38 - CHANGES IN VO_2MÁX AND BODY COMPOSITION THROUGH PUBERTY

ANTONIO STABELINI NETO, ROGÉRIO ADRIANO LAU,
ANDERSON ZAMPIER ULBRICH E LUIS PAULO GOMES MASCARENHAS
Universidade Federal do Paraná UFPR - Curitiba - Pr - Brasil
netostabelini@hotmail.com

INTRODUCTION

For years factors which influence the process of physical growth and biological maturation have been discussed, particularly that occurring during the period from childhood to adolescence. Genetic factors have been observed to remain unaltered, however, environmental factors such as malnutrition and the practice of physical exercise can influence these processes (GEITHNER et al, 2004; MALINA, 1994). On the other hand, the influence of the processes of physical growth and biological maturation within the levels of physical fitness in children and adolescents have not yet been clearly elucidated in the current literature in that some authors suggest that these biological changes can induce significant modifications in the physical fitness of children and adolescents in the same proportion as those produced by physical exercise (DANIS et al, 2003).

Currently, it is known that the practice of physical exercise has little or even no effect on growth with respect to final height (MALINA, 1994), however, it does demonstrate a clear influence on total body mass and in the quantity of body fat (GEITHNER et al, 2004), probably due to the greater use of energy caused by the practice of physical exercise (BERKEYet al, 2000).

Aerobic power is recognized as the most significant element of physical fitness related to health in individuals of all ages. With the diverse morphological and physical changes which occur during infancy to adolescence, this component is significantly modified (PINHO and PETROSKI, 1997; BERKEY et al, 2000; BRUM et al, 2004), these alterations being associated to body size, chronological age and biological maturation (ARMSTRONG et al, 1999).

For this reason, with the intent of advancing the understanding of how oxygen consumption and body composition respond to the stimulus of regular physical activity in the years preceding puberty, and during puberty itself, various studies have been conducted in order to shed light on the behavior of these physiological components, however conflicting results have been found (DANIS et al, 2003; SCHEET et al, 2002).

Taking into consideration that the results of the research evaluating the effects of biological maturation on the variables of physical fitness in individuals in this age group are still inconclusive, the purpose of this study was to analyze changes in VO_2max and in body composition throughout puberty in male adolescents.

METHODS

Subjects

The test group consisted of 87 males ranging from 7 and 19 years old from the public school system in the city of Curitiba, PR, who had not participated in any type o organized physical training for at least one year and only were participating in physical education classes twice a week. The subjects were divided into groups according to the stages of sexual maturation proposed by Tanner (1962), as presented in Table 1 along with their respective chronological ages, body mass (BM) and height. Before testing began, all individuals and their corresponding guardians were informed of all procedures involved in this research and filled out an authorization and release form consenting to the used of their data.

Table 1: Classification of the subjects according to the maturational stages.

Tanner Stages	N	Age (Years)		BM (Kg)		Stature (cm)	
		Mean	SD	Mean	SD	Mean	SD
1	35	8,31	(1,02)	27,62	(3,7)	127,11	(8,53)
2	23	10,65	(1,30)	33,10	(5,91)	135,91	(8,02)
3	11	12,45	(1,04)	42,26	(13,08)	148,95	(12,41)
4	12	14,75	(1,44)	55,37	(12,84)	164,29	(10,8)
5	8	18,13	(1,33)	63,16	(9,08)	172,87	(6,49)

Instruments and Procedures

Sexual maturation: The method proposed by Tanner (1962) was employed. Maturational stages are divided into 5 where stage 1 is prepubescent and stage 5 is when the pubescent maturational process has concluded (post pubescent). The test was applied in the form of self-evaluation of pilosity of the pubic region as suggested by Martin et al., (2001) which showed a satisfactory concordance with medical examination (0,61).

Anthropometrics Measurements: Total height (cm) and body mass(kg) were measured using a WCS stadiometer and a PLENNA digital scale, respectively.

