Available online at www.sciencedirect.com

ScienceDirect

Journal of Electromyography and Kinesiology 19 (2009) 915–921

Journal of Electromyography and Kinesiology

www.elsevier.com/locate/jelekin

Cocontraction and economy of triathletes and cyclists at different cadences during cycling motion

Cláudia Tarragô Candotti [b,*], Jefferson Fagundes Loss [a], Daniel Bagatini [a], Denise Paschoal Soares [a], Everton Kruel da Rocha [a], Álvaro Reischak de Oliveira [a], Antônio Carlos Stringuini Guimarães [a]

[a] *School of Physical Education, Federal University of Rio Grande do Sul, Porto Alegre, Brazil*
[b] *School of Physical Education, University of Vale do Rio dos Sinos, São Leopoldo, Brazil*

Received 5 October 2006; received in revised form 28 February 2008; accepted 10 April 2008

Abstract

The purpose of this study was to compare the cycling technique of triathletes and cyclists on the basis of the cocontraction of selected muscles of the lower limbs and economy at different cadences. The economy (EC) and percent cocontraction from nine triathletes and eight cyclists were compared at 60, 75, 90 and 105 rpm cadences. Tests were performed on two separate days. The maximal oxygen uptake was measured and the second ventilatory threshold (VO_{2VT}) was estimated on the first day using a stationary bicycle. On the second day the four different cadences were tested at approximately 5% below the VO_{2VT}. The EMG activity of the rectus femoris (RF), biceps femoris (BF) and vastus lateralis (VL) was recorded and the EMG signal was normalized using the 60 rpm dynamic contraction. The percent cocontractions were calculated from RF/BF and VL/BF muscles. The EC was also calculated. The results showed that cyclists were significantly more economic, indicating that they exerted more power with less VO_2, and presented significantly lower percent cocontraction than triathletes ($p < 0.05$). Thus, the results suggest that the cyclists had a better technique than the triathletes. The simultaneous use of the percent cocontraction and economy seems to be a good performance indicator for cyclists and triathletes.

Keywords: Cycling; Triathlon; EMG; Economy; Cocontraction

1. Introduction

The interesting and complex interaction between a rider and a bicycle has made cycling attractive to scientists. In some investigations the focus is the cycling technique itself, and the goal is to produce relevant information for coaches and athletes (Sanderson and Cavanagh, 1990), by measuring electromyographic activity (EMG) of the muscles of lower limbs (Hautier et al., 2000; Sarre et al., 2003; Lucia et al., 2004; Sarre and Lepers, 2005). Analysis of pedaling technique with EMG can be performed using cocontraction indexes (Hautier et al., 2000), since cocontraction can be interpreted as a pattern of inefficiency in a dimension in which antagonist muscles fight against each other to produce a net movement (Winter, 2005). In a study involving cycling activity in which children with typical development were compared with children with cerebral palsy, the latter had increased cocontraction (Johnston et al., 2007). The authors go on to discuss the relative efficiency of this pattern in cycling.

Recent studies have investigated the effect of cadence on EMG and economy during cycling (Lucia et al., 2004), suggesting an increase in EMG activity and decrease in economy at slow cadences compared with higher pedaling rates. From a physiological point of view the economy can be understood as a quotient between

* Corresponding author.
E-mail addresses: claudiacandotti@hotmail.com (C.T. Candotti), jefferson.loss@ufrgs.br (J.F. Loss).

1050-6411/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jelekin.2008.04.008

power output and corresponding oxygen uptake (Moseley and Jeukendrup, 2001). The increased viscous resistance to motion of contracting muscle filaments associated with the speed of contraction (Elliott and Worthington, 2001) together with the failure of a muscle to relax between contractions could potentially contribute to an increased metabolic cost of cycling (McDaniel et al., 2002), affecting the cycling economy.

Considering that, in competitive cycling, performance is highly dependent on how economic the athletes are, it is not surprising that in some investigations the authors have attempted to associate biomechanical variables with economy (Marsh and Martin, 1995; Gotshall et al., 1996; Marsh and Martin, 1997; Neptune and Herzog, 1999; Brisswalter et al., 2000). Taking into account that economy seems to be affected by the technique employed by athletes it is reasonable to speculate that expert cyclists, who have good technique, will also be economical.

