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# The Effect of a Second Runner on Pacing Strategy and RPE During a Running Time Trial

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***Purpose:*** The aim of this study was to examine performance, pacing strategy and perception of effort during a 5 km time trial while running with or without the presence of another athlete. ***Methods:*** Eleven nonelite male athletes participated in five 5 km time trials: two self-paced, maximal effort trials performed at the start and end of the study, and three trials performed in the presence of a second runner. In the three trials, the second runner ran either in front of the subject, behind the subject, or next to the subject. Performance times, heart rate, RPE, and a subjective assessment of the effect of the second runner on the athlete's performance were recorded during each of the trials. ***Results:*** There was no significant difference in performance times, heart rate or RPE between any of the five trials. Running speed declined from the 1st to the 4th kilometer and then increased for the last kilometer in all five trials. Following the completion of all trials, 9 of the 11 subjects perceived it to be easier to complete the 5 km time trial with another runner in comparison with running alone. ***Conclusions:*** While the athletes perceived their performance to be improved by the presence of another runner, their pacing strategy, running speed, heart rate and RPE were not significantly altered. These findings indicate that an athlete's subconscious pacing strategy is robust and is not altered by the presence of another runner.

***Keywords:*** pacing, perceived exertion, RPE, fatigue, running

Completion of an athletic event in the fastest possible time requires modulation of the exercise intensity in order to maintain appropriate fuel reserves and to prevent the occurrence of fatigue before reaching the finish line, a strategy referred to as pacing.[1] The theory of teleoanticipation suggests that pace is predetermined in a feedforward manner,[2] and is constantly modified and processed by the brain using feedback information from a variety of peripheral and central signals to avoid catastrophic failure of the physiological systems.[3,4] The pacing algorithm used by the brain for a particular event with a known endpoint incorporates previous knowledge of distance, duration, and pacing strategies to optimize performance.[5–8]

The subconscious homeostatic control systems which adjust power output based on feedback from the physiological systems may also be associated with conscious emotional responses that generate "feelings."[3,9] The conscious awareness of the sensation of fatigue has been suggested to regulate exercise intensity as part of a centrally controlled process[7] but is altered by psychological factors,[10] which suggests that factors which influence subconscious awareness may also alter pacing strategies and performance.

During an athletic event, a variety of external factors including environmental cues, emotion, intrinsic and extrinsic motivation are present and create a unique situation for each different event that may also influence performance. Studies involving manipulation or deception of time and distance feedback information have previously shown to alter pacing strategies,[11,12] while others have not.[13,14] Further, the absence of external visual or auditory timing cues have shown no effect on power output, performance or ratings of perceived exertion,[15] supporting the notion that pacing control mechanisms of the brain are robust. In contrast, motivational factors may play a role in pacing, specifically, it has been shown that if an athlete leads an event, motivation is increased, RPE is reduced and performance is likely to be optimized.[3,16] Furthermore, emotional responses that are evoked in response to the presence of faster competitors or crowd support are suggested to influence RPE and pacing, which may be beneficial to performance.[3,17,18]

To our knowledge, the presence of other athletes competing in the same athletic event on an athletes' pacing strategy has not been evaluated to date. Therefore, the aim of this study was to examine pacing strat-

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egy, perceived exertion and performance of an athlete completing a 5 km time trial in the presence of another athlete (second runner). The effect of the position of the second runner relative to the athlete (in front, behind, or side-by-side) was also examined. We hypothesized that the presence of a second runner would alter the pacing strategy of the athlete compared with the self paced trials, resulting in changes to physiological activity and overall performance time.

# Methods

## Subjects

Eleven club level male athletes (mean ± SD; age 33 ± 8 y, height 180.6 ± 11.6 cm, weight 75.9 ± 10.1 kg, BMI 23.2 ± 1.2 kg/cm$^2$) were recruited from previous studies, local running clubs and training facilities. All subjects were able to complete a 5 km time trial between 18 and 23 min. The subjects were informed that the purpose of the study was to investigate the repeatability of a 5 km time trial performance on an indoor track.