Body composition: The two-compartment model was used (Fatty Mass and Free Fatty Mass) through the indirect method of skin fold measurement, using one CESCORF scientific plicometer. The focus points were the tricipital and medial leg skin folds. The equation from Slaughter (1988) was used to estimate the percent of body fat. From this percentage of fat, the fatty mass (FM) and the free fatty mass (FFM) were determined in kilograms by use of basic mathematical equations: FM=FM(%F/100) e FFM = BM-FM.

VO_2máx: The indirect test proposed by Legér (1988), which consists of running back and forth over a delineated distance of 20 meters, was employed. The subject being evaluated runs in time with a rhythmic sound that determines the velocity he is to run. The frequency of the sound increases progressively at a rate of 0.5 km/h each minute, starting at 8,5km/h and finishing when the individual can no longer accompany the velocity of the rhythm. The last successful stage is then recorded and a mathematical formula, which takes into account the age of the individual and the velocity of the final completed stage is applied in order to reach the VO_2max. The test is considered reliable with a score of r=0,89 for children and adolescents (LEGÉR, 1988).

Data Analysis

The study was of an ex post facto nature having as an independent variable the stage of sexual maturation and as dependant variable VO_2máx and body composition. Descriptive statistics (mean and standard deviation) were used to characterize the test group. ANOVA's (one way) and post hoc of Tukey were calculated to identify the significant differences between the groups. The stipulated level of significance (alpha level) for analysis was $p<0,05$.

RESULTS AND DISCUSSION

Over the course of childhood to the end of adolescence, body weight and height change with great velocity due to growth and maturation. For this reason, the gradual increase of these variables (table 1) with advancing age shown by this study was expected. Table 2 demonstrates the characterization of the sample group with the mean and standard deviation values for the variables of physical fitness and body composition in each of the 5 stages of sexual maturation.

The results of the analysis of variance indicated significant differences between maturational stages for percent of

body fat (F=3,26; p<0,01), fatty mass (F=18,33; p<0,0001), free fatty mass (F=56,69; p<0,0001) relative VO_2máx (ml/kg/min) (F=21,29; p<0,0001) and absolute VO_2máx (L/min0 (F=24,40; p<0,0001).

Table 2: Comparison of the variables of physical fitness and body composition in the different maturational stages.

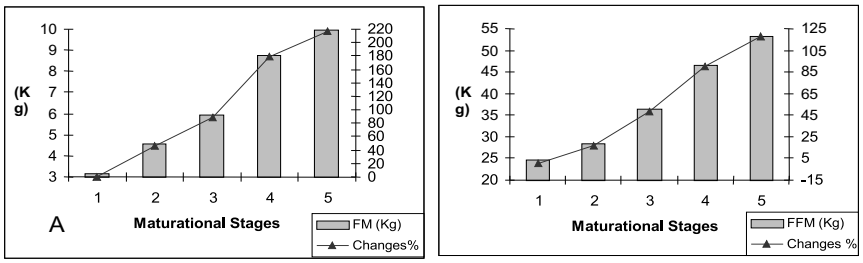
	Tanner 1	Tanner 2	Tanner 3	Tanner 4	Tanner 5
% FAT	11,19 (3,19)	13,02 (5,68)	13,54 (4,06)	15,56 (4,27) [a]	15,31(4,01) [a]
FM (Kg)	3,14 (1,21)	4,56 (2,83)	5,93 (3,07) [a]	8,75 (3,43) [ab]	9,95 (4,05) [abc]
FFM (Kg)	24,48 (2,94)	28,54 (3,74)	36,32(10,58) [ab]	46,62 (10,67) [abc]	53,21 (5,43) [abc]
VO^2 (ml.kg.min)	49,81 (2,73)	47,95 (2,38)	47,1 (3,5)	41,61 (5,04) [abc]	40,75 (4,82) [abc]
VO^2 (L.min)	1,37 (0,18)	1,58 (0,29)	1,96 (0,48) [a]	2,25 (0,39) [ab]	2,74 (1,03) [abc]

p<0,05; Tukey contrasts: a- significant difference for stage 1; b- significant difference for stage 2; c- significant difference for stage 3; d- significant difference for stage 4.

