54 - THE MAIN ENERGETIC PATHWAY (AEROBIC OR ANAEROBIC) DURING AN EXERCISE PERFORMED ABOVE THE LACTATE TRESHOLD IN CICLOERGOMETER

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INTRODUCTION

Energy supply pathways that are quickly activated during exercise, mainly the anaerobic alactic, lactic aerobic and anaerobic, and are strongly influenced by duration and exercise intensity (ALEXANDRE J. D. et. al. 1996). According to McArdle, Katch and Katch (2001), during maximum effort with different duration, aerobic and anaerobic pathways may relatively contribute to energy supply. For example in a two-minute maximum effort aerobic and anaerobic metabolism are responsible, each, for 50% of energy supply. But to Foss and Keteyian (2000), anaerobic system is engaged on maximum effort that can be sustained for approximately two minutes.

Total exercise duration has been used by many authors to evaluate physical performance (COSTILL, DALSKY E FINK, 1978; SEGURA & VENTURA, 1988; DENADAI, 1990). According to Rodrigues (1992) this is the best parameter related to fatigue tolerance in exercises performed to exhaustion.

According to Hofmann et al., (1997) and Denadai and Denadai (1997), anaerobic threshold is the most important parameter to establish exercise intensity to achieve a predominant anaerobic exercise, considering serum lactate level a better physical performance indicator comparing to $VO_{2\,máx}$.

Heck et al., (1985), apud Ascensão et al. (2001), have proposed the blood lactate level of 4mMol/L as the maximum constant blood level in adults. Many studies, however, have been demonstrating that blood lactate corresponding to MLACSS may vary between individuals and according to exercise (STEGMANN et al., 1981; BENEKE & DUVILLARD, 1996). Others have also considered the anaerobic threshold as a physiologic indicator of aerobic to anaerobic metabolism switch (HECK, MADER, HESS, MULLER & HOLLMAN, 1985c; MADER, 1991; MADER & HECK, 1986; MADER, LIESEN, HECK, PHILIPPI, ROST, SCHÜRCH & HOLLMANN,1976, in ASCENSÃO et al., 2001).

According to Ascensão et al. (2001), any increase on exercise intensity that promotes an increment on blood lactate levels, above the threshold of 4mMol/L leads to a higher rate of energy supply by the glycolitic metabolism, comparing to the piruvate oxidation. So this study have evaluated the main energy supply pathway, aerobic or anaerobic, during an exercise in cycloergometer performed above the lactate threshold.

METHODS

Nine health men, according to Par-Q and coronary heart disease risk factor questionnaire (ACMS, 1998; RODRIGUES et al., 1999), non-smokers, with $VO_{2\,peak}$, superior to 35 mlO_2/kg/min, non medication users were selected. Ethical approval was obtained from the Committee on Human Experimentation of the Centro Universitário de Belo Horizonte. During the study was recommended to the volunteers not to perform moderately or intense physical activity 24 hours before the testes, inform the use of any kind of medication, sleep for eight hours the night before the test, do not ingest alcohol and cafein at the 24 hours before the tests and keeping the same pattern of food ingestion before each test.

Tests were performed at environment temperature between 22º and 24ºC, always in the afternoon period.

The study was performed in two phases. First volunteers were submitted to anthropometric characterization. Body fat percentual was estimated by the skinfold fat thichness technique (Sany) according to the equation proposed by Guedes and Guedes (2003).

The $VO_{2\,pico}$ was achieved through open circuit espirometry (VO2000), according to the protocol proposed by Balke, in cycloergometer (Monark pattern) (MARINS & GIANNICHI, 1998). During the test maxim cardiac frequency was measured trough a heart rate monitor (Polar, S610).

In the second phase, each volunteer was submitted to three experimental situations, in a two week period, at different days with a 48 hours interval between each experimental situation. The experimental situations were the following: a) exercise until voluntary fatigue, at 90% of maximum power achieved at Balke test, b) exercise until voluntary fatigue, at 95% of maximum power achieved at Balke test, c) exercise until voluntary fatigue, at 120% of maximum power achieved at Balke test. During the experimental situations the total exercise duration was evaluated (digital chronometer, Cassio) to characterize fatigue and the main energetic pathway (aerobic or anaerobic). Serum lactate levels were measured by enzymatic means (Accusport) before and two minutes after exercise. VO_2 was monitored during the exercise through espirometry (VO2000). The highest VO_2 value observed at the end of each experimental situation was used to analysis.

