Correlation between blood lactate curve and absolute muscle power on lower limbs in athletes with predominance of slow twitch (S.T.) and fast twitch (F.T.) fiber

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Abstract: Knowing the metabolic and functional differences between muscle fiber types is important not only in the process of the athlete’s physical evaluation, but also for a better elaboration of training programs. For this study, 16 elite male athletes (22.3±2.94 years old) have been examined, divided in two groups of eight athletes each according to the estimated composition of muscle fibers (Face Validity): Group 1 (sprint runners – Type II fiber – FT) and Group 2 (marathon runners – Type I fiber – ST). After an evaluation of body composition, the athletes underwent a test of alactic anaerobic power and, to confirm the muscle metabolic profile, a running test with intervals was done, using three stimuli of increasing intensity and with decreasing distances, where, at the end of the third minute of each phase, a blood sample was extracted in order to determine the blood lactate concentration, using the method of enzymatic determination and reflectance photometry (Accusport). The statistics test used was Pearson’s correlation analysis, combined with Student’s t-test. The conclusion is that all correlations found were significant (p > 0.05), regardless of the fiber type and that there is a direct proportionality relation (r > 0) between the concentration levels of blood lactate and AAPU. Putting the variables together, we evidence that the muscle fiber type is a determinant factor in muscle power indexes and is strongly responsible for the higher blood lactate concentration levels.

Keywords - lactate; muscle power; muscle fiber type

**INTRODUCTION**

In the last 25 years, much information was gathered about how muscles contract (FOX, BOWERS & FOSS, 1989, p.65). From the functional point of view, muscle cells don’t constitute a homogeneous tissue. Many muscles are built of muscle fibers with different mechanical properties (ASTRAND & RODAHL, 1980, p.42), existing a correlation between these properties and the morphological and histochemical fibers characteristics (BURKE & EDGERTON, 1975).

In humans, fibers (or motor units) were known as aerobic type: type I, red, tonic, slow contraction (CL), and the fibers of the anaerobic type were called: type II, white, fast, fast contraction (CR).

Currently, another subdivision of the fibers CR, CR A (II A, oxidative . fast glicolitic), RC B (IIB, fast glicolitic) and RC C (II C, differentiated, unclassified, intermediate of interconversion) can be done (FOX et al., 1989, p.74).

Functionally, fibers have a CL aerobic capacity relatively large and anaerobic capacity relatively small compared with the RC fibers. This remains true even when the capabilities of the highest oxidative fibers RC A are taken into account, that is, there is a oxidative hierarchy with CL> The CR> RC B (FOX et al., 1989, p.78). The functional / biochemistry relation can be seen by the muscle production of e lactic acid. The RC fibers have greater capacity for acid production compared to the CL fibers. This increased capacity to form lactic acid, could be one of the factors that contribute to the highest performance capacity of the CR anaerobic fibers (FOX et al., 1989, p.80).

DONAVAN & BROOKS (1983) demonstrated that the release of lactate by the muscle increases with the intensity of exercise. IVY (1980) found that the percentage of red fibers were related with the intensity of the Threshold of lactate-LL (lactate point of inflection), expressed in absolute values, in $\text{VO}_2$ ($r = 0.74$), and relative to the $\text{VO}_2_{\text{max}}$ ($r = 0.70$) during exercises in ergometric bicycle. Because of this, the authors suggested that the LL suffers an important influence from the genetic factor. KOMI, ITO, SJODIN, WALLENSTEIN & Karlsson (1981), also found correlation between percentage of red fiber and the speed of race in wake rolling for the OBLA (Onset of Blood Lactate Accumulation) - 4 mmol / L. TESCH, DANIELS and SHARP (1981), noted that 92% of the variation in speed of race equivalent to OBLA can be explained by the percentage of red fiber, plus the local capillary density. This correlation may occur because the type I fibers appear to lower production and / or bigger capacity of lactate removal when compared with the type II muscle fibers (BALL - BURNETT, GREEN and HOUSTON, 1991).

According to FLEGNER (1983, p. 73), there is a correlation between the quality of lean mass (muscle composition of the fiber) and a better performance on anaerobic power tests, suggesting that the predominance of rapid contraction fibers can affect directly the absolute anaerobic power.
Knowing the metabolic and functional profile of muscle fibers in athletes is one of the most significant information for physical instructors. This knowledge is extremely important both in the athlete’s selection and training process, as the qualification and quantification of the directives of sports training. Due to the importance of knowing and interpreting more deeply the physical abilities of athletes, the development of alternative non-invasive instruments is important, to facilitate better diagnosis and, consequently, a better understanding of the athletes athletic profile (SADOYAMA, MASUDA, MIYATA & KATSUTA, 1988).

