and negative deviation scores indicate that they ran too fast during the pacing test.

Data analysis. The data were analyzed using IBM SPSS Statistics (version 22.0; SPSS Inc., Chicago, IL), with level of significance set at $P < 0.05$. For the deviation scores, both the absolute deviation (AD) and the relative deviation (RD) were used as dependent measures. AD represents the mean deviation from the target time, without taking into account the direction of the deviation and provides information about the absolute size of the deviation. RD provides information about the direction of the deviation (negative values representing running too fast and positive values representing running too slow). For the in-depth analyses of AD and RD, 2 (group: with and without II) × 11 (split time points) analyses of variance were performed for both trials separately with repeated measures on the latter factor. For the comparison of average AD between trials, after the initial 200 m and after the final 200 m, 2 (group: with and without II) × 2 (trial 1 vs trial 2) repeated-measures analyses were performed. Effect sizes were calculated for the deviation from the target time (http://www.uccs.edu/~lbecker/). An effect size of 0.2 is small, 0.5 represents a medium effect, and 0.8 represents a large effect (4).

RESULTS

The average AD from the target time after the initial 200 m and after finishing the complete 400 m run of both trials is presented in Table 1.

TABLE 1. Absolute deviation from the target time after the initial 200 m and after the final 200 m of both 400-m trials.

	With II (n = 34)			Without II (n = 33)		
	M	SD	95% CI	M	SD	95% CI
Absolute deviation (s) after initial 200 m						
Trial 1 (with coach feedback)	1.1	1.6	0.6–1.6	0.7	0.6	0.5–0.9
Trial 2 (no coach feedback)	1.8	2.7	0.9–2.7	0.5	0.4	0.4–0.6
Absolute deviation (s) after end of trial (400 m)						
Trial 1 (with coach feedback)	3.2	3.9	1.8–4.6	1.7	1.0	1.3–2.1
Trial 2 (no coach feedback)	4.4	4.3	2.9–5.9	0.9	0.8	0.6–1.2

CI, confidence interval.

a. Initial 200 m: Are well-trained runners with II able to run at an imposed submaximal velocity making use of external auditory and visual cues?

A 2 (group: with and without II) × 2 (trial 1 vs trial 2) repeated-measures analyses revealed a significant effect for the between-factor group (F = 7.58, P < 0.05, power = 0.77), indicating that II runners deviate more from the target time, already after 200 m, independent of the trial. No significant main effect was found for trial, neither any significant interaction effects.

b. Final 200 m: self-regulating pace without any feedback

The repeated-measures ANOVA revealed a significant main effect for the between-factor group, $F(1, 64) = 19.45$, $P < 0.001$, power = 0.99, with II runners deviating more from the target time than control group runners. The significant trial–group interaction effect (F = 4.15, P < 0.05, power = 0.51, Cohen d effect size = 1.1) indicated that the differences in AD between trials were different for II runners compared with runners without II. Runners without II improve their performance (smaller deviation) between trial 1 and trial 2, whereas runners with II perform worse (larger deviation) in the second trial.

c. Learning effect between the first and the second trials (AD and RD)

Figure 2 presents the mean and SD values of AD for the 11 time points for the two trials and two groups of runners (II vs control) separately. The 11 time points represent all the split time points during the test. To refresh the readers' memory, split time points are depicted in Figure 1, with 7 time points within the first 200 m (with auditory feedback at every time point) and time points 8–11 in the final part of the 400-m lap (without any feedback). The repeated-measures ANOVA yielded a significant main effect for the between-factor group (F = 10.42, P < 0.05, η^2 = 0.15, power = 0.89). The AD was larger for II runners than for athletes without II, and this held independent of the trial. The analysis also revealed a significant main effect of the within factor time (F = 8.79, P < 0.05, η^2 = 0.63, power = 1), indicating that the AD varies for the 11 time points, as visually depicted in Figure 1. Significant time–group interaction effects (F = 2.89, P < 0.05, η^2 = 0.36, power = 0.95) and time–trial–group interaction effects (F = 2.01, P < 0.05, η^2 = 0.28, power = 0.82) revealed that the II runners start deviating from the target time at earlier time points (cone 5) in trial 2 (without coach feedback) compared