An additional eleven athletes who could perform a 5 km time trial faster than 18 min were also recruited from the same population as previously described, to act as "second runners" (pacemakers) in the study. The second runners were informed about their role within the study, but were instructed not to relay the information to the subjects or any others during the trial. During the "paced" trials the second runners conducted themselves as another research subject, and were treated as runners participating in the study by the investigators. The study was approved by the Research and Ethics Committee of the Faculty of Health Sciences of the University of Cape Town.

## Experimental Design

Subjects were required to visit the track on six occasions, separated by a minimum of 3 d, with all trials conducted at the same time of day to minimize diurnal variations in heart rate. Subjects were asked to maintain their current physical activity pattern for the duration of the study, and to avoid strenuous exercise 24 h before each visit. During the first visit, the subjects were familiarized with all equipment and procedures used during the trials. The experimental trials (visits 2–6) required subjects to perform a 5 km time trial under various conditions.

The 5 km time trials consisted of (1) a self-paced trial (no second runner present) which formed the subjects' baseline performance (TT1) and determined running speeds for pace-setters in subsequent trials; (2) a second runner that ran approximately 10 m in front of the subject (Fast Paced Trial, FPT); (3) a second runner that ran approximately 10 m behind the subject (Slow Paced Trial, SPT); (4) a second runner that ran next to the subject (Equal Paced Trial, EPT); and (5) a self-paced trial (no second runner present) to establish the occurrence of any training effect during the course of the study (TT2). A different second runner was used for each trial (trials 2–4), and trials were randomized to minimize any ordering effect on performance.

## 5 km Time Trials

The 5 km time trials were performed on a 140 m indoor athletics track to control for environmental factors such as temperature and humidity, minimizing any influence on performance. Before each paced trial, the second runner was instructed to begin at a predetermined pace based on the subject's performance in TT1 and to adjust their running speed in response to the speed of the subject. Thus, in FPT, the second runner began the trial faster than the subject, but slowed down if the subject fell too far behind, and increased the speed if the subject was catching up, maintaining a distance of approximately 10 m in front of the subject. Similarly, in SPT, the initial pace of the second runner was slower than the subject, and speed was adjusted by the second runner throughout the trial to maintain a gap of approximately 10 m behind the subject. The second runner received verbal commands from the investigator where necessary to increase or decrease their speed in a manner which the subjects were not aware of any communication. Accordingly, the role of the second runner was to attempt to manipulate the pace from the onset of the trial, but to respond to the subject in order to remain in contact during the trial.

The subjects were provided minimal information regarding the presence of the second runner, they were informed that in the previous time trial both athletes ran at similar paces and would therefore now be running together. Thus, they were not told that they must ignore the other runner, or that they have to run at the same speed as the second runner. Verbal communication between second runner and subject was limited to that which was initiated by the subject.

## Measurements

Time for each lap, the kilometer time and overall completion time were recorded for each time trial. Heart rate was recorded every kilometer during the trial using short-range telemetry (Polar S410, Polar Electro Oy, Kempele, Finland).

Subjects were asked to call out a rating of perceived exertion (RPE) every kilometer and at the end of each time trial using the Borg 15-point (6–20) RPE scale.[19] Subjects were instructed to provide a single appropriate score on the 15-point scale that provided the best representation of an overall level of exertion. Appropriate scale anchor procedures were described to each subject at the start of the study and no assistance was provided in translating their feelings into numerical ratings on the RPE scale during the trials. The second runners were also asked for RPE scores at each time point to prevent the subject becoming aware of the true study design.

Following the completion of all five trials, subjects were asked to complete a series of questions about running with a partner. The questions were devised in order to elicit how the subjects thought running partners affected their running performance, whether they were affected by the running partner during the trial and whether they were aware of the function of the second runner during the trial.

## Statistical Analysis

Overall performance times and final heart rates were assessed using a one-way ANOVA. Changes in kilometer times, heart rates and ratings of perceived exertion were analyzed using a two-way (trial × distance) repeated-measures ANOVA. Where a significant interaction effect was revealed, Tukey's post hoc analysis was performed. Significance was accepted at $P < .05$. Data are presented as means ± SD.

