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ORIGINAL ARTICLE

Physiological responses at critical running speed during continuous and intermittent exhaustion tests

Réactions physiologiques à la course à vitesse critique pendant des tests d'épuisement en continu et par intermittence

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KEYWORDS
Critical speed;
Running;
Intermittent;
Blood lactate

Summary
Objectives. — The main aim of this study was to compare the time to exhaustion and physiological responses at critical speed during continuous and intermittent running in order to provide support to use critical speed during interval training sessions.
Equipments and Method. — Nine male runners and triathletes completed an incremental treadmill test, two track performances of 800 m and 2400 m, in order to determine the critical speed, and finally two randomized tests until exhaustion, one continuous and other intermittent running (consisting of 4 min running and 1 min of passive recovery) performed at critical speed.
Results. — The mean critical speed was 14.8 ± 2.0 km.h^{-1}. The continuous and intermittent times to exhaustion were 19.3 ± 6.4 min and 37.9 ± 14.6 min respectively. The blood lactate response during continuous running showed an increase in values of about 9.0 ± 0.8 mmol.l^{-1} at the end of the exercise. On the other hand, only one of the 9 subjects analyzed, showed an abrupt increase in blood lactate during the intermittent running. The heart rate, perceived exertion and blood lactate measured at the end of both exhaustion tests were not significantly different compared with the incremental treadmill test values.

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Conclusions. — Our findings support the use of critical speed when looking for a blood lactate steady state during endurance interval sessions using a 4:1 ratio.

MOTS CLÉS
Vitesse critique ;
Course ;
Course à pied ;
Intermittence ;
Taux de lactat

Résumé

Objectifs. — Le but de cette étude est de comparer le temps jusqu'à l'épuisement ainsi que les réactions physiologiques à vitesse critique pendant un effort physique en continu et intermittent afin de justifier l'utilisation de la vitesse critique lors des sessions d'entraînement intermittent.
Équipement et méthodes. — Neuf coureurs et triathlètes masculins ont complété une épreuve de course à pied incrémentale sur tapis roulant et deux courses sur piste de 800 m et 2400 m afin d'établir la vitesse critique. Ils terminent par deux essais aléatoires effectués à vitesse critique jusqu'à l'épuisement : l'un en continu et l'autre par intermittence (course de 4 minutes, puis une minute de récupération passive).
Résultats. — La vitesse moyenne critique obtenue est de 14,8 ± 2,0 km.h^{-1}. Les temps d'épuisement pour les efforts en continu et par intermittence obtenus sont respectivement de 19,3 ± 6,4 min et 37,9 ± 14,6 min. Le taux de lactate dans le sang à la fin de la course en continu a augmenté d'environ 9,0 ± 0,8 mmol.l^{-1}. Par contre, un des 9 sujets a présenté une augmentation brutale du taux de lactate dans le sang pendant la course par intermittence. Les valeurs extrêmes de la fréquence cardiaque, de l'effort perçu et du taux de lactate dans le sang pour les deux tests d'épuisement ne sont pas significativement différentes des valeurs obtenues lors des tests sur tapis roulant.
Conclusions. — Nos résultats appuient l'utilisation de la vitesse critique afin d'établir un état d'équilibre de lactate dans le sang pendant les séances d'intervalle endurance en utilisant un ratio de 4:1.

1. Introduction

Critical speed (CS), velocity or power (CP) have been investigated over the last four decades and questioned through different approaches in different sports and populations [1]. Many of these studies were conducted to investigate the similarity between these indices with the maximal lactate steady state intensity during swimming [2], cycling [3] and running [4]. Although the pioneering studies [5,6] had suggested that the CS or CP would be an intensity that could be maintained for a very long time, different subsequent studies have shown that during continuous exercise at this intensity, a systematic increase in blood lactate concentration occurs and times to exhaustion range between 20—40 min [7—11]. From this point of view, CP or CS can be characterised by the physiological responses to constant power exercise performed above (i.e., non-steady state) and below (i.e., steady state) CP level. They represent the boundary between heavy (below) and severe (above) intensity exercise domain [12]. Because of its practicality, the critical speed test has become widely accepted as an important performance-based field test that provides an index of endurance-specific performance [13]. Although there are different mathematical models and approaches to calculate CS [9], for practical applications, the ''traditional'' distance-time model is a more suitable for coaches and athletes [14].

Continuous running at CS or slightly above is known as ''tempo training'' and is often used by endurance runners [15]. On the other hand, runners, cyclists and triathletes have also used long interval training, close to 85—90% of maximal aerobic power or around CS intensity [15—17]. When designing long interval-training sessions, time to exhaustion (TTE) at the CS could be an interesting variable, which can be used to determine a rational basis to establish the volume for interval-training sessions in athletes. Interestingly, Dekerle et al. [10] showed that during an intermittent swimming session consisting of 10 × 400 m (∼ 5 min each repetition) at CS, with 50-s pauses, the blood lactate remained stable and the exercise could be maintained for about 50 min. This study demonstrated the possible application of CS for long interval session designs. In addition, de Lucas et al. [16] examined the relationship between CS and speed at maximal lactate steady state, the latter determined by continuous and intermittent models. These authors used 5 min repetitions with 1 min of passive rest, in order to identify the intermittent maximal lactate steady state in running. The results showed no significant difference between CS and the speed at intermittent maximal lactate steady state, and obtained better agreement (i.e. 95% limits of agreement) when comparing CS to continuous maximal lactate steady state. However, no acute physiological response was analysed during CS performed at continuous and/or intermittent running sessions.

The magnitude of rest periods influences the physiological responses during an interval training session [18] and a few studies have attempted to investigate the exercise:rest ratio in particular (i.e. CS). Based on previous studies [19—21] we determined that the exercise interval of 4 min would be the optimal duration for eliciting a high physiological demand (i.e. VO_2, HR). Furthermore, Seiler et al. [21] showed that a fourfold increase in passive recovery time (i.e. 1 to 4 min) had very little impact on the running velocity or physiological responses during an interval training session