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Annals of Pediatrics & Child Health

Research Article

Body Composition and Thoracic Hyperkyphosis: A Study with Adolescents

Cristianne Morgado Montenegro[1]*, Tatiana Affornali Tozo[1], Beatriz Pereira[2] and João Otacilio Libardoni dos Santos[3]

[1]*Research Center on Child Studies (CIEC), University of Minho, Portugal*
[2]*Professor at the Institute of Education and Researcher at the Research Center on Child Studies (CIEC), University of Minho, Portugal*
[3]*Adjunct Professor at the Physical Education and Physiotherapy course, Professor at the Postgraduate Program in Education at the Federal University of Amazonas, Brazil*

***Corresponding author**

Cristianne Morgado Montenegro, Street Dr. Jorge Abrahim, 24 / Conjunto Barra Bella, Parque Dez, Zip code: 69054 – 400, Manaus, Amazonas, Brasil; Tel: 55(92) 98124-3030

Submitted: 11 October 2022

Accepted: 16 November 2022

Published: 19 November 2022

ISSN: 2373-9312

Keywords

• Kyphosis; Body mass index; Body Fat Percentage; Waist Circumference; Adolescent

Abstract

Objective: To analyze whether the Body Mass Index (BMI), Body Fat Percentage (%BF), Waist Circumference (WC), Age, Fat-Free Mass (FFM), and Gender are associated with thoracic hyperkyphosis in adolescents.

Methods: 380 adolescents aged between 10 and 18 participated in the study. The selected variables were: BMI, %BF, FFM, WC, Age, Gender, and Thoracic Hyperkyphosis. To verify possible associations, Wald's Chi-Square test and Poisson's regression were used. The significance level adopted was $p \leq 0.05$. Data were processed using the IBM SPSS Statistics 24 software program.

Results: Regarding the BMI of students with thoracic hyperkyphosis, they were: 43% underweight, 30% normal weight, 36% overweight, and 27% obese. Considering %BF, 24% of students with thoracic hyperkyphosis were classified as unhealthy. Significant associations were found between Thoracic Hyperkyphosis and WC (p= 0.039), Age (p= 0.002) and FFM (p= 0.041), with a prevalence ratio of 2.386, 0.888, and 0.979, respectively. No significant associations were found between thoracic hyperkyphosis and BMI (p= 0.066), %BF (p= 0.067), and Gender (p= 0.676).

Conclusion: Considering WC, adolescents classified as unhealthy are twice as likely to develop thoracic hyperkyphosis. Regarding age, the younger the age, the higher the probability of developing thoracic hyperkyphosis; the lower the FFM content, the higher the probability of developing thoracic hyperkyphosis.

ABBREVIATIONS

BMI: Body Mass Index, Body; %BF: Fat Percentage; WC: Waist Circumference; FFM: Fat-Free Mass; PR: Prevalence Ratio; CI: Confidence Interval.

INTRODUCTION

Structural disorders of the spine can cause serious degenerative and pathological disorders in the thoracic region [1]. In this sense, early investigation of postural changes that occur in the sagittal plane can prevent the installation of several pathologies during childhood and adolescence [2].

Among the most frequent postural disorders, thoracic hyperkyphosis is the postural alteration that has the highest occurrence among the child and youth population [3] and, when associated with age, can cause untold damage to the quality of life, physical function, and health of this population specifically [4].

A recent study indicates that thoracic hyperkyphosis increases with age, reaching values above 40 degrees [5]. Wilczyński and Bieniek [6], report that the healthy development of body posture is related to the balance of all components of body composition, determined by muscle content and adipose tissue [7]. Furthermore, Araújo et al [8], indicate the association of body composition and its influence on the modulation and maturation of body posture.

From this perspective, the objective of the present study was to analyze whether the Body Mass Index, Body Fat Percentage, Waist Circumference, Age, Fat-Free Mass, and Gender are associated with thoracic hyperkyphosis in adolescents.

MATERIALS AND METHODS

Type of Study and Sample

The research is a cross-sectional, analytical, and descriptive study with a convenience sample. A total of 380 students participated in the research, of which 54% (n= 204) were female, and 46% (n= 176) were male, aged between 10 and 18 years and with a mean age of 12.6±1.68 years for girls and 13.03±1.76 years for boys. All participants were duly enrolled from the 5th to the 9th year of two Municipal Schools in Manaus, Amazonas, Brazil. This research was approved by the Ethics Committee of *Faculdade Estácio do Amazonas* under opinion nº 2,297,695, following the ethical principles contained in the Declaration of Helsinki of 1995.