**OBJECTIVE**

The objective of this study is to understand the metabolic and functional differences between the two main types of muscle fibers: Slow Type I (ST) and Fast Type II (FT), based on the athlete’s performance, in two totally different types of tests, providing the physical education professor the opportunity to evaluate more accurately the athletes physical abilities. This procedure aims to facilitate the development of training programs with more criteria, besides being an important benchmark for identification, and consequent channeling of talent prospects for some particular sport which is more appropriate to a scientific basis.

**METHODOLOGY**

The convenience type sample was used (FLEGNER & DIAS, 1995), made by 16 male athletes, with average age of 22.3 ± 2.94. The first group was composed of experts in short distance tests (100 meters, n = 8), the second group was composed of experts in long distance tests (marathon, n = 8). Intentional sampling was used, which is one of the requirements for this type of search, where all selected athletes (velocists and fundists) were classified as belonging to the “elite” in their specialties. For the group 1 formation, composed of athletes with predominance of the fast contraction type II fibers (FT), specialists were selected in the race of 100 meters, as for this, they should present personal records, marks less than 12 seconds in this type of test. Group 2, composed of athletes with predominance of the slow contraction type I fibers (ST), were selected specialists in a marathon, as for this, they should present personal records, marks less than 2 hours and 20 minutes to this type of test.

**DATA COLLECTION**

The first part of the evaluation was built on anamnesis and anthropometric measurements, such as: weight, stature, skin folds and circumferences (POLLOCK, WILMORE & FOX III, 1986), the second step was the Flegner Test Power implementation (TPF), the third step, the test was aerobic performed in athletics track (Cooper), to estimate the maximum oxygen consumption (VO$_2$ máx.), the fourth and final stage, the athletics official races in discontinuous track protocol was applied, for fresh capillary blood samples extractions.

In the first part of the evaluation, the athletes were submitted to primarily measures of total body weight and stature. Later, the skin folds were measured, triceps, chest and above-iliac, and the calves circles, thigh and arm (right and left sides). In the second part, the anaerobic absolute power test was made, in which the athletes performed a sequence of 10 horizontal jumps with the legs together, aiming to achieve maximum distance in a short time as possible. They were allowed 03 attempts, with a 5 minute interval between them, which, after application of the formulas described in the results, only the best result was taken into account for calculating the index of absolute power anaerobic (Anaerobic Absolute Power Unit - AAPU).

$$\text{Absolute Anaerobic Power Unit (AAPU) = } \frac{\text{Corporal Weight (kg) x Distance (m)}}{\text{Time (sec)}}$$

In the third stage, a 12 minute aerobic resistance test was applied, (Cooper), which permitted to estimate the maximum oxygen consumption (VO$_2$ máx), this test, was done by presenting good correlation (0.90 and 0.92) with laboratory tests (MATHEWS, 1980 p. 253).

After checking the distance achieved, the formula below was applied, in order to estimate the maximum oxygen intake (COOPER, 1968):

$$\text{Maximum VO}2 = \frac{D \times 504.09}{44.78}$$

Where: D = total distance

**Final result is expressed in ml/kg.min⁻¹**

In the fourth and final stage, the discontinuous races test was applied, based on the protocol proposed by FLEGNER (1992), which is based on the interval stimulus of three races with increasing intensities and decreasing distances, so that the stimulus of each race, the metabolism can react, producing a physiological response for each individual intensity of effort made, that, through accumulation in the concentration of lactate in the blood and, by the increase in heart rate (HR).

The first testing stage was planned so that the speed of race was enough to produce a blood lactate concentration of approximately 2.2 mmol / L, this value, which is characterized by being a good predictor for the maximal steady state (LAFONTAIN, 1981). The second point chosen for the curve was the concentration of 4 mmol / L (anaerobic threshold of Mader (HECK, 1985). To obtain the third and last point that should be characterized as a time of maximum effort, the 800 meters race has been chosen,
because this one presents the best correlation for predictions of maximum anaerobic work capacity (SHAVER, 1975).

