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Peak height velocity in anthropometry and body composition of students

Pico de velocidade de crescimento em antropometria e composição corporal de escolares

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Abstract – The aim of this study was to analyze the age of Peak Height Velocity (PHV), anthropometric variables and body composition of students from the western state of Paraná. The study included 1,011 male students aged 12-15 years from 11 municipalities located around the Itaipu lake. Anthropometric and body composition variables were obtained according to international criteria. Biological maturation was determined by age of PHV and for the purpose of analysis, it was categorized into developmental levels. The results reinforce, as expected, an increasing trend of variables analyzed as students advanced in maturity. Thus, it was concluded that with the advancement of maturation, anthropometric variables maintain a linear growth observed in each PHV stratum. This linear trend is not observed in body composition. Body fat showed a decrease in average values as the individual approaches PHV.

Key words: Adolescent; Anthropometry; Body Composition; Growth.

Resumo – *O objetivo deste estudo foi analisar a idade do PVC, variáveis antropométricas e composição corporal de estudantes da região do estremo oeste do Paraná. Participaram do estudo 1.011 escolares do sexo masculino de 12 a 15 anos de 11 municípios localizados no entorno do lago de Itaipu. As variáveis antropométricas e de composição corporal foram obtidas seguindo os critérios internacionais. A maturação biológica foi determinada pela idade do PVC e para efeito de descrição e análise foi categorizada em estratos. Os resultados reforçam, conforme esperado, uma crescente evolução das variáveis analisadas à medida que os escolares avançaram na maturação. Sendo assim, concluímos que com o avanço da maturação as variáveis antropométricas mantêm um crescimento linear que é observado em cada estrato do PVC. Este comportamento linear não é observado na composição corporal. O percentual de gordura apresenta uma diminuição de seus valores médios principalmente na proximidade do PVC.*

Palavras-chave: *Adolescente, Antropometria; Composição Corporal; Crescimento.*

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INTRODUCTION

Adolescents undergo skeletal, neuroendocrine transformations, and sexual maturation, thus, the anthropometric and body composition evaluation becomes necessary to follow the entire process of growth and development[1,2].

The peak height velocity (PHV) is one of the most used indicators in studies that investigate the maturation processes in adolescents[3-5], and may appear as an alternative of biological classification. The moment the individual reaches PHV can be estimated by monitoring the growth of body structures. Although it is possible to determine the peak velocity of height, body weight, skinfolds, among others, the somatic landmark most used in studies on growth and maturation is the age of peak height velocity[6]. By objectively measuring physical growth rates, it is suggested that children should be stimulated according to biological development as opposed to chronological age, adding individualized aspects to physical development during a phase of significant increases in somatic growth.

Originally, to use PHV, several measures were required during a given growth period, making this methodology impracticable for cross-sectional investigations, when only a single measurement was possible[7]. Therefore, researchers[3] developed a practical technique with good reliability ($r^2 = 0.89$) and with low standard error of estimation (SEE = 0.569). It is a noninvasive technique that requires a single evaluation of a few anthropometric variables, capable of predicting the distance in years from the individual´s age at PHV.

Using the known differential synchronisms of height, trunk-cephalic height, and lower limb length, it is possible to assume that the proportional relations of change between these segments can provide an indication of maturational status[6]. In this model, interactions between leg length and trunk-cephalic height, age and leg length, age and trunk-cephalic height, as well as between weight and height ratio were included.

In the literature[7], there are few epidemiological studies that have used PHV as an indicator of somatic maturation, especially involving schoolchildren. Therefore, the aim of this study was to describe the values of anthropometric and body composition variable by age at Peak Height Velocity in students aged 12-15 years.

METHODOLOGICAL PROCEDURES

This cross-sectional study with descriptive design involved students from 11 municipalities located around the Itaipu lake: Foz do Iguaçu, Santa Terezinha de Itaipu, São Miguel do Iguaçu, Itaipulândia, Missal, Santa Helena, Entre Rios do Oeste, Pato Bragado, Marshal Cândido Rondon, Mercedes and Guaira. The data used in the study came from a database of the thesis "Regional Survey on Growth and Development: Relations with Maturity, Overweight and Obesity, Socioeconomic Level and Motor Performance". This sample included a subset with male students aged 12-15 years from public schools.

This study was approved by the Research Ethics Committee of the Faculty of Medical Sciences of the State University of Campinas - FCM / UNICAMP, through protocol No. 370/2011, according to Resolution 196/96 of the National Health Council.

