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EFFECT OF SOCCER TRAINING ON THE RUNNING SPEED AND THE BLOOD LACTATE CONCENTRATION AT THE LACTATE MINIMUM TEST

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Abstract. Tegtbur *et al.* [23] devised a new method able to estimate the intensity at maximal lactate steady state termed "lactate minimum test. According to Billat *et al.* [7], no studies have yet been published on the affect of training on highest blood lactate concentration that can be maintained over time without continual blood lactate accumulation. Therefore, the aim of the present study was to verify the effect of soccer training on the running speed and the blood lactate concentration (BLC) at the lactate minimum test (Lac_{min}). Thirteen Brazilian male professional soccer players, all members of the same team playing at National level, volunteered for this study. Measurements were carried out before (pre) and after (post) eight weeks of soccer training. The Lac_{min} test was adapted to the procedures reported by Tegtbur *et al.* [23]. The running speed at the Lac_{min} test was taken when the gradient of the line was zero. Differences in running speed and blood lactate concentration at the Lac_{min} test before (pre) and after (post) the training program were evaluated by Student's paired t-test. The training program increased the running speed at the Lac_{min} test (14.94±0.21 vs. 15.44±0.42* $km \cdot h^{-1}$) and the blood lactate concentration (5.11±2.31 vs. 6.93±1.33* $mmol \cdot L^{-1}$). The enhance in the blood lactate concentration may be explained by an increase in the lactate/H^+ transport capacity of human skeletal muscle verified by other authors.

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Key words: Soccer training – Blood lactate concentration – Lactate minimum test

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Introduction

The blood lactate response to incremental exercise was used in different modalities of sport to predict endurance performance [13,18] and to determine training workloads [14,23]. The lactate is produced in the muscle and transported to the blood where it can be removed by heart tissue, liver and inactive muscle.

The maximal lactate steady state (MLSS) is defined as the highest blood lactate concentration and work load that can be maintained over time without continual blood lactate accumulation [2-6]. However, there are some disadvantages to the assessment of MLSS in sports teams like the cost of the test and the requirement for individuals to complete 4-6 constant-load exercise bouts on separate days. Therefore, a lot of authors have developed methods which allow endurance capacity to be estimated from the blood lactate response to incremental exercise tests. Some studies proposed the interpolation to fixed blood lactate reference concentrations of 1mmol·L^{-1} [11], 3.0 mmol·L^{-1} [9] and 4.0 mmol·L^{-1} [14,16]. The strong correlation between running speed at this fixed lactate reference concentrations and endurance performance has validated these measures [16,22].

Tegtbur *et al.* [23] devised a new method able to estimate the intensity at MLSS termed "lactate minimum test". The practical advantage of lactate minimum (Lac_{min}) test is that an intensity corresponding to MLSS can be obtained from one laboratory test instead of the series of tests in separate days, normally required to establish MLSS. The Lac_{min} test involves a three-stage protocol consisting of a brief period of high intensity exercise to elicit hyper lactemia, following an 8-min recovery period and a multistage incremental exercise test with blood samples for the analysis of lactate concentration (Lac) taken at the end of each exercise stage.

The incremental part of Lac_{min} test starts when the athlete has a high blood lactate concentration. Initially this high (Lac) falls because of the low intensity of exercise; the substrate is being used to produce energy, but then it increases again as a result of the lactic acid appearance being greater than its removal, once a minimum point is reached. The Lac_{min} intensity is represented by this minimum point and is objectively determined by a horizontal line tangenting a cubic spline fit to the exercise blood lactate data.

Jones and Doust [15] showed that the lactate minimum speed was significantly lower than the independently determined running speed at the MLSS. However, the Lac_{min} speed was not significantly different from the running speed at the lactate threshold and was correlated with 8 km running performance. It has also been reported that the Lac_{min} speed is not affected by prior exercise [23]. Carter *et al.* [10] concluded that the lactate minimum speed, when assessed using the same exercise protocol before and after 6 weeks of aerobic training, is not sensitive to changes in endurance capacity.

However, according to Billat *et al.* [7], no studies have yet been published on the affect of training on highest blood lactate concentration that can be maintained over time without continual blood lactate accumulation. Therefore, the aims of the present study were to verify the effect of soccer training on the running speed and the blood lactate concentration (BLC) at the Lac_{min} test.

Materials and Methods

Participants: Following approval from the Institute's Ethics Committee, written informed consent was obtained from thirteen Brazilian male professional soccer players, all members of the same team playing at National level, who volunteered for this study. Mean age, body weight, height and percentage of body fat were 23±1.4 years, 74.6±5.7 kg, 178.5±4.4 cm and 10.18±3.82 %, respectively. Percentage of body fat was estimated using the measurements of four skinfolds according to Durnin and Womersley [12]. A Harpenden caliper was used to measure skinfold thickness (i.e. biceps, triceps, subscapular and suprailiac) on the right side of the body, with the subject in a standing position.