Data obtained was analyzed by analysis of variance One-Way with repeated measures ($p \leq 0,05$) and Tukey Post Hoc Test ($p \leq 0,05$).

RESULTS

Volunteers data are shown on table 1.

Table 1 : Characteristics of the volunteers

	Age (years)	Body mass (kg)	Stature (cm)	Body fat percentual
Mean	25.67	72.93	175.33	13.38
Standard deviation	4.06	9.07	5.07	3.89

Table 2 shows the values of highest VO_2 observed in during each experimental situation, the mean VO_2 value of each test and $VO_{2\,peak}$ measured during the Balke test in cycloergometer (MARINS & GIANNICHI, 1998). No significant difference was observed to the VO_2 values at the experimental situations ($p>0.05$).

Table 2 : Mean and standard deviation of higher VO_2 during the exercise and $VO_{2\ peak}$ according to the protocol proposed by Balke, in cycloergometer.

	Final the tests VO_2 (ml/kg/min)			$VO_{2\ peak}$ (ml/kg/min)
	Exercise intensity (% of maximum potency of Balke test)			
	90%	95%	120%	Balke test
Mean	42.58	44.71	42.64	42.72
Standard deviation	5.71	5.22	5.87	6.36

* Intensities 90, 95 and 120%, mention a percentage to it of the gotten maximum power in the test of Balke.

The data on cardiac frequency measured before and after each experimental situation are shown on table 3. No significant difference was observed between the cardiac frequency obtained after each experimental situation ($p > 0,05$).

Table 3: Rest cardiac frequency and after each experimental situation.

	Rest cardiac frequency (bpm)	Cardiac frequency after experimental situation (bpm)		
		Exercise intensity (% of maximum potency of Balke test)		
		90%	95%	120%
Mean	67.78	178.78	184.00	174.78
Standard deviation	7.10	12.88	6.76	10.43

The weight values imposed to achieve the percentual of maximum potency obserd on Balke test are shown on table 4. The weight was statistically different when comparing the three experimental situations ($p < 0.05$).

Tabela 4: Mean and standard deviation of weight during exercise

	Weight (kg)		
	90%	95%	120%
Mean	4.70	4.96	6.27
Standard deviation	0.33	0.35	0.44

The total exercise duration (TED) in each experimental situation are shown on figure 1. The TDE is signficant different when comparing the three experimental situations (TED at 90% > 95% >120%) ($p < 0,05$).

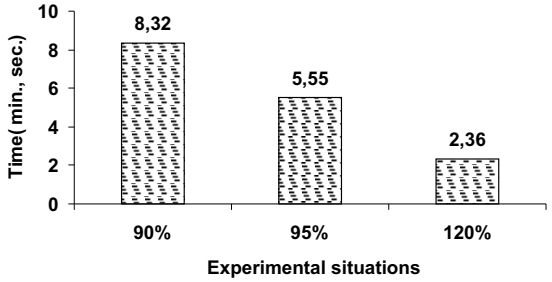

Figure 1: Total exercise duration for the three experimental situations.

Serum lactate levels were measured before and after each experimental situation (figure2). Serum lactate levels before exercise were not different ($p>0,05$). Also, no difference was observed on serum lactate levels after each experimental situation ($p>0,05$).

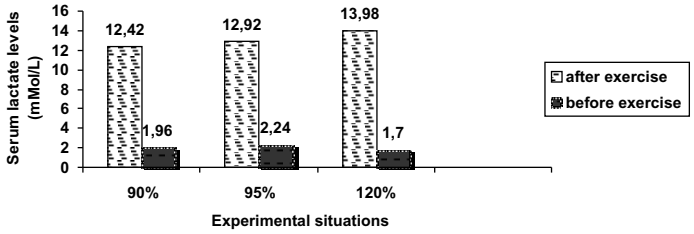

Figure 2: Serum lactate levels before and after the three experimental situations.

DISCUSSION

According to McArdle, Katch and Katch (2001), and Foss and Keteyian (2000), and Brooks (2000), the main energy supply pathway during exercise depends on exercise intensity and duration. Aerobic pathways provide energy for long duration exercise and predominate after two minutes of exercise. Anaerobic pathways are employed during high intensity exercise, during a short period of time, in exercises that can be sustained for two minutes maximum. In this context maximum exercise duration can be used to characterize the main energy supply pathway when exercise is performed until exhaustion.

