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NUTRITIONAL STATUS, PHYSICAL ACTIVITY LEVEL, WAIST CIRCUMFERENCE, AND FLEXIBILITY IN BRAZILIAN BOYS

ESTADO NUTRICIONAL, NÍVEL DE ATIVIDADE FÍSICA, CIRCUNFERÊNCIA DE CINTURA E FLEXIBILIDADE EM MENINOS BRASILEIROS

ABSTRACT

This study examined the relationships between nutritional status, physical activity, waist circumference, and flexibility in boys. The sample comprised 74 boys (11,8 years old, SD= 1,6). The following were measured: body weight, height, waist circumference, physical activity, body fat (bioelectrical impedance) and flexibility. Body fat percentage was calculated, and the children were classified as well nourished (G1), overweight (G2), or obese (G3) according to the age and sex adjusted cutoffs described by Taylor et al.[18]. The statistical procedures adopted were: mean, standard deviation, analysis of variance, chi-square test, linear correlation and binary logistic regression. The level of significance was set at $p < 0.05$. There was a statistical difference between G3 and G1 in flexibility scores (p = 0.048). Obese and inactive boys were more than twice as likely to exhibit a poor flexibility score than well nourished and active boys, respectively (odds ratio= 2.9; p = 0.046, and 5.1; p = 0.047, respectively). This study identified the existence of relationship and association between obesity, physical inactivity and poor performance in flexibility test.

Key words: Flexibility; Body fat; Physical activity; Waist circumference.

RESUMO

Este estudo examinou o relacionamento entre estado nutricional atividade física, circunferência de cintura e flexibilidade em meninos. A amostra compreendeu 74 meninos (11,8±1,6 anos). Foram medidos o peso corporal, a estatura, a circunferência de cintura, atividade física, gordura corporal (impedância bioelétrica) e flexibilidade. O percentual de gordura corporal foi calculado e os sujeitos foram classificados como eutróficos (G1), com sobrepeso (G2) ou obesos (G3) de acordo com a tabela específica para sexo e idade proposta por Taylor et al.[18]. Os procedimentos estatísticos adotados foram: média, desvio-padrão, análise de variância, teste qui-quadrado, correlação linear e regressão logística binária. O nível de significância foi estabelecido em $P < 0.05$. Houve diferenças entre G3 e G1 nos escores de flexibilidade (p = 0,048). Garotos inativos e ou obesos, quando comparados a garotos ativos e ou eutróficos, possuíam mais do que duas vezes mais chances de apresentar um escore baixo de flexibilidade (razão de chance= 2,9; p = 0,046, e 5,1; p = 0,047, respectivamente). Este estudo identificou a existência de relação e associação entre obesidade, inatividade física e fraca performance no teste de flexibilidade.

Plavras-chave: Flexibilidade; Gordura corporal; Atividade física; Circunferência de cintura.

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INTRODUCTION

The rapid increase in obesity worldwide[1] is a concern among health professionals and is one of the most significant public health challenges. The high prevalence of obesity is a concern because of its association with several risks factors for heart and other chronic diseases later in life[2,3], and hence, significant increase in number of "years of life lost"[4], and to increased healthcare costs on treatment[5].

The development of obesity in the human body is complex, and can be broken down into components of genetic and environmental origins. Inappropriate food intake and reduced level of physical activity are two environmental components, and in combination are strongly associated with the development of the obesity[6].

Physical activity level (PAL) can be a determinant factor in development of and/or protection against excessive weight gain, and has a relationship with all four components of health-related physical fitness: muscular strength and endurance[7], body composition[8], cardiorespiratory endurance[8], and flexibility[9]. In general, studies have reported that higher values of body mass index (BMI) are associated with a poor performance in all fitness tests, except flexibility[10,11].

Regarding flexibility, during a human's life, it is an important physical skill to accomplish most daily activities, and shows a positive relationship with PAL[9]. Based on the results of prior studies reporting that obese individuals are less active than their non obese counterparts[12], it is feasible that obesity is associated with lower flexibility scores. However, this assumption is not confirmed.