Experimental procedures: Measurements were carried out before (pre) and after (post) eight weeks of soccer training that corresponded to the basic preparation period of the second periodisation in the year. The training sessions during the 8-weeks (Table 1) were set by the team coach and were not influenced by the experimental study. Athletes were instructed not to engage in strenuous activity the day before an exercise test and to maintain a consistent routine with regard to training, sleeping and diet throughout the duration of the study. The tests were performed on a 400-m track.

Lactate minimum test: The Lac_{min} test was adapted to the procedures reported by Tegtbur *et al.* [23]. Participants performed 5-10 min of warm-up followed by two supramaximal runs of 200 m with a 2 min rest between runs. Then, they rested for 8 min and started the incremental phase of the test that consisted of 5 x 600 m with 12.0, 13.3, 15.0, 16.4 and 17.1 $km \cdot h^{-1}$, respectively. The running speeds of the incremental phase after the training period were 12.0, 13.3, 15.0, 17.1, 18.9 $km \cdot h^{-1}$, respectively. The running speed at the Lac_{min} test was determined at the lowest point in blood lactate concentration on the BLC versus running speeds curve using second-order polynomial function. The running speed at the Lac_{min} test was taken when the gradient of the line was zero (Fig. 1).

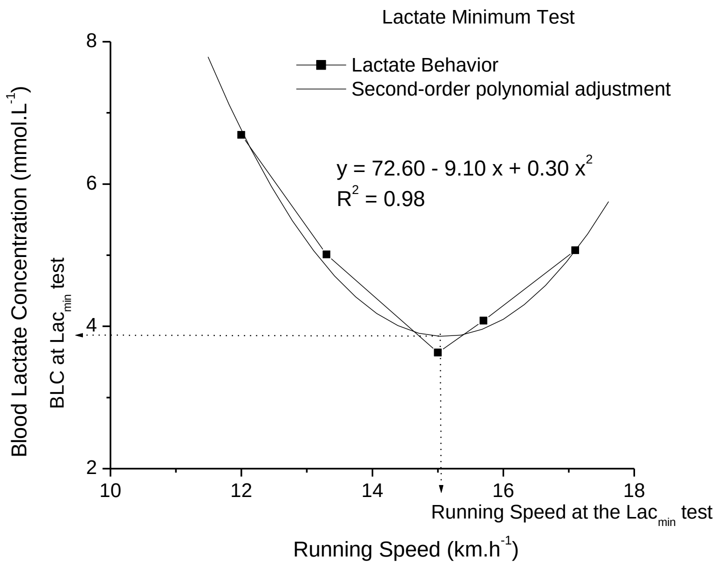

Fig. 1
Determination of running speed and blood lactate concentration

Blood sampling: Capillary blood samples were collected from subject's earlobes in 25-µL heparinized capillary tubes at the following moments: 3rd, 5th and 7th min after the two supramaximal runs and at the end of each stage of incremental phase. Blood lactate concentration was then assayed by lactate analyzer (YSL 1500 Sport, Yellow Spring, OH, USA).

Statistical analysis: Origin 6.0 (Microcal™) program was used to analyze the data. Differences in running speed and blood lactate concentration at the Lac_{min} test before (pre) and after (post) the training program were evaluated by Student's paired t-test. A significance level of 5% was chosen. Data are presented as mean ±standard deviation.

Results

Training: According to Table 1, the training program consisted of 55 sessions of endurance, anaerobics, agility, strength, coordination and sprint training developed during 8 weeks.

Table 1
Type, method and frequency of training

Type of training	Method of training Duration of training	Number of training sessions
Endurance	Continuous of 15-16 km/h 30 min	10
	Interval of 3 x 2400 m 50 min	5
	Fartlek 40 min	5
Anaerobic	4 x 400. 4 x 300. 4 x 200 m 60 min	5
	7 x 300 m 20 min	5
Agility, Strength and Coordination	Circuit Training 90 min	10
Sprint	5 x 40. 4 x 60. 3 x 80 m 30 min	5
	10 x 10. 8 x 20. 6 x 30 30 min	10

Running speed at the lactate minimum test: Table 2 shows the individual results of the Brazilian soccer players. Moreover, it is possible to verify that the soccer training program led to a statistical increase in the running speed at the Lac_{min} test (14.94±0.21 vs. 15.44±0.42* $km \cdot h^{-1}$).