# Results

## Performance Times

The overall performance times of the 5 km time trials were not significantly different ($P = .208$) between trials (Table 1). There was a significant increase ($P < .001$) in time taken for each kilometer from kilometer 1 to kilometer 4, before decreasing in kilometer 5 (Figure 1). There was no significant difference ($P > .941$) in time taken for any kilometer between trials.

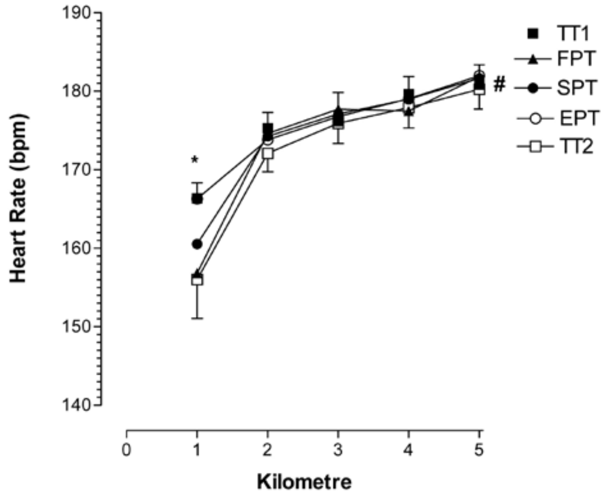


**Figure 2** — Heart rates for each kilometer during the five 5 km time trials. #Significant increase in heart rate with increased distance across all trials ($P < 0.001$). TT1, baseline self-paced trial; FPT, fast paced trial; SPT, slow paced trial; EPT, equal paced trial; TT2, self-paced trial.

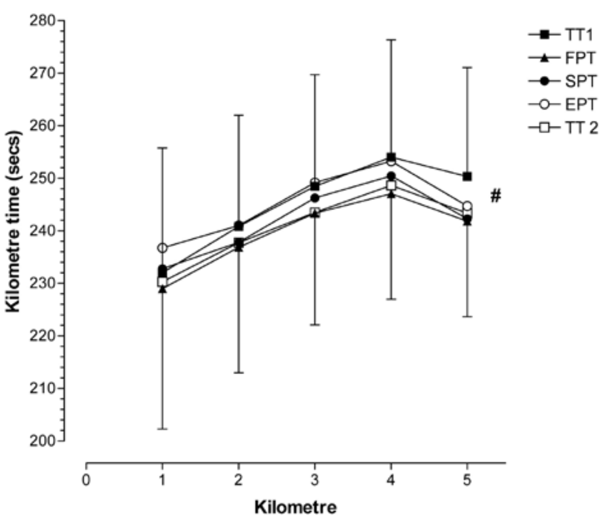


**Figure 1** — Times (in seconds) for each kilometer during the five, 5 km time trials. #Significant increase in kilometer time from kilometer 1 to kilometer 4, across all trials ($P < 0.001$). TT1, baseline self-paced trial; FPT, fast paced trial; SPT, slow paced trial; EPT, equal paced trial; TT2, self-paced trial.

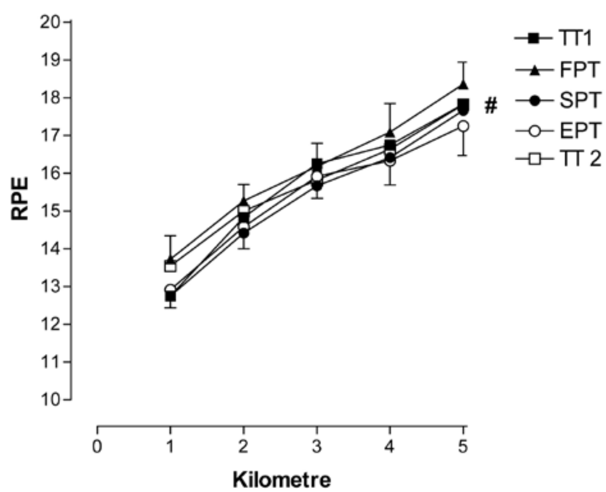


**Figure 3** — RPE values for each kilometer during five 5 km time trials. #Significant increase in RPE with increased distance across all trials ($P < 0.001$). TT1, baseline self-paced trial; FPT, fast paced trial; SPT, slow paced trial; EPT, equal paced trial; TT2, self-paced trial.

