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Original Article

Postural deviations and physical activity: a cross-sectional study with children

Desvios posturais e atividade física: estudo transversal com crianças

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ABSTRACT

Introduction: Currently, postural deviations represent one of the biggest epidemiological problems among children and adolescents. **Objective:** To analyze whether there is an association between aerobic fitness and the level of physical activity in children and adolescents and the occurrence of postural deviations in children and adolescents. **Methods:** The study analyzed 380 children and adolescents, 54% female and 46% male, between 10 and 18 years old. The selected variables were: Aerobic fitness, Physical activity level, and Postural deviations. To determine the variables, Fitnessgram, International Physical Activity Questionnaire, and the method of photogrammetry of Postural Assessment Based on Digital Image version 3.1 were used. **Results:** There were statistically significant association between aerobic fitness and lumbar hyperlordosis in males (p = 0.049). Binary logistic regression adjusted for the boys' group (OR = 3.268) showed the possibility of lumbar hyperlordosis to develop three times more in boys with adequate aerobic fitness. **Conclusion:** Boys with lumbar hyperlordosis had satisfactory levels of aerobic fitness. Other risk factors, such as muscle fitness, seem to influence the occurrence of lumbar hyperlordosis.

Key-words: Posture, Physical fitness, Physical activity, Children.

RESUMO

Introdução: Atualmente, os desvios posturais representam um dos maiores problemas epidemiológicos entre a comunidade infantojuvenil. **Objetivo:** Analisar se existe associação entre a aptidão aeróbia e o nível de atividade física em crianças e adolescentes e a ocorrência de desvios posturais em crianças e adolescentes. **Métodos:** O estudo analisou 380 crianças e adolescentes, sendo 54% do sexo feminino e 46% do sexo masculino, entre 10 e 18 anos idade. As variáveis selecionadas foram: Aptidão aeróbia, Nível de atividade física e Desvios posturais. Para determinar as variáveis foram utilizados: *Fitnessgram*, Questionário Internacional de Atividade Física, e o método de fotogrametria de Avaliação Postural Baseada em Imagem Digital versão 3.1. **Resultados:** Verificaram-se associações estatisticamente significativas entre a aptidão aeróbia e a hiperlordose lombar no sexo masculino (p = 0,049). A regressão logística binária ajustada para o grupo dos meninos (OR = 3,268) apresentou a possibilidade da hiperlordose lombar se desenvolver três vezes mais em meninos com aptidão aeróbia adequada. **Conclusão:** Meninos com hiperlordose lombar apresentaram níveis adequados de aptidão aeróbia. Outros fatores de risco, como a aptidão muscular parecem influenciar na ocorrência da hiperlordose lombar.

Palavras-chave: Postura, Aptidão física, Atividade física, Crianças.

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Introduction

It is crucial to have extended knowledge of the benefits that the practice of physical activity promotes, mainly when performed respecting the recommendations about type, intensity, and duration of this practice among children and adolescents [1]. The usual practice of physical activity among children and adolescents improves physical fitness and contributes positively to countless health-related benefits [2] based on both the quantity, quality, and type of physical exercise performed [3]. However, despite knowing the importance of regular physical activity, currently, only 33% of adolescents perform 60 minutes of physical activity daily [4].

This type of behavior is of great concern, as it may be contributing to the increase in chronic diseases, for example, postural deviations, which currently represent one of the biggest epidemiological problems among the children and youth community [5]. Diseases of the musculoskeletal system have negatively influenced both quality of life and mortality in the general population [6]. Different types of body posture disorders have been related to physical inactivity in both passive and active forms [5,7].

This situation has led some authors to link postural deviations and level of physical activity [8,9], as it is believed that its regularity is essential for postural control and can consolidate and automate motor functions, increasing the stimulus neuromuscular [10]. However, we understand that it is not possible to focus only on quantity but to have a close look at the type of physical activity performed. Therefore, the present study aimed to analyze whether there is an association between aerobic fitness, level of physical activity, and the occurrence of postural deviations in children and adolescents.

Methos

This research is a cross-sectional, analytical, and descriptive study in which a sample for convenience was included. 380 students participated in the study, being 54% (n = 204) female and 46% (n = 176) male. Participants were between 10 and 18 years old (mean age 12.6 ± 1.68 years old for girls and 13.03 ± 1.76 for boys) and average body mass of 47.5 ± 12.1 kg and height of 1.6 ± 0.1 m. 101 children, between 10 and 11 years of age, were analyzed, and between 12 and 18 years of age, 279 adolescents were evaluated [11]. All were properly enrolled from the 5th to the 9th grade of two Municipal Schools in the Municipality of Manaus, State of Amazonas, Brazil.

