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Physiological adaptation during short distance triathlon swimming and cycling sectors simulation

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Abstract

The aim of this study was to typify cardiorespiratory and metabolic adaptation capacity at race pace of high-level triathletes during simulations of short distance triathlon swimming sector, first transition and cycling sector. Six national and international-level triathletes performed a 1500 m swimming trial followed by a transition and one hour on ergocycle at race pace, with sequenced measures of blood lactate concentration, gas exchange and heart rate recording.

The mean speed obtained in the swimming sector was 1.29 ± 0.07 m s^{-1}, matching $98 \pm 2\%$ of MAS (Maximal Aerobic Speed), lactate concentration 6.8 ± 2.1 mM and heart rate 162 ± 15 beats min^{-1}. In the cycling sector, the mean power was 266 ± 34 W, matching $77 \pm 10\%$ of MAP (Maximal Aerobic Power), oxygen uptake 3788 ± 327 mL min^{-1} (82.8% of VO_{2max}), heart rate 162 ± 13 beats min^{-1} (92% of maximal HR) and ventilation 112.8 ± 20.8 L min^{-1}. MAS was correlated with performance in swimming sector ($r = 0.944$; $P < 0.05$). Despite intake 1.08 ± 0.44 L of a solution with 8% of sugars, a significant loss of body weight (2.80%; $P < 0.01$) was observed. Changes in cycling power, speed and frequency, especially towards the end of the effort, were also found. By contrast, differences in lactate concentration and in cardiorespiratory or metabolic variables between the end of the swimming sector and the end of the first transition did not appear.

In conclusion, this study remarks different relative intensities in cycling and swimming sectors. The observed loss of body weight does not modify pedalling economy in national and international-level athletes during the cycling sector, where effort intensity adapts itself to the one found in individual lactate threshold. However, changes in competition tactics and other effects, such as drafting in swimming and cycling, could alter the intensities established in this study for each sector.

Keywords: Short distance triathlon; Race pace; Movement economy; Energetic metabolism

1. Introduction

The short distance triathlon is a recently created sports category that made its official debut in the 2000 Sydney Olympic Games. This category must not be understood as three activities (swimming, cycling and running) that are performed separately but as three activities linked by two transitions (T_1, T_2) and resulting in a continuous and long endurance effort.

Several studies [8,18,16] have stated a decrease in performance towards the end of the trial and one of these [18] have suggested a possible loss in movement economy all along the short distance triathlon. It seems that the running sector suffers a residual effect caused by swimming and cycling sectors that, associated with a central temperature increase and a loss in the homeostasis of hydroelectrolytic balance, provokes an increase of energetic demands [18,23,24]. Due to the specific effects of cycling, these physiological modifications become more noticeable at the

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start of the running race. Specifically, Hue et al. [24] observed that the concatenation of ergocycle and running race efforts caused a remarkable increase in ventilatory response, as well as in CO_2 pulmonary diffusing capacity, setting off respiratory musculature fatigue and/or a pulmonary interstitial edema. This group [23] has also observed, during transition into the running race (T_2), a series of changes in metabolic and cardiorespiratory parameters (with respect to a control test) that provokes a higher energetic cost with lower ventilatory efficiency. This decrease in ventilatory efficiency was firstly suggested to be caused by respiratory changes recorded during long endurance exercise [23], especially hypoxia induced by exercise [5]. However, it was secondly demonstrated to be specific to both the transition in itself (i.e., the cycle to run transition) [24] and the performance level, since the best triathletes have a lower energetic and mechanical cost in the running race sector [35] and may have developed specific adaptation to the transition [25].

Moreover, these alterations concur with muscular discomfort probably related to differences in movement frequency observed in the cycling sector (1.5–2 Hz) respect to the running race sector (1.0–1.5 Hz). In addition, muscular activation, mainly concentric while pedalling, becomes eccentric in the running race sector [24].

Most triathlon studies analyze the second transition (T_2). Only one recent report [12], although not focused on sports reality, have carried out research on the physiological consequences of the first transition (T_1), despite their recognized tactical relevance [8,16].

