Lactate threshold in rowers: comparison between two methods of determination

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ABSTRACT

The objective of this study was to compare the 4 mM (AT4) and Dmax methods for lactate threshold determination. Ten male (23.7 ± 3.33 years) and four female rowers (18 ± 0.81 years), divided into three groups: heavy weight (n = 6), light weight (n = 4), and female (n = 4), (87.23 ± 6.10, 73.22 ± 2.38, 63.27 ± 8.86 kg and 187.66 ± 1.63, 183 ± 6.05, 172 ± 5.16 cm respectively), were submitted to a maximal rowing ergometry, with initial workload of 130 to 150 W and increases of 30 to 50 W every 5 minutes, with 1 minute pause for blood sampling. Power output, heart rate and lactate values were determined at every workload and used for the determination of the thresholds according to both methods. Lactate concentration, power output and heart rate, identified by Dmax method were compared with the AT4 method in the heavy weight (3.01 ± 0.73 vs. 4 mM, 268.33 ± 29.44 vs. 312 ± 44.02 W and 164 ± 4.81 vs. 174 ± 10.09 bpm), light weight (2.51 ± 0.53 vs. 4 mM, 232.50 ± 15.00 vs. 277.50 ± 25.98 W and 160 ± 8.47 vs. 177 ± 3.79 bpm) and female (3.21 ± 0.41 vs. 4 mM, 160 ± 14.41 vs. 167.50 ± 15.00 W and 175 ± 20.42 vs. 185 ± 12.12 bpm) groups through the paired Student t-test, being significantly lower ($p < 0.05$) when the method Dmax was used. The results suggest that the AT4 method overestimates the variables analyzed in the lactate threshold when compared with the Dmax method.

Key words: Rowing. Lactate anaerobic threshold.

INTRODUCTION

Currently, the anaerobic threshold is one of the most employed parameters, both as indicative of the aerobic physical performance capacity and in the training prescription[1], and evidences that the performance in continuous and prolonged sportive activities is better correlated with the anaerobic threshold that with the maximum aerobic power output are observed[1,2].

The anaerobic threshold may be considered as the unbalance point between lactate removal and production[3-5], however, the determination of the anaerobic threshold through the blood lactate measurement (Lactate Threshold) involves an invasive and high-cost approach.

An alternative method is the determination of the ventilatory thresholds through non-invasive and low-cost techniques. The works of Wasserman *et al.*[6] demonstrated that the blood lactate levels present strong correlation with ventilation in function of the buffering of hydrogen ions (H^+) through bicarbonate ion (HCO_3^-), and subsequent elimination as carbon dioxide (CO_2) through respiration ($H^+ + HCO_3^- \leftrightarrow H_2CO_3 \leftrightarrow CO_2 + H_2O$).

These responses may be evaluated through the graphic analysis of variables such as ventilation, carbon dioxide production ($\dot{V}CO_2$), oxygen ventilatory equivalents, (O_2) and CO_2 and expiratory pressures of O_2 and CO_2, using a visual evaluation of the breakage of linearity in curves in relation to the different work intensities[6].

In rowing, however, the respiration trained standard presented by athletes[7] impairs and even makes the detection of ventilatory thresholds impossible due to its coupling to the technical gesture, and in this case, an alternative evaluation method is required. Thus, the method adopted for the specific case of rowing is the lactacidemia.

There are a large diversity of different nomenclatures and methodologies in literature with regard to the detection of the lactate threshold (LT) in athletes. Basically, methods that use fixed lactate concentrations and methods that use variable lactate concentrations can be distinguished. The adoption of the 4 mM fixed blood lactate concentration (AT4 – Anaerobic Threshold of 4 mM) by authors such as Heck *et al.*[8] and Urhaunsen *et al.*[9,10] is justified as the maximum lactate steady state in a treadmill test (MLACSS – Maximal Lactate Steady State)[11]. The exercise intensity corresponding to this fixed concentration, when imposed to athletes in a 20-minute fixed load test presents no increase greater than 1 mM in the plasma lactate[8] and is called by other authors as the beginning of the blood lactate accumulation or usually called as OBLA (Onset of Blood Lactate Accumulation)[12].

A criticism that can be made to OBLA is with regard to the variability found in the original work (3.05 to 5.5 mM), allowing that individuals submitted to this intensity would not be actually working at the threshold, but rather above or below it[8]. However, despite this variability, the AT4 method is one of the most used methods in our environment[13].