This research follows the ethical principles contained in the 1995 Declaration of Helsinki and approved by the Human Research Ethics Committee under opinion No. 2.297.695. The students were only included in the study after the parents and/or guardians consented to their participation through the Informed Consent Form (ICF). The exclusion criteria were: schoolchildren diagnosed with neurological, rheumatological diseases, or any other disease that affected the conditions of body posture and the locomotor system. No withdrawal or exclusion from any of the participants was identified during the survey.

For data collection, students were invited individually to enter a room adapted for data collection procedures. The procedures involved the following steps:

1) Filling out the Identification Form: The students were instructed by the responsible researcher to fill out the identification form with the following information: age, sex, date of birth, year of schooling, educational level of parents or guardians, these data being later confirmed at the school office by the responsible researcher.

2) Aerobic Aptitude Assessment: After completing the previous steps, students were taken to a multisport court where aerobic fitness tests were performed. For the assessment of aerobic fitness, the shuttle run test was used, recommended by the Fitnessgram test battery [12], in which children were encouraged to run as far as possible with increasing speeds with each sound signal emitted, registering the largest number of laps that the child could manage.

3) Physical Activity Level Assessment: To assess the level of physical activity, the International Physical Activity Questionnaire (IPAQ) was applied, which indicates the frequency, intensity, type, and duration of physical activity performed one week before the application of the IPAQ [13]. The results were classified according to the recommendations of the World Health Organization (WHO) [14], which indicates the need for children and adolescents to exercise daily 60 min or more of moderate to vigorous physical activity, totaling 300 minutes per week. We used two categories: healthy and unhealthy, with the group of children and adolescents who followed WHO recommendations [14] being classified as healthy and children who were unable to reach these recommendations as unhealthy.

4) Postural Assessment: it was performed in a standardized room for the analysis of body posture considering the guidelines of the Digital Image-based Postural Assessment (DIPA) photogrammetry method version 3.1.9 [15]. This method is not very invasive, has low cost, representing a simple, valid, and practical evaluation tool to analyze the spine in the sagittal and frontal planes. During this procedure, the students were asked to position themselves first on the right sagittal plane. The students were in an orthostatic position, with relaxed arms at their sides, chin parallel to the ground, and barefoot. A black cloth (2.00 x 2.00 m) was fixed at the bottom of the evaluation room. Then, the following steps were performed: 1) palpation and marking of specific reference points of the DIPA protocol, through 6 small white markers (styrofoam balls) with a diameter of 1.0 cm (BP) that were fixed in the anatomical points of CO, C1, C2, C4, C6 and C7; and 10 rod-shaped markers, each formed by a plastic base and a small white ball (BP), which total length is 4.5 cm, to then be fixed at the anatomical points: T1, T2, T4, T6, T8, T10, T12, L2, L4, and S2. After the analysis in the right sagittal plane, we performed the postural analysis in the coronal plane in the posterior view through palpation and marking of reference points of 11 small white markers (styrofoam balls) with a diameter of 1.0 cm (BP) so that they could be applied with double-sided tape to the anatomical points, with 2 markers in CO and C7 (cervical spine) and 9 markers in the anatomical points of the thoracic, lumbar and sacral spine in T2, T4, T6, T8, T10, T12, L2, L4, and S2. After postural analysis, the following procedures were performed; 2) preparation and positioning of the Canon digital Power Shot SX500 IS photographic camera, 16 megapixels, positioned on a tripod with level to couple the camera at 2.80m from the evaluated and 0.95m from the ground, with a 35mm lens; 3) a plumb line with two average white markers (BM) 1m apart; 4) acquisition of photographs, observation, and analysis of photos by Samsung computer model AD 4019F; 5) digitization of points in the software; 6) generation of the DIPA Postural Report. The classification of thoracic kyphosis was carried out using the following reference values of the DIPA method for children: increased dorsal kyphosis (angle > 50°) and for lumbar hyperlordosis, the following classification was used: increased lumbar lordosis (angle > 49.5°), scoliosis was classified by the component of the lateral inclination by the scoliotic arrow method [15].