To participate in the study, the students' parents and/or guardians signed the Free Informed Consent Term (FICT), and the students signed the Term of Assent. The exclusion criteria were: students who had a diagnosis of neurological, rheumatological, or any other disease that affected the conditions of body posture and the locomotor system, as well as being infrequent to classes and who refused to perform any of the evaluations during the research.

Data collection instruments

Initially, an identification form was applied with the student's personal data, being confirmed at the school secretary by the responsible researcher.

The analysis of the Body Mass Index (BMI) was calculated by the ratio between the measurement of body mass in kilograms and height in meters squared [BMI = mass (kg)/height^2 (m)] [9]. Body mass was measured with a Filizolla anthropometric scale with a maximum capacity of 150 kilograms, with a precision of 100 grams, and a stadiometer was used to measure height, with a unit of measurement of 1 mm attached to the scale. The measurement is obtained in centimeters, with one decimal place through the categories: low weight, regular weight, overweight and obese, classified for Brazilian children according to age and gender [9].

The percentage of body fat analysis was performed using the formula of Slaughter et al [10], highlighting 02 (two) skinfolds: the triceps and geminal, using the compass for skinfolds, of the Lange brand with a unit of measure 1mm and 0.5mm resolution. The measured values were classified according to the reference values of the test battery of the FITNESSGRAM physical assessment program. Classified as healthy: girls between 17 and 32 %BF and boys between 10 and 25 %BF, and unhealthy: individuals who did not fit this classification [11].

Adolescents' FFM was assessed using the equation by Chortane et al. [12], which uses age and gender as specific reference criteria for predicting FFM [12].

For measuring the Waist Circumference (WC), a flexible and inelastic tape measure with a resolution of 0.1 mm was used. To classify adolescents according to WC, the reference values proposed by Taylor et al [13], were used.

Body posture assessment was performed using the Digital Image-based Postural Assessment (DIPA) version 3.1 photogrammetry method. The classification of thoracic kyphosis was performed using the following DIPA method reference values for children: increased dorsal kyphosis (hyperkyphosis) angle > 50° and normal dorsal kyphosis, angle < 50° [14].

Data collection procedures

The research was initiated by filling in the student's identification form. In the next step, in the same place, height and body mass were measured to calculate the BMI, inviting the students to position themselves on the anthropometric scale with their back to the scale and facing the researcher, barefoot, arms relaxed at the sides and chin parallel to the floor. Soon after this procedure, the percentage of body fat analysis was performed with the student in the orthostatic position, highlighting the midpoint of the 02 (two) skinfolds: the triceps, in the posterior middle region of the right arm, and the geminal, in the medial region of the right leg [11].

Subsequently, WC was measured with a tape measure, and the subject was asked to raise their arms at shoulder height in the frontal plane, still in an orthostatic position, identifying the midpoint between the lower edge of the last rib and the upper edge of the individual's iliac crest.

In the next phase, the body posture analysis was performed using the Digital Image-based Postural Assessment (DIPA) photogrammetry method, version 3.1 [14]. During the procedure, the students were invited to stand in an orthostatic position, in the right sagittal plane, with arms relaxed in the extension of the body, and chin parallel to the ground, to begin the anatomical points marking with a dermatographic pencil. First, palpation and marking of reference points were performed, using 06 (six) small white markers (styrofoam balls) with a diameter of 1.0 cm (BP) in the cervical spine and 10 (ten) markers in the shape of rods, each one formed by a plastic base and a small white ball (BP), glued to the thoracic, lumbar and sacral spine. After these procedures, the Canon Power Shot SX500 IS 16-megapixel digital camera was prepared and positioned on a tripod with a level to attach the camera at 2.80 m from the evaluated and 0.95 m from the floor, with a 35mm objective. A plumb line was fixed to the ceiling with two medium white markers (BM) 1.00 m apart and from the back wall 1.05 m away. It was positioned so that it could coincide with the same depth of the lateral malleolus of the right heel of the evaluated person so that 02 (two) body posture photos of each student were taken, in the right sagittal plane, with the student's hands statically together in front of the body so that the evaluator could make the photographic records. The acquisition of photographs and the postural report was performed by digitizing the points in the software and analyzing the photos by the Samsung computer model NP300E5K.

Statistical analysis

To analyze the association between variables, Wald's Chi-Square test and Poisson's regression with robust variance were used. The significance level adopted was $p \leq 0.05$ The data were processed using the IBM SPSS Statistics 24 software program [15].

RESULTS AND DISCUSSION

When we analyzed the students considering the BMI variable and the absence or presence of thoracic kyphosis (Table 1), no significant association was observed (p= 0.668) between the BMI variable and the frequency of thoracic kyphosis.

In Table 2, regarding the percentage of Body Fat (%BF), considering the absence or presence of thoracic hyperkyphosis, there was no significant association (p= 0.067) between %BF and the occurrence of thoracic hyperkyphosis.

