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RESEARCH

Adductor pollicis muscle thickness in Brazilian adolescents and associations with nutritional status, sexual maturation and physical activity (EVA-JF Study)

Espesor del músculo aductor del pulgar en adolescentes brasileños y asociaciones con el estado nutricional, la maduración sexual y la actividad física (Estudio EVA-JF)

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ABSTRACT

Objective: The present study aims to assess the associations of adductor pollicis muscle thickness (APMT) with age, skin color, sexual maturation, anthropometric indicators and physical activity in Brazilian adolescents.

Materials and methods: Cross-sectional study of adolescents aged 14-19 years. Weight, height, body mass index (BMI), arm circumference (AC), APMT, body fat, fat-free mass (FFM), fat-free mass index (FFMI), sexual maturation, time of physical activity and skin color were evaluated. APMT was associated with categorical variables using Mann-Whitney or Kruskal-Wallis tests and correlated with anthropometric variables using Spearman's correlation. Linear regression was used with APMT as a dependent and the other variables as predictors. Data analysis was carried out in SPSS® software (version 17.0) with a 5% significance level.

Results: 828 adolescents were evaluated, 57.6% female, with a mean age of 16.13 ± 1.20 years. APMT had an average value of 18.0 mm in females and 21.0 mm in males. The measure was greater in males, in more advanced stages of sexual maturation, overweight and physical activity. It presented a moderate correlation with FFM, FFMI, body fat and AC. In the final model of multiple linear regression for females, the variables AC and body fat explain 20.1% of the APMT variability. For men, the variables AC and FFMI explain 30.5% of the APMT variability.

Conclusion: It is recommended that APMT be used in a complementary manner in the nutritional assessment of adolescents.

Keywords: Adolescent; Anthropometry; Nutrition Assessment; Muscles.

RESUMEN

Objetivo: El presente estudio tiene como objetivo evaluar las asociaciones del grosor del músculo aductor del pulgar (EMAP) con la edad, el color de la piel, la maduración sexual, los indicadores antropométricos y la actividad física en adolescentes brasileños.

Material y métodos: estudio transversal con adolescentes de 14 a 19 años. Peso, talla, índice de masa corporal (IMC), circunferencia del brazo (CB), EMAP, grasa corporal, masa libre de grasa (MLG), índice de masa libre de grasa (IMLG), maduración sexual, tiempo de actividad física y color de piel fueron juzgado. EMAP se asoció con variables categóricas mediante pruebas de Mann-Whitney o Kruskal-Wallis y se correlacionó con variables antropométricas mediante la correlación de Spearman. Se utilizó regresión lineal con EMAP como variable dependiente y el resto de variables como predictores. El análisis de los datos se realizó mediante el software SPSS® (versión 17.0) con un nivel de significancia del 5%.

Resultados: se evaluaron 828 adolescentes, 57,6% mujeres, con una edad media de 16,13 ± 1,20 años. EMAP tuvo un valor promedio de 18.0 mm en mujeres y 21.0 mm en hombres. La medida fue mayor en varones, en estadios más avanzados de maduración sexual, sobrepeso y practicantes de actividad física. Presentó una correlación moderada con MLG, IMLG, grasa corporal y CB. En el modelo final de regresión lineal múltiple para mujeres, las variables CB y grasa corporal explican el 20,1%; para los hombres, las variables CB y MLG explican el 30,5% de la variabilidad EMAP.

Conclusión: Se recomienda que EMAP se utilice de forma complementaria en la valoración nutricional de adolescentes.

Palabras clave: Adolescente; Antropometría; Evaluación Nutricional; Músculos.