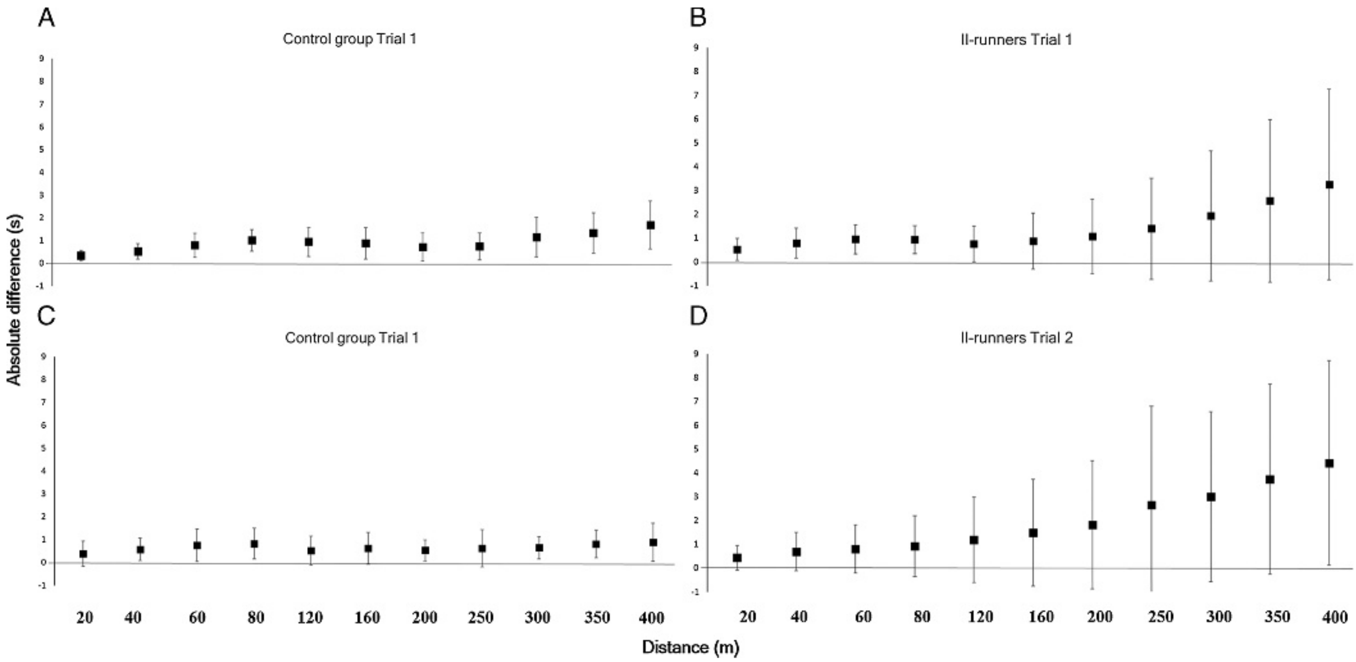

FIGURE 2—Absolute differences from the target time per split time point. Data are presented for control group Trial 1 (A), II-runners Trial 1 (B), Control group Trial 2 (C), II-runners Trial 2 (D), II = intellectual impairment.

with trial 1 (cone 8), but for the control group athletes, the deviation from the target time occurs at earlier time points (cone 9) in trial 1 (with coach feedback) compared with trial 2 (cone 11).

The RD from the target time provides an indication of the direction of the deviation. Figure 3 presents the mean and SD values of RD for the 11 time points for both groups in both trials. The repeated-measures ANOVA yielded a significant between-group effect ($F = 11.3$, $P < 0.001$, $\eta^2 = 0.2$, power = 0.90). The direction of the deviation is negative (i.e., acceleration for the II runners whereas a centering on the axis is observed for the control group runners. A main effect for the within factors time is observed ($F = 8.5$, $P < 0.001$, $\eta^2 = 0.60$, power = 1) and also a main effect for the within factor trial ($F = 5.6$, $P < 0.05$, $\eta^2 = 0.1$, power =0.6), indicating that

