

HEART RATE AND BLOOD LACTATE CONCENTRATION RESPONSE AFTER EACH SEGMENT OF THE OLYMPIC TRIATHLON EVENT



Renata Fiedler Lopes^{1,2}
Raul Osiecki¹
Luis Manuel Pinto Lopes Rama²

1. CEPEFIS – Center of the Physical Performance Studies, Federal University of Paraná – Curitiba, PR, Brazil.
2. Sports Sciences and Physical Education College, University of Coimbra – Coimbra, Portugal.

Mailing address:

Faculdade de Ciências do Desporto e Educação Física, Estádio Universitário Coimbra Pavilhão-III, 3040-156 Coimbra, Portugal
E-mail: refiedlerlopes@gmail.com

ABSTRACT

Introduction: The physiological responses of each part of Triathlon are different; better training loads could be prescribed for athletes considering each segment of this sport. **Objective:** The purpose of this study was to investigate the behavior of physiological variables – heart rate and blood lactate concentration – before the event, after each segment of an Olympic Triathlon: swimming, cycling and running, and after recovery time. **Methods:** The sample included twelve male triathletes who participated in a triathlon event with Olympic distance. Capillary blood samples were taken from the fingertip in the beginning of the event (pre-event), after each segment (swimming, cycling, running) and after 1 hour of recovery. Each athlete was monitored during the entire event by a heart rate monitor (Polar® S610). Statistical procedures included: Spearman correlations and Wilcoxon non parametric tests ($p < 0.05$). **Results:** The study results showed that the highest intensity was reached during cycling (HR_{max} : 86.3%; Lac: 6.98 mmol/L) in both physiological parameters, followed by swimming (HR_{max} : 85.2%, Lac: 5.75 mmol/L) and running (HR_{max} : 83.6%, lac: 4.47mmol), respectively. **Conclusions:** Training load prescription based on different physiological markers responses – such as heart rate and blood lactate concentration - of each triathlon segment will be more efficient for the Olympic triathlon demands.

Keywords: swimming, cycling, running, blood, cardiac monitoring.

INTRODUCTION

Regarding long-duration sports, the use of the heart rate (HR) is frequent in the prescription of the training load. This physiological parameter has been assumed as a good marker of the training intensity, constituting a simple method for the training monitoring for athletes and coaches¹.

Another frequently used indicator in this context is the blood lactate concentration response. This marker has been efficient in controlling training, and the athletes' performance can be evaluated from steady values in different moments and the demand imposed by the training load be adjusted. Although the individual behavior in the kinetics of the lactate accumulation has been reckoned, in this study we will consider in agreement with Sjodin and Jacobs² the steady value of 4.0mmol/L (OBLA – *Onset Blood Lactate Accumulation*). Many authors³⁻⁵ consider this steady value as the point of break of balance between lactate production and removal, which leads to increase of its concentration in the blood (*anaerobic threshold*).

The association of these two parameters – heart rate and blood lactate concentration – may constitute an important instrument in the control of the training loads. Some studies support the ratio between these two variables in the process adaptation during the training season and in competitions in several modalities, such as in skaters⁶, cyclists^{7,8}, runners^{9,10} and racing drivers¹¹.

The aim of our study was to observe whether there is straight relation between exercise intensities and the physiological variables of exertion prediction during an Olympic triathlon event, relating the heart rate values and blood lactate concentration after the performance of each of the segments-modality: swimming, cycling and running.

METHODS

The sample was composed of 12 Brazilian male triathletes with involvement of a minimum of two years of systematic training, participants in official competitions sponsored by the Brazilian Confederation of Triathlon with Olympic distance. The twelve athletes (mean (SE) aged 27.9 (1.73) years, weight of 73.88 (2.16) kg, height of 177.9 (1.73) cm and % fat 7.3 (0.55) %) performed a triathlon event with distances corresponding to an Olympic triathlon (1,500m swimming, 40km cycling and 10km running).

The experimental protocol was approved by the Ethics Committee of the Federal University of Paraná, according to the Declaration of Helsinki (1975) for human experimentation, and all athletes signed a responsibility and confidentiality consent form before the evaluations performance.

Laboratory test

Individual maximum heart rate (HR_{max}) was determined in a laboratory. A progressive exertion protocol on treadmill consisted in the performance of two-minute thresholds of initiated exertion, with velocity of 6km/h with increase of 1km/h at every threshold and 1% of steady inclination was used. All athletes reached a respiratory coefficient above 1.0 at the end of the maximal test. All athletes were monitored by Polar® S610 frequency meter for the HR response.

