16 - ANAEROBIC PERFORMANCE OF PRE-PUBERTAL GIRLS AND ADULT WOMEN ON CYCLE-ERGOMETER AND BLOOD AMMONIA AND LACTATE CONCENTRATIONS

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INTRODUCTION

Some investigations suggest that children and adolescents may have a reduced anaerobic capacity, mainly before and during the initial stages of puberty (VAN PRAAGH, 2000; ARMSTRONG et al. 2000). Pre-pubertal subjects show lower blood and muscle lactate concentrations after maximal, short-burst activities or after progressive exercises until exhaustion (INBAR & BAR-OR, 1986; BAR-OR, 1987; ARMSTRONG & WELSMAN, 1997). Lower concentrations and activity of the glycolysis rate-limiting enzyme phosphofrutokinase (PFK) have been observed in children, when compared to adults (ERIKSSON et al., 1973; ERIKSSON & SALTIN, 1974; FOURNIER et al., 1982). This has been considered one of the reasons for the lower anaerobic capacity of children.

Blood ammonia concentrations may be used as an important marker of anaerobic metabolism during intense, short-durations exercises (NAZAR et al., 1992; PRADO, 1997). During this sort of exercise, ammonia is produced in muscle mainly through the purine nucleotide cycle (PNC), in which AMP is hydrolyzed to IMP with ammonia formation (LOWENSTEIN,1990; SAHLIN & KATZ, 1993). AMP degradation allow the ATP/ADP and ATP/AMP ratios to be maintained as high as possible and, therefore, avoid the diminution of exercise intensity (TERJUNG et al., 1986; SAHLIN & KATZ, 1993). Prado (1997) observed lower blood ammonia concentrations in pre-pubertal boys after short-duration, all-out efforts when compared to young male adults, which may be a consequence of lower acidosis levels observed in children. The enzyme ATP-deaminase catalyses ammonia formation in muscle cells during intense exercise and its activity is regulated by H^+ levels (LOWENSTEIN, 1990).

Many authors associate biological maturation during puberty to the development of anaerobic metabolism which is observed during this period in boys (ERIKSSON et al., 1973; ERIKSSON & SALTIN, 1974; NAUGHTON et al., 1992). However, this relationship is not clear in females.

The purpose of the present study was to compare performance of pre-pubertal girls and adult women during a 15 seconds all-out effort on cycle-ergometer and the maximal post-exercise blood lactate (La) and ammonia (NH_3) concentrations.

METHODS

The present investigation was approved by the Committee for Ethics in Research of the Universidade Federal de Minas Gerais. Written consent for participation was given from all subjects and their parents after the experimental procedures were fully explained. 12 healthy girls and women were studied. Girls should have been classified as Tanner's stage 1 for sexual maturation, anthropometric variables and body composition should have been within the normal range for the mean ages in both groups, all subjects should not participated in any training programs and the adult subjects should show a regular menstrual cycle.

Body composition was evaluated according to the methods proposed by Slaughter et al. (1988) and Jackson et al. (1980) for girls and women, respectively. Skin folds were measured with a LANGE caliper. Total body mass (BM) and body height were assessed with a regular scale (Filizola, Brazil). The level of biological maturation was self-determined (MATSUDO & MATSUDO, 1991) according to Tanner (1962).

Experimental treatment

Warm-up: prior to experimental exercise itself all subjects carried out a low intensity exercise on cycle-ergometer for 4 minutes, pedaling at 50 rpm.

Maximal intensity exercise: subjects carried out one all-out exercise on the cycle-ergometer (Inserra, Belo Horizonte) during 15 seconds against a pedal resistance of 75 $g.kg^{-1}$ body mass. Exercise testing was done between 12:00 and 14:00 hours. The cycle-ergometer was adjusted for the subject's body dimensions and children used a pedal arm crank with 15cm.

Measured variables

Peak power (Ppeak): the highest power achieved during the 15s exercise (in watts).

Mean power (Pmean): is the mean power during the whole exercise duration (in watts).

