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Relationship between the Anaerobic Threshold Identified Through Blood Lactate between the Discontinuous and Resisted Dynamic Exercises in Long Distance Runners

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ABSTRACT

Campos YAC, Guimarães MP, Souza HLR Silva GP, Domingos PR, Resende NM, Silva SF, Vianna JM. Relationship between the Anaerobic Threshold Identified Through Blood Lactate between the Discontinuous and Resisted Dynamic Exercises in Long Distance Runners. **JEPonline** 2017;20(1):83-91. The purpose of this study was to verify the relationship between the anaerobic threshold (AT) identified through blood lactate concentrations [Lac] between incremental protocols performed on the treadmill (TE) and the leg press 45° (LP 45°). Twelve male runners were randomized to perform two incremental protocols on TE and LP 45°. The results did not show significant differences in [Lac] between both protocols, and there was agreement between them. Despite the findings between both protocols, further studies are still needed to confirm the results.

Key Words: Runners, Treadmill, Leg Press 45°

INTRODUCTION

The determination of anaerobic threshold (AT) is considered an appropriate physiological parameter to identify the different intensity domains present in endurance exercise (20) and, in particular, its relationship with performance during long distance tests (14,29). In this regard, Kindermann and colleagues (13) observed in their study that aerobically trained individuals are able to sustain exercise intensities close to the AT for a period of 45 to 60 min without a continuous accumulation of blood lactate (2). Thus, AT is an important marker of the physiological limit that can be sustained without the evidence of muscle fatigue (12), which reinforces its applicability for evaluating endurance performance as well as for the prescription of aerobic training (15).

Traditionally, AT can be identified through blood lactate concentrations [Lac], termed lactate threshold (LT) (27). It can also be determined through the intensity of effort in which there is a maximum balance between lactate production and removal rates from the blood (9). Hence, if the exercise intensity is too high, the [Lac] begins to increase exponentially, which coincides with the eventual muscular fatigue (27).

Numerous studies have attempted to determine LT by applying protocols with incremental loads performed on a cycle ergometer (17, 5), a treadmill (13,16), and during resistance exercise (24,25). However, there are relatively few studies that have verified the relationship between metabolic behavior, [Lac], and different incremental protocols performed during discontinuous and resisted dynamic exercises (26).

Some recent studies have highlighted the use of strength training (ST) to improve running economy, causing significant improvements in running performance in men with different levels of training (10,23,28). To assess the magnitude of the response induced by ST it is common to use 1RM, isometric, and jumping tests (6,10,28). However, it is presumed that the tests usually applied to verify the improvements are quite distant in relation to the specificity of the test. The fact that the tests do not consider the physiological transition thresholds that are specific to the adaptations caused by endurance training needs further clarification. In this way, a study that evaluates the metabolic response during protocols performed on treadmill (TE) and leg press 45° (LP 45°) is justified. As a result, the probable relationship between the different protocols could justify the inclusion of the incremental protocol performed in LP 45° as a reliable tool to evaluate ST responses in long distance runners.

Thus, the purpose of the study was to verify the relationship of LT identified through the blood lactate concentrations [Lac] between the incremental protocols performed on the TE and the LP 45°. Our hypothesis was that the relationship between the incremental protocols exists despite the distinct characteristics of the two types of exercise.

METHODS

Subjects

Twelve male runners (age = 29.27 ± 3.24 yrs; fat percentage = 10.33 ± 2.62%; height = 1.77 ± 0.04 m; body mass = 73, 44 ± 4.38 kg, time for 5000 m = 20 min and 37.8 sec ± 2 min and 21 sec; training time = 4.26 ± 0.68 yrs). To be included in the study, volunteers must have no bone, joint, muscle, and/or cardiovascular pathologies, and they must have a history of participating regularly in street races competing at distances between 5,000 m and 10,000 m. Before the procedures were carried out, a legal opinion was obtained through the local ethics committee in accordance with the Declaration of Helsinki.

Procedures

To verify blood lactate responses during the incremental protocols performed on the TE and during the LP 45°, we established five separate test sessions for a 48-hrs interval. To perform the sessions, the subjects were instructed to abstain from vigorous physical exercises and to avoid the consumption of alcohol and caffeinated beverages during the 48 hrs preceding the tests. During the first session, the subjects' body mass, height, and body composition were assessed. In the second and third sessions, the subjects were tested and retested for the dynamic force test with 1 maximal repetition (1RM). During the fourth and fifth sessions, the subjects were randomized in order to collect blood samples for the incremental protocols performed on the TE and LP 45°.

Anthropometric Evaluation

To characterize the sample, we determined the subjects' stature and body mass by using a scale that had a stadiometer (110 FF, Welmy®, Santa Bárbara d'Oeste, Brazil). The fat percentage was estimated using a bioimpedance device (Quantum BIA-II, RJL Systems®, Clinton Township, USA). The electrodes used for the collection were of the tetrapolar type (Bio Tetronic, Sanny®, São Bernardo do Campo, Brazil).