One possible explanation for these indecisive results is based on the use of body mass index (BMI) as the principal index of adiposity in all studies that have analyzed this relationship. In epidemiological studies, BMI is a useful index of adiposity. Nevertheless, it exhibits limitations for the identification of nutritional status[13], and, furthermore, previous studies have indicated that BMI may not be the best measure of body fatness in children[14].

Due to the absence of studies that have evaluated nutritional status based on body fat levels, and later analyzed its relationship with flexibility. The purpose of this study was to verify the existence of possible relationships between waist circumference (WC), PAL, and flexibility in Brazilian boys with varying nutritional status.

METHODS

Sample

The sample size of 71 subjects was calculated to detect an obesity prevalence of 8% (prevalence observed in schoolchildren from the city in a prior pilot study), with absolute precision of 6.3% and significance of 5%. The study was conduced in the town of Presidente Prudente (population ~180,000), located in the west of São Paulo State, southeast region of Brazil. The sample was recruited through advertisements in a local newspaper. The advertisements invited male subjects (any nutritional status) from nine to 14 years old interested in participating in a body composition assessment and a physical activity program free of charge (a University project). Informed written consent was obtained from the participants and their parents before they were enrolled on the study. At the start of the study, 81 individuals presented at the laboratory indicated in the advertisements. However, some of the children had not returned their written informed consent form (*n*= 5), and others were female (*n*= 2). Individuals were excluded from the analysis if any of the data to be collected was missing (*n*= 1). The sample therefore comprised 73 Brazilian boys with an age range of nine to 14 years. The ethics committee at the (São Paulo State University), UNESP - Presidente Prudente approved the study.

Anthropometry

Inside the laboratory, data were collected on body weight and stature. Body weight was measured to the nearest kg using a Filizola scale. Stature was measured to the nearest cm using a wall-mounted stadiometer. The BMI was then calculated by dividing weight by the stature squared (kg/m^2).

The WC was measured in duplicate with an anthropometric tape (cm), at the minimum circumference between the iliac crest and the rib cage. Based on the age and sex specific cutoffs for WC presented by Taylor et al.[15], the sample was classified as having normal (*n*= 33; 45.2%) or elevated WC (*n*= 40; 54.8%). All the anthropometric methods used in this study are those presented by Lohman et al.[16].

Nutritional Status

Whole-body resistance and reactance were measured with use of a tetrapolar bioelectrical body composition analyzer (BIA Analyzer – 101Q, RJL Systems, Detroit, USA). The unit was calibrated before testing using the 500-ohm resistor provided by the manufacturer, and resistance and reactance were recorded to the nearest ohm. The BIA measurement took place in the morning after overnight fasting and after voiding, in a supine position on a flat, nonconductive bed. Subjects removed socks, shoes, and any metal jewelry before measurement. Source electrodes were placed on the posterior surface of the right hand at the distal end of the third metacarpal and on the anterior surface of the right foot at the distal end of the second metatarsal, and were at least 5cm distal of the receiving electrodes, which were placed between the styloid processes of the radius and ulna and between the medial and lateral malleoli of the ankle[17].

The body fat percentage (%BF-BIA) was calculated using the manufacturer's software. The entire sample was then classified as well nourished (G1), overweight (G2), or obese (G3), according to the age and sex specific cutoffs for %BF presented by Taylor et al.[18].