The data were analyzed using frequency and percentage. To compare the associations between the study variables, the Chi-Square test and Fisher's Exact test were used, the latter being used when the assumption of the expected frequency size

was not satisfied. When significant associations were observed, the binary logistic regression model was applied. The data were treated using the IBM SPSS 24 Statistics software program, considering p<0.05.

Results

Table I shows the frequencies (absolute and relative) of the occurrence or not of thoracic hyperkyphosis, according to the different levels of aerobic fitness in the students analyzed. No significant associations were found between aerobic fitness levels and the occurrence or not of thoracic hyperkyphosis in the entire group (p = 0.876) and not considering gender.

Table I - Table I - Aerobic fitness, depending on the occurrence or not of thoracic hyperkyphosis.

Variable	Thoracic hyperkyphosis								
	Total n=380		Female n=204		Male n=176		p-value T	p-value F	p-value M
	Yes	No	Yes	No	Yes	No			
Aerobic fitness									
Healthy	33 (30%)	76 (70%)	17 (255%)	51 (75%)	41 (30%)	94 (70%)	0.876	0.306	0.397
Unhealthy	86 (32%)	185 (68%)	45 (33%)	91 (67%)	16 (39%)	25 (61%)			

T = Total; F = Female; M = Male; * p<0.05.

Table II shows the frequencies (absolute and relative) of the occurrence or not of lumbar hyperlordosis according to the levels of aerobic fitness in the students analyzed. No significant associations were found on the existence or not of lumbar hyperlordosis according to aerobic fitness in the entire group (p = 0.224) and not considering gender. However, when we related aerobic fitness and the occurrence of lumbar hyperlordosis, statistically significant results (p = 0.049) were found in males.

Table II - Aerobic fitness, according to the occurrence or not of lumbar hyperlordosis.

Variable	Lumbar hyperlordosis								
	Total n =380		Female n=204		Male n=176		p-value T	p-value F	p-value M
	Yes	No	Yes	No	Yes	No			
Aerobic fitness									
Healthy	11 (10%)	98 (90%)	4 (6%)	64 (94%)	7 (17%)	34 (83%)	0.224	0.999	0.049*
Unhealthy	16 (6%)	255 (94%)	8 (6%)	128 (94%)	8 (6%)	127 (94%)			

T -Total; F - Fale; M - Male; * p<0.05.

Thus, for the statistically significant result, the odds ratio was analyzed, and it was observed that healthy male students were approximately 3 times more likely to develop lumbar hyperlordosis when compared to unhealthy male students (Table III).

Table III - Logistic regression model for the variable aerobic fitness with lumbar hyperlordosis, for male students.

	Lumbar hyperlordosis		
		p-value	OR
Aerobic fitness	1.18	0.032	3.268

OR = Odds Ratio; *p<0.05.

Table IV shows the frequencies (absolute and relative) of the occurrence or not of scoliosis, according to the different levels of aerobic fitness in the students analyzed. No significant associations were found between aerobic fitness levels and the occurrence of scoliosis in students (p = 0.789).

Table IV - Aerobic fitness, according to the occurrence of scoliosis.

Variable	Scoliosis								
	Total n=380		Female n=204		Male n=176		p-value T	p-value F	p-value M
	Yes	No	Yes	No	Yes	No			
Aerobic fitness									
Healthy	49 (45%)	60 (55%)	28 (41%)	40 (59%)	21 (51%)	20 (49%)	0.789	0.9600	0.4523
Unhealthy	116 (43%)	155 (57%)	58 (43%)	78 (57%)	58 (43%)	77 (57%)			

T -Total; F - Female; M - Male; * p<0.05.

Table V shows the relative and absolute frequency of the levels of physical activity and the occurrence or not of lumbar hyperlordosis, thoracic hyperkyphosis, and scoliosis in the analyzed students, according to the classification recommendations for the levels of physical activity of WHO [14]. When we correlated the occurrence of the three pathologies studied and the level of physical activity, it was observed both in children with lumbar hyperlordosis and in thoracic hyperkyphosis that the individuals analyzed were healthier, 9% and 36% respectively, when compared to unhealthy ones. About scoliosis, very similar results were identified in both groups of healthy and unhealthy students, 43% and 44%, respectively. However, no significant associations were found between the levels of physical activity and the occurrence of the three postural deviations analyzed: lumbar hyperlordosis (p = 0.452); thoracic hyperkyphosis (p = 0.140), and scoliosis (p = 0.894).