The literature contains EMG patterns obtained from recreational riders as well as from international level athletes, but interestingly there is little information on triathletes (Neptune et al., 1997; Li and Caldwell, 1998; Baum and Li, 2003). If the cycling technique is important for the performance of cyclists, it should be at least as important for triathletes. Triathlon has recently been introduced into the Olympic Games, and although cycling is only one of three activities that triathletes need to perform, it takes most of the total time of the race and it precedes running, an activity that also predominantly demands use of the lower limbs. Besides, the running in triathlon has an oxygen cost 7–8% higher than isolated running (Hausswirth et al., 1997; Hausswirth et al., 1999). So, during a triathlon race there is a decrease in economy (Hausswirth et al., 1996), and the success of triathletes depends on how economic they are (Miura et al., 1997). Therefore, it is important for triathletes to have a good cycling technique since it may also affect their running. Given that cyclists are entirely devoted to cycling whereas triathletes need to practice two other activities, it seems interesting to compare the cycling technique of the two different types of athletes, assuming the technique of cyclists to be the gold standard. The purpose of this study was to compare the cycling technique of triathletes and cyclists on the basis of cocontration of selected muscles of the lower limbs and economy at different cadences.

2. Methods

2.1. Subjects

Nine cyclists and eight triathletes were analyzed. This study was approved by the university ethics committee, and the subjects signed a written consent form. All athletes were involved in competitions that lasted at least 2 h and participated in state and national events. Information regarding age, years of practice and physical characteristics is shown in Table 1.

Table 1
Characteristics of the athletes: mean (±standard error)

	Age (yrs)	Time of practice (yrs)	Mass (kg)	Height (m)	Body fat[a] (%)
Cyclists	25.1	7.7	67.1	1.73	8.9
$n = 8$	(±1.0)	(±0.8)	(±0.7)	(±0.01)	(±0.2)
Triathletes	27.5	6.9	68.1	1.73	8.1
$N = 9$	(±1.0)	(±0.5)	(±1.0)	(±0.01)	(±0.2)

[a] Calculated using Yuhasz's equation.

2.2. Data acquisition

The evaluation of the athletes was performed on two separate days when acquisition of VO_2, EMG of three muscles and video recordings were performed.

2.2.1. First day testing

The subjects performed a cycle ramp test using an ergometer (Cardio2 bicycle, Medical Graphics Corp. St. Louis, USA) adapted with competitive clipless pedals, handlebars and saddle. The initial warm-up power of 30 W was maintained for 3 min, and the power was then increased at 30 W min^{-1}, until exhaustion. The subjects were allowed to adopt their preferred cadence.

Ventilatory data were recorded during of the ramp test using a breath-by-breath automated metabolic system (CPX/D Medical Graphics, Corp. St. Louis, USA): minute ventilation (VE), VO_2, carbon dioxide production (VCO_2), respiratory exchange ratio (RER), ventilatory equivalent for oxygen (VE/VO_2), ventilatory equivalent for carbon dioxide (VE/VCO_2), breathing frequency (*f*), and tidal volume (*V*).

Two criteria were used to determinate that the athletes had reached their VO_{2max}: (1) a constant leveling off of VO_2 despite an increase in exercise intensity and (2) RER greater than 1.10. The second ventilatory threshold (VO_{2VT}) was determined using the criterion of increase in VE/VO_2 and VE/VCO_2, with a concomitant decrease in end tidal pressure (Ribeiro et al., 1986).

In contrast to previous studies that have established fixed loads for different subjects (Marsh and Martin, 1995; Sarre et al., 2003), in this investigation the load at which each subject was evaluated on the second day test was defined by their individual VO_{2VT}. In other words, a physiological normalization criterion was used in an attempt to ensure that different individuals worked at a similar metabolic rate (Candotti et al., 2007).

2.2.2. Second day testing

Four different cadences (60, 75, 90 and 105 rpm) were randomly assigned to each participant. During the test VO_2 was continuously monitored in order to keep it at approximately 5% below the VO_{2VT}. Thus, it was necessary to individually adjust the load to keep the VO_2 close to the desired level until each athlete reached their own steady state (Coyle et al., 1991). Approximately 5 min was needed to reach VO_2 (steady state), after which, no changes in the load was necessary and each trial was performed for a further 3 min. The EMG data was collected during the last 30 s of this period.

The EMG activity of the rectus femoris (RF), biceps femoris (BF) and vastus lateralis (VL) was recorded from the right lower limb of the subjects, in accordance with "Standards for reporting EMG data" (Electromyography and Kinesiology, 1997). These thigh muscles were selected because they are major contributors