Field test

The swimming segment of the event took place in an acclimatized and indoors swimming pool (27°C) of Olympic dimensions (50m); cycling and running were held outdoors, the former in a

closed circuit of 2,100m and the latter on a 400-meter running track. The weather temperature amplitude was of minimum of 18.2°C and maximum of 25°C and relative humidity was 77.1%.

Blood samples were collected before the event (pre-event), after swimming, after cycling, after running and also one hour after the event. In each of the five collections 25µl of blood were collected from the digital pulp.

The blood was removed from the digital pulp through a heparinized capillary tube calibrated for 25µl and immediately transferred to plastic tubes with a lid (Ependorf) containing 50µl of sodium fluoride at 1%. The samples were analyzed in a lactate analyzer YSP 1500 STAT®.

During the protocol performance all athletes were wearing a Polar® S610 frequency meter programed to record and store data at every five seconds of exertion.

No food or caloric supplementation was allowed during the event in order to minimize factors which could contaminate the results. Only water *ad libitum* was made available during cycling and running.

Statistical procedures

Data were expressed in mean and standard error. Due to the sample's dimension, and the fact that distribution normality could not be guaranteed in all variables through the Shapiro-Wilk test, the non-parametric Wilcoxon test with significance level of $p < 0.05$ was used. The studied variables were correlated between each other through non-parametric Spearman correlation ($p < 0.05$). The analyses were performed with the SPSS computer statistical package, version 13.0 for Windows.

RESULTS

The olympic triathlon requires that the athletes present high physical fitness for a period longer than two hours. In this study the mean total time of the event was 2h12min31sec, and 23min19s out of this total time were spent in swimming, 1h02min21s during cycling and 47min31s in running.

The main aim of this study is to assess the behavior of some variables which present a straight relationship with performance of an Olympic triathlon event.

The maximal exertion test enabled the maximum heart rate determination and from these values, the percentage of the exertion during the Olympic triathlon event was diagnosed. (table 1).

The HR results revealed that the highest intensity was reached during cycling, followed by swimming and running. This intensity was significantly different between cycling and running ($p < 0.05$).

All heart rates were highly correlated; that is to say, the athletes who presented higher absolute values in swimming also presented higher heart rates in cycling (0.825, $p < 0.01$) and running (0.681, $p < 0.05$); as well as between cycling and running (0.869, $p < 0.01$).

Table 2 describes the absolute values of the lactate concentration immediately before the event and after each segment of the triathlon and after one hour of recovery.

The pre-event lactate values were slightly high since they have been collected after warm-up in the swimming pool of the athletes. Although the blood lactate concentrations have suffered some alterations due to the room temperature and dehydration, they were higher during cycling (6.98mmol/L), followed by swim-

ing (5.75mmol/L) and running (4.47mmol/L). Such values were in agreement with the percentage intensities of each modality, evidenced by the higher heart rate in cycling (86.3%) followed by swimming (85.2%) and running (83.6%), according to figure 1.

Table 1. Heart rate (HR) behavior in absolute and relative terms during the event. Values expressed in mean (standard error).

	Swimming		Cycling		Running	
	HR (bpm)	HR (%)	HR (bpm)	HR (%)	HR (bpm)	HR (%)
HR _{max} (bpm)	162.7 (3.9) ^{ab}	85.2 (1.5)	164.6 (2.3) ^a	86.3 (0.9)	159.5 (3.3) ^b	83.6 (1.3)

*significant difference between different letters ($p \leq 0.05$). Variables with equal letters are statistically equal. ab value does not present statistical differences in the value with letter a or in the value with letter b; however, $a \neq b$.

Table 2. Blood lactate concentration during the event. Values expressed in mean (standard error).

	Pre-event	After swimming	After cycling	After running	1h later
LAC(mmol/L)	2.06 (0.22) ^a	5.75 (0.35) ^{bc}	6.98 (0.74) ^b	4.47 (0.5) ^c	2.5 (0.19) ^a

*significant difference between different letters ($p \leq 0.05$). Variables with equal letters are statistically equal. When $a = a$, the values do not present statistical differences. When $b = b$, the values do not present statistical differences. When bc, the bc value does not present statistical differences neither in the values with letter b, nor in the values with letter c; however, $b \neq c$.