KEY MESSAGES

- The measurement of APMT consists of a simple, non-invasive and low-cost procedure. This muscle is flat, is fixed between two bone structures and can be measured directly, without the need for equations or adjustments to estimate the real value, a fact that highlights it among other anthropometric measures used to assess muscle mass.
- APMT showed a moderate correlation with FFM ($r = 0.405$ in females and $r = 0.506$ in males), FFMI ($r = 0.397$ in females and $r = 0.516$ in males), body fat ($r = 0.435$ in females and $r = 0.344$) in males and with AC ($r = 0.427$ in females and $r = 0.498$ in males), with $p < 0.001$. No correlation was found with BMI variables (kg /m2) ($p > 0.005$ in both sexes).
- In the final model of multiple linear regression for females, the variables AC and body fat percent remained. This model explains 20.1% of the APMT variability. In the final model of linear regression for males, only the variables AC and FFMI remained, which explain 30.5% of the APMT variability.
- APMT was higher in male adolescents, in more advanced stages of sexual maturation, overweight and physically active. Moreover, in both sexes, the measure was moderately correlated with AC, FFM, FFMI and body fat percent.

INTRODUCTION

Adolescence is a period of transition from childhood to adulthood, which is characterized by accelerated physical growth, with metabolic changes and sexual maturation, which promotes specific changes in body composition (in the distribution of muscles and fat), and changes in cutaneous and glandular secretions, in addition to breast, genital, adrenal and gonadal developments[1]. Due to these characteristics, the nutrition assessment of this age group becomes more complex, and further research is needed on techniques and effective indicators, which are able to predict changes in body composition.

In recent decades, researchers have proposed the use of new measures and anthropometric indices to fill existing gaps in practicality, cost, reliability and reproducibility, among them, the adductor pollicis muscle thickness (APMT)[2] stands out. The measurement of APMT consists of a simple, non-invasive and low-cost procedure. This muscle is flat, is fixed between two bone structures and can be measured directly, without the need for equations or adjustments to estimate the real value, a fact that highlights it among other anthropometric measures used to assess muscle mass. Furthermore, it suffers minimal interference from subcutaneous fat and it is influenced by nutritional deficit, energy catabolism and physical inactive[3,4].

APMT is increasingly studied in sick and healthy adults and elderly, being considered potentially useful to assist both in monitoring nutritional status and in detecting early changes related to muscle mass depletion[3,4,5]. However, in the case of young population, there are few studies on this subject. So far, there is only one original study developed in this perspective in the literature, with hospitalized Brazilian children aged 4 to 8.9 years, in which it was demonstrated that low APMT values, were associated with low weight, short stature, low percentage of body and muscle mass, moderate and severe malnutrition and high nutritional risk[6]. Thus, studies evaluating the use of this measure in adolescents and associated factors are necessary in order to assess the applicability of the APMT in this age group. The hypothesis of the present study is that the APMT is influenced by factors such as age, skin color, sexual maturation, anthropometric indicators and physical activity in Brazilian adolescents. Therefore, the present study aims to evaluate the associations of APMT with age, skin color, sexual maturation, anthropometric indicators and physical activity in Brazilian adolescents.

METHODOLOGY

Study design

This study is part of the Study of Lifestyle in Adolescence (EVA-JF, Portuguese acronym), whose objective was to outline an overview of the relationship between obesity and clinical, biochemical, demographic, socioeconomic and behavioral characteristics in Brazilian adolescents. This is a cross-sectional study of adolescents aged 14-19 years, of both sexes, duly enrolled in public schools located in the urban area of a medium-sized municipality located in the Southeast region of Brazil. The detailed description of the methodological aspects and general characteristics of the sample of EVA-JF Study can be accessed in another publication[7].

Sample and selection participants

The calculation of the sample size (n ≈ 790) was performed using the Epi Info™ software (version 7.2.2.6, Centers for Disease Control and Prevention, USA), adopting these specifications[7]: 9502 enrollments in Basic Education, in 2018-2019; estimate of the 8% prevalence of obesity in Brazilian adolescents; 2% precision around prevalence, with standard error of 1%; 95% confidence interval and 20% loss forecast. In order to ensure that the number of participants defined a priori would be sufficient to meet the objective of the present study, the sample size (n ≈ 443) was recalculated to estimate the prevalence of 50% (unknown outcome), with precision in around 5% prevalence, 95% confidence interval and 20% loss forecast.