While evaluating the body composition in the subjects of this test group, an increase in total body mass during the maturation process was observed (table 1). This occurs in virtue of gains in fatty mass and free fatty mass, where both variables demonstrate significant increases from stage 3 on (table 2), probably coinciding with the peak growth spurt (MALINA and BOUCHARD, 2002; CAMPOS and BRUM, 2004).

Much of the literature has reported that with biological maturity, males tend to present a greater increase in lean mass than of fatty mass (MCMURRY ET AL, 2003). Caution should be exercised when interpreting this occurrence because the analysis of the proportion of these variables during puberty of this study shows the opposite result (figures: 1-A and 1-B).

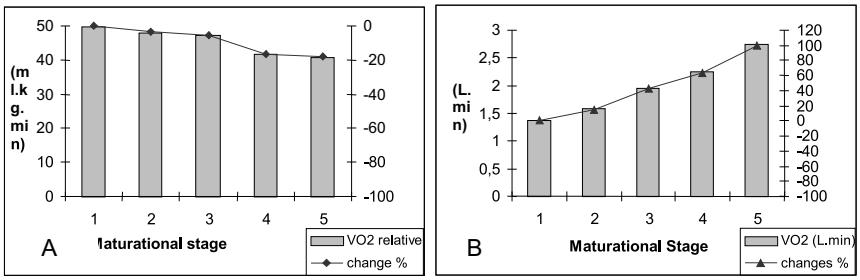
It can be observed that FM almost triples from stage 1 to stage 5, showing gains in absolute values of 6,81 kg or FM=216,9% (figure 1-A). With respect to free fatty mass, it demonstrates an increase of 28,73 kg, or a gain from the onset to the end of puberty of 117,4% (figure 1-B).



Figures (1-A e 1-B): Changes in fatty mass and free fatty mass during puberty (kg and %)

For physical fitness, it is noted that the relative VO_2máx (ml/kg/min), even with a slight decrease in the initial stages of puberty, did not show a significant difference until a fall of 18,2% from stage 3 to 4 which then remained stable from 4 to 5.

The significant increase in absolute Vo_2máx (L/min) starting at maturational stage 3 is due to the gain in total body mass which occurs along the growth process since both the FM and the FFM values change as well in individuals from this stage on. This in turn influences the gains in aerobic power when the values are expressed in absolute terms, where the total gain percentage-wise was 100,2% (figure 2-B).



Figures (2-A e 2-B): Relative and absolute VO_2máx throughout puberty

The values observed in figure 2-B for this test group through puberty accompany the literature, which shows a linear progression in the values o the absolute VO_2máx from childhood to the verge of adulthood (ARMSTRONG and WELSMAN, 2001; MCMURRY et al., 2002).

Considering the relative VO_2máx, the results are similar to those of McMurry et all (2002), where the study of 1200 healthy children not involved in the regular practice of organized sport demonstrated a decrease in the VO_2máx (ml/kg/min) from childhood to adolescence. This can be associated to the fact that during this transitional period, adolescents normally tend to decrease their level of physical activity, which would most likely influence the values found in our study concerning aerobic power. There are many studies which points out that adolescents with higher physical activity levels show higher levels o physical fitness (PINHO and PETROSKI, 1997; BERKEY et al., 2000; BRUM et al., 2004).

In this sense, Johnson (2000) emphasizes that the increase or maintenance of aerobic power is an important element in the prevention of the development of excess body fat during childhood and adolescence since there exists an inverse relationship between physical fitness and quantity of body fat.

CONCLUSION

The VO_2máx (L/min) in the study group continues to rise with maturation, just as do the values of free fatty mass and fatty mass the latter demonstrating the highest percentage of change. The VO_2máx (ml/kg/min) however, presented a significant decrease from stage 4 on, probably due to the tendency of adolescents to attenuate the level of physical activity with advancing age, a factor not analyzed in this study which calls for the implementation of programs to increase physical fitness in the population studied. Longitudinal studies are needed to further the understanding of the role of oxygen consumption and body composition on the maturation process.