The ideal speed for each of the stages, was established by the results of the estimated maximum oxygen consumption (VO\textsubscript{2}\textsubscript{máx}), Obtained in the Cooper test. YOSHIDA et al. (1982), the relationship between VO\textsubscript{2} and certain concentrations of lactate (1.0, 2.0 and 4.0 mM. l\textsuperscript{-1}), were examined and the coefficient of correlation to predict the performance of race in 12 minutes was noted, was at least 0.87. To obtain the speed target rate for the first stage of approximately 2,2 mM.l\textsuperscript{-1}, the point of 75\% of VO\textsubscript{2}\textsubscript{máx} was extracted from the equation prediction: VO\textsubscript{2}\textsubscript{máx}. = (Distance-504.9) / 44.78 (COOPER, 1968). Applying the regression equation suggested by the American College of Sports Medicine (1980): VO\textsubscript{2} = 0.2 \times speed + 3.5- we can get the ideal race speed for each test stage, according to the protocol used by FLEGNER (1992). The target rate for the second stage, aimed to obtain a concentration of lactate approximately to 4.0 mM.l\textsuperscript{-1}, and was established in 90\% of VO\textsubscript{2}\textsubscript{máx}. The speed of the third stage, in theory, could be determined by applying 100\% of VO\textsubscript{2}máx but the orientation is to let the athlete print your maximum effort possible, that means, trying to enforce a speed higher than the ones from 100\% of VO\textsubscript{2}máx. After all VO\textsubscript{2}máx calculations were made, and, given the speed of the race for individual pre-determined percentage of VO\textsubscript{2}máx of the protocol relating to each of the phases, the tests were initiated.

In the first phase, one shot of 1,600 meters was done, and in each lap (400 meters), the athletes were monitored and directed about the pace appropriate for that particular passage of the race. After a fixed interval of 5 minutes, the second stage was started with the distance planned for 1,200 meters. In the third and final stage, the scheduled distance was 800 meters. The distances chosen followed the methodology proposed by FLEGNER (1992).

The blood collections were performed by puncture in the right lobe of the ear, using disposable microlanquets, Softclix\textregistered{} pen applicator and disposable surgical gloves. The aseptic place for the puncture was made with Benzalconic chloride to 0.1. After the puncture, and the removal of the clot in the effort collections, the first drop of blood was despered, in order to avoid contamination by lactate secreted by the sweat glands (SHEPHARD, 1992).

**Instrumentation**

The portable blood lactate Accusport TM analyzer was used, model 1488767 (Serial Number 00020145/254); disposable microlanquets and Softclix\textregistered{} pen applicator; tapes reagents for lactate (BM Lactate Test Strip), all manufactured by Boehringer Mannheim Corp.GmbH, Mannheim, Germany, 1999. The operation principle of the method is based on the enzymatic determination by photometric reflection in the fresh blood capillary, in the ear lobe or in the fingertip.

The validity of the method used for analysis of blood lactate at Accusport TM is through simultaneous comparative measurements, between this instrument and one of known accuracy, which all studies were analyzed in humans who exercised. The instrument has been tested and approved using protocols of the European Committee for Clinical Laboratory Standards, Federal Drug Administration and the American College of Sports Medicine, which found a good correlation coefficient of \( r = 0.954 \) (ACSM, 1996). The reliability and objectivity of this equipment are considered satisfactory, showing correlation coefficients of above 0934 for multiple tests, by an instrument or more (GAMBKE et al, 1994). A clinical Filizola scale was used (Brazil), to measure body weight; wall fixed estadiometer Sanny brand (Brazil) for stature measurements; Lange brand fold compass (Cambridge, Maryland), for the skin folds measurements; flexible fiber glass measure tape, Sanny brand (Brazil), to measure body circumference; flexible and inelastic fiber glass measure tape Stanley brand (Brazil) for distance in the field tests measurements; digital thermometer / higrometer Vacumed brand (Brazil), to monitor weather conditions; frequency meter Polar brand, VantageTM model for CF tracking, and after the tests, all data were transferred directly to the computer through the Polar Electro Inc interface (Finland).

**Graphic 1 - Comparison between Curve of Lactate Concentration x Muscle Fiber Type**

![Graphic 1 - Comparison between Curve of Lactate Concentration x Muscle Fiber Type](image)
The level of significance adopted for this study was $p \leq 0.05$, that is, 95% confidence for the affirmatives and / or negatives that this study will denote.

In this statistical study, the Pearson correlation analysis was applied, combined to the Student’s t test, in order to verify the existence of direct relationship of proportionality between the curves of blood lactate (Lactate1-lactate 2-Lactate 3) and absolute muscle power of the lower members (AAPU), as also, the existence of significant differences ($p > 0.05$) between the average values of these variables, referenced by the type of muscle fibers: Fast Type II-FT (group 1) and Slow Type I-ST (group 2) (DAWSON - SAUNDERS & TRAPP, 1994).

**RESULTS**

In the first phase of testing of intervalled races, the largest average of blood lactate concentration was observed with the athletes with predominantly fast contraction fibers - FT (Group 1), with $2.56 \text{ mmol} / L + / - 0.26$. Athletes with predominance of slow contraction fibers - ST (Group 2), recorded a lower average concentration, with $1.94 \text{ mmol} / L + / - 0.33$ (Picture 1 and Graphic 1).