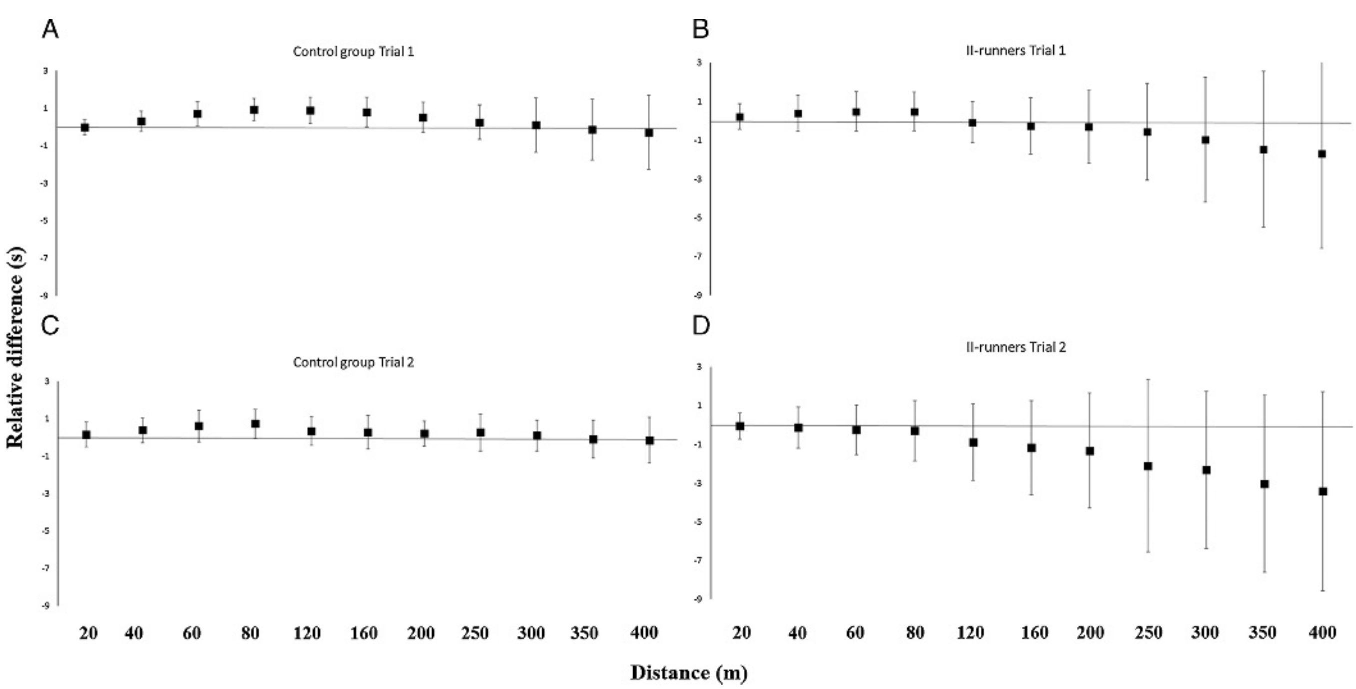

FIGURE 3—RD from the target time per split time point. Negative values on the *y*-axis = acceleration; positive values on the *y*-axis = deceleration. Data are presented for control group Trial 1 (A), II-runners Trial 1 (B), Control group Trial 2 (C), II-runners Trial 2 (D), II = intellectual impairment.

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the RD differs between the first and the second trials, and this held independent of the group. The significant time–group interaction effect ($F = 3.8$, $P < 0.001$, $\eta^2 = 0.40$, power = 1) indicates that the RD varies differently over time for II runners compared with control group runners. Figure 3 shows that the majority of the II runners accelerate in the last 200 m of both trials (negative RD), whereas no acceleration is observed in control group runners.

DISCUSSION

This study was designed to explore pacing ability in elite runners with II evaluating if there was a relation between pacing performance and cognitive development. It was expected that well-trained runners with II would be able to run at an externally imposed submaximal velocity, but that they would have more problems than an equally well-trained group of runners without II to maintain this velocity based on internal information. Our findings confirmed that well-trained runners with II lack the ability to self-regulate their pace when the task is to rely on internal information, and moreover, even during the first 200 m when the pace was externally imposed, they had problems with pacing. Although athletes without II improved their pacing performance between the first and the second trials, this learning effect was not observed in athletes with II. On the contrary, the absence of any coach feedback in the second trials caused deterioration in performance. Ample literature outlines the requirement of adequate pacing to elicit optimal performance (1), and pacing is commonly described as one of the most important cognitive determinants in running (26,31). However, not many studies are available that specifically investigate pacing in relation to II. A study of Micklewright et al. (15) has confirmed that forming a pacing strategy is at least in part associated with cognitive mechanisms, and pacing differences were distinguished between children (5–14 yr) in a different stage of cognitive development. The stage of cognitive development was assigned using cognitive tests in typically developing schoolchildren, so no individuals with cognitive impairments were included as performed in the present study.

A novel field test was used in this study to assess the ability to maintain a preplanned velocity. The running speed was imposed using auditory signals, respectively, with or without additional coach feedback.

a. Initial 200 m: Are well-trained runners with II able to run at an imposed submaximal velocity making use of external auditory and visual cues?