REFERÊNCIAS

ARMSTRONG N, WELSMAN JR, NEVILL AM, KIRBY BJ. Modeling growth and maturation changes in peak oxygen uptake in 11-13 yr olds. **Journal of Applied Physiology**, v.87, 2230-2236, 1999.

BERKEY CS, ROCKETT HRH, FIELD AE, GILLMAN MW, FRAZIER AL, CAMARGO CA, COLDITZ GA. Activity,

dietary intake and weight changes in a longitudinal study of preadolescent and adolescent boys and girls. **Pediatrics**, v. 105, n. 4, 2000.
BOISSEAU N, DELAMARCHE P. Metabolic and Hormonal Responses to Exercise in Children and Adolescents. **Sports Medicine**, v. 30, n. 6, p. 405-418, 2000.
BRUM VPC, WECHINEWSKY BA, SILVA SG, CAMPOS W. The influence of physical activity level on aerobic and anaerobic power of prepubescent boys. **Medicine & Science in Sports & Exercise,** v. 36, n. 5, p. S67-S67, 2004.
CAMPOS W, BRUM VPC. **Criança no Esporte**. Os autores: Curitiba, 2004.
DANIS A, KYRIAZIS Y, KLISSOURAS V. The effect of training in male prepubertal and pubertal monozygotic twins. **European Journal of Applied Physiology,** v. 89, p. 309-318, 2003.
JOHNSON MS. Aerobic fitness, not energy expenditure, influences subsequent increase in adiposity in black and white children. **Pediatrics,** v. 106, n. 4, 50-56, 2000.
LÉGER LA, MERCIER D, GADOURY C, LAMBERT J. The multistage 20-meter shuttle run test for aerobic fitness. **Journal of Sports Sciences,** v. 6, 93-101, 1988.
LEMURA LM, DULLIVARD SP, CARLONAS R. Can Exercise Training Improve Maximal Aerobic Power (VO2max) in Children: A Meta-Analytic Review. **JEP online,** v. 2, 1-14, 1999.
MALINA RM. Physical activity and training: effects on stature and the adolescent growth spurt. **Medicine and Science in Sports and Exercise**, v. 26, n. 6, p. 759-766, 1994.
MALINA RM.; BOUCHARD, C. **Atividade física do atleta jovem: do crescimento à maturação.** 1. ed. São Paulo: Roca, 2002.
MARTIN RHC, UEZU R, PARRA AS, ARENA SS, BOJIKIAN LP, BOHME MTS. Auto-avaliação da maturação sexual masculina por meio da utilização de desenhos e fotos. **Revista paulista de Educação Física,** v. 15, n. 2, p. 212-222, 2001.
MCMURRAY RG, HARRELL JS, BRADLEY CB, DENG S, BANGDIWALA SI. Predicted maximal aerobic power in youth is related to age, gender, and ethnicity. **Medicine and Science Sports Exercise,** v. 34, n.1, p. 145-151, 2002.
MCMURRAY RG, HARRELL JS, BANGDIWALA SI. Tracking of physical activity and aerobic power from childhood through adolescence. **Medicine and Science Sports Exercise,** v. 35, n. 11, p. 19141922, 2003.
PINHO R, PETROSKI E. Nível de atividade física em crianças. **Revista brasileira de atividade física e saúde,** v. 2, n. 3, p. 67-79, 1997.
SCHEETT TP, NEMET D, STOPPANI J, MARESH CM, NEWCOMB R, COOPER DM. The effect of endurance type exercise training on growth mediators and inflammatory cytokines in pre-pubertal and early pubertal males. **Pediatric Research**, v. 52, p. 491-497, 2002.
SLAUGHTER MH, LOHMAN TG, BOILEAN CA, STILLMAN RJ, VAN VOAN ME, BEMEBN DA. Skinfold equations for estimation of body fatness in children and youth. **Human Biology,** v.60, p. 709-723, 1988.
Tanner JM. **Growth and adolescence**. Oxford: Blackwell Scientific Publication, 1962.

