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ORIGINAL ARTICLE

Association between forced expiratory volume and waist-hip ratio in school with overweight and obesity

Associação entre volume expiratório forçado e a relação cintura-quadril em escolares com sobrepeso e obesidade

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KEYWORDS
Obesity
Adolescents
Waist-hip ratio

ABSTRACT

Objective: To evaluate the association between forced expiratory volume in the first second (FEV1) and waist-to-hip ratio (WHR) in overweightand obese students. **Method:** A cross-sectional study was conducted to evaluate children and adolescents of both sexes (7 to 17 years old) classified according to body mass index (BMI) in the eutrophic (EG), overweight (OWG), and obesity group (OG). The WHR and pulmonary volumes were evaluated using digital spirometry. **Result:** Sample (N=320) with an average age of 11.51 ± 2.74 years (EG [n=140]; OWG [n=88]; OG [n=92], with WHR of 0.78 [0.73 – 0.82] cm, 0.80 [0.76 – 0.83] cm, and 0.85 [0.80-0.89] cm, respectively. There was a significant difference in FEV1 between OG (2.20 L) and EG (2.71 L) (p= 0.037), with WHR varying between EG (0.78 cm) and OG (0.85 cm) (p<0.001) and between OWG (0.80 cm) and OG (0.85) (p<0.001). There was a significant, inverse, and moderate correlation between WHR and FEV1 in the EG (p<0.001, r= -0.448) and OWG (p<0.001, r= -0.421) whereas in the OG, there was a significant, inverse, and weak correlation (p<0.002, r=-0.325). **Conclusion:** FEV1 was inversely associated with WHR, indicating that excess body weight affects lung function.

PALAVRAS-CHAVE
Obesidade
Adolescentes
Relação cintura-quadril

RESUMO

Objetivo: Avaliar a associação entre o volume expiratório forçado no primeiro segundo da capacidade vital forçada (VEF1) e a relação cintura-quadril (RCQ) de escolares com sobrepeso e obesidade. **Método:** Estudo transversal que avaliou indivíduos de ambos os sexos de 7 a 17 anos, alocados de acordo com o índice de massa corporal (IMC) no Grupo Eutrófico (GE), Sobrepeso (GS) e Obesidade (GO). A função pulmonar foi avaliada por espirometria digital e a RCQ por meio de medida antropométrica. **Resultado:** Amostra (N=320; GE [n=140]; GS [n=88] e GO [n=92]) com média de idade de 11,51±2,74 anos e com RCQ de 0,78 [0,73 – 0,82] cm, 0,80 [0,76 – 0,83] cm e 0,85 [0,80 – 0,89] cm, respectivamente. Houve diferença significativa no VEF1 entre GO (2,20 L) e GE (2,71 L) (p= 0,037) e da RCQ entre GE (0,78 cm) e GO (0,85 cm) (p<0,001), bem como entre GS (0,80 cm) e GO (0,85 cm) (p<0,001). Houve associação significativa, inversa e moderada

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entre a RCQ e o VEF1 no GE (p<0,001; r= -0,448) e no GS (p<0,001; r= -0,421), enquanto no GO, houve associação significativa, inversa e fraca (p<0,002; r= -0,325). **Conclusão:** Escolares obesos apresentaram menor VEF1 em relação aos eutróficos, entretanto, ocorreu associação inversa entre tal volume pulmonar e a RCQ independente do peso corporal.

INTRODUCTION

Obesity is one of the most prevalent public health problems in the world, resulting from excess body fat and characterizedby a low-degree inflammatory state that can influence lung function[1].

Overweight, in turn, is defined as the occurrence of a greater than desirable weight ratio for a given height, resulting in a body mass index (BMI) in the percentile curve between 85% and 95% for the age group[2].

Obesity increases the incidence of cardiovascular diseases[3], metabolic syndromes[3], and respiratory dysfunctions[4], which contribute to higher morbimortality in this population in the adult phase.

