Science & Sports (2014) 29, 51—54

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BRIEF NOTE

Metabolic stress at cycling critical power vs. running critical speed

Stress métabolique : comparaison vitesse critique en course à pieds et puissance critique sur ergocycle

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Received 19 March 2013; accepted 15 July 2013
Available online 29 October 2013

KEYWORDS
Human endurance;
Mode of exercise;
Exhaustion;
Fatigue

Summary
Introduction. — This aim of the present study was to compare metabolic rates at critical running speed vs. critical power in cycling.
Summary of facts. — Eight participants (33.6 ± 12.1 years) performed a series of constant-intensity exhaustive trials to model the speed—time^{-1} (treadmill; 1% gradient) and power time^{-1} relationship (cycle ergometry) for intercept of the two relationships to be determined (Critical Speed [CS], Critical Power [CP]). A time to exhaustion (tlim) at CS and CP then followed. tlim did not differ between conditions (CS: 30.2 ± 4.7 min, CP: 26.8 ± 1.4 min, p = 0.58). The mean VO_2 values at minute 3 of the tlim were not significantly different with a strong relationship between the two sets of data (r = 0.87, p < 0.01). Values reached 86 ± 2% (CS) and 90 ± 2% of VO_2max (CP) at end exercise, with no difference between the two sets of data (p < 0.05).
Conclusion. — There is a metabolic, critical intensity (i.e. CS and CP) that induces similar metabolic stress, thus independent of the muscular contraction regimens.

MOTS CLÉS
Endurance humaine ;
Mode of exercise ;
Fatigue ;
Épuisement

Résumé
Introduction. — Cette étude a pour objectif de comparer les réponses physiologiques lors d'un test réalisé en course à pieds à vitesse critique et un test réalisé sur ergocycle à puissance critique.
Synthèse des faits. — Huit participants (33,6 ± 12,1 ans) ont réalisé une série de tests exhaustifs à intensité constante pour modéliser la relation vitesse—temps^{-1} (tapis roulant, gradient de 1 %) et puissance - temps^{-1} (ergocycle). Les ordonnées à l'origine des deux relations ont été déterminées (vitesse critique [CS], puissance critique [CP]) pour que les participants puissent ensuite

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0765-1597/$ - see front matter
http://dx.doi.org/10.1016/j.scispo.2013.07.014

effectuer un temps limite à CS et CP (tlim). Ces tlim n'étaient pas différents entre les deux conditions (CS : 30,2 ± 4,7 min, CP : 26,8 ± 1,4 min, $p = 0{,}58$). Les VO_2 mesurées à la troisième minute des deux tlim n'étaient pas significativement différentes et étaient fortement corrélées ($r = 0{,}87$, $p < 0{,}01$). Les valeurs ont approché 86 ± 2 % (CS) et 90 ± 2 % VO_2max (CP) en fin d'exercice, sans différence significative entre les deux tests ($p < 0{,}05$).

Conclusion. — Il existe une intensité critique métabolique qui induit un stress métabolique similaire, ce indépendamment du régime de contraction musculaire.

1. Introduction

In cycle ergometry, the relationship between power output (*P*) and time to exhaustion (t_{lim}) is hyperbolic [1]. Constant load exercise is not well tolerated when *P* is close to maximum and t_{lim} tends to increase in a non-linear fashion as the set *P* is lowered [1]. The P—t_{lim} relationship can be modelled using a 2-parameter equation from which an asymptote (Critical Power [CP]) can be derivated [1]. The CP concept has also been applied to treadmill running [2] with the asymptote of the hyperbolic running speed (s)—t_{lim} relationship representing Critical Speed (CS).

A recent study demonstrated the deleterious effect of high pedalling frequencies on CP (100 vs. 60 rpm) while the metabolic rate at both CP was unchanged [1]. This was demonstrated in both endurance and sprint cyclists [1]. The authors suggested for VO_2 at CP to be a specific metabolic rate, similar in a given subject despite being achievable at different combinations of external power outputs and pedalling frequencies.

Following the work of Barker et al. [1], the purpose of this study was to test for the existence of an individual ''Critical Intensity'' (metabolic rate) in large muscle mass exercise via the manipulation of exercise mode (cycling vs. running). If the conclusion of Barker et al. [1] held true, VO_2 at CS (treadmill running) and VO_2 at CP (cycle ergometry) should not differ significantly and should be significantly correlated.

2. Methods

This study was approved by the University's local ethics committee.

2.1. Participants

Eight recreational trained volunteers (four males, four females; age 33.6 ± 12.1 years, 172 ± 9 cm, 71.3 ± 7.1 kg) took part in this study. All were familiarised with treadmill running and ergocycling.

2.2. Experimental protocol

Participants performed two incremental tests to exhaustion in randomized, counterbalanced order starting either on a motorised treadmill (Woodway, Cardiokinetics, Salford, UK) or on a cycle ergometer (SRM, Schoberer Radmeβtechnik, Jülich, Germany). The starting speed for the running test was 7.5—10 km.h^{-1} (1% gradient) according to training history and was increased by 0.5 km.h^{-1} every minute to volitional exhaustion. The cycling test started with an initial intensity between 80 and 150 W and increase by 15 W every minute. Cadence during the cycle ergometer trials was freely chosen and kept within a range of 10 rpm. Gas exchange and heart rate were recorded throughout the two tests. Peak treadmill speed (PTS) was the average treadmill speed for the final one minute of the test. Maximal minute power (Pmax) was calculated as the highest 1 min average from the SRM power output data.

Trials to determine CP and CS consisted of randomised constant-intensity tests to exhaustion on each ergometer. Participants were instructed to perform as much work as possible during trials lasting 4, 9, and 14 minutes so that the s—t_{lim} and P—t_{lim} relationships were both modeled using identical range of t_{lim}. Initial work rate for these trials was set at 95% (for 4-min), 90% (for 9-min), and 85% (for 14-min) of Pmax/PVS. Once in to the trial, participants were free to pace and adapt the power/speed. Participants were always aware of remaining time, heart rate (HR), and actual power/speed. Participants finally performed randomly a time to exhaustion at CP and at CS with capillary blood lactate concentration ([La]) and VO_2 recorded at 3 min and end exercise. The exhaustive running trial ended when the participants could no longer run at the pre-determined pace despite strong verbal encouragement. The time to exhaustion at CP was recorded when the participants could no longer maintain their preferred selected cadence minus 5 rpm despite strong verbal encouragement.

2.3. Computation of CS and CP

CP and CS values were calculated from the modeling of the linear P—${t_{lim}}^{-1}$ and s—${t_{lim}}^{-1}$ models [2] using least-squares linear regression ($P = W' + \mathrm{CP}.\ {t_{lim}}^{-1}$; Anaerobic Work Capacity [W']; $s = ARC + \mathrm{CS}.\ {t_{lim}}^{-1}$; Anaerobic Running Capacity [ARC]).

2.4. Physiological measures and analysis

Fingertip capillary blood samples (~25 µl) were collected in capillary tubes and subsequently analysed [La] using an automated analyser (YSI 2300, Yellow Springs, Ohio, USA), which was auto-calibrated prior to analysis. A breath-by-breath gas analyzer (Ergocard; Medisoft), calibrated prior to each test according to manufacturer instructions, allowed the measurement of gas exchange during the tests.