Table V - Classification of the level of physical activity, according to the occurrence or not of lumbar hyperlordosis, thoracic hyperkyphosis, and scoliosis.

PA	Lumbar Hyperlordosis		Thoracic Hyperkyphosis		Scoliosis		p-value HL	p-value TH	p-value S
	NO	YES	NO	YES	NO	YES			
Unhealthy (n = 230)	216 (94%)	14 (6%)	165 (75%)	65 (28%)	129 (56%)	101 (44%)	0.452	0.140	0.894
Healthy (n = 150)	137 (91%)	13 (9%)	96 (64%)	54 (36%)	86 (57%)	64 (43%)			
TOTAL (n = 380)	353 (93%)	27 (7%)	261 (69%)	119 (31%)	215 (57%)	165 (43%)			

Note: Physical activity levels were defined as healthy or not, according to the WHO (World Health Organization) indications; PA = Physical activity; LH = Lumbar Hyperlordosis; TH = Thoracic Hyperkyphosis; S = Scoliosis; NS = Not Significant for the x^2 Test.

Discussion

Since the objective of this research was to analyze if there is an association between aerobic fitness, the level of physical activity, and the occurrence of postural deviations in children and adolescents, it was possible to identify, through the analysis of the results, that there was only significant association between a single variable, aerobic fitness and a type of postural deviation, the lumbar hyperlordosis in males.

When Table I was examined, although the levels of aerobic fitness and the occurrence or not of thoracic hyperkyphosis did not show statistically significant results, it was observed that children and adolescents who presented this postural change indicated similar levels of aerobic fitness. However, when we analyzed the association between the occurrence of lumbar hyperlordosis and scoliosis (Table II, IV) and levels of aerobic fitness, the results indicated adequate levels of this component of physical fitness in the group of children with these postural deviations. Still, when we stratified the association between the occurrence of lumbar hyperlordosis and the levels of aerobic fitness between sexes, it was observed that, in the healthy group of boys, the results were statistically significant ($p = 0.0486$), indicating that lumbar hyperlordosis has a three times greater chance of developing in aerobically healthy children (OR = 3.268).

This situation may be related to the fact that students have shown greater participation in aerobic activities with the ball when compared to students who do moderate to vigorous physical activities of muscle strengthening during physical education classes [16]. Thus, it has also been pointed out that boys who practice light, moderate, and vigorous sports activities are more frequent in this type of physical exercise when compared to the group of girls who practice physical activities in a school environment [17]. It is noteworthy that the physical activities mentioned have the aerobic capacity as an essential characteristic. Therefore, other components of Health-Related Physical Fitness (HRPF), such as cardiorespiratory endurance, muscle fitness (strength and endurance), flexibility, and body composition [18] could be influencing the development of lumbar hyperlordosis, thus suggesting that only and in isolation, aerobic fitness might not be a factor in preventing postural deviations. In this sense, Molina-Garcia *et al.* [19] point out that all components of physical fitness related to health are associated with good alignment of the lumbar and thoracic

spine. And yet, the authors Coledam, Batista Júnior and Glaner [20] point out that a single component of physical fitness related to health cannot classify the general level of this physical condition among children and adolescents.

Other studies also signal the importance of additional components of HRPF for the general development of the health of the child and adolescent population, as pointed out by the researchers Ortega *et al*. [21]. Their research reports that muscle strength and endurance had a higher positive contribution to the health of the skeletal system when compared to cardiorespiratory resistance. Still, the authors Lemos *et al*. [22] pointed out, in their work, an association between lumbar hyperlordosis and low levels of strength among the children analyzed, as it has also been observed specifically, the great preference for physical activities that stimulate aerobic fitness among males, equally pointed out by the research of Chen *et al*. [23], which reports a significant association between this component of HRPF and the time spent on physical activity among boys.

In table V, when analyzing the association between the level of physical activity and the three postural deviations analyzed (thoracic hyperkyphosis, lumbar hyperlordosis, and scoliosis), no statistically significant results were found ($p > 0.05$). Our study confirms the research by Conceição, Henrique, and Neto [9], who also found no significant association between the level of physical activity in adolescents between 15 and 18 years of age and lumbar hyperlordosis. However, the authors identified that boys with this pathology were physically active, considering that the nature of physical activity directly influences the components of physical fitness. The researchers, Oliveira *et al*. [24] similarly did not show statistically significant results when they related the practice of physical activity with the postural control of children and adolescents between 8 and 11 years of age.