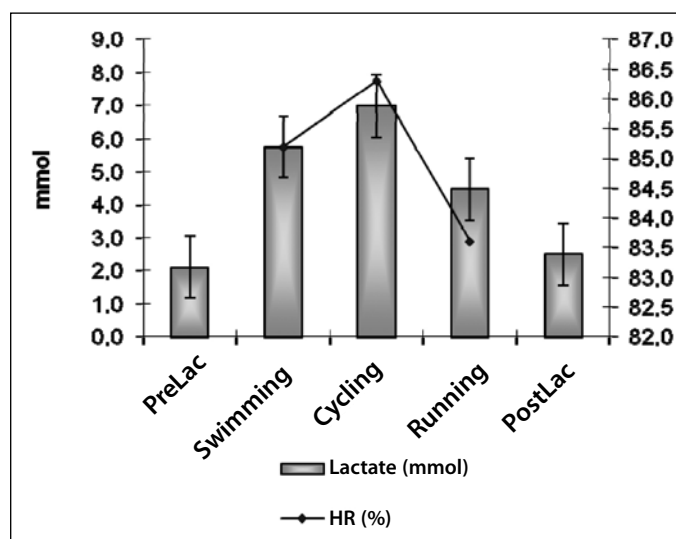


Figure 1. Blood lactate concentration and maximal heart rate percentage during the Olympic triathlon. Data expressed in mean and standard error.

DISCUSSION

According to the physiological variable – heart rate – it can be observed that the absolute and relative values of the maximum heart rate were higher than the ones exposed by Rohde *et al.*¹², who found a heart rate mean of 148bpm, or 74% of HR_{max} during cycling and mean of 159bpm or intensity of 81% in running, concerning the maximum heart rate in a triathlon with distances higher than in an Olympic event. However, in this study supplementation and fluid intake were allowed and not controlled, which could have influenced on a better level of physical and metabolic fitness of the athletes compared to the results obtained in the current study.

Using a ratio proposed by the American College of Sports Medicine¹³, and corroborated by some authors in different populations^{14,15}, the intensity of 70% of heart rate of reserve would

be equivalent to 70% of O_{2max} and such intensities would be reference of approximately 85% of maximum heart rate.

Having this ratio as a starting point, the only modality which would be slightly below the 70% of O_{2max} , but would be still considered as intense exercise, would be the 10-km run, which presented mean of 83.6% of HR_{max} ; the swimming at 85.2% of HR_{max} and cycling at 86.3% of HR_{max} reveal the capacity of these athletes in working at this intensity level for more than two hours.

In a similar level of exertion intensity, different individuals can be at distinct phases concerning the lactate kinetics, which is crucial to the determination of the duration and maintenance of the exercise quality¹⁶.

The blood lactate values during the event show that, despite the triathlon being a predominantly aerobic event, the glycolytic metabolism is fairly present in all its segments. It is known that the lactate accumulation profile is individual; however, the interpolation to a steady value guarantees an extension control of the training loads concerning the intensities of triathlon event. If the standard proposed by Sjödín and Jacobs², in which the steady value of 4.0mmol/L identifies the anaerobic threshold (OBLA), is considered, the event would have to be performed with intensity above this value. Authors³⁻⁵ who adopt lactacidemia of 4.0mmol/L justify the choice of this steady concentration due to the majority of the subjects present, at this exercise intensity, the maximum balance between lactate production and removal.

As far as we are concerned, no study has ever reported lactate reference values during a triathlon event or the association of the lactacidemia by modality with the respective heart rate values and final performance of an event.

We believe that since swimming is the first modality of a triathlon, it contributes to the initial accumulation of lactate which reflects on the subsequent modalities. Although there seems to be a tendency to the lactate removal during running, the values in cycling were high, characterizing an intense production of metabolites which influence on performance.

It was concluded that the correlation between the two performance physiological variables used in this study, namely heart rate and lactate concentration, were closely related to the intensity of each of the segments-modalities of the Olympic triathlon. The use of these physiological variables enabled to discriminate and characterize the exertion intensity in all modalities, being higher during cycling (86.3% HR_{max} ; 6.98mmol), followed by swimming (85.2% HR_{max} ; 5.75mmol) and running (83.6% HR_{max} ; 4.47mmol).

Considering these results, the need to differently adjust the intensity prescription of the training tasks according to each segment of the triathlon event is justified.

All authors have declared there is not any potential conflict of interests concerning this article.

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