Table 2
Running speed at the Lac_{min} test before (pre) and after (post) 8-weeks professional soccer player training; individual results

Soccer players (n=13)	Players position	$Lac_{min-pre}$ (km·h^{-1})	$Lac_{min-post}$ (km·h^{-1})
1	Goalkeeper	14.70	15.43
2	Goalkeeper	14.90	14.96
3	Defender	15.10	15.53
4	Defender	14.75	14.82
5	Defender	15.20	15.55
6	Defender	15.07	15.54
7	Defender	14.98	15.57
8	Midfielder	15.03	15.75
9	Midfielder	14.55	15.03
10	Midfielder	15.13	16.41
11	Midfielder	14.95	15.63
12	Forward	15.23	15.53
13	Forward	14.69	14.99
Median	-----	14.94	15.44*
SD	-----	0.21	0.42

*statistical difference from pre-training; $p<0.01$

Blood lactate concentration at lactate minimum test: According to Table 3, the blood lactate concentration at the Lac_{min} test increased significantly after the training program (5.11±2.31 vs. 6.93±1.33* mmol·L^{-1}).

Table 3
Blood lactate concentration (BLC) at the Lac_{min} test before (pre) and after (post) 8-weeks professional soccer player training; individual results

Soccer players (n=13)	Players position	BLC_{-pre} (mmol·L^{-1})	BLC_{-post} (mmol·L^{-1})
1	Goalkeeper	2.83	6.30
2	Goalkeeper	4.47	7.50
3	Defender	3.86	7.90
4	Defender	9.43	7.38
5	Defender	7.70	8.53
6	Defender	3.94	5.58
7	Defender	3.37	7.48
8	Midfielder	1.92	7.61
9	Midfielder	5.99	6.61
10	Midfielder	3.81	6.51
11	Midfielder	8.35	6.74
12	Forward	4.00	3.51
13	Forward	6.80	8.38
Median	-----	5.11	6.93*
SD	-----	2.31	1.33

*statistical difference from pre-training; $p<0.05$

Discussion

The lactate minimum test has been considered a valid method to estimate the maximal lactate steady state [1,15,17] and a good predictor of endurance performance in running [15] and cycling [17]. On the other hand, few researchers have been studied the effects of training on the intensity corresponded to the lactate minimum test [10].

According to our results, the specific soccer training program developed during 8 weeks had a positive effect on the running speed at the Lac_{min} test. Carter *et al.* [10] showed that a 6 week endurance training program, which produced both a clear improvement in running speed at the MLSS and a significant rightward shift in the blood lactate response to a standard incremental treadmill test, had no effect on the lactate minimum speed of Tegtbur *et al.* [23]. However, it is not adequate to compare our results directly with Carter *et al.* [10]'s because of the differences in initial training status of the participants, the type, the method and the frequency of the training program.

The main finding of our study was the enhance in blood lactate concentration at the Lac_{min} test after the specific soccer training program. To our knowledge, this data are novel in the literature and we don't have sufficient material to explain it. Based on accessible references, a possible elucidation for these results might be the increase in the concentration of the monocarboxylate transporter (MCT) proteins in skeletal muscle.

During high-intensity exercise, large amounts of lactate and H^+ can be produced in skeletal muscle, and the resulting accumulation of lactate and lowering of pH in the muscle can impair the ability of the muscle to maintain force. So, the capacity to transport lactate and H^+ out of the muscle fibers may, therefore, be expected to affect the ability to perform sustained high intensity exercise [20].

The lactate/H^+ transport capacity of human skeletal muscle were reported to be enhanced by training [8]. Furthermore, a cross-sectional study showed that speed endurance-trained athletes have a higher capacity to transport lactate than untrained and less trained subjects [19]. The latter findings suggest that the lactate/H^+ transport can be improved by training also in humans, but it cannot be excluded that the lactate/H^+ transport capacity observed in the athletes was due to biological selection. The enhance of lactate/H^+ transport capacity of human skeletal muscle may increase the release rates of lactate and H^+ after a training program.

Although Pilegaard *et al.* [21] verified that high-intensity training induced an increase in the sarcolemmal lactate/H^+ transport capacity as well as an enhanced content of MCT1 and MCT4 protein in human skeletal muscle, these changes were associated with similar release rates of lactate and H^+ during intense exercise before and after training. However, they only worked with strength training.

We can conclude that the specific soccer training program developed during 8 weeks had a positive effect on the running speed at the lactate minimum test. The enhance in the blood lactate concentration may be explained by an increase in the lactate/H^+ transport capacity of human skeletal muscle verified by other authors. However, more studies must be carried on with this training protocol to evaluate the lactate/H^+ transport capacity response.

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