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Anaerobic Threshold Individualized Assessment in a Young Swimmer

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Abstract: The assessment of blood lactate concentrations is considered one essential procedure in physiological diagnosis of swimming performance. Our purpose was to assess the metabolic anaerobic threshold of an 11 year old swimmer through an individualized intermittent incremental protocol. Complementarily, stroking parameters were also determined. The subject performed a front crawl 5 x 200 m test, being the velocity controlled by an acoustic signal. The blood samples were collected from the ear lobe at rest and after each step. Stroke rate was registered by a chronofrequencemeter base 3, and stroke length and velocity were calculated at the end of each 200 m. The individual anaerobic threshold occurred at 1.2 mmol/l, rather lower than the traditionally used 4 mmol/l value suggested for trained swimmers. The velocity corresponding to anaerobic threshold was 1.06 m/s, representing a 5 s difference in a 100 m effort comparing to the velocity of 4 mmol/l. Stroke rate increased and stroke length decreased throughout the incremental protocol, i.e., with the velocity increments. It was concluded that the velocity corresponding to 4 mmol/l does not represent the individual anaerobic threshold in this young trained swimmer, and that he prefer to increase their velocity through the raise of stroke rate. Thus, given the importance of developing swimming technique in age-group swimmers, this swimmer should implement the lengthening of his stroke cycles in the training practice routines, trying to resist to the degradation of the stroke length when velocity increases.

Keywords: Anaerobic threshold, children, lactate, physiology, swimming.

INTRODUCTION

The specific swimming velocity corresponding to the blood lactate steady state is considered one of the primary areas of interest in training and testing in swimmers. Indeed, there are some previously described methodologies that aim to assess the swimming intensity after which the lactate production exceeds its removal, i.e., the anaerobic threshold (AnT). One of the most used methods for AnT assessment is the well-known "two speed test" proposed by Mader *et al*. [1] that accepts the value of 4 mmol/l of blood lactate concentrations ($[La^-]$) as a gold standard. However, nowadays, it is accepted that the 4 mmol/l of $[La^-]$ reference, determined by linear inter or extrapolation of the $[La^-]$/velocity curve, has serious gaps, namely: (i) it is an averaged value; (ii) it was assessed in recreational swimmers and (iii) there were considerable changes in the training concepts and in the involvement of the swimmers in the training practice in the last 30 years.

Accepting the above-referred facts, and knowing that the $[La^-]$ values corresponding to AnT present great variability between swimmers [2, 3], other methodologies have arisen, proposing more specific and individualized values for the assessment of the AnT. Nevertheless, these methods also contain some limitations, for instance: (i) the subjectivity of the observation of the inflection point of the $[La^-]$/velocity curves; (ii) the use of long test distances with significant velocity differences between steps (MaxLass) and (iii) the necessity of very high values of $[La^-]$ (15 $mmol.l^{-1}$) that implies strenuous exercise intensities.

In this sense, following the recent proposal of assessing individual AnT though an intermittent incremental protocol [4], the purpose of this study was to implement the referred mathematical approach to assess individual AnT (IndAnT) of a young swimmer. Complementarily, stroking parameters were also assessed.

METHODS

A trained male age group swimmer (age: 11 years old; weight: 50.2 kg; height: 147.0 cm; 4 training units per week; 7 years of swimming background and 180 s of personal best at the 200 m freestyle), performed a front crawl intermittent incremental protocol of 5 x 200 m with increments of 0.05 m/s per each stage, and 1 min rest intervals. The initial velocity was established according to the swimmer individual performance of the moment [5]. Swimming velocity was controlled using an acoustic feedback, being observed no significant differences between the target and the real times (the Root Mean Square error was 0.017 m/s). Capillary blood samples for $[La^-]$ analysis were collected from the earlobe at rest, after each stage and at the end of the experimental protocol (Lactate Pro auto-analyser). These $[La^-]$ values allowed assessing IndAnT, which was determined by $[La^-]$/velocity curve modelling through the least square method (for further details see Machado *et al*. [6]). IndAnT

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was assumed to be the intersection point, at the maximal fit situation, of a combined pair of regressions (linear and exponential). The velocity corresponding to 4 mmol/l of $[La^-]$ (v4) was determined by linear interpolation of the $[La^-]$/velocity curve. Stroke parameters were also assessed being the stroke rate determined using a chronofrequencemeter. The stroke length was calculated by the ratio established between velocity and stroke rate. The protocol was conducted in a 25 m indoor swimming-pool and in-water starts were used.