In order to assemble the thesis database, a survey, with the collaboration of the State Department of Education (SEED-PR), and the Municipal Secretaries of Education, was carried out to identify the total number of schools and students in each of the participating municipalities. Thirty-four schools were randomly selected, considering only the geographic location, aiming to achieve a significant representation of the municipalities´ populations. The sample of each municipality was randomly established considering the proportionality of students in each school region. The sample size was calculated in a stratified probabilistic manner for each sex and age group separately, following the procedure: ICA = SN / N and n = ICA x SN. Where: ICA = Sample Calculation Index; SN = Sub-Universe; N = Universe; n = calculated sample size. Exclusion criteria were: presence of pathologies, the non-delivery of the informed consent form duly signed by parents or legal guardians and non-attendance in data collection.

Specifically for this study, data corresponding to sex and age group were used, therefore, the present sample was composed of 1,011 male students.

The selection of 12 to 15-year-old males was based on the study of Malina and Koziel[8], who concluded that PHV is influenced by chronological age and by the state of real maturity, suggesting that this somatic evaluation technique has applicability in boys who are in the maturation period and during the growth spurt that occurs approximately between 12 and 15 years of age.

Body weight, height, sitting height, tricipital and subscapular skinfold measurements followed well known international protocols[9,10]. Fat percentage was computed using the predictive equation of Lohman[11].

The chronological age of students was decimally determined by comparing the date of birth and the date of data collection, according to established criteria[12].

Data quality control

The Technical Error of Measurement - TEM was calculated to demonstrate the measurement quality control dimension adopted by the International Society for Advancement in Kinanthropometry – ISAK[13].

The TEM calculation was performed between the two evaluators who performed the collections (Inter-raters) on height (TEM = 1.2%), body mass (TEM = 1.1%) and sittingd height (TEM = 1.6%). The calculation of skinfold TEM was performed by a single evaluator (Intra-evaluator), triceps skinfold (TEM = 4.6%) and subscapular skinfold (TEM = 5.3%). The results have shown acceptable values of relative TEM according to criteria adopted by the International Society for Advancement in Kinanthropometry – ISAK[13], indicating good reliability of measurements.

For the PHV determination, the predictive equations elaborated by

Mirwald et al.[3] were used, which are differentiated by sex.

- Male

$$PHV = -9.236 + 0.0002708\ (LLxCT) - 0.001663\ (AGExLL) + 0.007216\ (AGExCT) + 0.02292\ (BW / STA)$$

Where: LL is the leg length (cm) obtained by the difference between height (STA) in centimeters and cephalic trunk height (CT), SH is the sitting height (cm), decimal age measured in years, BW is body weight (kg).

For purposes of analysis, the adolescents were grouped into PHV categories defined according to Table 1.

Table 1. Peak of Growth Velocity Classification.

Level	Interval (years) considered
-5	$Yi \leq -4.49$
-4	$-4.50 \leq Yi < -3.50$
-3	$-3.50 \leq Yi < -2.50$
-2	$-2.50 \leq Yi < -1.50$
-1	$-1.50 \leq Yi < -0.50$
0	$-0.50 \leq Yi < 0.50$
1	$0.50 \leq Yi < 1.50$
2	$1.50 \leq Yi < 2.50$
3	$Yi \geq 2.50$

Source: Machado and Bonfim[14]

Statistical treatment

Statistical analyses were performed with statistical software SPSS for Windows® - version 15.0. The students were grouped by PHV age aiming the analysis and description of results. To characterize the sample, parametric measures of central tendency were calculated (Mean and standard deviation). Measurements of all variables showed normal distribution observed in the K-S distance test (Kolmogorov-Smirnov).

In order to identify the differences of independent variables among PHV levels, one way ANOVA was used considering one factor (PHV) followed by the Tukey Post-hoc test. For all analyses, the statistical significance level adopted was less than or equal to 5%.

RESULTS

The average Peak Height Velocity (PHV) of the 1,011 adolescents occurred at 14.25 ± 0.49 years. Average body weight observed at PHV was 61.80 ± 12.45 kg and height at 170.82 ± 5.96 cm. Sitting height at PHV was higher than leg length in all strata analyzed, with values of 87.87 ± 2.52 cm and 82.94 ± 4.88, respectively. (Mean values at PHV for tricipital skinfold thickness was 10.85 ± 6.36 mm and for subscapular skinfold thickness, 10.91 ± 7.30 mm. With respect to body fat percentage, there was an increase in values between PHV strata -3 and -2, followed by a decrease in strata -1, 0 and 1. The highest value was observed in PHV stratum -2 (17.26 ± 7.99%). In PHV, the mean body fat percentage value was 15.77 ± 7.57% (Table 2).