Endereço para Contato
UFPR Dep. de Educação Física
Centro de Pesquisa em Exercício e Esporte
Rua Coração de Maria, 92 Jardim Botânico
Cep: 80.215-370 - Curitiba - Pr Brasil
netostabelini@hotmail.com

CHANGES IN VO_2MÁX AND BODY COMPOSITION DURING PUBERTY

ABSTRACT

Introduction: the changes in VO_2máx and body composition during puberty it is not well elucidated. **Objective:** to analyze the changes in VO_2máx and body composition during the puberty in male subjects. **Methods:** the data consisted of 87 subject, from 7 to 19 years old, classified by the sexual maturation stages proposed by Tanner (1962): stage 1 (n=35), stage 2 (n=23), stage 3 (n=11), stage 4 (n=12) e stage 5 (n=08). Initially were measured height and weight (W). To estimate the percentage of fat (%F) the Slaughter (1988) equation was used. The fat mass (FM) and the fat free mass (FFM) were calculated: FM= W (%F/100) and FFM= W-FM. To determinate the VO_2máx was used the 20m shuttle-run test propose by Léger (1988). Analyzes of variance (one-way) and the post-hoc of Tukey were used to test possible differences between the groups, with p<0,05. **Results:** the analyzes of variance indicated significant difference between the maturational stages for %F (F=3,26; p< 0,01), FM (F=18,33; p< 0,0001), FFM (F=56,69; p< 0,0001), VO_2máx relative (F=21,29; p< 0,0001) and VO_2máx absolute (F=24,40; p< 0,0001). **Conclusion:** body composition and VO_2máx presented similar values until the maturational stage 3, demonstrating significant changes after stage 4.

Key words: VO_2máx, body composition and puberty.

CHANGEMENTS DANS LA CONSOMMATION MAXIMALE D'OXIGENE ET DANS LA COMPOSITION CORPOREL PENDANT LES ANNEES QUI PRECEDENT LA PUBERTE

Résumé

Introduction: Des changements dans la VO_2máx et dans la composition corporel dans les annés qui précèdent la puberté et pendant le période pubertaire ne sont pas completement établis. **Objectif:** analiser les changements dans le VO_2max et dans la composition corporel pendant la puberté dans des individues du sexe masculin. **Metodologie:** l'échantillon s'est constitui de 87 pesonnes avec l'âge entre 7 et 19 ans, séparées en cinq grupes d'accord les stages de maturation sexuel proposés par Tanner (1962) : stage 1 (n=35), stage 2 (n=23), stage 3 (n=11), stage 4 (n=12) et stage 5 (n=08). Ont été mésurées la stature et la masse corporel (MC). Pour la estimative du percentuel de graisse (%G) a été utilisé l'equation de Slaughter (1988). La masse grasse (MG) et la masse livre de graisse (MLG) ont été determinés a partir des calcules suivants : MG = MC (%G / 100) et MLG = MC MG. Pour la determination du VO_2max, le teste de 20 m proposé par Léger (1988) a été utilisé. Des analises de variances (*one-way*) et *post-hoc* de Tukey ont été utilisés pour tester s'il y a des differences significatives entre les groupes, avec p<0,05. **Résultats:** l'analise de variance a indiqué des differences significatives entre les stages de maturation pour le %G (F=3,26; p< 0,01), MG (F=18,33; p< 0,0001), MLG (F=56,69; p< 0,0001), VO_2max relatif (F=21,29; p< 0,0001) et VO_2max absolut (F=24,40; p< 0,0001). **Conclusion :** A été observé que les valeurs des variables de composition corporel et du VO_2max se sont mantenues pratiquement similaires jusqu'au stage de maturation 3, en démontrand des altérations significatives à partir du stage 4.