Inclusion criteria were: adolescents between 14 and 19 years old, of both sexes, enrolled in public schools in the urban area of a medium-sized city in Minas Gerais, Brazil. The following non-inclusion criteria were considered: chronic or prolonged use of any medicine that leads to changes in the metabolism of carbohydrates and lipids, such as corticosteroids, anticonvulsants and anti-inflammatories; use of a pacemaker or orthopedic prosthesis that compromises anthropometric assessment and/or body composition; and girls who reported pregnancy or lactation.

The sample was stratified by administrative regions of the municipality (Center, East, Northeast, North, West, Southeast and South), schools, school years, classes and sexes, with proportional allocation. The participants were selected by means of proportional stratified sampling, with simple random drawing[7].

Ethical aspects

The study received approval from the Institutional Research Ethics Committee (CAEE: 68601617.1.0000.5147; approval: 3.017.847). Previously, permissions were obtained from the Regional Superintendence of the municipality, and from the schools principals of each eligible school. At the time of data collection, the terms of assent and consent duly completed and signed by their participants and their legal guardians, respectively, were also requested.

Data collection

Data collections took place in the schools, in a private place, in the morning. The anthropometric and body composition assessment of all participants were performed by a single trained health professional.

Weight was measured using a digital scale (Tanita Ironman™, model BC-553, Tanita Corp., Japan). To measure height, a portable stadiometer (Alturexata®, Brazil) was used. Both measured were obtained according to a standard protocol[7,8]. The body mass index (BMI) was classified using a growth curves recommended by World Health Organization (WHO), (BMI for age, according to sex)[9]. To measure the arm circumference (AC), a fiberglass tape measure (Sanny®, American Medical Ltd., Brazil), was used. The measure was measured at the midpoint between the acromion and the olecranon of the dominant arm[8].

APMT was measured with an analogue adipometer (Lange®, Beta Technology Inc., USA), with an opening pressure of 10 g / mm2, a 60 mm scale and an accuracy of 0.1 mm, with the participants seated, with the back reclined, the legs not crossed and the dominant palm resting on the thigh. The adipometer was applied at the apex of the imaginary triangle formed by the extension of the thumb and index[3]. The measurement was performed three non-consecutive times, with an interval of approximately one minute between each measurement. In the presence of a outlier, this was discarded and the simple arithmetic mean was calculated considering the two closest values. The APMT evaluation was carried out by a single researcher properly trained and experienced in measuring this measure[3].

Body fat was measured using a bipolar bioelectrical impedance device (Tanita Ironman™, model BC-553, Tanita Corp., Japan), a technique validated for adolescents[10]. The participants remained in an orthostatic position, in the center of the platform, barefoot, wearing light clothes and without earrings, watch, bracelets, rings or something related. The equipment was used according to the guidelines established by the manufacture. Furthermore, as part of the protocol, it was requested to comply with these conditions: keep fasting and do not practice sport or physical exercise in the previous 8-12 hours; do not drink alcohol in the previous 24 hours; and urinate at least 30 minutes before the exams begins. The fat-free mass (FFM) was calculated by subtracting the body fat weight (Kg) from the total weight (kg). Subsequently, a fat-free mass index (FFMI = FFM/ height^2) was calculated since this index is recommended as an indicator of nutritional status in this age group[11].

Sexual maturation was self-assessed according to the criteria systematized by Tanner[12-14], with a design adapted by the Ministry of Health in Brazil[15]. Moreover, in a face-to-face interview, self-reported information on skin color or race was collected, in addition to the time of physical activity in a usual week through the short form of the International Physical Activity Questionnaire (IPAQ), considering how active individuals who practiced physical activity for at least 300 minutes for a week[16].