Peak and mean power were continuously measured during the 15s exercise through and specific software (Multi Cycle Ergometer, version 2.3, Poland).

Blood lactate and ammonia concentrations: blood samples were obtained from the finger tip using a sterilized steel lancet and a 20 µL capillar (Eppendorf, Germany). Specific reagent stripes were then inserted into different spectrophotometers for determinations of blood lactate (Accusport, Boehringer, Germany) and ammonia (Ammonia Checker II, Menarini, Italy) concentrations. Lactate concentrations were determined 1 and 3 minutes after exercise (La1 and La3). Ammonia levels were determined only after 3 minutes of exercise cessation (NH_3). The Student's t-test was used to compare each variable between groups after testing the variables for normal distribution (Kolmogorov-Smirnov). Significance level was set at 5% ($p<0,05$).

RESULTS

Table 1 presents the general characteristics of the studied groups.

Table 1.: General characteristics of the studied groups

	Girls	Women
Age (years)	9,7 ± 0,9	22,4 ± 3,3**
Body height (cm)	138,0 ± 5,0	162,4 ± 5,0**
Total body mass (kg)	32,5 ± 4,3	54,9 ± 5,1**
% fat	18,6 ± 3,4	23,7 ± 4,6**
lean body mass (kg)	26,3 ± 2,5	41,8 ± 3,8**

**p<0,01

Table 2 presents the mean absolute and relative values for peak power (Ppeak, Ppeak/BM) and mean power (Pmean, Pmean/BM). Ppeak and Ppeak/BM were significantly different between girls (270,3 28,3 W; 8,3 0,9 W/kg) and women (595,9 59,3 W; 10,8 0,6 W/kg) ($p<0,01$). The same was observed for Pmean (228,0 26,5 W for girls and 503,8 49,1 W for women, $p<0,01$) and Pmean/BM (7,0 0,9 W/kg for girls and 9,1 0,4 W/kg for women, $p<0,01$).

Table 2. Peak power (Ppeak), peak power relative to body mass (Ppeak/BM), mean power (Pmean) and mean power relative to body mass (Pmean/BM)

	Girls	Women
Ppeak (W)	270,0 ± 28,3	595,9 ± 59,3**
Ppeak / Body mass (W/kg)	8,3 ± 0,9	10,8 ± 0,6**
Pmean (W)	228,0 ± 26,5	503,8 ± 49,1**
Pmean / Body mass (W/kg)	7,0 ± 0,9	9,1 ± 0,4**

Table 3 shows the mean lactate and ammonia concentrations after exercise. The mean lactate concentrations 1 minute after exercise (La1min) were not significantly different between groups (girls = 6,8 2,0 mmol/L and women = 8,0 1,3 mmol/L). However, the lactate (La3min) and ammonia (NH_3) concentrations 3 minutes after exercise were both significantly higher in women (La 3min: girls = 6,2 1,6 mmol/L and women = 9,1 1,3 mmol/L and NH_3: girls = 140,8 58,6 g/dL and woman = 249,4 42,0 g/dL).

Table 3. Blood lactate (La1min, La3min) and ammonia (NH_3) concentrations

	Girls	Women
La 1 min (mmol/L)	6,8 ± 2,0	8,0 ± 1,3
La 3 min (mmol/L)	6,2 ± 1,6	9,1 ± 1,3**
NH_3 (g/dL)	140,8 ± 58,6	249,4 ± 42,0**

** ($p<0,01$)

DISCUSSION

The absolute peak power values observed in the present study are in accordance with those found in the literature (DORE et al., 2001). Here, Ppeak was significantly higher in women ($p<0,01$). However, even when normalized for body mass, peak power was significantly higher in the adult group. This observations suggest that the muscle mass increases may not be related to the improved anaerobic performance in short-burst, all-out exercises normally noted during puberty.