Mots clé : VO_2max, composition corporel, puberté.

LAS ALTERACIONES EN LO VO2MÁX Y EN LA COMPOSICIÓN CORPÓREA DURANTE LA PUBERTAD

RESUMEN

Introducción: las modificaciones en lo VO_2máx y en la composición corpóreo por los años que precede la pubertad y durante el período pubertário no son totalmente elucidado. **Objetivo**: analizar las alteraciones en VO2máx y en la composición corpórea durante la pubertad en individuos masculinos. **Metodología:** la muestra se constituyó de 87 asunto con las edades entre 7 y 19 años, separe en cinco los grupos de acuerdo con los aprendizajes de maduración sexual propuestos para Tanner

(1962) la fase 1 (el n=35), la fase 2 (el n=23), la fase 3 (el n=11), la fase 4 (el n=12) y la fase 5 (el n=08). Ellos eran moderados la estatura y masa del corporal (MC). Para estime del percentil de grasa (% G) la ecuación se usó de Slaughter (1988). La masa gorda (MG) y la masa libre de la grasa (MLG) eran cierto empezando de los cálculos siguientes: MG =MC (% G/100) y MLG=MCMG . Para la determinación de VO2máx la prueba de 20m se usó propuesto por Leger (1988). Análisis de la variación (one-way) y poste-hoc de Tukey fue usado para probar ellos existen las diferencias significantes entre los grupos, con p <0,05. **Resultados:** la análisis de la variación indicó las diferencias significantes entre las fases maturacionais para el % G (F=3,26; p <0,01), MG (F=18,33; p <0,0001), MLG (F=56,69; p < 0,0001), VO2máx relativo (F=21,29; p <0,0001) y VO2máx absoluto (F=24,40; p < 0,0001). **Conclusión:** fue observado que los valores de las variables de la composición corpóreo y del Vo2máx se quedaron prácticamente similar hasta el la fase maturacional 3, demostrando alteraciones significantes empezando del la fase 4.

Palabras claves: Vo2máx, la composición corpórea, la pubertad.

ALTERAÇÕES NO VO_2MÁX E NA COMPOSIÇÃO CORPORAL DURANTE A PUBERDADE

RESUMO

Introdução: o comportamento do VO_2máx e da composição corporal durante o período pubertário não estão totalmente elucidados. **Objetivo:** analisar as alterações no VO_2máx e na composição corporal durante a puberdade em indivíduos do sexo masculino. **Metodologia:** a amostra constituiu-se de 87 sujeitos com idades entre 7 e 19 anos, classificados de acordo com os estágios de maturação sexual propostos por Tanner (1962): estágio 1 (n=35); estágio 2 (n=23); estágio 3 (n=11); estágio 4 (n=12); estágio 5 (n=08). Foram mensuradas estatura e massa corporal (MC). Para estimativa do percentual de gordura (% G) utilizou-se a equação de Slaughter (1988). A massa gorda (MG) e a massa livre de gordura (MLG) foram determinadas a partir dos seguintes cálculos: MG=MC (%G/100) e MLG=MCMG. Para determinação do VO_2máx foi utilizado o teste de 20m proposto por Léger (1988). Análises de Variância *(one-way)* e *post-hoc* de *Tukey* foram utilizados para verificar se existem diferenças significativas entre os grupos, com p<0,05. **Resultados:** a análise de variância indicou diferenças significativas entre os estágios maturacionais para o %G (F=3,26; p< 0,01), MG (F=18,33; p< 0,0001), MLG (F=56,69; p< 0,0001), VO_2máx relativo (F=21,29; p< 0,0001) e VO_2máx absoluto (F=24,40; p< 0,0001). **Conclusão:** observou-se que os valores das variáveis de composição corporal e do VO_2máx (ml/kg/min) mantiveram-se praticamente similares até o estágio maturacional 3, demonstrando alterações significativas apenas partir do estágio 4.

Palavras chave: VO_2máx, composição corporal, puberdade.