Data analysis

Initially, exploratory analyzes were performed to verify the integrity and consistency of the data. Quantitative variables were assessed for the presence of outliers and type of distribution using the Kolmogorov-Smirnov. In the descriptive analysis of the sample, continuous variables with normal distribution were represented by mean ± standard deviation, being compared using the T-test; non-parametric ones were described with median and interquartile range and compared using the Mann Whitney test; the categorical ones were presented using absolute and relative frequencies and compared using Pearson’s qui-square test.

APMT values according to sex, age, skin color, physical activity, BMI and sexual maturation were expressed using measures of central tendency and dispersion (median and interquartile range). In order to compare them between the categories of these variables, Mann-Whitney or Kruskal-Wallis tests were used, followed by Bonferroni’s post hoc tests, in cases where the F test was significant.

The sample was stratified according to sex. APMT was correlated to BMI, FFM, FFMI, body fat percent and AC using Spearman's correlation. Weak correlations were considered less than 0.30; moderate correlations were considered between 0.30 and 0.70; and strong correlations were considered greater than 0.70[17].

Simple linear regression was performed between APMT and age, BMI, AC, FFM, FFMI e body fat percent. Multiple linear regression was performed to predict the APMT value from explanatory variables. To be used as a dependent variable, APMT underwent logarithmic transformation. For the construction of the model, $p \leq 0.20$, obtained in the bivariate analysis, were used as criteria for inclusion of the variables. In the final model, the backward method was used, and the variables with less significance were removed one by one. The procedure was repeated until all variables present in the model were statistically significant (p <0.05). The significance of the final model was assessed by the F test of the analysis of variance and the quality of the adjustment by the coefficient of determination (adjusted *R2*). The residues were evaluated according to the premises of normality, homoscedasticity, linearity, and independence. In addition, a multicollinearity check was performed between the included variables.

The analyzes were performed using SPSS® software (version 17.0, IBM Corp., USA), with a significance level set at 5%.

RESULTS

The sample consisted of 828 adolescents, 57.6% of whom were female, with a mean age of 16.13 ± 1.20 years, according to sexual maturation, 69.4% post-pubertal. As for the BMI for age, the majority presented eutrophy (70.4%). APMT had a median value of 18.0 mm (17mm - 20mm) in females and 21.0 (18mm - 23mm) in males. The prevalence of active individuals (≥ 300 minutes per week) was 64.1%. (Table 1).

The measure of APMT was higher in boys, in pubescent compared to pre-pubescent and in post-pubertal compared to pubescent, in overweight and physically active in individuals. (Table 2).

Table 1 – Sample characteristics according to sex, 2019.

Variables		Female	Male	Total	p
Age (years)		16.0 (1.2)	16.3 (1.1)	16.1 (1.2)	0.003
Sexual maturation	Pre-pubescent	1 (0.2)	24 (6.8)	25 (3.0)	<0.001
	Pubescent	176 (37.0)	51 (14.5)	227 (27.4)	
	Pos-pubertal	299 (62.8)	276 (78.6)	575 (69.5)	
Skin color	White	158 (34.6)	133 (38.7)	291 (36.4)	0.266
	Non-white	298 (65.4)	211 (61.3)	509 (63.6)	
BMI (kg/m²)		21.9 (4.1)	22.6 (4.8)	22.2 (4.4)	0.035
BMI for age	Low weight	6 (1.3)	8 (2.3)	14 (1.7)	0.224
	Eutrophy	329 (69.0)	254 (72.4)	583 (70.4)	
	Overweight	142 (29.8)	89 (25.4)	231 (27.9)	
AC (cm)		25.5 (23.3 – 28.4)	26.2 (24.3 – 29.1)	25.9 (23.8 – 28.6)	0.002
Body fat (%)		26.3 (21.6 - 31.3)	12.3 (9.3 - 17.6)	21.3 (12.9-28.2)	<0.001
FFM (kg)		41.6 (39.1 - 45.0)	54.8 (50.3 - 60.7)	45.7 (41.0 – 53.9)	<0.001
FFMI (kg/m²)		16.03 (15.1 – 17.1)	18.24 (17.2 – 19.5)	16.9 (15.6 – 18.4)	<0.001
APMT (mm)		18.0 (17.0 - 20.0)	21.0 (18.0 - 23.0)	20.0 (17.0 – 22.0)	<0.001
Physical activity	Active	280 (58.7)	251 (71.5)	531 (64.1)	<0.001
	Inactive	197 (41.3)	100 (28.5)	297 (35.9)	