On the other hand, the study by Sedrez *et al*. [8] pointed out a significant association between lumbar lordosis, back pain, and physical exercise among students aged 11 and 16 years old. It was observed that 95.5% of students who practiced physical activity, 59.7% were active three or more days a week, and 56.5% practiced exercise competitively. Thus, in the study by Latalski *et al*. [7], an association was also found between postural deviations in 14-year-old children and the type of physical activity performed (actively or passively), and it was observed that children who exercised with passive physical activities, presented a higher percentage of changes postural (15%) when compared to children who had postural deviations and actively exercised (14.5%).

All of the studies mentioned above met in part the guidelines and recommendations for the practice of physical activity, as the regularity of the practice of physical activity must be based not only and in isolation on one of its aspects but must cover the three pillars of support and development for the health of children and adolescents, which are: the type, quantity, and quality of physical exercise [3]. In this regard, the systematic review and meta-analysis of Marker, Steele & Noser [25] recently pointed out the need for future research to analyze the relationship between the level of physical activity and the quality of life related to the health of young individuals, emphasizing the importance of evaluating all components of physical activity, such as type, intensity, duration, and frequency. Taking into account all ACSM [18] and WHO [14] guidelines for the practice of physical activity in children and adolescents, who recommend aerobic physical activities of 60 minutes daily and bone-strengthening 3 times per week, included in the weekly total of 300 minutes; in addition to performing at least 3 times per week of muscle strengthening, from 8 to 15 repetitions of submaximal exercise in structured and unstructured physical activities.

Conclusion

Boys with lumbar hyperlordosis had adequate levels of aerobic fitness. Other risk factors seem to influence the occurrence of lumbar hyperlordosis and, it is possible to observe that the chance of this postural deviation manifesting itself in children with good aerobic fitness is three times more than when compared to unhealthy children. It indicates that perhaps other components of Health-Related Physical Fitness, such as muscle fitness, could be influencing the manifestation of this postural deviation.

Potential conflict of interest
No conflicts of interest have been reported for this article.

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Authors' contributions
Conception of the research project: Montenegro CM. **Data collection, analysis and interpretation:** Montenegro CM. **Writing of the scientific article:** MontenegroCM and Santos JOL. **Critical review of intellectually important content:** Tozo TA, Pereira BO and Santos JOL.

References

1. Fredriksson SV, Alley SJ, Rebar AL, Hayman M, Vandelanotte C, Schoeppe S. How are different levels of knowledge about physical activity associated with physical activity behaviour in Australian adults? PLoS One 2018;13(11):e0207003. https://doi.org/10.1371/journal.pone.0207003

2. Williams PT. Dose-response relationship of physical activity to premature and total all-cause and cardiovascular disease mortality in walkers. PLoS One 2013;8(11). http://doi.org/ 10.1371/journal.pone.0078777

3. Weggemans RM, Backx FJ, Borghouts L, Chinapaw M, Hopman MT, Koster A *et al*. The 2017 Dutch physical activity guidelines. Int J Behav Nutr Phys Act 2018;15(1):58. https://doi.org/10.1186/s12966-018-0661-9

4. Foster C, Moore JB, Singletary CR, & Skelton JA. Physical activity and family based obesity treatment: a review of expert recommendations on physical activity in youth. Clinical Obesity 2018;8(1):68-79. http://doi.org/ 10.1111/cob.12230

5. Brzęk A, Knapik A, Sołtys J, Gallert-Kopyto W, Famuła-Wąż A, Plinta R. Body posture and physical activity in children diagnosed with asthma and allergies symptoms: A report from randomized observational studies. Medicine 2019;98(7):1-7. https://doi.org/10.1097/MD.0000000000014449

6. Schramm JMDA, Oliveira AFD, Leite IDC, Valente JG, Gadelha ÂMJ, Portela MC, Campos MR. Transição epidemiológica e o estudo de carga de doença no Brasil. Ciênc Saúde Coletiva 2004;9:897-908. http://doi.org/10.1590/S1413-81232004000400011

7. Latalski M, Bylina J, Fatyga M, Repko M, Filipovic M, Jarosz MJTT. Risk factors of postural defects in children at school age. Ann Agric Environ Med 2013;20(3):

8. Sedrez JA, Furlanetto TS, Noll M, Gontijo KNS, da Rosa BNCC. Relação entre alterações posturais e hábitos de vida de escolares do ensino fundamental. Rev Baiana Saúde Pública 2014;38(2):279-96. http://doi.org.10.5327/Z0100-0233-2014380200005

9. Conceição F, Henrique J NG. Hiperlordose lombar em adolescentes e sua associação com atividade física e aptidão musculoesquelética. Brasília Méd 2011;48(1):35-41.