Denadai and Silveira (2002), have reported exhaustion time superior to two minutes, for riders men and women , in exercise performed in cycloergometer at five different intensities (10, 20, 30, 40, 50% above lactate threshold), what lead the authors to characterize the exercise as mainly aerobic. The data presented here are in agreement with those reported by Denadai and Silveira (2002). The exercises performed above lactate threshold and bellow $VO_{2\ max}$ were mainly aerobic, considering the total exercise duration observed at first and second experimental situation (90 and 95% of maximum aerobic power). In both exercise duration was superior to two minutes (8min 32seg, 5min 55seg, respectively). However, despite the aerobic predominance the energy supply had been also maintained by anaerobic metabolism, considering serum lactate levels after both experimental situations (12,4 mmol/L e 12,9 mmol/L, respectively).

The data obtained are also in agreement with the study of Denadai, Ortiz and Mello (2004) that have reported an exhaustion time of 6.36 ± 2.54 minutes during exercises performed at $VO_{2\ max}$ by endurance athletes, characterizing the exercise as mainly aerobic.

The fatigue time was different for the three exercise intensities employed at this study ($p < 0.05$). At the highest

intensities the exercise duration was reduced and the fatigue was determined by volunteer request to stop the test or when the 18km/h velocity was not maintained (8 min 32sec. for 90% , 5 min 55sec. for 95% and 2 min 36sec. for 120%).

During the third experimental situation (120% of maximum aerobic power observed at the Balke test) the predominance of anaerobic metabolism was expected. Time to exhaustion in this experimental situation was of 2 min 36 sec., suggesting participation of aerobic metabolism as a main energetic pathway. According to McArdle, Katch and Katch (2001), two minutes of maximum effort would be energetically supplied by both aerobic and anaerobic pathways in a 50-50 fashion. This may be explained by the fact that the exercise intensity of the present study was determined based on $VO_{2\,peak}$ and not $VO_{2\,max.}$. $VO_{2\,max}$ is defined by McArdle, Katch and Katch (2001), as the region when oxygen consumption became constant despite the increase on exercise intensity. At the present study volunteers have not reached constant oxygen consumption, and the exercise was interrupted before maximum aerobic power. In this context exercise weight (90, 95 and 120% of maximum $VO_{2\,peak}$) was probably super estimated. This also leads to the suggestion that exercise time could result on different values to the same percentual intensity, in the case of use of VO_{2max} as reference, what means that exhaustion time could be reduced.

Although the test to determine the lactate threshold was not performed it can be concluded that, at the three experimental situations, the exercises were performed above the lactate threshold, considering the final serum lactate levels observed at each exercise (90% = 12.4, 95% = 12.9 and 120% 13.9 mMol/L), superior to the reference value of 4 ± 1 mMol / L (McArdle, Katch and Katch 2001), Bompa (2002), Ascensão et al. (2001) and Heck et al. (1985) in Greco et al. (2003).

At the end of the exercise no difference was observed for the final serum lactate levels, maximum cardiac frequency and higher VO_2 during the exercise. However the weight imposed in each experimental situation and the total exercise duration was significant different. The reason that leads the volunteers to interrupt the exercise at different time at the same physiologic conditions can not be explained. It is possible that a localized muscle fatigue or metabolites accumulation, like ammonium, could lead to fatigue. According to Santos (2002), high ammonium levels are observed at brain during high intensity short duration and long duration exercisers. Metabolites accumulation may be enough to compromise motor control and leads to fatigue. However other studies must be designed to determine the possible mechanisms responsible to fatigue that might have interfered with the test employed in this study.

CONCLUSION

The present study leads to the conclusion that exercise performed at 90, 95 and 120% of $VO_{2\,peak}$ maximum power are above lactate treshold, and that total exercise duration in this condition, although diferent, characterize the exercise as mainly aerobic, despite the great participation of anaerobic metabolism. So, the lactate inflexion point could not be the more adequate moment to determine the main energetic pathways supply to the exercise.