BMI: body mass index; AC: arm circumference; FFM: free-fat mass; FFMI: free-fat mass index APMT: adductor pollicis muscle thickness;
Variables were compared according to sex. The categories of the variables sexual maturation, skin color, BMI for age and physical activity were compared using Pearson's chi-square test. The variables age and BMI were compared using the T test. The variables AC, body fat, MLG and APMT were compared using the Mann Whitney test.

Table 2 – Factors associated with the adductor pollicis muscle thickness in adolescents of both sexes, 2019.

Variable		N (%)	APTM Median (IQR)	p
Age group	14-15 years	249 (30.1)	19.0 (17.0 – 21.0)	0.118
	16-17 years	471 (57.0)	20.0 (17.0 – 22.0)	
	18-19 years	107 (12.9)	20.0 (17.2 – 22.0)	
Sexual maturation	Pre-pubescent	25 (3.0)	20.0 (17.0 – 22.0) [a, c]	<0.001
	Pubescent	227 (27.5)	18.0 (16.0 – 20.0) [b]	
	Pos-pubertal	575 (69.5)	20.0 (18.0 – 22.0) [c]	
Skin color or race	White	291 (35.1)	19.0 (17.0 – 21.0)	0.063
	Non-white	509 (61.5)	20.0 (17.0 – 22.0)	
BMI for age	Low weight	14 (1.7)	16.0 (15.0 – 18.0) [a]	<0.001
	Eutrophy	583 (70.4)	19.0 (17.0 – 21.0) [b]	
	Overweight	231 (27.9)	21.0 (19.0 – 23.7) [c]	
Physical activity	Active	531 (64.1)	20.0 (18.0 – 22.0)	0.001
	Inactive	297 (35.9)	19.0 (17.0 – 21.0)	

APMT: adductor pollicis muscle thickness; IQR: Interquartile Range; BMI: body mass index.
The categories of the variables sex, skin color and physical activity were compared using the Mann Whitney U test. The categories of the variables age, sexual maturation and BMI were compared using the Kruskal-Wallis test.
Different letters indicate differences between the categories of the variable.
Statistical significance when p <0.05.

APMT showed a moderate correlation with FFM (*r* = 0.405 in females and *r* = 0.506 in males, *p* <0.001, in both), FFMI (*r* = 0.397 in females and *r* = 0.516 in males, *p* <0.001, in both), body fat (*r* = 0.435 in females and *r* = 0.344, *p* <0.001, in both) in males and with AC (*r* = 0.427 in females and *r* = 0.498 in males, *p* <0.001, in both), with *p* <0.001. No correlation was found with BMI variables (kg /m2) (*p*> 0.005 in both sexes).

According to simple linear regression, APMT was influenced by AC, FFM, FFMI and body fat. FFM contributes 10.8% and 26.7% of the variation of APMT, in women and men, respectively. It is estimated that with each kilo of FFM, the APMT measurement increases by 0.01mm in both sexes (Table 3).

Table 3 - Simple linear regression of variables associated with the adductor pollicis muscle thickness in adolescents of both sexes, 2019.