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Physical Activity Level

The PAL was assessed using the International Physical Activity Questionnaire (IPAQ)[19], in its short version. All 73 boys were assembled in an auditorium, and after a lecture of 15 minutes (on how to complete it correctly, and providing examples of physical activity intensities), filled out the IPAQ. There was no communication between the subjects during the filling-out of the questionnaire, and researches helped any boys who had doubts. The cutoffs adopted for PAL are those presented by Cavill et al.[20]. The time spent in vigorous and moderate physical activities (min/day) were calculated, and the entire sample was classified as active (more than 60 min/day of moderate and vigorous activity) or inactive (less than 60 min/day of moderate and vigorous activity). One week later, the IPAQ was applied to a randomly selected subset of the sample (*n*= 20), to calculate interclass correlation (*r*) for the physical activity time (min/day), and Kappa index (*K*) for the physical activity level (active and inactive). The observed values were high (*r*= 0.85 and *K*= 0.80, respectively).

Flexibility

In the study presented here, the sit and reach test (SRT) was adopted as flexibility indicator. This test measures the flexibility of the hamstrings, buttocks, and lower back. During performance of the SRT, the procedures presented by the American Alliance for Health Physical Education Recreation and Dance (AAHPERD) were adopted[21]. Flexibility scores were measured to the nearest cm. The age and sex specific cutoffs for SRT proposed by AAHPERD were adopted, and the subjects were classifieds as “fit” or “unfit” in the flexibility test.

Statistical Procedures

The Komolgorov-Smirnov test was adopted to assess data distribution, and all data were adjudged to be normally distributed. Quantitative variables are presented as mean values and standard deviations, while qualitative variables are presented as relative frequencies. Pearson’s correlation was adopted to analyze the relationships between %BF-BIA, WC, PAL, and the SRT score. The homogeneity of variances was assessed through Levene’s test, and again all data were adjudged to be normality distributed. Thus, the analysis of variance (one-way ANOVA) was adopted to compare the mean values between the three levels of nutritional status. When necessary, post hoc analysis was performed using the Tukey correction. Chi-square was used to test variations in the prevalence of “fitness” and “unfitness”; physical activity and physical inactivity; and normal and elevated WC between the three body fat categories. The association of predictive variables with performance in SRT (fit or unfit) was examined using binary logistic regression analysis.

The analysis was carried out using SPSS version 10.0 (Statistical Package for Social Science, SPSS Inc, Illinois, USA). The level of significance was set at $p < 0.05$.

RESULTS

The general characteristics of the sample are shown in Table 1. According to nutritional status, there

Table 1. General characteristics of the sample.

Variables	G1 (*n*= 32)		G2 (*n*= 30)		G3 (*n*= 11)		P
	Mean	SD	Mean	SD	Mean	SD	
Age (years)	12.1	1.3	11.8	1.4	11.1	1.6	0.181
Body weight (kg)	44.5	11.1	61.1	14.4	70.1	17.4	0.001
Stature (m)	1.56	0.11	1.56	0.10	1.52	0.12	0.634
BMI (kg/m ^{2})	18.1	2.4	24.6	3.4	29.8	4.4	0.001
WC (m)	0.65	0.07	0.83	0.10	0.96	0.08	0.001
%BF-BIA	13.5	3.8	28.2	3.9	39.1	2.8	0.001
PAL (min/day)	72.8	34.2	68.5	31.4	38.5	12.8	0.098

Note: BMI= body mass index; WC= waist circumference; PAL= physical activity level; G1= well nourished group; G2= overweight group; G3= obese group; SD= standard deviation

Table 2. Sit and reach test performance, physical activity level and waist circumference according to body fat categories.

Classification		G1 % (*n*)	G2 % (*n*)	G3 % (*n*)	P*
SRT	Fit boys	56.2% (18)	50.0% (15)	18.2% (02)	0.052
	Unfit boys	43.8% (14)	50.0% (15)	81.2% (09)	
PAL	Active boys	31.2% (10)	16.7% (05)	27.3% (03)	0.105
	Inactive boys	68.8% (22)	83.3% (25)	72.7% (08)	
WC	Normal values	93.8% (30)	10.0% (03)	0% (0)	0.001
	Elevated values	6.2% (02)	90.0% (27)	100% (08)	

***Note:** *= chi-square test; SRT= sit and reach test; WC= waist circumference; PAL= physical activity level; G1= well nourished group; G2= overweight group; G3= obese group* was a statistical difference in the variables: body weight, WC, BMI, and %BF.