According to what has been exposed, several laboratories have attempted to find a model for the individual LT determination. In this context, one of the most recent and easy-to-apply models found in literature is the model initially proposed by Cheng *et al.*[14] and later used also by Nicholson and Sleivert[15] called as Dmax (maximal distance). In this proposal, the blood lactate, ventilation, heart rate and CO_2 production ($\dot{V}CO_2$) values collected during incremental test in cycle ergometer are plotted against $\dot{V}O_2$ values, thus constructing a third order exponential tendency curve. This curve demonstrates the behavior of physiological responses in relation to the exercise performed and presents an increasing behavior in function to the increase on the intensity. Later, a straight line connecting the initial and final points of the curve is constructed, and the longest distance between the curve and the new straight line is considered as the lactate threshold, thence the denomination Dmax.

Thus, the objective of this study was to compare the 4 mM fixed concentration method (AT4)[8] with the blood lactate variable concentrations method (Dmax)[14,15], searching to determine differences of HR and power output developed by rowers in each model.

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MATERIAL AND METHODS

Subjects

Ten male (23.7 ± 3.33 years) and four female rowers (18 ± 0.81 years), divided into three groups: heavy weight (n = 6), light weight (n = 4), and female (n = 4), (87.23 ± 6.10, 73.22 ± 2.38, 63.27 ± 8.86 kg and 187.66 ± 1.63, 183 ± 6.05, 172 ± 5.16 cm respectively), all experienced in the modality and familiarized with the rowing ergometer, who belong to the Náutico União rowing society team of Porto Alegre, RS. The study followed the norms of the resolution 196/96 of the Health National Council. The athletes signed an informed consent term and the study was previously approved by the Ethics Research Committee of the Rio Grande do Sul Federal University (number 2003101 of July 24th 2003).

Determination of the anaerobic threshold

The rowers performed a progressive maximum test in rowing ergometer (Concept II – VT, USA) with stages of 5 minutes duration and 1-minute interval for blood collection. The initial load was of 150 Watts with increments of 50 and 30 Watts for male heavy weight and light weigh groups, respectively. The female group performed test with initial load of 130 Watts and increments of 30 Watts. The athletes were verbally encouraged in order to reach maximum effort level in test, which was interrupted when the athlete could no longer maintain the established rowing output. 20 mL of blood were collected from the right earlobe each stage. The lactate concentration was analyzed through lactimeter Accutrend® (Roche – Basel, Switzerland), while the heart rate was controlled through frequencimeter Polar S-610 (Polar Electro Oy® – Finland).

The blood lactate values of each stage were plotted in graphic against power output values of the respective stage. The lactate threshold may be expressed as the exercise intensity and/or power produced by the athlete and was evaluated based on AT4 and Dmax methods (figure 1). The lactate threshold defined by the AT4 method was determined using a 4 mM fixed blood lactate concentration through linear interpolation. The Dmax method[14,15] was used by constructing a tendency line through a 3rd degree polynomial function and a straight line connecting the initial and final points of the lactate curve. The longest distance was considered as the lactate threshold point and its reference power output and heart rate values were recorded.

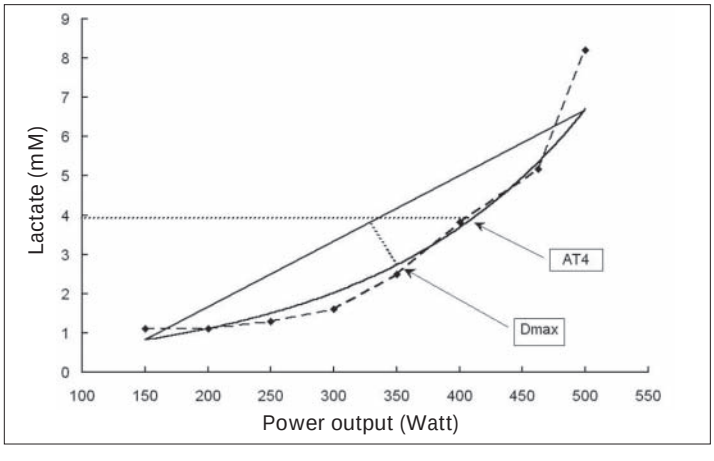

Fig. 1 *– Representation of AT4 and Dmax techniques to determine lactate threshold*

Statistical analysis

The lactate, power output and heart rate values identified through the Dmax method were compared among groups with values identified through the AT4 method through a t-Student test for paired samples (P < 0.05) using the SPSS for Windows version 8.0 software.

RESULTS

Once test protocols were different for each group and since the lactate threshold detection is highly dependent on the test protocol used[11,16], the intergroup lactate threshold comparison was not performed and only an intragroup comparison was conducted.