Predictor variables	α (CI 95%)	β (CI 95%)	R^2	*P*
		Female		
Age (years)	2.892 (2.695 - 3.089)	0.001 (-0.011 - 0.013)	0.000	0.899
BMI (kg/m²)	2.912 (2.830 – 2.995)	0.000 (-0.004 – 0.003)	0.000	0.853
AC (cm)	2,457 (2,365 - 2,550)	0,017 (0.014 – 0.021)	0.162	<0.001
FFM (kg)	2,473 (2,360 - 2,586)	0.010 (0.008 – 0.013)	0.108	<0.001
FFMI (kg/m²)	2.552 (2.435 – 2.669)	0.022 (0.015 – 0.029)	0.070	<0.001
Body fat (%)	2.642 (2.593 – 2.693)	0.010 (0.008 – 0.012)	0.195	<0.001
		Male		
Age (years)	2.876 (2.627 - 3.124)	0.009 (-0.006 - 0.025)	0.004	0.229
BMI (kg/m²)	3.027 (2.943 – 3.112)	0.051 (-0.004 – 0.004)	0.000	0.999
AC (cm)	2,426 (2,317 - 2,535)	0.022 (0.018 – 0.026)	0.256	<0.001
FFM (kg)	2,401 (2,291 - 2,511)	0.011 (0.009 – 0.013)	0.267	<0.001
FFMI (kg/m²)	2.190 (2.050 – 2.330)	0.045 (0.038 – 0.053)	0.286	<0.001
Body fat (%)	2.903 (2.865 – 2.940)	0.009 (0.006 – 0.011)	0.130	<0.001

α: constant of the equation or linear coefficient; β: angular coefficient; CI: confidence interval; BMI: body mass index; AC: arm circumference; FFM: free-fat mass; FFM: free-fat mass index.

In the final model of multiple linear regression for females, the variables AC and body fat percent remained. This model explains 20.1% of the APMT variability. In the final model of linear regression for males, only the variables AC and FFMI remained, which explain 30.5% of the APMT variability (Table 4).

Table 4- Final multiple linear regression model of variables associated with adductor pollicis muscle thickness in female adolescents, 2019.

Explanatory variables	β Coefficient (CI95%)	Standardized Beta	p Value
	Female		
Arm circumference	0.007 (0.001 – 0.0013)	0.163	0.023
Body Fat	0.007 (0.004 – 0.0010)	0.306	<0.0001
	Male		
Arm circumference	0.010 (0.0004 – 0.016)	0.222	0.002
FFMI (kg/m$^{2)}$	0.030 (0.018 – 0.043)	0.360	<0.0001

Female: R^2: 0.201. R^2 adjusted: 0.197. Backward method. F test: $p<0.0001$
Male: R^2:0.305. R^2 adjusted: 0.301. Backward method. F test: $p<0.0001$

DISCUSSION

APMT was associated with sexual maturation, overweight and physical activity, correlating with AC, FFM, FFMI and body fat percent. In females, AC and body fat percent explained 20.1% of the variability of APMT. In male, AC and FFMI explained 30.5%.

APMT appears as a new parameter and has been studied because it is low cost and easy to apply. However, most of the studies performed so far, have focused on its use in cases of malnutrition and in hospitalized patients[5].

In our study, APMT had a median value of 18.0 mm in females and 21 mm in males. However, there are no other studies in the literature to evaluate APMT in adolescents, sick or healthy, a fact that substantially limits comparisons. In Brazil, some studies have evaluated this measure in healthy adults of both sexes. Lameu[3], evaluating individuals around 45 years old, described APMT values of 10.5 ± 2.3 mm for women and 12.5 ± 2.9 mm for men. Bielemann et al.[18], studying the birth cohort in Pelotas, found values of 19.4 ± 3.9 mm in females and 24.2 ± 4.2 mm in male. In hospitalized Brazilian children, aged 4 to 8.9 years, the mean APMT was 11.1 ± 2.9 mm in both sexes[7]. In the literature, it is recognized that the measure tends to be reduced in older and sick people[2,3,19-21].

It was found that there was a difference in the median APMT values according to the stages of sexual maturation; however, such difference was not observed in relation to the age group. Sexual maturation has effects on growth and development, promoting changes in body composition due to sexual steroids. The boys expand the fat-free mass content in response to the lipolytic and protein synthesis actions triggered by testosterone. Girls, on the other hand, exhibit greater gain in adipose tissue due to the increase in the number of estradiol receptors, which in turn inhibits the lipolytic action of growth hormone[22]. However, a great variation in maturation can be found among adolescents on the same chronological age[23] and, therefore, the stages of sexual maturation must be considered for a better understanding of the nutritional status of adolescents.