In Table 3, we identified the associations between WC with p-value= 0.039, Age with p-value= 0.002, and FFM with p-value= 0.041 and thoracic hyperkyphosis. However, the three variables were not significant in the same model. The Prevalence Ratio (PR) found for WC was PR= 2.386; that is, the prevalence of thoracic hyperkyphosis is 2 (two) times higher in unhealthy

Table 1: Percentage of students by BMI level and Thoracic Hyperkyphosis.

BMI	Thoracic Hyperkyphosis		Total	*p*-value
	No	Yes		
Low weight	4 (57%)	3 (43%)	7 (100%)	
Regular weight	199 (70%)	86 (30%)	285 (100%)	
Overweight	47 (64%)	26 (36%)	73 (100%)	0.668NS
Obese	11 (73%)	4 (27%)	15 (100%)	
Total	**261 (69%)**	**119 (31%)**	**380 (100%)**	

BMI: Body Mass Index; **NS:** Not Significant for Test X^2.

Table 2: Percentage of Body Fat and Thoracic Hyperkyphosis.

%BF	Thoracic Hyperkyphosis		Total	*p*-value
	No	Yes		
Not healthy	71 (76%)	22 (24%)	93 (100%)	
Healthy	190 (66%)	97 (34%)	287 (100%)	0.067NS
Total	**261 (69%)**	**119 (31%)**	**380 (100%)**	

%BF: Percentage of Body Fat; **NS:** Not Significant for Test X^2.

Table 3: Waist Circumference, Age, FFM and Gender according to Thoracic Hyperkyphosis.

Variable	Thoracic Hyperkyphosis		Total	*p*-value	PR (CI 95%)
	Yes	No			
WC (cm)					
Healthy	5 (14.0%)	31 (86.0%)	36 (100.0%)	0.039*	2.386 (1.043 – 5.456)
Not healthy	114 (33.0%)	230 (67.0%)	344 (100.0%)		
Age	12±1.5	13±1.8	-	0.002*	0.876 (0.815 - 0.966)
FFM (kg)	36.63±8.0	38.51±8.0	-	0.041*	0.979 (0.960 – 0.999)
Gender					
Male	57 (32.4%)	119 (67.6%)	-	0.676	-
Female	62 (30.4%)	142 (69.6%)			

WC: Waist Circumference; **FFM:** Fat-Free Mass; ***p-** significant value (Test X^2); **PR:** Prevalence Ratio; **CI:** Confidence Interval.

adolescents concerning WC compared to healthy children. The model that only considers age presented PR= 0.888, that is, the younger the individual, the greater the probability of developing hyperkyphosis in 12.4% (intercept B=-0.133), and for FFM, with PR= 0.979, that is, the greater the decrease in FFM, the greater the probability of acquiring thoracic hyperkyphosis by 2.1% (intercept B=-0.21).

When analyzing the variable Gender and the occurrence or not of thoracic hyperkyphosis no significant association was observed (p= 0.676). However, it is important to highlight that students with thoracic hyperkyphosis (31%) had similar percentages when analyzed by females and males, indicating 30% and 32%, respectively. The variable Gender was not significant for the model, *p*-value equal to 0.676.

The present study aimed to analyze whether BMI, %BF, WC, Age, FFM, and Gender are associated with thoracic hyperkyphosis in adolescents. From the observed results, it was possible to verify a significant association between WC, Age, and FFM (p< 0.05) and thoracic hyperkyphosis. However, no significant associations were observed between BMI, %BF, Gender, and the frequency of thoracic hyperkyphosis.

Regarding thoracic hyperkyphosis in adolescents with different BMI levels, no significant associations were observed. Although we did not find significant associations between BMI and thoracic hyperkyphosis, there was a significant frequency of adolescents with thoracic hyperkyphosis in the low body weight group. These findings could be related to the fact that the various factors that promote low body weight can significantly compromise muscle strength [16], negatively influencing body posture patterns[7].

In this sense, Wyszyńska et al. [7], demonstrated in their study with adolescents aged between 11 and 13 years that individuals who presented low development of muscle content also had postural alterations in the scapular region. Also, Madden and

Smith [17], point out that changes in body mass may be related to muscle changes, hydration and body adiposity or the association between them. Thus, it is possible to identify that some studies already point to other postural deformities and their relationship with decreased body mass among children and adolescents. Jeon and Kim [18], associated low body weight and the risk of developing scoliosis among 1,062 Korean students.