The lactate concentration identified through the Dmax method in heavy weight (3.01 mM ± 0.73), light weight (2.51 mM ± 0.53) and female (3.21 mM ± 0.41) groups was significantly lower (p < 0.05) than the 4 mM fixed concentration method (AT4) as shown in figure 2.

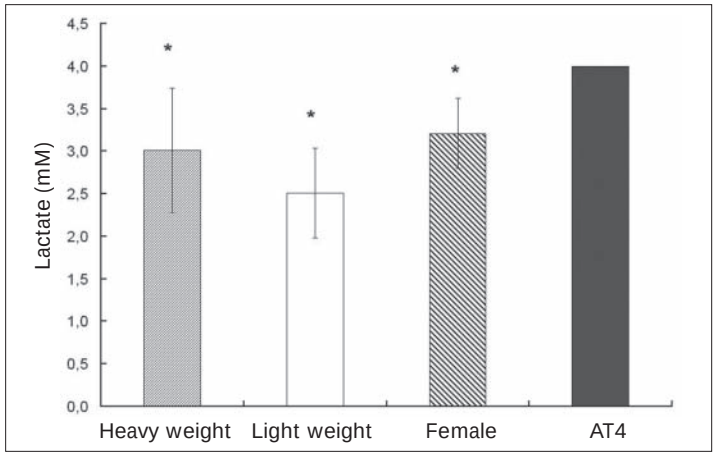

Fig. 2 *– Comparison between the lactate concentrations identified by the Dmax method in the three groups and the fixed 4mM concentration*
** Significant difference (p < 0.05) between the lactate concentration obtained by the Dmax method and the fixed 4mM concentration according to the AT4 method*

When the threshold power values identified through the Dmax method in heavy weight (268.33 W ± 29.44), light weight (232.50 W ± 15.00) and female (160.00 W ± 14.41) groups were compared to the 4 mM fixed concentration method (AT4) in the same groups (312 W ± 44.02), (277.50 ± 25.98) and (167.50 W ± 15.00) respectively, one could observe that the values identified through the Dmax method are significantly lower (P < 0.05), as shown in figure 3.

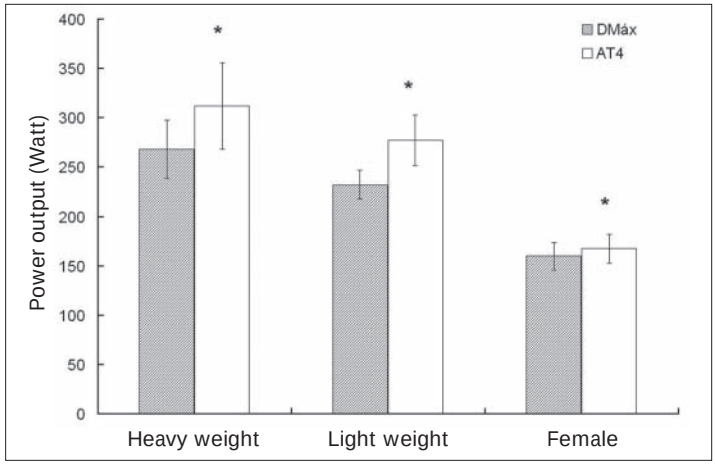

Fig. 3 *– Comparison between threshold power obtained by Dmax and AT4 methods*
** Significant difference (p< 0.05) between Dmax and AT4 methods*

When the threshold heart rate values obtained through the Dmax method in heavy weight (164 bpm ± 4.81), light weight (160 bpm ± 8.47) and female (175 bpm ± 20.42) groups were compared to values identified through the 4 mM fixed concentration method (AT4) in the same groups (174 bpm ± 10.09), (177 bpm ± 3.79) and (185 bpm ± 12.12) respectively, one could observe that the values identified through the Dmax method are significantly lower (P < 0.05), as shown in figure 4.

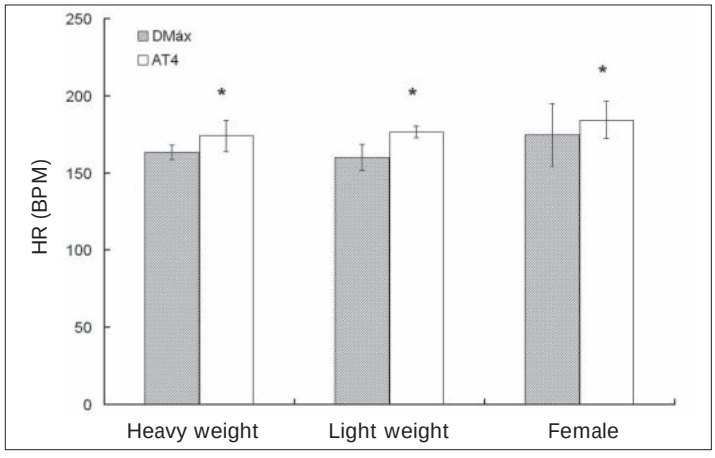

Fig. 4 *– Comparison of heart rate (HR) obtained by Dmax and AT4 methods*
** Significant difference (p < 0.05) between Dmax and AT4 methods*