Maximum Dynamic Force Rating (1RM)

The 1RM protocol followed the recommendations proposed by the National Strength and Conditioning Association (1). The 1RM test was applied after a warm up series in which lighter loads were used during the specific exercise. The first attempt corresponded to 50% of the subjects' estimated 1RM. Soon after the subjects had about 2 to 4 min for passive recovery or until they felt completely recovered from the previous attempt. Following the first attempt, based on the ease with which the exercise was performed, the weight was increased. The 1RM trial did not have more than five attempts during which all procedures were consistent during the test and retesting of 1RM.

Incremental Protocol Performed on Leg Press 45°

In order to perform the incremental load protocol, the subjects performed each stage progressively for a duration of 1 min each. The movement speed was controlled by a digital metronome (DM90, Seiko®, Tokyo, Japan). The subjects had 1 sec for the concentric phase and 2 sec for the eccentric phase, thus 3 sec to complete 1 repetition (7,8). After obtaining the charges in the 1RM test, they were divided into 10, 20, 25, 30, 35, 40, 50, 60, 70, 80, and 90% of 1RM (7,8). Between each stage, a 2-min recovery interval was observed to collect blood and adjust workload in preparation for the next stage (7,8). The test ended at the moment the subject did not perform the movement within the correct biomechanics previously established or due to the inability to perform the number of repetitions established for the phase (7,8). During the test, the subjects remained seated on the equipment with their trunk horizontally tilted at 45° and their knees and hips flexed at 90° (24). During the movement, the knees and hips were extended and returned to the initial position after flexion (24). Throughout the execution of the load incremental protocol we used a LP 45° machine and washers of varied weights, all from the brand (Physicus®, Auriflama, Brazil).

Incremental Protocol Performed on Treadmill

The subjects performed the incremental test on a treadmill (Super ATL, Inbramed®, Amparo, Brazil) with the initial velocity set at 8.0 $km \cdot h^{-1}$, adding increments of 1.2 $km \cdot h^{-1}$ at each stage, and maintaining a slope of 1% until exhaustion. Each stage lasted for 3 min with 30 sec of pause for blood collection (11). The maximum effort test ended when the subjects reached at least two of the following three criteria: (a) 90% of heart rate (HR) recommended for each age (established by the equation 220 - age); (b) placing in the Borg scale ≥18; and (c) inability to maintain race pace despite vigorous verbal encouragement.

Measurement of Blood Lactate

Initially, 1 min after completion of each stage, after asepsis the assessor responsible for taking blood lactate used lancets (Accu-Chek Safe-T-Pro Uno, Roche®, Hawthorne, USA) and disposable gloves (Cremer®, Blumenau, Brazil) to collect a blood sample by puncture in the earlobe. The first drop of blood was discarded and 25 µL of arterialized blood was collected shortly thereafter. Reagent strips (Accusport BM-lactate, Roche®, Hawthorne, USA) were used during collection. A portable lactate analyzer (Accusport, Boehringer Mannheim - Roche ®, Hawthorne, USA) was used, which was previously validated and reliable for use (3) for the analysis of blood lactate.

Determination of the Lactate Threshold

After the analysis, the values were individually expressed in $mmol \cdot L^{-1}$ as a function of the effort intensity, and visual graphical analysis identified the LT through the definition of the threshold where there was loss of linearity and the consequent exponential increase of [Lac] (27).

Statistical Analysis

The tests of Shapiro Wilk and Levene verified the normality and the homogeneity of the variances. After meeting these assumptions, a *t*-test for independent samples was used to compare the values of [Lac] and the AT was identified between the incremental protocols performed on the TE and LP 45°. Then, we adopted the Pearson test to verify the existence of correlation between the different incremental protocols in the [Lac] through which AT was determined. The visual analysis of the Bland Altman plot was used to verify agreement between the values of [Lac] in which AT was identified in the different incremental protocols adopted. Statistical significance was set at $P \leq 0.05$. The statistical treatment was performed using SPSS software (20.0, IBM, Armonk, USA).

RESULTS

No significant differences were found in the values of [Lac] at the AT that was identified between the incremental protocols performed on the TE and the LP 45°. However, no correlation was found between the values of [Lac] in which the AT was determined between the incremental protocols performed on the TE and the LP 45°.

DISCUSSION

The findings indicate there was no significant difference in the [Lac] between the incremental protocols performed on the TE and the LP 45° (Table 1). No significant correlation was found in the values of [Lac] in which the AT was determined between the incremental protocols performed on the TE and the LP 45°. The correlation was considered negligible (r = 0.068) (Table 1). However, visual analysis of the Bland Altman plot demonstrated agreement between the values of [Lac] in which the AT was identified between the two incremental protocols studied (Figure 1), with 95% of the data within the agreement limits of ± 1.96. This finding partially confirms the initial hypothesis for this study.

Table 1. Mean Scores ± SD Corresponding to Blood Lactate Concentration [Lac] (mmol·L^{-1}) in the Comparison of the AT Identified on the TE and the LP 45°.