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THE MAIN ENERGETIC PATHWAY (AEROBIC OR ANAEROBIC) DURING AN EXERCISE PERFORMED ABOVE THE LACTATE TRESHOLD IN CICLOERGOMETER

ABSTRACT

Introduction: Data concerning the main energetic pathway during exercises performed above lactate threshold are still conflicting. This study was designed to evaluate the main energetic pathway employed during exercise performed above lactate threshold in cycloergometer. **Methods:** Nine heatlh men, (age 25.67 ± 4.06 years; body mass 72.93 ± 9.04 kg; high 175.33 ± 5.07 m; body fat percentual 13.38 ± 3.89 % and $VO_{2\ peak}$ 42.72 ± 6.36 mlO_2/kg/min), were submited to three experimental situations: they exercised at 90%, 95% and 120% of maximum power achieved at Balke test, until voluntary fatigue. Exercises were performed within 48 hours interval. During experimental situations the following parameters were monitored to evaluate the main energetic pathway employed during exercise: serum lactate levels, cardiac frequency, the higher VO_2 observed during the test and the total exercise duration. Data were analyzed by analysis of variance One-Way with repeated measures (p 0,05) and Tukey Post Hoc Test (p 0,05). **Results:** No difference was observed for post-exercise serum lactate blood, maximum cardicac frequency, $VO_{2\ peak}$ and in the highest VO_2 throughout each situation (p>0.05). However imposed cargo to each experimental situation was significant different (p<0.05), as well as total exercise duration (90% = 8.53, 95% = 5.92 e 120% = 2.62 minutes) (p < 0.05). **Conclusion:** Based on data reported it can be concluded that for the exercises performed above lactate treshold are mainly aerobic, considering the duration superior to 2 minutes. It can be suggested that lactate inflexion point could not be the most appropriate parameter to determine the predominance of the lactic aerobic pathway as the energy supply to exercise.

Key word: Aerobic metabolism, anaerobic metabolism, lactate threshold

VERIFICACIÓN DE LA VÍA PREDOMINANTE DE LA ENERGÍA (ANAEROBIA O AEROBIA) DURANTE EL EJERCICIO HECHO SOBRE EL UMBRAL DEL LACTATO EN BICICLETA

RESUMEN

Introducción: Hay controversias para el predominio de la vía de la energía durante los ejercicios hechos sobre el umbral del lactato. Con ese, este estudio tiene el objetivo para verificar que manera predominante de la energía durante el ejercicio hecho sobre el umbral del lactato en bicicleta. **Método**: Nueve hombres sanos, físicamente activos (de la edad 25.67±4.06 años; corporal de la masa 72.93±9.04 kilogramos; de la estatura 175.33±5.07 m ; el porcentaje del de la gordura 13.38±3.89 % y el máximo VO_2 6.36±42.72 ml/O_2/kg/min), fueron sometidos a tres situaciones experimentales, el 90%, el 95% y 120% de la energía máxima observada en la prueba de Balke hasta la fatiga voluntaria máxima con el intervalo de 48 horas entre cada prueba. Durante las tres situaciones experimentales fueran analizadas la concentración del lactato [la], la frecuencia cardiaca (FC), el $VO_{2\ más\ grande}$ observado durante los ejercicios y del tiempo total del ejercicio (TTE) para la determinación de vía predominante la de la energía. Para el análisis estadística fue utilizada el análisis de la variación unidireccional con las medidas repetidas (p = 0,05). **Resultados**: No hubo diferencia en la [la] tanto en el reposo como después del ejercicio, en la FC máxima, del pico VO_2, y en el VO_2 más alto a través de cada situación (p>0,05). Sin embargo, la carga impuesta para cada situación fue estatisticamente diversa (p<0,05), así como el TTE en cada experimental de la situación (90% = 8.53, 95% = 5.92 y 120% = 2.62 minutos) (p<0,05). **Conclusión**: Siendo basado en los resultados, puede ser concluido que los ejercicios hechos arriba del umbral del lactato son predominante aerobios, por lo tanto, tuvieron la duración superior a dos minutos. Por lo tanto, el punto de la inflexión del lactato no se puede ajustar para determinar el predominio de la vía de la energía de la anaerobio lática.

Palabras-llave: Metabolismo aerobio, metabolismo anaerobio, umbral del lactato, capacidad aerobia. Solamente 3 palabras-llaves.

VÉRIFICATION DE LA VOIE ÉNERGÉTIQUE PRÉDOMINANTE(ANAÉROBIE OU AÉROBIE) PENDANT L'EXERCICE REALISÉES AU-DELÀ D'UN SEUIL DE LACTATE EM CYCLOERGOMÉTRIE.