**Table 1 Overall performance times, and final heart rates for each 5 km time trial**

| Trial | Trial Times (min) | Final HR (bpm) |
|---|---|---|
| TT1 | 20.43 ± 1.78 | 184 |
| FPT | 19.97 ± 1.76 | 184 |
| SPT | 20.16 ± 1.75 | 186 |
| EPT | 20.41 ± 2.02 | 186 |
| TT2 | 20.06 ± 1.71 | 183 |

*Note.* Trial times, overall performance times at the end of each 5 km time trial; final HR, the heart rate recorded at the end of each 5 km trial; TT1, baseline self-paced trial; FPT, fast paced trial; SPT, slow paced trial; EPT, equal paced trial; TT2, self-paced trial. There were no significant differences.

## Heart Rate

Heart rate significantly increased ($P < .001$) across each trial (Figure 2). However, there was no significant difference ($P > .079$) in heart rate between trials. The mean final heart rates for each trial are reported in Table 1.

## Rating of Perceived Exertion

Rating of perceived exertion increased significantly ($P < .001$) during each trial, but there was no significant difference ($P = .601$) between trials (Figure 3). Mean overall RPE recorded at the end of each trial ranged from ~17–19 in all groups.

## Subjective Assessment of Pacemaker Runner Effect

All 11 of the subjects believed that running with a partner increased their running speed and was beneficial to running performance. Nine of the 11 subjects found it easier to run the trials in the study with another runner, with the other two subjects finding it harder. Nine of the 11 subjects were not frustrated or irritated by having to run with another runner, whereas the other two subjects were frustrated/irritated by having to run in the presence of a second runner.

Eight of the subjects did not suspect anything peculiar during the trial, whereas three subjects suspected that the second runner running with them was part of a trial that had not been explained to them. Two of the subjects who suspected the second runner was part of an unexplained trial also described the trial as being harder to run with a pacemaker. After being told that the trial was a deception trial with regard to the pacemaker, four subjects stated that they were surprised by this, four subjects stated they had a suspicion that this was the case, two subjects said they had expected this to be the case, and one subject was undecided about whether he had expected this to be the case.

# Discussion

The main findings of this study were that performance time, heart rate and RPE were not changed in the presence of another athlete. Pacemakers are often incorporated in athletic events to optimize performance, and we hypothesized that the presence of another athlete (second runner) would improve performance. However, our results suggest that under laboratory conditions the presence of another runner did not alter performance.

Despite empirical evidence supporting the inclusion of pacemakers in high-level competition, there is limited research-based evidence examining their influence on performance. Perrault et al (1998)[16] have shown that when an athlete lost their lead to a competitor in a simulated cycle race, psychological momentum (influenced by changes in motivation, perceptions of control, energy, and confidence) was decreased, and was increased when the lead was regained, resulting in overall performance optimization. Therefore, previous findings suggest that when an opponent takes the lead, the athlete alters their behavior and increases their pace to regain control of the race. This is true of laboratory studies, but may not fully capture race situations, where tactical advantages of being in second place may override these affective/motivational factors. Further, there is a benefit of drafting, particularly in cycling, which confers a performance advantage on the athlete in second place in field competition. This has not been accounted for by any study we are aware of.