The absolute and relative mean power values obtained in the present study were also significantly higher in the adult group. Other authors showed an improvement of absolute and relative mean power during the Wingate anaerobic test during puberty (BLIMKIE et al., 1988). Van Praagh & Dore (2002) observed an enhancement of muscle power during puberty and suggest that adolescents in an advanced status of biological maturation may be able to achieve a higher glycolytic flow for anaerobic energy production. Eriksson & Saltin (1974) hypothesized that children may have a limited anaerobic glycolysis due to the lower concentrations of the rate limiting enzyme phosphofrutokinase (PFK) in skeletal muscle (ERIKSSON et al., 1973; FOURNIER et al., 1982).

Qualitative alterations on muscle function may occur during puberty (VAN PRAAGH & DORE, 2002). According to Inbar (1986) and Falgairette et al. (1991), anaerobic performance seem to be lower in children when compared to adolescents and adults in absolute terms, but also when normalized for body dimensions. Zanconato et al. (1993) registered evidences for a higher rate of glycolytic metabolism (through magnetic ressonance) in women during high intensity exercise, when compared to pre-pubertal girls. This is in accordance with the lower blood lactate and ammonia concentrations found in the present study 3 minutes after exercise. As mentioned before, Eriksson & Saltin (1974) suggest a lower activation of anaerobic pathways of energy production in children due to the lower glycolytic enzymes concentrations (PFK and LDH). The lower anaerobic capacity is evidenced through lower maximal blood and muscle lactate concentrations (ERIKSSON et al. 1973; PRADO, 1997).

In the present investigation blood ammonia concentrations were 140,8 58,6 g/dL for girls and 249,4 42,0 g/dL for women. NH_3 was significantly higher in the adult group, which is in accordance to the observed in Nazar et al. (1992) and Prado (1997) for pre-pubertal and adult males during short-duration, high intensity exercises. The lower acidosis observed in the pre-pubertal girls, expressed by lower blood lactate concentrations, may explain the also lower blood ammonia concentrations in this group. As mentioned before, high intramuscular concentrations of H^+ may activate the enzyme AMP-deaminase, which regulates AMP deamination and ammonia formation in muscle during short-duration, maximal exercises.

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ANAEROBIC PERFORMANCE OF PRE-PUBERTAL GIRLS AND ADULT WOMEN ON CYCLE-ERGOMETER AND BLOOD AMMONIA AND LACTATE CONCENTRATIONS

ABSTRACT

The purpose of the present study was to compare performance of pre-pubertal girls and adult women during a 15 seconds all-out effort on cycle-ergometer and the maximal post-exercise blood lactate (La) and ammonia (NH_3) concentrations. 24 female subjects were investigated (12 girls and 12 women), with an average age of 9,7 0,9 e 22,4 3,3 years, respectively. Girls were classified as Tanner's stage 1 for maturation of secondary sexual characteristics. First, body height, body mass, lean body mass and percent fat were assessed. Then, all subjects carried out a maximal exercise on cycle-ergometer during 15 seconds. Peak power (Ppeak) and mean power (Pmean) were continuously measured during exercise. Peak and mean power relative to body mass were then calculated. Blood samples were taken for determination of lactate and ammonia concentrations. Peak power (270,3 28,3W; 8,3 0,9 W/kg for the girls and 595,9 59,3W; 10,8 0,6 W/kg for the women) and mean power (228,0 26,5W; 7,0 0,9W/kg for the girls and 503,8 49,1W; 9,1 0,4W/kg for the women), were significantly different between the groups. La 1 min (girls = 6,8 2,0 mmol/L and women = 8,0 1,3 mmol/L) was not different between girls and women. However, La 3min (girls = 6,2 1,6mmol/L and women = 9,1 1,3mmol/L) and NH_3 (girls = 140,8 58,6 g/dL and women = 249,4 42,0 g/dL) were significantly higher in women. These results suggest that anaerobic performance is higher in adult women and that these differences can not be caused by different muscle mass or body dimensions. The higher capacity to generate anaerobic energy during high intensity, short-duration exercises in adult women may be associated to higher performance in this group.