RESUMÉ:

Introduction: Il y a controverses quant à prédominance dans la voie énergétique pendant les exercices réalisés au dessus d'un seuil de lactate. Alors, cet étude a par l'objectif vérifier quelle la voie énergétique prédominante pendant l'exercice realisé au-delà d´un seuil du lactate en cycloergométrie. **Méthode**: Neuf hommes sains, vifs physiquement(âge 25.67 ± 4.06 anées ; masse corporelle 72.93± 9.04 kg ; stature175.33± 5.07metros ; pourcentage de graisse 13,38 et VO2pic 42.72 ± 6.36 mlO_2/kg/min). ils ont soumis a 03 situations expérimentés, 90%, 95% et 120% de la plus grande puissance observée dans l' expérimentation de Balke jusqu'à la plus grande lassitude volontaire avec l´espace de 48 heures entre chaque expérimentation. Pendant les trois situations expérimentées ont analisés la concentration du lactate [La], la fréquence cardiaque (FC), le plus haut VO_2 au long de la expérimentation, le plus grande VO_2 observée pendant les exercices et le temps total de exercice (TTE) pour la définition de la prédominante voie énergétique. Pour l'étude statistique a été utilisé l'étude de variance *One-Way* avec les répétées mesures (p = 0,05).**Résultats**: Il n´y a pas eu différence dans le [La] tant em repousse quant après l'exercice, dans las plus grande FC, dans le $VO_{2\,pic}$ et dans la moyenne de VO_2 au long d'exercice (p>0,05). Cependant, la charge impôte pour chaque situation a été statistiquement distinct (p<0,05), ainsi comme le TTE em chaque situation expérimentale (90% = 8,53, 95% = 5,92 e 120% = 2,62 et minutes) (p < 0,05). **Conclusion**: En se basant dans les résultats, on peut conclure que les exercices réalisés au dessus d'un seuil du lactate sont prédominantement aérobie, car, ils ont eu la durée supérieure a 2 minutes. Donc, le point d'inflexion du lactate peut n'être pas le plus convenable pour se déterminer la prédominance de la voie énergétique anaérobie lactique.

Mots-Clefs: Métabolisme aérobie, métabolisme anaérobie, seuil du lactate.

VERIFICAÇÃO DA VIA ENERGÉTICA PREDOMINANTE (ANAERÓBIA OU AERÓBIA) DURANTE EXERCÍCIO REALIZADO ACIMA DO LIMIAR DE LACTATO EM CICLOERGÔMETRO

RESUMO

Introdução: Existem controvérsias quanto à predominância da via energética durante exercícios realizados acima do limiar de lactato. Com isso, este estudo tem por objetivo verificar qual a via energética predominante durante exercício realizado acima do limiar de lactato em cicloergômetro. **Método:** Nove homens sadios, fisicamente ativos (idade 25,67 ± 4,06 anos; massa corporal 72,93 ± 9,04 kg; estatura 175,33 ± 5,07 m; percentual de gordura 13,38 ± 3,89 % e $VO_{2\,pico}$ 42,72 ± 6,36 mlO_2/kg/min), foram submetidos a 03 situações experimentais, 90%, 95% e 120% da potência máxima observada no teste de Balke até a fadiga voluntária máxima com intervalo de 48horas entre cada teste. Durante as 03 situações experimentais foram analisadas a concentração de lactato [La], a freqüência cardíaca (FC), o maior VO_2 observado durante os exercícios e o tempo total de exercício (TTE) para a determinação da via energética predominante. Para análise estatística foi utilizado a análise de variância One-Way com medidas repetidas (p= 0,05). **Resultados:** Não houve diferença na [La] tanto em repouso como após o exercício, na FC máxima, no $VO_{2\,pico}$, no maior VO_2 ao longo de cada situação (p>0,05). No entanto, a carga imposta para cada situação foi estatisticamente diferente (p<0,05), assim como o TTE em cada situação experimental (90% = 8,53, 95% = 5,92 e 120% = 2,62 minutos) (p < 0,05). **Conclusão:** Baseando-se nos resultados, pode-se concluir que os exercícios realizados acima do limiar de lactato são predominantemente aeróbios, pois, tiveram a duração superior a 2 minutos. Portanto, o ponto de inflexão do lactato pode não ser o mais adequado para se determinar a predominância da via energética anaeróbia lática.

Unitermos: Metabolismo aeróbio, metabolismo anaeróbio, limiar de lactato.