The scores obtained in SRT, PAL, and WC were classified according to body fat levels (G1, G2, and G3 - Table 2)[15,20,21]. The highest WC values were observed in G3. There were no associations between body fat levels, PAL and SRT performance.

Table 3 shows the mean SRT scores, according to body fat levels. There was a significant differences between G1, which presented the highest flexibility score, and G3 (*p* = 0.048). No differences were found between G1 and G2, or between G2 and G3 (p = 0.856, and p = 0.117, respectively).

Table 3. Mean values for sit and reach test, and Pearson's correlation between sit and reach test, body fat, waist circumference and physical activity level.

Groups (SRT)	SRT and %BF	SRT and WC	SRT and PAL
G1 (26.2±6.1)	*r*= - 0.06	*r*= 0.27	*r*= 0.40* (r^2= 0.16)
G2 (25.2±7.5)	*r*= - 0.04	*r*= 0.21	*r*= 0.14
G3 (20.2±8.4)[a]	*r*= - 0.66* (r^2= 0.44)	*r*= - 0.36	*r*= 0.46

Note: **= P<0.05; [a]= different to G1; SRT= sit and reach test; %BF= body fat percentage; WC= waist circumference; PAL= physical activity level; G1= well nourished group; G2= overweight group; G3= obese group*

There was a significant correlation between %BF-BIA and SRT for G3 (p = 0.025), and no correlations were found in G1 (*P* = 0.744) or G2 (p = 0.834). There was only a significant correlation between PAL and SRT in G1 (p = 0.022). In all nutritional status groups, there was no correlation between WC and SRT score.

Table 4. Logistic regression analysis with sit and reach test performance as dependent variable

Independent Variables		Exp (B)	Confidence interval 95%	p
WC	Normal	ref	(0.64 – 4.11)	0.306
	Elevated	1.6		
PAL	Active	ref	(1.01 – 8.30)	0.046
	Inactive	2.9		
%BF-BIA	G1 and G2	ref	(1.02 – 25.65)	0.047
	G3	5.1		

Note: *ref = reference; WC= waist circumference; PAL= physical activity level; G1= well nourished group; G2= overweight group; G3= obese group*

The logistic regression analysis indicated that those who are obese, and/or physically inactive, were likely to present a poorer score in SRT (unfit). There was no associations between elevated WC and poor SRT performance.

DISCUSSION

Due to its associations with the development of chronic diseases[2,3], obesity is identified by health professionals as the most significant public health challenge. Prior studies have showed that elevated BMI exhibits a negative relationship with all physical fitness tests, except for SRT (flexibility indicator)[11,22]; However, one possible explanation for the absence of a relationship between obesity and flexibility observed in these studies, can be the use of BMI as the principal indicator of nutritional status. Although BMI is the most widely used body fatness indicator and offers a consistent correlation with total body fat[23], it has limitations for indicating nutritional status correctly[13]. Moreover, prior studies have shown that BMI is not the best measure of body fatness in children[14]

Therefore, to fill a gap in the absence of a relationship between flexibility and obesity, the authors believe that obesity levels need to be assessed based on body fat levels, and other important variables must be included in the investigation (WC and PAL). On the subject of the assessment of nutritional status, BIA is a good method for assessing body fat values in large samples[24]. Therefore, the %BF-BIA, and hence, nutritional status of the sample were assessed through use of the BIA.

In our study, although not significant, the rate of boys classified as unfit was higher in the obese group than in the other groups analyzed, and was higher than the data observed in other studies[10]. A similar tendency was observed mean flexibility values, where, in accordance with body fat levels, the obese boys exhibited the lowest scores in the SRT. Moreover, these scores were lower than has been observed in prior studies[9]. However, there were only statistical differences between the well nourished and the obese groups (not between well nourished and overweight groups).