Key-words: lactate, ammonia, maximal effort

L'EXERCISE DES JEUNES FILLE PRÉ-PUBÈRES ET DES ADULTES DU GENERE FÉMININ AU MAXIMUM EFFORT À L' EGOGRAPHE ET LES CONCENTRATIONS DÁMONIAC ET DE LACTATE SANGUINS

RÉSUMÉ:

L'objet du travail suivant consistait à comparer l'exercice des enfants pré-pubères et dês adultes du genre feminin pendant la pratique d'intensité subjective maximum pour quinze secondes em ergographe et à éstudier lê comportement des concentrations máxima d'ammoniac (NH_3) et de lactate (La) sanguins après l'exercice. Les personnes qui ont volontairement participé de cette étude étaient em nombre de 24 (douze jeunes filles et douze femmes) entre l'âge de 9,70,9 ans et 22,43,3 ans respectivement. Les enfants ont été classees au niveau 1 de l'échelle de Tanner pour la maturation dês caractères sexuels secondaires. On a évalué les variantes telle la masse corporelle, la masse corporelle maigre, la taille, lê pourcentage de graisse et la consommation d'oxigène estimé. Toutes les personnes ont réalisé un exercice d'intensité maximum subjective en ergographe. On a ménsuré les variantes suivantes: puissance pic (Ppic) et puissance moyenne (Pmoyenne) absolues et relatives à la masse corporelle. Les paramètres physiologiques mensurés ont été les concentration sanguines de NH_3 et La. Les variantes Ppic (270,328,3 W; 8,30,9 W/kg) pour les jeunes filles et (595,959,3 W; 10,80,6 W/kg) pour les femmes et Pmoyenne (228,026,5 W; 7,00,9 W/kg) pour les jeunes filles et (503,849,1 W; 9,10,4 W/kg) pour les femmes. Les groupes ont présenté de significatives diferences.Les valeurs de La, une minute après l'exercice, (les jeunes filles= 6,82,0mmol/L et les femmes= 8,01,3mmol/L) n'ont pas été differentes entre les groupes. Les valeurs de la trois minutes après l'exercice (les jeunes filles= 6,21,6mmol/L et les femmes= 9,11,3mmol/L et NH3 (les jeunes filles= 140,058,6g/dL et les femmes= 249,442,0g/dL) ont été sidérablement puls larges dans le groups des femmes. Les résultats de cette éstude indiquent que l'etraînement des exercices maximum, de courte durée chez les femmes a un meilleur résultat que chez les juenes filles. Cela ne peut néanmoins pas être attribué à des differences de masse musculaire ou à des dimensions corporelles. Des différences metaboliques quant a la production anaérobique d'énergie pour des exercice de cette nature peuvent être associées à des différences observées de cette pratique.

Mots clé: Maximum effort, ammoniac, lactate.

EL DESEMPEÑO DE NIÑAS PREPÚBERES Y MUJERES DEL GÉNERO FEMENINO EN EJERCICIO MÁXIMO EN EL CICLOERGÓMETRO Y LAS CONCENTRACIONES DE AMONÍACO Y LACTATO SANGUINEAS