RESULTS

As it is possible to observe in Fig. (**1**), the swimming velocity corresponding to IndAnT was not coincident with v4 (1.06 and 1.12 m/s, respectively), representing a 5 s difference in a 100 m effort. $[La^-]$ value at IndAnT was 1.2 mmol/l, which was rather lower than the traditionally used 4 mmol/l value or even to the 3.5 mmol/l value suggested by Heck *et al.* (1985) for trained swimmers (the v3.5 was 1.11 m/s). Additionally, the velocity obtained by the swimmer in a 400 m freestyle event in a competition close, in time, to the test date was of 1.15 m/s.

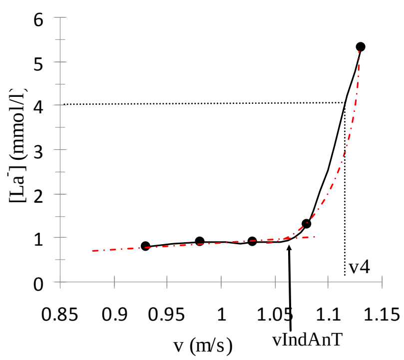

Fig. (1). Individual $[La^-]$/velocity curve in the incremental protocol for IndAnT determination, which is represented by the interception of a rectilinear and an exponential line (v4 is also pointed out).

Regarding the stroking parameters, it was observed a stroke rate increase and a stroke length decrease during the incremental protocol (Fig. **2**).

Additionally, high positive correlation values were found between stroke rate and velocity ($r>0.99$, $p<0.01$), as well as high inverse relationships between stroke rate and stroke length ($r=-0.93$, $p<0.05$), and stroke length and velocity ($r=-0.92$, $p<0.05$).

DISCUSSION

It is well known that more accurate, specific and individualized testing protocols are needed when the subjects are top level athletes. In this perspective, the protocol used in the present study, being specific for VO_2 kinetics analysis (cf. Fernandes *et al.* [5,7]), seems to be successful adapted for young swimmers, allowing a specific and precise individual AnT assessment. The individualization of training and testing methodologies are also important to implement in age group swimmers since these young subjects are involved in regular practice.

The presented results seem to confirm the fact that v4 (and v3.5) does not represent the individualized AnT in trained swimmers, independently of their age. Inclusively, v4 is closer to the velocity obtained in a 400 m freestyle event, which is accepted to be an effort conducted in the aerobic power bioenergetical training area [8]. In fact, the obtained $[La^-]$ corresponding to IndAnT is lower than those reported in the literature for older swimmers, which varies between 1.5 and 4.5 $mmol.l^{-1}$ [4]. This fact may be explained by the training regimen of the age group swimmers, focusing more on technique development at slow/moderate paces. In this sense, this young swimmer seems to be well trained in aerobic regimen which is in accordance with the training principles of the earlier stages of the training carrier [9].

Regarding the stroking parameters, our results are according with the literature since research has shown that the stroke rate and stroke length combinations change with increasing velocity [10]. Indeed, it was reported that that swimmers reach maximum velocity by increasing stroke rate and decreasing stroke length, while $[La^-]$ increased [10]. In this study, stroke rate appeared to be the most important parameter in achieving high swimming velocity in the incremental protocol. However, given the importance of developing swimming technique in age-group swimmers, coaches should implement the lengthening of their stroke cycles in their training practice routines, insisting that their swimmers should try to resist to the degradation of the stroke length when velocity increases.

This work could allow coaches to better understand that both anaerobic threshold and stroking parameters are individualized parameters and should not be seen as "averaged" values. Additionally, this test allows coaches to identify the most economical stroke kinematics combination for the velocities of interest and to focus on proper training drills.

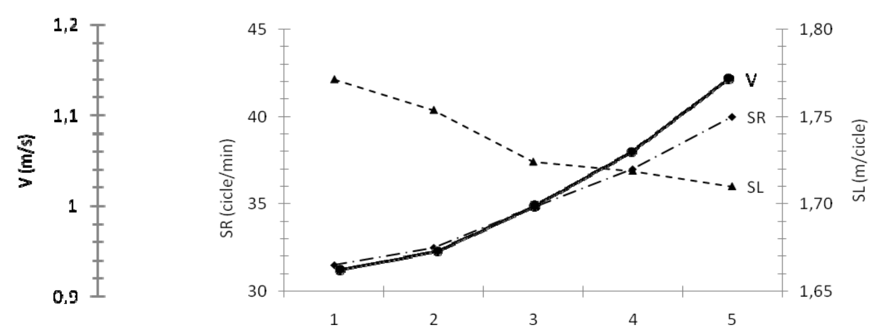

Fig. (2). Values for velocity (v), stroke rate (SR) and stroke length (SL) during the 5 x 200 m front crawl incremental protocol.

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