In the second stage, the trend repeated, with the Group 1 athletes (FT), getting a higher average, with $4.64 \text{ mmol} / L + / - 0.16$, in relation to what was registered on group 2 (ST), with $2.54 \text{ mmol} / L + / - 0.38$ (Picture 1 and Graphic 1).

In the third and final stage, the same former physiological tendencies were observed, where Group 1 (FT), formed by velocist athletes, presented the highest average concentration of lactate, with $7.34 \text{ mmol} / L + / - 0.23$. Resistance athletes, belonging to Group 2, had a lower average accumulation of blood lactate, with $3.86 \text{ mmol} / L + / - 0.23$ (Picture 1 and Graphic 1).

The Group 1 (fast fiber), presented significantly above average for the variable LA_1, (first collection of blood lactate), ($p > '0.05$), than Group 2, slow fiber (0.625).

Repeating the same physiological tendency variable LA_1, Group 1 (FT), presented significant superiority ($p > 0.05$) of lactate-2 / LA_2, with Group 2 (ST), in $2.10$.

In variable LA_3, results denoted only corroborate with what has been observed for the same variable in other temporal stratus (LA_1 and LA-2), i.e., Group 1 . fast fiber (FT), presented a significantly higher average ($p \leq 0.05$) to Group 2 . slow fiber (ST), in $3.475$.

Combined the three observations of lactate concentration levels, taken at different times in the observation process, we have, for all three extracts, significant differences observed between the mean values, according to the type of fiber, and the predominant distribution: Type 2 Muscular Fiber (Group 1) > Type 1 Muscular Fiber (Group 2). If this result is combined with what was observed in the variable LA_1 (Group 1 > Group 2), it can be understood that the significant time inference, as a cumulative process basis of the lactic acid formation in blood. This behavior is made of the lactate variable (LA), a good parameter selection of individuals, as to the type of muscle fiber.

In the muscle power test, the Flegner Power Test (TPF), revealed that Group 1, formed by velocist athletes (FT), was the one who presented the largest average, $301.70 + / - 23.03$ and also the most individual value, with $323.52$. Group 2, composed of resistance athletes (ST), presented a lower average, with $216.77 + / - 19.10$ and the lowest individual values observed, with $191.94$, as shown in Graphic 2.

<table>
<thead>
<tr>
<th>VARIÁVEIS INDEPENDENTES</th>
<th>Grupo 1 (Fibra Rápida –FT)</th>
<th>Grupo 2 (Fibra Lenta –ST)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAPU- Unidade Potência Anaeróbica Absoluta</td>
<td>N</td>
<td>MÉDIA</td>
</tr>
<tr>
<td>LACTATO 1 (1º coleta: veloc. a 75% do VO$_2$ máximo)</td>
<td>8</td>
<td>301,70</td>
</tr>
<tr>
<td>LACTATO 2 (2º coleta: veloc. a 90% do VO$_2$ máximo)</td>
<td>8</td>
<td>2,56</td>
</tr>
<tr>
<td>LACTATO 3 (3º coleta: velocidade em esforço máximo)</td>
<td>8</td>
<td>4,64</td>
</tr>
</tbody>
</table>

Table 4 - Differences between A.A.P.U. average

<table>
<thead>
<tr>
<th>AAPU</th>
<th>1 (FT)</th>
<th>2 (ST)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (FT)</td>
<td>84.9325(*)</td>
<td></td>
</tr>
<tr>
<td>2 (ST)</td>
<td>84.9325(*)</td>
<td></td>
</tr>
</tbody>
</table>

(*) SIG.P ≤ 0.05
Group 1 (FT), presented an average significantly greater for the AAPU variable \((P \leq 0.05)\), Group 2 (slow fiber). Considering that the AAPU is a good parameter for selection and separation for velocist groups (fast fiber = 1) and fundists (slow fiber = 2), as shown in Table 4.

Significance levels \((p)\) calculated by Student’s \((t)\) test, based on the comparison of the average values of the respective variables and the type of muscle fibers, have significant differences \((p> 0.05)\), where all comparisons between the average values for Type II fiber fast muscle - FT, are greater than those observed in the Type I muscle fibers . slow . ST, as evidenced by Picture 1.

**CONCLUSION**

It is concluded that all the correlations found in the research are significant, regardless the type of fiber, demonstrating that the dynamics of the blood lactate concentration curve follows the same pattern, with continuous characteristics, that is, a function possible to be parameterized in time. It was still noted that there is a direct relationship of proportionality \((r> 0)\) between the levels of blood lactate concentration and muscle absolute power of the lower limbs (AAPU). Combining the variables showed that the type of muscle fiber is a determining factor in the absolute power muscle rates (AAPU), and heavily responsible for higher levels of

Beyond that, it was observed that yet the functional relationships between the two are held at any time within the axis of the times of curves.

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