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 (GEITNER 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 (GEITNER et al, 2004), probably due to the greater use of energy caused by the practice of physical exercise (BERKEY et 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\textsubscript{max} 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 of 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.

<table>
<thead>
<tr>
<th>Tanner Stages</th>
<th>N</th>
<th>Mean Age (Years)</th>
<th>SD</th>
<th>Mean BM (Kg)</th>
<th>SD</th>
<th>Mean Stature (cm)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
<td>11.31</td>
<td>1.02</td>
<td>27.62</td>
<td>3.7</td>
<td>153.16</td>
<td>8.53</td>
</tr>
<tr>
<td>2</td>
<td>23</td>
<td>10.65</td>
<td>1.30</td>
<td>33.10</td>
<td>5.91</td>
<td>135.91</td>
<td>8.02</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>12.45</td>
<td>1.04</td>
<td>42.26</td>
<td>13.08</td>
<td>148.95</td>
<td>12.41</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>14.76</td>
<td>1.44</td>
<td>55.37</td>
<td>12.84</td>
<td>164.29</td>
<td>10.78</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>18.13</td>
<td>1.33</td>
<td>63.16</td>
<td>9.08</td>
<td>172.87</td>
<td>6.49</td>
</tr>
</tbody>
</table>

Instruments and Procedures

Sexual maturation: The method proposed by Tanner (1962) was employed. Maturation 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 plisosity of the pubic region as suggested by Martin et al., (2001) which showed a satisfactory concordance with medical examination (0.61).

Anthropometric Measurements: Total height (cm) and body mass(kg) were measured using a WCS stadiometer and a PLENNNA 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 plicrometer. 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(%/F100) e FFM = BM - FM.

VO\textsubscript{max}: 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.

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\textsubscript{max} 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\textsubscript{max} (ml/kg/min) (F=21.29; p<0.0001) and absolute VO\textsubscript{max} (L/min) (F=24.40; p<0.0001).

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

<table>
<thead>
<tr>
<th>Tanner 1</th>
<th>Tanner 2</th>
<th>Tanner 3</th>
<th>Tanner 4</th>
<th>Tanner 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>% FAT</td>
<td>11.19 (3.19)</td>
<td>13.02 (5.68)</td>
<td>13.54 (4.06)</td>
<td>15.36 (4.27)</td>
</tr>
<tr>
<td>FM (Kg)</td>
<td>3.14 (1.21)</td>
<td>4.56 (2.83)</td>
<td>5.93 (3.07)</td>
<td>8.75 (3.43)</td>
</tr>
<tr>
<td>FFM (Kg)</td>
<td>24.48 (2.94)</td>
<td>28.54 (3.74)</td>
<td>36.32 (10.58)</td>
<td>46.62 (10.67)</td>
</tr>
<tr>
<td>VO\textsubscript{max} (ml/kg/min)</td>
<td>49.81 (2.73)</td>
<td>47.95 (2.38)</td>
<td>47.1 (3.5)</td>
<td>41.61 (5.04)</td>
</tr>
<tr>
<td>VO\textsubscript{max} (L/min)</td>
<td>1.37 (0.18)</td>
<td>1.58 (0.29)</td>
<td>1.96 (0.48)</td>
<td>2.25 (0.39)</td>
</tr>
</tbody>
</table>

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 maturational 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).

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).

The significant increase in absolute VO\textsubscript{max} (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).

The significant increase for stage 3; d-significant difference for stage 4.

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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).

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INTRODUCCIÓN: las modificaciones en VO máx y en la composición corpórea durante la pubertad se producen en la vida adulta. Objetivo: analizar las alteraciones en VO máx 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, separar en cinco los grupos de acuerdo con los aprendizajes de maduración sexual propuestos para Tanner (1962): stage 1 (n=35), stage 2 (n=23), stage 3 (n=11), stage 4 (n=12) y stage 5 (n=08). Ont été mesurées la stature et la masse corporelle (MC). Pour la determination du VO máx, le test de 20 m proposé par Léger (1988) a été utilisé. Des analyses de variance (one-way) et post-hoc de Tukey ont été utilisés pour tester s'il y a des différences significatives entre les groupes, avec p<0,05.

Conclusion: A été observé que les valeurs des variables de composition corporel et du VO máx sont maintenues pratiquement similaires jusqu’au stage de maturation 3, en démontrant des altérations significatives à partir du stage 4.

Mots clé: VO máx, composition corporel, puberté.

RESUMEN: durante el período pubertario no son totalmente elucidado. Objetivo: analizar las alteraciones en VO máx 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): stage 1 (n=35), stage 2 (n=23), stage 3 (n=11), stage 4 (n=12) y stage 5 (n=08). Ont été mesurées la stature et la masse corporelle (MC). Pour la determination du VO máx, le test de 20 m proposé par Léger (1988) a été utilisé. Des analyses de variance (one-way) et post-hoc de Tukey ont été utilisés pour tester s'il y a des différences significatives entre les groupes, avec p<0,05. Resultados: l'analyse de variance a indiqué des significations entre les stades de maturation pour %F (F=3,26; p< 0,01), FM (F=18,33; p< 0,0001), FFM (F=56,69; p< 0,0001), VO máx relativo (F=21,29; p< 0,0001) y VO máx absoluto (F=24,40; p< 0,0001). Conclusión: A été observé que les valeurs des variables de composition corporel et du VO máx sont maintenues pratiquement similaires jusqu’au stage de maturation 3, en démontrant des altérations significatives à partir du stage 4.

Mots clé: VO máx, composition corporel, puberté.
ALTERAÇÕES NO VO MÁX E NA COMPOSIÇÃO CORPORAL DURANTE A PUBERDADE

RESUMO

Introdução: o comportamento do VO máx e da composição corporal durante o período pubertário não estão totalmente elucidados. Objetivo: analisar as alterações no VO máx e na composição corporal durante a puberdade em indivíduos do sexo masculino. Metodologia: a amostra constitui-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 máx 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 % G (F=3,26; p<0,01), MG (F=18,33; p<0,0001), MLG (F=56,69; p<0,0001), VO máx relativo (F=21,29; p<0,0001) e VO máx absoluto (F=24,40; p<0,0001). Conclusão: observou-se que os valores das variáveis de composição corporal e do VO máx (ml/kg/min) mantiveram-se praticamente similares até o estágio maturacional 3, demonstrando alterações significativas apenas partir do estágio 4.

Palavras chave: VO máx, composição corporal, puberdade.