The one factor analysis of variance (PHV) indicated statistically significant differences among strata in some of the factors compared (Table 2).

Table 2. Description of anthropometric variables ($\bar{x}$ / ±) according to PHV classifications of male adolescents aged 12-15 years (n = 1,011) living in municipalities around the Itaipu lake in western Paraná State.

PHV	-3	-2	-1	0	1	
	n=69 (6.8%)	n=320 (31.7%)	n=344 (34%)	n=244 (24.1%)	n=34 (3.4%)	F
AGE (years)	12.3±0.2	12.8±0.5	13.7±0.6	14.2±0.4	14.7±0.2	F= 1.095; p= 0.358
BW (kg)	37.4±7.1	45.9±8.9	53.6±10.4	61.8±12.4	72.0±16.1	F= 1.370; p= 0.242
STA (cm)	144.4±5.7	154.1±6.2	162.7±5.9	170.8±5.9	178.4±4.8	F= 1.436; p= 0.220
SH (cm)	72.8[a]±2.2	78.2[a]±2.5	82.8[b]±2.9	87.8[b]±2.5	93.1±1.9	F= 360.634; p= 0.000
LL (cm)	71.6±4.4	75.8[a]±5.1	79.9[a.b]±4.7	82.9[b]±4.8	85.2±4.2	F= 118.899; p= 0.000
TST (mm)	10.8[a]±5.4	12.3[a]±6.2	11.3[b]±6.2	10.8[b.c]±6.3	11.1[c]±7.9	F= 436.364; p= 0.000
SSF (mm)	8.3[a]±5.7	10.5[a]±7.4	10.5±7.5	10.9[b]±7.3	12.1[b]±9.0	F= 131.173; p= 0.000
BF (%)	15.0[a] ±7.4	17.2[a,b] ±7.9	16.1[b.c]±7.7	15.7[c]±7.5	15.5 ±7.4	F= 336.916; p= 0.000

Letters indicate significant differences p <0.05. BW = Body Weight; STA = Height; SH = Sitting Height; LL = Leg Length; TST = Tricipital skinfold thickness; SSF = Subscapular skinfold thickness; BF = Body Fat Percentage.

DISCUSSION

The age at PHV, calculated in the present study, was 14.2 ± 0.5 years. Machado and Bonfin[14] developed a cross-sectional study with Brazilian soccer practitioners using the same methodology of this study and found an average age PHV corresponding to 14.7 years. This value is close to that observed in students of our study. In a longitudinal study, with 70 students aged 10-14 years, earlier PHV, between ages of 12 and 13, was observed[15,] when controlling for height, body weight, tricipital and subscapular skinfold thickness.

A cross-sectional study[16] involving schoolchildren identified PHV at 13.4 years. Two other studies[17,18] found PHV values at 13.8 years. In general, the PHV age of participants of this study differs from most studies, since it occurs at later age. Malina et al.[19] analyzed a series of European studies involving male subjects and identified that PHV occurred between 13.8 and 14.2 years of age and reported a probable interference of sociocultural and ethnic factors in PHV variations.The mean age PHV in the European studies, 14.2 years, is similar to the age PHV in the present study.

When analyzing the anthropometric measurements by PHV strata, the results are similar to results obtained in another study[8]. Small variations in mean values were observed in variables height, body weight, trunk-cephalic height and leg length.

The increase in height in the PHV period was 26.4 cm and body weight was 24.4 kg. These results are similar to those obtained by Bergmann et al.[15], who analyzed differences that occurred from 10 and 14 years and identified an increase in total height of 25.9 cm but different in body weight (20.8 kg). Another variable they analyzed was the sum of tricipital and subscapular skinfolds thickness, where a reduction of 1.34mm was observed[15], whereas in the present study, the alterations in this variable was lower (0.95mm). A longitudinal study investigating changes in growth and performance of soccer athletes[18] indicates that PHV coincides with the peak weight velocity. Our data corroborate the hypothesis that these variables show parallel increases.

For the analysis of body fat percentage, the descriptive form classified by PVC strata was adopted, and significant oscillations were observed in most strata.

The cross-sectional design is a study limitation because it makes it impossible to establish cause and effect relations. The study sample, which is limited to the male adolescent population of a region of the State of Paraná characterized by municipalities with high HDI and ethnic descent population are also limitations.

CONCLUSION

The results of the present study demonstrated that with the advancement of maturation, the anthropometric variables maintain a linear growth that is observed in each PHV stratum. This linear trend is not observed in body composition. Fat percentage presents a decrease in average values mainly near the maximum peak of maturation.

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