RESUMEN

El objetivo del presente estudio fue comparar el desempeño de niñas prepúberes y adultos del género femenino durante ejercicio de intensidad subjetiva máxima por 15 segundos en cicloergómetro, y estudiar el comportamiento de las concentraciones máximas de amoníaco (NH_3) y lactato (La) sanguíneas después del ejercicio. Participaron del estudio 24 voluntarias (12 niñas y 12 mujeres), con edad media de 9,70,9 años y 22,43,3 años, respectivamente. Las niñas fueron clasificadas en el nivel 1 de la escala de Tanner para maduración de caracteres sexuales secundarios. Fueron evaluadas masa corporal, masa corporal magra, estatura, porcentaje de grasa y consumo máximo de oxígeno estimado. Todas las voluntárias realizaron un ejercicio de intensidad máxima subjetiva en el cicloergómetro. Fueron medidas las siguientes variables: potencia pico (Ppico) y potencia media (Pmedia) absolutas y relativas a la masa corporal. Los parámetros fisiológicos medidos fueron las concentraciones sanguíneas de NH_3 y La. Las variables Ppico (270,328,3 W; 8,30,9 W/kg) para las niñas y (595,959,3 W; 10,80,6 W/kg) para las mujeres y Pmedia (228,026,5 W; 7,00,9 W/kg) para las niñas y (503,849,1 W; 9,10,4 W/kg) para las mujeres presentaron diferencias significativas entre los grupos. Los valores de La un minuto después del ejercicio (niñas = 6,82,0 mmol/L y mujeres = 8,01,3 mmol/L) no fueron diferentes entre los grupos. Los valores de La 3 minutos después del ejercicio (niñas = 6,21,6 mmol/L y mujeres = 9,11,3 mmol/L) y NH3 (niñas = 140,858,6 g/dL y mujeres = 249,442,0 g/dL) fueron significativamente mayores en el grupo de mujeres. Los resultados de este estudio indican que el desempeño en ejercicios máximos, de corta duración, es mejor en mujeres que en niñas, lo cual, no puede ser atribuido a diferencias de masa muscular o dimensiones corporales. Diferencias metabólicas en cuanto a la generación anaeróbica de energía para ejercicios de ésta naturaleza, pueden estar asociadas a las diferencias observadas en el desempeño.

Palabras-clave: amoníaco, lactato, ejercicio máximo

O DESEMPENHO DE MENINAS PRÉ-PÚBERES E ADULTOS DO GÊNERO FEMININO EM EXERCÍCIO MÁXIMO NO CICLOERGÔMETRO E AS CONCENTRAÇÕES DE AMÔNIA E LACTATO SANGUÍNEOS

RESUMO

O objetivo do presente estudo foi comparar o desempenho de crianças pré-púberes e adultos do gênero feminino durante exercício de intensidade subjetiva máxima por 15 segundos em cicloergômetro, e estudar o comportamento das concentrações máximas de amônia (NH_3) e lactato (La) sanguíneos após exercício. Participaram do estudo 24 voluntárias (12 meninas e 12 mulheres), com idade média de 9,70,9 anos e 22,43,3 anos, respectivamente. As crianças foram classificadas no nível 1 da escala de Tanner para maturação dos caracteres sexuais secundários. Foram avaliadas as variáveis massa corporal, massa corporal magra, estatura, percentual de gordura e consumo máximo de oxigênio estimado. Todas as voluntárias realizaram um exercício de intensidade máxima subjetiva no cicloergômetro. Foram mensuradas as seguintes variáveis: potência pico (Ppico) e potência média (Pmédia) absolutas e relativas à massa corporal. Os parâmetros fisiológicos mensurados foram as concentrações sanguíneas de NH_3 e La. As variáveis Ppico (270,328,3 W; 8,30,9 W/kg) para as meninas e (595,959,3 W; 10,80,6 W/kg) para as mulheres e Pmédia (228,026,5 W; 7,00,9 W/kg) para as meninas e (503,849,1 W; 9,10,4 W/kg) para mulheres apresentaram diferenças significativas entre os grupos. Os valores de La um minuto após o exercício (meninas = 6,8 2,0 mmol/L e mulheres = 8,01,3 mmol/L) não foram diferentes entre os grupos. Os valores de La 3 minutos após o exercício (meninas = 6,21,6 mmol/L e mulheres = 9,11,3 mmol/L) e NH3 (meninas = 140,858,6 g/dL e mulheres = 249,442,0 g/dL) foram significativamente maiores no grupo de mulheres. Os resultados deste estudo indicam que o desempenho em exercícios máximos, de curta duração, é melhor em mulheres que em meninas, o que, entretanto, não pode ser atribuído a diferenças de massa muscular ou dimensões corporais. Diferenças metabólicas quanto à geração anaeróbica de energia para exercícios desta natureza podem estar associadas às diferenças de desempenho observadas.

Palavras-chave: amônia, lactato, exercício máximo