With regard specifically to %BF and the frequency of thoracic hyperkyphosis (Table 2), although no significant associations were observed between %BF and the frequency of thoracic hyperkyphosis, we indicate that individuals classified as having healthy body fat showed a significant frequency of this postural change (34%). Jankowicz-Szymańska et al. [19], reported that adolescents with thoracic hyperkyphosis had healthy levels of body fat when compared to obese individuals. Although the results were not statistically significant, other risk factors could be influencing the development of this postural change, unlike excess body fat, alerting us that the manifestation of thoracic hyperkyphosis may be associated with possible multifactorial causes.

In Table 3, it is possible to observe an association between WC ($p= 0.039$), Age ($p= 0.002$), FFM ($p= 0.041$), and thoracic hyperkyphosis. Also, when analyzing the prevalence ratio, it was possible to verify that adolescents with unhealthy WC are 2 (two) times more likely to develop this postural change. These findings, in contrast to the variables with no significant association, direct us to a more in-depth and comprehensive look at body composition and, especially, at the anthropometric indicators used to infer these results since it was observed that patients with thoracic hyperkyphosis showed adequate levels of body fat. However, they indicated undesirable FFM, which demonstrates that the body composition would in imbalance. This weighting corroborates the study by Perez and Mattielle [20], in which they point out that the application of objective measures, such as WC, which has great influence on the analysis of body composition. Furthermore, the authors Tuz, Maszczyk, and Zwierzchowska [21], signaled in their longitudinal study with young individuals statistically significant results in the angular values of thoracic hyperkyphosis and great variation in WC relating it to changes in body composition during the osteogenic period of the analyzed individuals.

Corroborating this, Goi et al. [22], although they did not point to a significant association between obesity and postural changes in the spine, this study indicates an improvement in the realignment of the thoracic spine when observed a reduction in body weight in 34% of those investigated. Also, the research of Teixeira and Macena [23], pointed out that 81.5% of the investigated students who presented major postural changes in the thoracic spine also had a healthy waist-hip ratio (WHR) (80.5%). These studies indicate that changes in the thoracic spine may be related to both healthy and unhealthy individuals, possibly being influenced by other risk factors, such as the imbalance of body composition components.

Regarding the association between the variable Age and thoracic hyperkyphosis, the results indicate that the greater the prematurity of the adolescent's age, the greater the probability of acquiring this postural alteration. This situation is also highlighted in the study by Pérez and Mattiello [20], in which they point out that many changes in body composition are observed from childhood to early adolescence. This alerts to the need for constant monitoring of the development of body posture by health professionals, not only in clinical spaces but also in the educational space.

When we analyzed the FFM, we observed that the lower the FFM content, the greater the risk of manifestation of that postural change. Chiplonkar et al. [24], pointed to a decrease in FFM in the group of boys up to 12 years of age and in girls up to 15 years, stabilizing, respectively, at 17 years and 15. In this sense, Corbeil et al. [25], add in their work that inadequate distributions of central adiposity and muscle mass could compromise body balance and even that the imbalance related to the content of body composition components could stimulate the development of thoracic hyperkyphosis [26].These findings make us reflect on the importance of systematic stimulation of the habitual practice of physical activity, whether in formal or informal environments, with activities that encompass all components of physical fitness related to health, as it is clear that the stimulus to specific components of physical fitness has not been sufficient to prevent unwanted postural deviations. We believe that for the healthy development of body posture in the adolescent population, all components of body composition must be in perfect balance, signaling both the importance of adipose tissue and muscle mass in changes in body posture in children and school-age adolescents [27].

When analyzing the significant association between the variable Gender and the frequency of thoracic hyperkyphosis (31%), no significant associations were observed. However, it was possible to observe that 30% of the girls and 32% of the boys presented this postural alteration. Silva et al. [28], found results in line with ours, in which they point to a lower frequency of this postural change in the girls' group (30.43%) compared to the boys' group (90.9%). Furthermore, in the study by Pacenko et al. [29], the thoracic hyperkyphosis occurrence was 26.3% in the group of girls and more than 50% among boys aged between 10 and 12 years. In this sense, it is important to point out that, regardless of BMI and WC, girls tend to have larger volumes of adipose tissue, lower lean mass, and central adiposity when compared to boys [30].

CONCLUSION

The present study had some limitations that should be considered, such as the sample selection, which was intentional and for convenience, and may have influenced the number of participants in certain strata of analysis; the design of this research was transversal, making it difficult to establish cause and effect relationships between the variables studied.

Therefore, based on the findings of this study, we believe that one of the key points in the prevention of postural deviations in adolescents is the understanding by health professionals of their role in this process, understanding that, to be successful, it is necessary to stimulate adequate levels of all components of body composition (fat mass and fat-free mass) through activities that stimulate fullness, especially during adolescence. And yet, to use educational strategies that can collaborate in the prevention and identification of the innumerable dysfunctions of the corporal posture, because when installed, they cause enormous damages to the health of this population specifically.

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