As expected, the measure was higher in males, corroborating with other studies carried out with adults and the elderly [3,4,18,21,24,25]. Testosterone levels influence the composition of skeletal muscle mass, so men often have higher muscle density[26].

In addition to the differences mentioned, APMT was higher in overweight adolescents. Studies indicate that the measurement is directly proportional to BMI, and therefore, individuals with high BMI for age have higher APMT. Positive and moderate correlations between APMT and BMI were reported by Neves et al.[2], Karst[19], Gonzalez et al.[20], Ghorabi et al.[21] e Lameu et al.[3].

Physical activity also affects the value of APMT. Physically active individuals have higher APMT values, since the muscle tends to atrophy as a result of inactivity[3,4].

Although no association was found in the present study, some authors report that skin color can influence APMT. Research has shown that blacks and Hispanics have higher bone mineral density and muscle mass than whites[27-28]. According to Ghorabi et al.[21], who evaluated Iranians, this may be a reason for the high values of APMT that were found in their study. However, the results of Lameu et al.[3], also showed no variation according to race/color.

APMT showed moderate correlations with AC and FFM in both sexes. Other authors also found weak or moderate correlations between APMT and Subjective Global Assessment and anthropometric indicators, such as weight, AC, calf perimeter, BMI and muscle mass[3,4,21,]. In hospitalized pediatric patients, low APMT values were associated with low weight, short stature, low percentages of body fat and lean mass, moderate and severe malnutrition (through the pediatric Subjective Global Assessment – SGA) and high nutritional risk (through Screening Tool Risk on Nutritional Status and Growth – STRONGkids). Based on this set of findings, it is presumed to consider APMT as an indicator of nutritional status and muscle mass content.

Useful, practical and economical screening tools to detect important changes in nutritional status during adolescence and early adulthood are of special interest, as they can facilitate the implementation of more timely and effective interventions in individuals who are most at risk. Therefore, based on our result, in addition to the body evidence previously available in the literature, it is plausible to affirm that APMT appears as a promising anthropometric indicator in nutritional assessment of adolescents, both in epidemiological studies and in clinical medicine, because it involves a simple, low-cost, non-invasive measurement procedure, which does not require further calculations or adjustments and because it is associated with sex, sexual maturation, overweight and other anthropometric and body composition indicators. This information is very relevant to the public health context. However, as most clinical professionals and research are still unaware of APMT, it would be necessary to increase substantially the evidence proving its reliability and proposing cut-off points to convince the adoption of this measure.

Despite being the first study to address APMT in adolescents, some limitations must be considered. First, given the cross-sectional nature of the study, the cause and effect relationship cannot be determined; in fact, a prospective analysis would be beneficial to ensure that changes over time are not the result of inter-individual variations. Second, we do not perform an internal validation of bipolar bioelectrical impedance to stablish its accuracy in the assessment of body composition; however, the same type of device we use has already been validated compared to dual energy X-ray absorptiometry (DEXA)[29]. Third, the fact that the sample included only adolescents attending public schools makes it impossible to extrapolate the results to adolescents from private schools. Fourth, the Brazilian population is highly mixed and consequently, more population-based studies in other ethnic groups are needed.

CONCLUSIONS

APMT was higher in male adolescents, in more advanced stages of sexual maturation, overweight and physically active. Moreover, in both sexes, the measure was moderately correlated with AC, FFM, FFMI and body fat percent.

Ultimately, we emphasize that due to the scarcity of more robust evidence, especially regarding the prediction of FFM, it is recommended that APMT be used in a complementary manner, prioritizing the nutritional assessment protocols already systematized in the specialized literature.

AUTHORS’ CONTRIBUTIONS

The authors are responsible for the research and have participated in the concept, design, analysis, and interpretation of the data, writing and correction of the manuscript.

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The authors state that there are no conflicts of interest in preparing the manuscript.

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