10. Gallahue DL, Ozmun JCGJ. Compreendendo o desenvolvimento motor: bebês, crianças, adolescentes e adultos. 7 ed. Porto Alegre: Phorte; 2013.

11. Brasil. Estatuto da criança e do adolescente: Lei no 8.069 de 13 de julho de 1990, e legislação correlata [recurso eletrônico]. Brasília: Câmara dos Deputados, Edições Câmara, 2010. 207 p. – (Série legislação, 83). Disponível em: http://www.crianca.mppr.mp.br/arquivos/File/publi/camara/estatuto_crianca_adolescente_9ed.pdf.

12. Welk GJ, De Saint-Maurice Maduro PF, Laurson KR, Brown DD. Field evaluation of the new FITNESSGRAM®criterion-referenced standards. Am J Prev Med 2011;41(4Suppl2):S131-42. https://doi.org/10.1016/j.amepre.2011.07.011

13. Matsudo S, Araújo T, Matsudo V, Andrade D, Andrade E, Oliveira LCBG. International physical activity questionnaire (IPAQ): study of validity and reliability in Brazil. Rev Bras Ativ Fis Saúde 2001;6(2):5-18. https://doi.org/10.12820/rbafs.v.6n2p5-18

14. World Health Organization (WHO). Global recommendations on physical activity for health. Geneva: World Heal Organ; 2010. p. 60. https://www.who.int/dietphysicalactivity/publications/9789241599979/en/7.

15. Furlanetto TS, Candotti CT, Comerlato T, Loss JF. Validating a postural evaluation method developed using a Digital Image-based Postural Assessment (DIPA) software. Comput Methods Programs Biomed 2012;108(1):203-12. https://doi.org/10.1016/j.cmpb.2012.03.

16. Tanaka C, Tanaka M, Tanaka S. Objectively evaluated physical activity and sedentary time in primary school children by gender, grade and types of physical education lessons. BMC Public Health 2018;18(1):948. https://doi.org/10.1186/s12889-018-5910-y

17. Borghese MM, Janssen I. Duration and intensity of different types of physical activity among children aged 10–13 years. Can J Public Health 2019;110(2):178-86. https://doi.org/10.17269/s41997-018-0157-z

18. Medicine ACS. Diretrizes do ACMS para testes de esforço e sua prescrição. 10 ed. Rio de Janeiro: Guanabara Koogan; 2018.

19. Molina-Garcia P, Plaza-Florido A, Mora-Gonzalez J, Torres-Lopez LV, Vanrenterghem J, Ortega FB. Role of physical fitness and functional movement in the body posture of children with overweight/obesity. Gait & Posture 2020;80:331-8. https://doi.org/10.1016/j.gaitpost.2020.04.001

20. Coledam DHC, Batista Júnior JP, & Glaner MF. Low agreement between the fitnessgram criterion references for adolescents. Rev Paul Pediatr 2015;33(2):181-6. https://doi.org/10.1016/j.rpped.2014.11.010

21. Ortega FB, Ruiz JR, Castillo MJ, Sjöström M. Physical fitness in childhood and adolescence: a powerful marker of health. Int J Obes 2008;32(1):1-11. https://doi.org/ 10.1038/sj.ijo.0803774

22. Lemos AT, Santos FR, Gaya ACA. Hiperlordose lombar em crianças e adolescentes de uma escola privada no Sul do Brasil: ocorrência e fatores associados. Cad Saúde Pública 2012;28(4):781-8. https://doi.org/10.1590/S0102-311X2012000400017

23. Chen W, Hammond-Bennett A, Hypnar A, Mason S. Health-related physical fitness and physical activity in elementary school students. BMC Public Health 2018;18(1):195. https://doi.org/10.1186/s12889-018-5107-4

24. Oliveira TPD, Santos AMDC, Andrade MCD, Ávila AOV. Controle postural de crianças praticantes e não praticantes de atividade física regular. Rev Bras Biomecânica 2008;9(16):416.

25. Marker AM, Steele RG, Noser AE. Physical activity and health-related quality of life in children and adolescents: A systematic review and meta-analysis. Health Psychology 2018;37(10):893-903. https://doi.org/10.1037/hea0000653