Lactate Minimum Identification in Youth Runners Through a Track Test of Tree Incremental Stages

EXERCISE AND SPORTS SCIENCES

ORIGINAL ARTICLE

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ABSTRACT

Objective: To analyze the possibility of determining the lactate minimum (LM) velocity in pre-pubertal runners applying only three incremental stages. Methods: Eleven teens (13.7 ± 1.0 years; 47.3 ± 12.1 kg; 160.0 ± 1.0 cm; 18.3 ± 1.8 kg/m2) performed three run tests on athletic running track on different days: 1) performance at 3000m (Mv3000) 2) LM test consisting of a 500m sprint for hyperlactatemia induction, followed by 10min of recovery and six sets of 800m at intensities of 83, 86, 89, 92, 95 and 98% of Mv3000, 3) LM test with three-stage (LMp3) similarly to the previous protocol; however, with only three sets of 800m at intensities of 83, 89 and 98% of Mv3000. During the first recovery minute between the second and third test stages, blood samples were collected in order to measure blood lactate. The following criteria were used to determine LM: a) visual inspection (LM), b) polynomial function of second order to LM six stages (LMp) and to three stages (LMp3). Results: ANOVA showed no differences between speeds (m.min-^{1}) identified in the studied methods (LM = 221.7 ± 15.4 vs. LMp = 227.1 ± 10.8 vs. LMp3 = 224.1 ± 11.2). High correlations were observed between the studied protocols and between these protocols and the Mv3000 ($p < 0.01$). Conclusion: It was possible to identify the velocity corresponding to the LM in youth runners even when applying only three incremental stages for identification of the LM intensity (LMp3).

Keywords: anaerobic threshold, aerobic capacity, predictive equation, field test, run.

INTRODUCTION

The blood lactate responses ([lac]) during incremental exertion tests performed before and after high intensity exercise, has been the issue of many investigations carried out since the 70's decade [1-9]. The balance point between blood lactate production and removal observed during incremental test after high intensity exercise performance has been termed lactate minimum (LM). Tegtbur *et al.*[4] were the first authors to propose the LM protocol as assessment for aerobic fitness in running tests performed on an athletic running track. During the LM protocol it is possible to observe predominance of removal until a minimum point in the [lac] kinetics, from which there increase of [lac] is leading to fatigue and consequently interruption of exertion. This minimum point was considered the balance point between lactate production and removal, named intensity of lactate minimum (ILM).

In order to understand the validity and explore the potential application of the ILM, different studies were carried out applying different ways of hyperlactatemia induction, time of induction and pause, as well as different types of recovery[5,7,10-15]. Moreover, different populations [4,5,7,15,19], including animals[16-18], different ergometers[19-21], environmental conditions [6,13], intensities, durations and distances of the incremental test stages[4,9,12,22], have also been target of investigations related to the LM test.

The ILM validation was investigated in the face of the tests considered gold standard in the assessment of aerobic fitness, named maximum lactate steady state test (MLSS). The MLSS represents the highest exercise intensity whose [lac] remains at dynamic balance during the exercise at steady load [8,9,22-26]. Moreover, the MLSS establishes an exercise intensity with physiological steady state of the lactate/pyruvate ratio, oxygen pressure, carbonic acid (HCO_3^-), base excess, oxygen consumption ($\dot{V}O_2$), respiratory exchange ratio (RER), ventilation (VE), oxygen ventilatory equivalent ($VE/\dot{V}O_2$) and of carbonic gas (VE/VCO_2) and of systolic blood pressure [27]. This is the optimum intensity to exercise prescription in training which has the aim to promote many benefits associated with development of aerobic fitness [28].

Many authors [7,8,18,19,21,23,29] have demonstrated that the ILM does not differ from the MLSS intensity. These authors have used the [lac] kinetics in the LM protocol, which is presented in a parabolic shape, for the application of the second order polynomial function to adjust the lactate curve and accurate ILM determination.

Sotero *et al.*[23], when investigating different methods of ILM determination in adults with reduction in the points of blood collection and applied to the second order polynomial function, did not observe differences between the LM and MLSS intensities. The results found by these authors suggest the possibility of decrease in the number of stages and blood collections during the LM test. However, until the present moment no study has been performed on the LM determination with reduced number of incremental stages. Moreover, the LM determination in adolescents has not been investigated yet. Therefore, the present study had the aim to determine the ILM in adolescents, assessing also the possibility to use only three incremental stages with second order polynomial adjustment for mathematical identification of ILM.