Motivation toward sport has been described in the form of intrinsic and extrinsic motives. An athlete that is intrinsically motivated engages in the task for their own enjoyment and accomplishment, in the absence of any external influences. In contrast, extrinsic motivation promotes behaviors that can only be achieved by external constraints which may also be internally regulated; these include monetary rewards, seeking praise, and avoidance of negative consequences.[20] The inclusion of a second runner in the current study was intended to present an external factor that would increase the motivation of the athlete[21] and consequently increase their 5 km time trial performance. The influence of motivational factors on pacing strategies and performance is equivocal, and while some studies have shown positive effects,[16,22] others have not.[23] The results of this study have shown that the presence of a second runner did not influence overall performance of a 5 km time trial. It is possible that because the distance between the athlete and second runner was maintained at approximately 10 m for the duration of the time trial and consequently the athlete was unable to take the lead (running behind) or gain distance (running ahead) over the second runner, motivation may not have been increased or may even be reduced, if extrinsically motivated,[20] resulting in no change in running performance.

The perception of the athlete's performance is an important factor in motivation and therefore overall performance. Previous studies have demonstrated that positive performance feedback increased motivation, whereas negative performance feedback decreased motivation.[24]

Further, recent observations have shown that if an athlete perceives themselves to be underperforming in a 4 km cycling time trial, speed was reduced and overall performance impaired, identifying the importance of demotivation in performance.[22] Despite the reported differences in subjective feelings toward running with a partner, all subjects in our study perceived the presence of a second runner to be beneficial to performance by increasing their running speed. However, our study demonstrated that the presence of a second runner did not alter RPE or performance, suggesting that motivation remained unchanged. The findings of this study support previous research which has shown that monetary rewards which were intended to increase motivation for cyclists to adopt a more all-out pacing pattern, and improve their 1500 m time trial time did not alter the athlete's pacing strategy or performance.[23] It is suggested that pacing strategy is determined before the onset of exercise in a feedforward manner[2] using a preset algorithm based on previous knowledge and experience.[5–8] During the athletic event, the teloeanticipatory processes incorporate large amounts of information from afferent inputs from various physiological systems and external sources,[3] and based on the algorithm, pace is maintained or altered to prevent catastrophic failure.

Several studies have attempted to manipulate the preset algorithm through manipulation or deception of time trial distance; however, the results of these studies found that both runners and cyclists selected a running velocity/power output that was appropriate for the distance that they perceived to be completing (6-km running time trial or 20 km/40 km cycling time trial) rather than the actual distance they completed.[6,13,14] Further, the presence or absence of external cues (timing, visual, auditory) during a 40 km time trial has also shown no effect on power output, heart rate RPE or performance,[15] which is consistent with the findings of the current study. Thus, evidence supports the premise that the pacing control mechanisms of the brain are robust, and in order to prevent catastrophic failure, an unknown threshold is created for the physiological systems that prevents "maximum" being attained.[25] Furthermore, it is plausible that if the threshold is increased closer to maximum then performance may be optimized. Mauger et al (2009) have shown that providing objective feedback during a 4 km time trial improved performance, which is suggested to be a consequence of increased task motivation, thereby changing the conscious perception of a specific sensation (ie, fatigue or effort) and increasing the exercise intensity threshold.[22] Despite the perception that performance was improved by the presence of another runner and thus motivation may have increased in the current study, the absence of change in heart rate and RPE between trials would indicate that the physiological threshold for afferent control remained unchanged. Therefore, the level of motivation generated by the presence of a second runner in this study may have been insufficient to overcome negative sensations associated with the protective threshold.

An alternative explanation for the findings of this study may relate to the perception of the second runner's speed and pace by the athlete. Under noncompetitive situations, behavioral observations indicate movement synchronization between individuals. Jacobs and Schiffar (2005)[26] have shown that when walking with another individual, gait speed is altered in order to ensure walking speed is synchronized, indicating that your own actions may change in response to the perception of actions of others.