DISCUSSION

The main objective of this study was to compare two different lactate threshold identification methods, one using a variable blood lactate concentration in order to respect the physiological individuality of athletes and another using a fixed concentration, especially because rowing is traditionally a sportive modality influenced by the German exercise physiology school, so that the AT4 method is widely employed in this sportive modality. In our study, the lactate threshold identified through this method[8] overestimated all parameters evaluated when compared with the lactate threshold identified through the Dmax method, initially proposed by Cheng *et al.*[14] for cyclists and later used by Nicholson and Sleivert[15] for runners.

Cheng *et al.*[14] used the Dmax method based on ventilation, respiratory frequency, $\dot{V}CO_2$ and blood lactate responses, and verified that the lactate threshold was not significantly different from that determined through ventilatory equivalents and OBLA. Moreover, when the different ventilatory and metabolic variables were used in the Dmax method, no significant differences were found in the lactate threshold determination.

Some years later, Nicholson and Sleivert[15] compared the threshold velocity between Dmax, AT4 methods and the lactate threshold proposed by Thoden[17] in running, what suggests that the lactate threshold is better represented by the running velocity that precedes the intensity that would result in increases of 1 mM on the plasma lactate. The results obtained in this research are in agreement with ours, where the lactate threshold obtained in AT4 overestimated the threshold velocity when compared to other methods.

Maybe due to the limitation from the use of fixed lactate concentrations in the identification of the anaerobic threshold, many authors proposed the use of individualized anaerobic thresholds. In this context, authors such as Stegmann *et al.*[18] proposed the use of an individual anaerobic threshold (IAT). This method, developed by researchers in Germany, is based on the individual ability of the athlete in maintaining a lactate steady state during prolonged exercises. Indeed, in a subsequent study conducted by McLellan and Jacobs[19], the exercise intensity corresponding to the IAT showed to be the highest power output that athletes could maintain for an exercise period between 15 and 20 minutes with no increase on the blood lactate accumulation and thence, it is also called by some research groups as the maximal lactate steady state (MLSS)[12].

According to Beneke[16], the lactate threshold obtained in AT4 and the IAT are the methods most commonly used for the detection of the lactate threshold in water rowers and seem to be quite representative of the MLSS in running and cycling. With the objective of verifying if these two methods would also present good correlation with MLSS in rowing, the researchers used a maximum rowing ergometer in order to compare the threshold power between AT4 and IAT methods. The study found no significant difference between methods; however, the workloads identified by both methods were always higher than the load of MLSS.

Contrarily, Urhaunsen *et al.*[10] evaluated cyclists, triathletes and rowers and verified that the IAT proposed by Stegmann *et al.*[18] is strongly correlated with MLSS, but once the IAT intensity is exceeded in only 5%, half of the athletes studied presented progressive increase on the blood lactate accumulation.

As can be seen, in relation to the lactate threshold determination, the literature is quite diverging with regard to methods and nomenclature used, sometimes using similar methods with different denominations and sometimes using the same nomenclature for different methods. The differences identified between methods seem to be found especially in the test protocols used, in the mathematic models employed for the lactate threshold identification and in the type of exercise evaluated[20,21].

Only some of the many methods for the lactate threshold determination are presented here, verifying the difference between the use of a fixed lactate concentration and the use of a variable lactate threshold in order to respect differences between individuals.

A limitation on this study that must be mentioned was the use of an initial sample composed of 14 individuals, which were divided into 3 groups, where 2 groups were composed of 4 individuals and 1 group composed of 6 individuals. This sample stratification may limit the results, especially in relation to extrapolations.

However, when Dmax and AT4 lactate threshold determination methods were compared, significant differences were found in the group studied with the Dmax method, presenting lower lactate, heart rate and threshold protein production values in rowers when compared to the AT4 method.

Such differences must be taken into consideration when some of the methods approached here are used for the prescription and follow-up of the rowing training. Further studies are required in order to evaluate if these differences that point to an overestimation of the AT4 threshold determination when compared to the Dmax method, present significant repercussion in the performance and training control of these athletes.

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