METHODS

Sample and experimental outlining

The present study was approved by the Ethics in Research Committee of the Universidade Católica de Brasília (UCB – Nº 019/2004). All participants were instructed not to perform physical exercises or ingest alcoholic and caffeinated drinks during the 24 hours before the experimental procedures. After have been informed on the risks and benefits of the study and have their parents signed the Free and Clarified Consent Form, 11 adolescent runners of the Joaquim Cruz Institute (13.7 ± 1.0 years, 47.3 ± 12.1kg, 160.0 ± 1.0cm, 18.3 ± 1.8kg/m^2) were submitted to the following evaluations (figure 1).

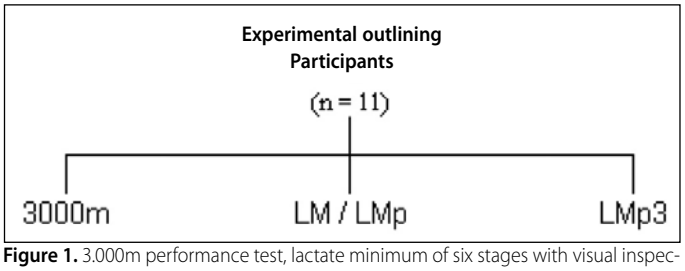

Figure 1. 3.000m performance test, lactate minimum of six stages with visual inspection (LM) and by polynomial adjustment (LMp) and lactate minimum three stages by polynomial adjustment (LMp3).

The tests were conducted with minimum interval of 48h, and the LM and LM with three stages tests (LMp3) were randomly performed on a 400m athletic running track.

Performance test in 3.000m run

The participants performed a 3.000m running performance test for the mean velocity (Mv 3000) in the running. The volunteer was told to complete the distance in the shortest possible time. The result obtained was used as the basis for calculating intensities of the stages of testing incremental LM.

Incremental tests for determination of LM,LMp and LMp3

The LM protocol modified by Simões *et al.*[5] was applied for determination of the ILM by the visual method (LM) and polynomial (LMp) method. The participants performed a 500m run at maximum velocity for induction of hyperlactatemia, followed by 10 minutes of recovery and six incremental sets of 800m at the 83, 86, 89, 92, 95 and 98% intensities of the Vm3, 000. Concerning the minimum lactate with three stages determination (LMp3), the protocol consisted of a 500m run at maximum velocity for hyperlactatemia induction, followed by 10min of recovery and three incremental sets of 800m at 83, 89 and 98% of Mv3000 intensities.

The velocities developed during the incremental tests (LM and LMp3) were controlled by auditory stimuli at each 100m.

In both protocols, there were one-minute pauses between each set for collection of 25µl of blood from the earlobe, using gloves, disposable lancets, as well as calibrated and heparinized glass capillaries. Subsequently, the samples were stored in Eppendorf microtubes containing 50µl of NaF at 1%. The [lac] were analyzed by the electroenzymatic method (Yellow Springs 2700, STAT, OH, USA).

The procedures for ILM identification are presented in figure 2. The running velocity corresponding to the lowest [lac] during the incremental tests was determined by visual inspection (LM)[4] and mathematical adjustment, using the second order polynomial function in the test with six stages (LMp)[23] and in the test from three stages (LMp3).

Statistical analysis

The data were expressed in mean ± standard deviation. ANOVA for repeated measures was applied in the comparison of the intensities obtained from the different applied protocols.