These results may suggest that only obesity and not overweight influences flexibility. This hypothesis is confirmed when the linear correlation values are considered, where only the obese group's flexibility score exhibited a negative, and significant correlation with %BF. In relation to the absence of a relationship between overweight and flexibility, these results are in agreement with other studies[10,11]. In our study, the influence of obesity on flexibility was also confirmed by logistic regression analysis. The odds ratio indicated that obese boys have the highest likelihood of being classified as unfit in SRT.

In adult subjects, WC values are a useful indicator of body fat distribution, and are strongly associated with the development of diseases. In children, WC also represents a good, and useful adiposity indicator[15,25]. In this study, the initial author's assumption was that, during the realization of the SRT, elevated values of body fat accumulated in the trunk region (characteristic of obesity) could be a biomechanical limitation factor to the realization of the SRT. In the study presented here, the obese group exhibited the highest mean WC

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values, and highest rates of elevated WC, however, our results reject the hypothesis that WC influences flexibility. This rejection is based on the results of the linear correlation and logistic regression analysis. The linear correlation did not indicate the existence of a significant relationship between WC values and flexibility score in any of the groups, and the logistic regression analysis did not indicate the existence of an association between elevated WC and poor performance in SRT. Therefore, the authors point out that elevated WC is not a biomechanical factor with influence on flexibility.

Prior studies have indicated that flexibility and PAL exhibit a positive relationship, [9] and some studies[12], but not all[26], that obese individuals are less active than their lean counterparts. In our findings, according to the three nutritional status groups, there were no differences in time spent in moderate and vigorous physical activities.

The lack of association between PAL and nutritional status might reflect that other variables, such as inappropriate food intake and inactive behavior, have a greater influence than physical activity on obesity development[14,26,27]. With relation to inactive behavior, our results indicate the existence of an association between insufficient physical activity and poor performance in SRT. Moreover, in agreement with other studies[9], the results presented here also confirm the existence of a positive relationship between PAL and flexibility score (well nourished group).

These results indicate the importance, during childhood, of combating the increased amount of time spent in sedentary activities, and therefore the unhealthy behavior related to it (inappropriate food intake during computer use or TV viewing). Furthermore, as is true for adults, this study confirms the relevance of engaging in physical activity programs aiming at the improvement of flexibility in children[8,9,25,26].

This paper is the first to indicate the existence of an association between nutritional status and flexibility in children, in disagreement with other studies that used BMI as adiposity indicator and failed to find such a relationship[10,11]. These controversial results can be attributed to the fact that flexibility exhibits relationships with both physical activity and physical inactivity, whereas BMI is comprised of both fat mass and lean mass, and at the same time is influenced by different forms of physical activity levels and physical inactivity levels[14,26]. Therefore, other useful body fatness indicators, such as the fat mass index[23] and %BF-BIA, should be used to analyze the relationship between flexibility and obesity.

The limitations of this study should be recognized, and the findings must be interpreted in the light of these limitations. The first limitation of the study is its design. The study is cross-sectional, therefore it is not possible to infer a causal relationship. Moreover, the measures of physical activity levels were self-reported, and the group of obese boys had a smaller number of subjects. Therefore, the authors suggest that future studies could use more objective measures of physical activity, including a higher number of obese subjects, and also analyze this relationship with females.

CONCLUSION

In summary, our findings show that, in the obese group only, body fat percentage and flexibility score exhibited a significant correlation, and that obese boys exhibited lower scores and performance in the flexibility test than well-nourished boys. Furthermore, our findings demonstrate that physical inactivity is associated with poorer performance in the SRT, and that elevated WC does not exhibit an association and/or relationship with performance in the SRT.

Therefore, these results could be used to promote public actions among children aiming at the promotion of a more active lifestyle, which improve the performance in health-related physical fitness components, and hence protect the future adult against the development of chronic diseases.

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