The coupling of action perception and execution has been suggested to be described by the mirror neuron system, involving mirror neurons originally observed in the brain of the macaque monkey, and recently in the cortical regions of the human brain during observation/execution movement tasks.[27,28] Specifically, the mirror neuron system proposes that observation of an action by another individual results in an interaction that reproduces some of the same behaviors by the observer.[28] This hypothesis may suggest that the presence of a second runner, either in front or behind of the athlete would influence the behavior of the athlete to mirror the actions of the running partner. This may have had the effect of anchoring the running speed of the subject, because by design, the second runner (our pacemaker) was instructed to adjust their pace accordingly to the subject's pace. Rather than achieving a desired pace and "pulling" the subject faster, the second runner may have anchored the speed of the subject. Previous research has shown that the perception of another individuals gait speed is influenced by the athletes own speed, experience level (elite vs nonelite) and prior experience.[26] Further, when the athlete's level of effort is high, the visual analysis and interpretation of another individual's movement is influenced, typically resulting in an overestimate of movement speed.[26] The near-maximal level of effort experienced by the athletes in this study (RPE ~17–19; final HR ~185 bpm) and consequential level of afferent input may have resulted in an overestimate of the running partner's speed. Thus, based on the preset algorithm, teleological feedback control mechanisms may "decide" that the running speed of the second runner is above the athletes protective physiological threshold and may "override" any response to changes in activity potentially initiated by the observation of the second runner in order to avoid premature fatigue or catastrophic failure.

Further evidence for the robust nature of the control mechanisms of pacing are supported in a study by Buekers et al (1999),[29] which demonstrates that when individuals were required to correctly walk through a pair of oscillating doors which were externally paced, walking speed was not synchronized to the pace of the external constraints, but rather self-selected speed was maintained until the final approach. Therefore, despite previous evidence that suggests that external factors may influence the functional behavior of an athlete and alter pacing strategies,[16] the findings of this study do not support the premise, at least when individuals are competing at a near-maximal level against the clock rather than other individuals.

Despite the lack of significant difference between the trials, it is evident that the athletes did adopt a pacing strategy across all trials. The kilometer split times shown in Figure 1 represent a variable pacing strategy which is characterized by maximal pace at the start of the event, slower pace during the middle period of the event and increased pace toward the end of the race (also referred to as the "endspurt").[3] The identification of an optimal pacing strategy for performance is inconclusive and may be event, duration, or individual specific.[30] De Koning et al (1999)[31] have shown that during a 1000 m cycling time trial (~60 s), an all-out pacing strategy produced the best performance, in comparison with a 4000 m pursuit (200–340 s), where an all-out start followed by an evenly paced trial produced the best time. The pacing strategy adopted by elite rowers during a 2000 m race (~6–8 min) is similar to the pacing strategy of the athletes in the current study, indicating a more complex system of power output regulation during more prolonged events.[32] Further, Hulleman et al (2007)[23] suggests that an all-out strategy, which would normally be detrimental in prolonged events may be advantageous in high-level competitions, where the environmental conditions may override the preset pacing template allowing an athlete to produce an unexpected optimal performance. Therefore, it is possible that the competition level of the athletes in the present study may not have been high enough, where elite athletes may be able to tolerate disturbances in homeostasis and risk catastrophic failure to a greater degree than subelite athletes in order to win. However, the pacing strategy adopted in the present study was consistent with previous 5 km races, including world-record performances,[33] indicating that the athletes in the present study may have adopted their optimal pacing strategy across all trials.

### Practical Applications

In competitive races, an official pacemaker that is "known" by the athletes is often used to set record-breaking times. Despite these empirical observations, our study suggests that the presence of another runner does not alter 5 km performance time. However, the findings of the present study may have been influenced by the fact that subjects were unaware that the purpose of the second runner was to act as a pacemaker. Therefore, practically it may be important to performance to know that someone is running to try to "push" you to complete a faster time.

## Conclusion

In conclusion, a running partner has been shown not to alter an athlete's pacing strategy, performance time, heart rate or RPE. This finding suggests that an athlete's pacing strategy is robust and is determined before the athletic event. However, further research in this field should take into consideration the motivation of an athlete, the behavior patterns of the subject and pacemaker and the interaction effect of the subject and pacemaker, in addition to the nature of the competitive environment. These factors could elicit a result different from those found in this study.

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