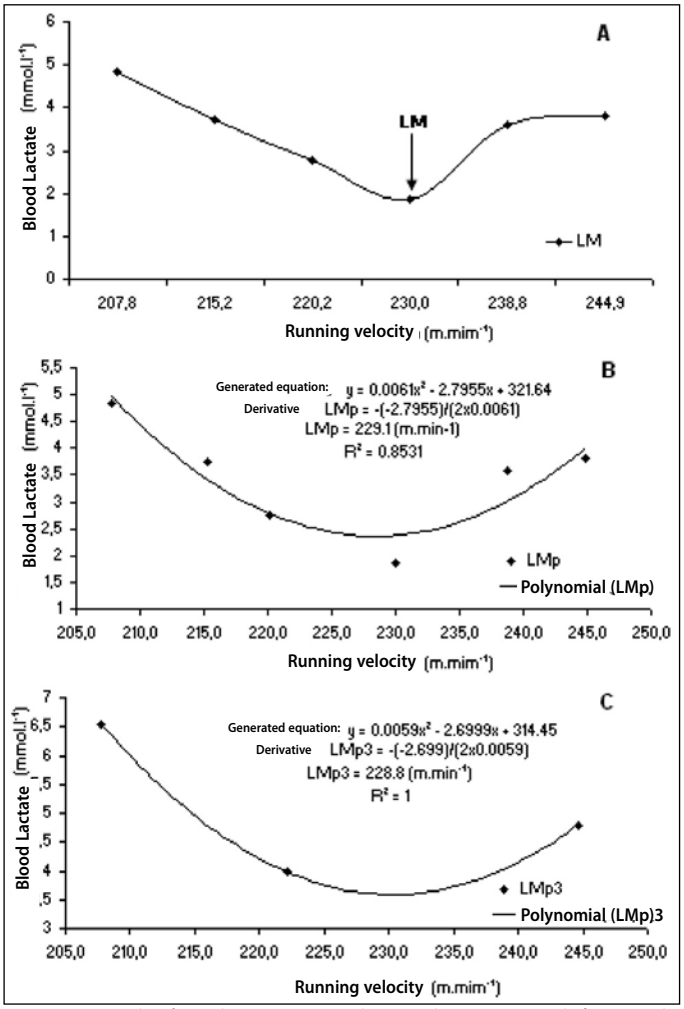

Figure 2. Example of ILM determination in the complete LM protocols for one subject, from visual inspection using six stages (A) (LM = 230.0m.min-1), by second order polynomial adjustment using six stages (B) (LMp = 229.1m.min-1) and by second order polynomial adjustment using only three stages (C) (LMp3 = 228.8m.min-1).

Tukey Post hoc was adopted with the aim to confirm or not possible differences between the multiple pairs of data. The statistical power was calculated when significant differences were observed. Moreover, Pearson linear correlation was applied to verify the association level between the methods of ILM identification. Additionally, the Bland and Altman technique was applied [30] to verify the agreement among different protocols. The significance level adopted was of $p < 0.05$ (SPSS, version 11.5 and Stata, version 9.1).

RESULTS

The mean values (± SD) and respective comparisons between performance in the 3.000m test and the ILM identified by the visual inspection method using six stages (LM), as well as by the application of second order polynomial function with six stages (LMp) and with only three stages (LMp3) are presented in table 1.

As can be seen in table 1, no differences between the ILM concerning the different studied protocols ($p > 0.05$) have been observed; moreover, strong and significant ($p < 0.01$) correlations were observed between the methods of identification of ILM (table 2). Concerning the significant difference observed between Mv3000 and the different protocols of identification of the LM, the statistical power presented mean of 0.91, which means high power (91%) to the comparisons of the present study.

The Bland and Altman technique [30] evidenced high level of agreement between the LM and LMp3 and the LMp and LMp3, considering the low bias as the narrow limits of agreement (bias ± 95% reliability interval for LM and LMp3 [2.4 (12.5) m.min^{-1}] and for LMp and LMp3 [-3.0 (15.4) m.min^{-1}]) (figure 3).

Table 1. Mean and standard deviation (± SD) of the running intensities (m.min^{-1}) in the 3.000m (Mv3000), LM, LMp and LMp3 (n = 11) tests.

Mv3000 (m.min^{-1})	LM (m.min^{-1})	LMp (m.min^{-1})	LMp3 (m.min^{-1})
245.6 ± 17.0*	221.7 ± 15.4	227.1 ± 10.8	224.1 ± 11.2

Mv3000= mean velocity in the 3,000m running test; LM = visual lactate minimum; LMp = polynomial lactate minimum using six stages; LMp3 = polynomial lactate minimum using three stages. *$p < 0.05$ concerning the LM, LMp and LMp3.

Table 2. Correlation matrix between the LM, LMp, LMp3 and Mv3000 velocities (n = 11).

	LMp	LMp3	Mv3000
LM	0.74*	0.94*	0.89*
LMp	--	0.75*	0.80*
LMp3	--	--	0.92*

* Significant correlation $p < 0.01$.

DISCUSSION

The aim of the present study was to verify the possibility of reduction of the number of stages and blood collections, applying the second order polynomial function in a LM test with only three incremental stages for determination of the ILM in adolescents. The main finding in the present study was that even with the decrease of the number of incremental stages during a LM test, that is, only three stages; it was possible to detect the ILM in adolescent runners (table 1). This procedure minimizes the stress to the evaluated, the work of the evaluator, as well as the evaluation costs, besides reducing the risks to the evaluated, due to the reduced number of blood collections performed compared to the traditional protocols.