AT	TE (Lac)	LP 45° (Lac)	Significance (P)	Correlation (r)	Significance of a correlation coefficient	Classification
mmol·L^{-1}	4.80 ± 1.27	5.30 ± 1.33	0.367	0.068	P = 0.835	Negligible

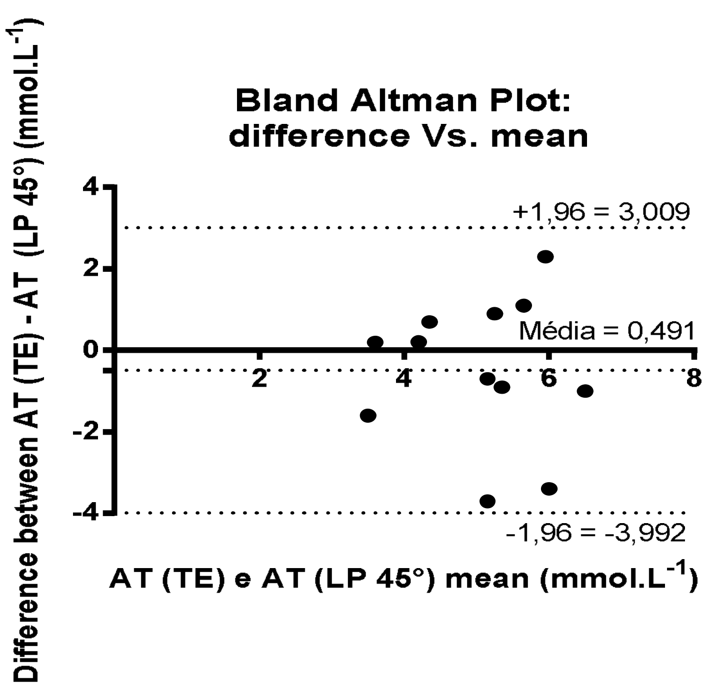

Figure 1. Concordance Between the [Lac] in Which the AT was Identified Between the Incremental Protocols Performed on the TE and the LP 45° (mmol·L^{-1}).

To our knowledge, only one study evaluated the relationship between metabolic behavior, [Lac] in discontinuous and resisted dynamic protocols (26). Simões and colleagues (26) evaluated elderly healthy subjects and did not observe significant differences in the [Lac] in which the AT was determined between incremental protocols performed on the cycle ergometer and the LP 45°. However, they observed that after AT, the [Lac] values were proportionally higher in the LP 45° than in the cycle ergometer. In our study, although we did not find significant differences in AT values between the different incremental protocols performed, the LP 45° protocol showed higher values of [Lac] when compared to the TE protocol. These findings can be attributed to hemodynamic factors that are more prominent during the LP 45° (26) where a static component is observed between the concentric and eccentric phases of the exercise (26), which is similar to isometric exercises (20). Thus, according to Petrofsky et al. (20), the elevation of muscle tension would cause a collapse in blood vessels, restricting blood flow, and decreasing oxygenation to the active muscle, which can cause metabolic changes and, consequently, an increase in lactate production.

Some studies have shown that there is a significant difference between AT identified in incremental exercises with different characteristics (18,22). For example, Medelli and colleagues (18) evaluated elite triathletes and reported a statistically significant difference between the percentage of maximal oxygen consumption (%VO_2 max) in which AT was identified, being 1.5% higher in the incremental test performed on the TE when compared to the cycle ergometer. Also, Bouckaert et al. (4) have shown that the specificity of the exercise used in the training, as well as the instrument used to perform the incremental test, can influence variables such as the maximum lactate steady state (MLSS) and the maximum oxygen consumption (VO_2 max). Hence, it is reasonable to infer that factors such as the inexperience of those evaluated in an incremental protocol performed in the resistance exercise, as well as the restriction of blood flow causing metabolic changes that lead to increases in lactate production, may have contributed to higher values in [Lac] in which the AT was identified during the incremental test performed at LP 45° compared to the TE (although there was no significant difference in the values found in both protocols).

Nevertheless, although our study found similarities between the [Lac] in which AT was identified and concordance between the incremental tests performed during the LP 45° and on the TE, additional studies are still necessary to present a more complex methodological approach and more evaluation parameters to solidify the existing relationships between both incremental protocols. However, the existing affinities in relation to the metabolic parameters between the protocols applied could, in part, justify the use of the incremental protocol performed during the LP 45° as a tool to assess the changes originating from the ST in founding corridors as well as to prescribe ST based on AT for that specific population.

Limitation of This Study

An important limitation in the present study was that a preliminary incremental test to obtain the peak of the running velocity in TE was not used, which was a proposed by Noakes et al. (19). Had that been the case, it would have been possible to divide the exercise intensities into 10, 20, 25, 30, 35, 40, 50, 60, 70, 80, and 90% of the running speed's peak, and to later to carry out a new progressive test to identify the AT. Then, it could be compared in a more standardized and reliable way with the progressive test performed in the LP 45°.

CONCLUSION

The results showed that there was no significant difference in the [Lac] in which AT was found during the incremental protocols performed on the TE as well as the LP 45°. However, it is important to point out that the results demonstrated an agreement between the protocols applied, which can indicate that the incremental protocol performed at the LP 45° may be an interesting test to evaluate ST changes in runners. The limitations of the present investigation highlight the need for additional studies with more comprehensive methodologies to ratify the results.

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