The aim of the present study was to typify, among a group of national and international level athletes, cardiorespiratory and metabolic adaptation (at race pace) during short distance triathlon swimming sector, first transition and cycling sector simulations.

2. Material and methods

2.1. Subjects

Six male triathletes, involved in their competitive period, volunteered for the study, which was approved by the Sant Cugat del Vallés (Barcelona) High Performance Center (CAR) ethical committee. Triathletes were international ($n=4$) and national ($n=2$) level. Training and competition experience was 6.3 ± 3.8 yearlong and the age was 25.3 ± 4.2 year-old. At the time of the study, weekly training distances were 23 Km for swimming, 250 Km for cycling and 60 Km for running race. The results in the 2001 national championship were 1:57:24 h ± 0:01:54 h with a difference in their performance of 7.5 ± 2.6% in relation to the national champion (5th place in the Sydney Olympic Games).

2.2. Physical conditioning evaluation

The following tests were performed at the Sant Cugat del Vallés CAR:

2.2.1. Kinanthropometric assessment

Fat percentage and muscular mass determinations were carried out following the four-compartment method described by Drinkwater and Ross [14]. Anthropometrical measurements were performed following the Ross and Marfell–Jones methodology [48], using a skinfold caliper (John Bull, England), a flexible and non-extendable metallic anthropometrical belt, an anthropometer (Holtain L TD, England) and a sliding caliper (Holtain LTD, England).

2.2.2. Determination of swimming Maximal Aerobic Speed (MAS)

Swimming MAS was assessed in a 25 m covered swimming pool, following a Lavoie and Leone modified protocol [31]. After a 500 m warm-up, at a cadence about 80–90% of the MAS and a 5–10 min passive pause, a continuous test, at 3.8 km h^{-1}, is started. It will increase its speed 0.1 km h^{-1} every two minutes until exhaustion. An acoustic system composed by two loudspeakers connected to a PC (with an Excel 95 calculation sheet where the test was programmed) was used to impose speed and guide triathletes. The trainer walked along the border of the swimming pool, marked at 5 m intervals, coinciding with the acoustic signals. All along the carrying out of the test, heart rate (XtrainerPlus®, Polar, Finland), stroke frequency (s min^{-1}) and timings every 50 m were recorded. Distance per stroke was calculated in meters per stroke (m s^{-1}). Lactate concentration 5 min after the end of the effort was determined in a portable lactate analyzer (Lactate Pro®, Arkray, Japan) [44]. For this analysis blood samples were taken from the ear lobe.

2.2.3. Determination of ergocycle Maximal Aerobic Power (MAP)

It was carried out on an electromagnetic brake ergocycle (Cardgirus®, Spain), following a Padilla et al. [42,43] modified protocol. After a 10 min warm-up at 100 W, 4 min long rectangular stages with no pause and 30 W risings are carried out until exhaustion. Ventilatory frequency (BF), volume stream (VT), O_2 exhaled fraction (FEO_2), CO_2 exhaled fraction ($FECO_2$), ventilation exhaled fraction (VE), respiratory quotient (RQ) and oxygen uptake (VO_2) were measured all along the test in real time by means of a Quark PFT® (Cosmed, Italy) pulmonary gas exchange system, breath by breath. Blood lactate concentration ($[La^-]$) was measured during the last 15 s of each rectangular stage and 3 and 5 min after finishing the test. MAP was calculated as the mean value developed in the last 4 min of effort. In this protocol VO_{2max} was defined as the highest VO_2 obtained in a 60 s-interval previous to reaching a plateau. A plateau of VO_2 was identified if the VO_2 of the latest stage was not greater than the previous one by 1.75 mL kg^{-1} min^{-1} [34]. When subjects did not reach a VO_2 plateau, VO_{2max} was defined as the highest 60-s oxygen uptake value reached during this incremental test with a respiratory exchange ratio greater than 1.0 ($RER = VCO_2/VO_2$) [37], and a peak HR at least equal to 95% of the age-predicted maximum [51]. Ventilatory threshold was determined using the "V-Slope" method [1]. Finally, evolution of lactate concentration