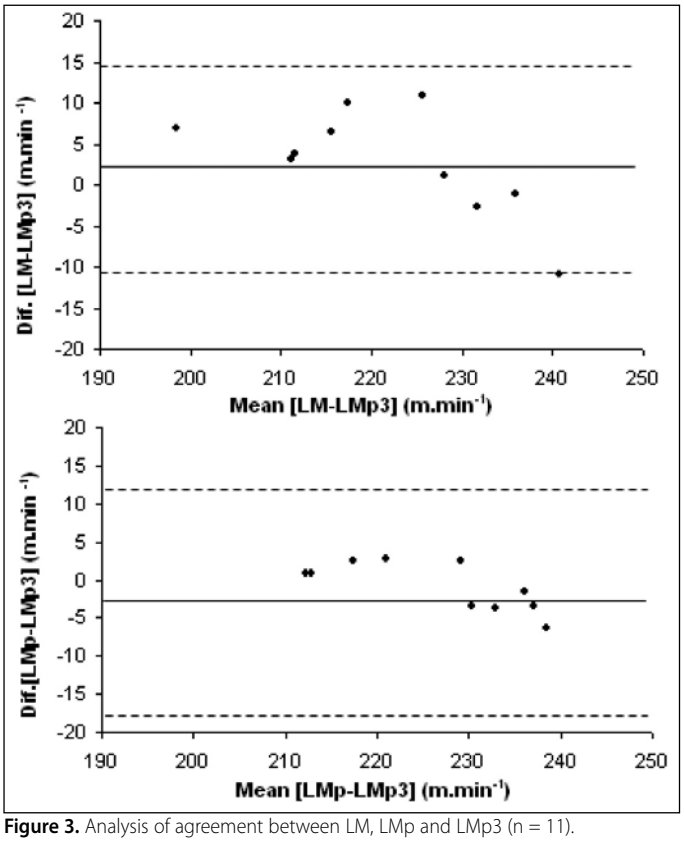

Figure 3. Analysis of agreement between LM, LMp and LMp3 (n = 11).

Sotero *et al.*[23] proposed the LM protocol on athletic running track with reduction in the number of stages to three, choosing different combinations of incremental stages. However, the stages were selected from a complete-traditional incremental test of six performed stages. These authors did not find differences between the LM velocities identified from a lower number of stages and the MLSS velocity. In the present study an incremental test with only three stages was used, which had not been performed yet. In addition to that, this study was a pioneer in the identification of the LM in adolescents.

The MLSS protocol is considered gold standard in assessment of aerobic fitness from the [lac] responses[24,27,28]. The ILM efficiency in estimating the MLSS loads has been studied, and different research has demonstrated that there are not differences between the loads associated to LM and MLSS[7,9,18,19,21,22].

The LM protocol proposed by Tegtbur *et al.*[4], a protocol valid and practical in estimating the MLSS intensity[7,9,18,19,21,22], provides a [lac] kinetics in a parabolic shape (U shape). Having this kinetics as starting point, it is possible to mathematically adjust by application of the second order polynomial function[7,18,19,21]. The polynomial function enables greater accuracy in the determination of the ILM through the equation generated by the tendency line between the collection points[8,23,29].

Besides the similarity between the ILM's obtained among the different studied protocols, strong and significant correlations were observed among these (table 2), especially between the LMp3 with the LM traditional protocol ($r = 0.94$; $p < 0.01$) and with performance in the 3.000m run ($r = 0.92$; $p < 0.01$). Additionally, the Bland and Altman technique[30] confirmed the good

concordance between the different protocols (figure 3). These findings corroborate the possibility of reduction of the stages as well as blood collections for the ILM determination, once the LMp3 protocol did not differ from the remaining protocols.

A limitation of the present study was the absence of MLSS tests, which are considered gold standard in the assessment of aerobic fitness. Nevertheless, Sotero *et al*.[23], when investigated the validation of the LM test which, in the present study, did not differ from the LMp3 intensity obtained (table 1), confirmed its equivalence with the MLSS, suggesting hence that the LMp3 protocol also represents the MLSS intensity.

Previous studies[8,23,29] investigated the application of the mathematical adjustment as well as the possibility to reduce the number of collections during the LM protocol. Considering that significant differences have not been found between the six and three stages tests for determination of the ILM, with strong and significant correlation as well as with good concordance between them, the results of the present study indicate that the performance of only three incremental stages is sufficient to determine the ILM in adolescent runners, making the assessment of the aerobic fitness possible in shorter time, cost and risk to the evaluee.

Further studies should be conducted in order to investigate the validity and reproducibility of the LMp3 protocol, comparing it to the MLSS intensity, testing alterations in the protocol application, as well as its application in different populations.

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