Already after 200 m, II runners deviated more from the target time than athletes without II. This is remarkable because in both trials, auditory signals were given to impose the required running velocity. The II runners had the tendency to start too fast. In particular, in the second trial, without coach feedback, this trend became more explicit. This means that coaches of II athletes have an important role in helping their athletes to adequately pace their training sessions and their races. The importance of the coach with respect to pacing for people with an II was also demonstrated by Kunde and Rimmer (14). They found that participants with an II performed better on a 1-mile walking test when they were accompanied by a person giving constant feedback and encouragement (i.e., coaching). Although in this study athletes had to be tempered in order not to run too fast instead of being encouraged to walk as fast as possible, the positive effect of the coach is common. Individuals with II have problems with self-regulation and perform better with external support. The study of Keary et al. (12) also showed a positive effect of coaching on a 100-m sprint performance. The ideal profile of a coach for athletes with II is characterized as a calm, balanced, and stress-resistant person who has a combination of sport-specific expertise and experience with coaching athletes with II (24). In the control group athletes, we generally observed that the absence of coaching had no negative effect on their performance. On the contrary, the combination of smaller AD and the smaller variance between trial 1 and trial 2 indicated that a learning process had occurred between the first and the second trials, as also observed in other pacing studies (5,8).

b. Final 200 m: self-regulating pace without any feedback

During the pacing test, the deviations from the target time were significantly larger for II athletes compared with the control group athletes. After a short learning process, athletes without II were perfectly able to maintain an imposed velocity (without any type of external feedback) in the second part of trial 2 (only 0.9 s deviation); the athletes with II deviated more than 4 s from the target time. These findings outline an important problem that athletes with II experience when exercising: the inability of II runners to self-regulate an imposed pace, which may have major consequences for training (e.g., dosed training sessions) but probably also in competition (e.g., executing a preplanned strategy), and even in everyday life (e.g., independent living). In general, self-regulation includes abilities of planning, identifying, and using adequate resources, evaluating effects of actions, controlling actions, and mobilizing attention and motivation to attain a goal (3). Self-regulation develops depending on cognitive resources, and studies have identified people with II at different ages and developmental levels as presenting either developmental delay in self-regulation or deficits in self-regulatory strategies in problem solving or in daily life management (17).

c. Learning effect between the first and the second trials (AD and RD)

With further detailed analysis of results, there were clear differences in performance between the first and the second trials. For the II runners, the deviation from the target time started to occur at measure point 8 in the first trial (with feedback from the coach in the first 200 m) and even earlier in the exercise bout, at measure point 5, in the second trial (without any external feedback). Although the AD provided insight into the magnitude of the deviation, the RD indicated the direction of the deviation (acceleration or deceleration). The average RD in both groups (runners with and without II) was negative in both trials, meaning they had the tendency to accelerate in the second half of the 400-m run. The differences in RD between II runners and control group runners were only significant for the second trial in which no coach feedback was allowed. When asked afterward, most of the athletes indicated that the imposed running velocity (80% of the PB on 1500-m distance) did not feel very comfortable. It is commonly accepted in sport science literature that the most economical pace is close to the freely chosen pace (20), which may contribute to the findings in our study where a standardized (slow) pace was imposed.

Practical implications. Pacing is a crucial aspect of running performance; therefore, the results of this study may help coaches and instructors, specifically those involved in elite sports for athletes with II, to improve the quality of their training. The results of this study also had direct practical implications for international sport participation of elite athletes with II because these findings led to the decision to reinclude long-distance running as one of the first sports for athletes with II in the Paralympic Games. Based on the differences in one of the crucial elements of pacing ability between runners with and without II, as assessed in this study, the eligibility criteria were developed for II runners to enter competitive events, sanctioned by the International Paralympic Committee.

Limitations. Although this study provides new insights regarding pacing in relation with II some shortcomings should not be overlooked. Groups were matched on the basis of their comparable training history and training volume. However, some other aspects (age, cultural differences, etc.) may also have contributed to the observed differences. Although their training volume was comparable, the control group was on average 7 yr older (significant difference), which might be related to a more mature pacing strategy. The control group consisted only of Flemish athletes as opposed to the international base of the INAS group; hence, cultural differences in training for pacing might have an effect the findings. In addition, large interindividual differences are commonly observed when testing a population with II. This was mimicked in this study, where the variation in pacing ability was large, mainly for the II athletes.

CONCLUSION

A novel field test was applied to investigate pacing ability in persons with II to improve our understanding of the potential problems that runners with II might experience when exercising. Their ability to perform at a preplanned submaximal velocity, which is an essential aspect of pacing, was assessed and differences between athletes with and without II were evident: athletes with II had difficulties to run at an externally imposed pace, and they were not able to maintain their pace without continued auditory feedback. Learning effects were only observed in runners without II. Knowledge gained from this research outlines that athletes with II have difficulties maintaining a preplanned submaximal velocity. They have the tendency to accelerate, and this acceleration starts sooner and is more pronounced when no coach feedback is allowed. The fact that this aspect of pacing ability differs significantly between runners with and without a cognitive impairment supports the assumption that pacing involves a cognitive aspect. Further research is required to determine the relationship between maintaining an imposed submaximal velocity and running performance in competition.

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