The waist-to-heel ratio (WHR), in turn, is an anthropometric measure widely used to measure central obesity in adults[5] and children and adolescents[6] with metabolic syndromes[3]. The anthropometric markers of overweight or obesity are associated with respiratory dysfunctions resulting from changes in respiratory mechanics and can cause a reduction in pulmonary volumes and capacities with subsequent reduction of exercise capacity and quality of life[7].

Adiposity may alter lung function owing to low thoracic expansibility, reduced airway radius, and respiratory muscle strength, as well as the inhomogeneity of the ventilation/perfusion ratio[8].

Excess weight causes accumulation of adipose tissue on the chest and abdominal surface, contributing to the reduction of residual functional capacity and expiratory reserve volume, increasing the risk of limitation of expiratory flow and the closure of the airways[1].

However, there are inconsistencies in the published studies regarding the existence of a causal relationship between obesity and lung function[9,10], and it is not possible to extrapolate the evidence existing in adults because children and adolescents are still in the process of developing lung function and the configuration of the chest wall[11].

Given the above, the present study aimed to assess the type of association existing between the forced expiratory volume in the first second of forced vital capacity (VEF_1) and the WHR of overweight and obese children and adolescents.

METHODS

This is a cross-sectional study secondary to a research project entitled "Correlation between lung volumes and performance in the six-minute step test in adolescents with normal weight, overweight and obesity", which evaluated children and adolescents of both genders and ages between 7 and 17 years who were regularly enrolled in municipal and state schools in Santa Cruz do Sul in the Rio Grande do Sul state of Brazil, from May to November 2016.

The study was approved by the Research Ethics Committee of the University of Santa Cruz do Sul (decision nº 1.514.647; CAEE nº 52651915.0.0000.5343). The study protocol followed Resolution 466/12 of the Brazilian National Council of Health.

Healthy individuals of both sexes (7 and 17 years old) duly enrolled in municipal, state, private, urban, and rural schools in the municipality of Santa Cruz do Sul were included. Students with diabetes or cancer and those with disabilities, orthopedic, or cognitive problems that made it impossible to adequately understand the instructions for performing the tests were excluded.

Individuals were allocated according to BMI into the Eutrophic (EG), Obesity (OG), or Overweight Group (OWG).

The sample size calculation considered the first 10 participants from each group analyzed, with a significance level of 5%, statistical power of 95%, and coefficient of determination for the correlation between FEV_1 and WHR (r^2) of 0.270 for the EG, 0.056 for OWG, and 0.406 for OG, defining a sample of 281 participants. A 10% loss was also added, totaling a minimum sample size of 310 participants.

Data collection and instruments

The screening of students was carried out in schools in the municipality of Santa Cruz do Sul, from which authorizations were obtained to carry out data collection. Initially, contact was made with the management of the aforementioned schools to schedule the research team's visit to screen adolescents who met the research inclusion criteria. Identification, height, weight, and BMI data were obtained, and anamnesis was carried out with the individual or their legal guardian. To assess body weight, an anthropometric scale (Welmy®, model R-110, Brazil) was used, with height assessed using a stadiometer attached to the scale.

The students remained in the Frankfurt position, with the BMI obtained by the ratio between weight/height^2 (kg/m^2) and classified according to the percentile curves published by the World Health Organization (WHO) paired by age and sex, considering overweight, those with percentile ≥85 and <97 and obese, those with percentile ≥97[12,13]. Ethnicity was classified as caucasian, mixed race, and afrodescendant through self-identification, respecting the personal perception of the identity of the individual or their legal guardian, and also based on specific criteria defined by the Brazilian Institute of Geography and Statistics (IBGE)[14].

Waist circumference (WC) was measured using an inextensible measuring tape (cm) (Sanny Medical® model SN-4010, Brazil), which was positioned above the umbilical scar, and measurements were obtained at the end of expiration.

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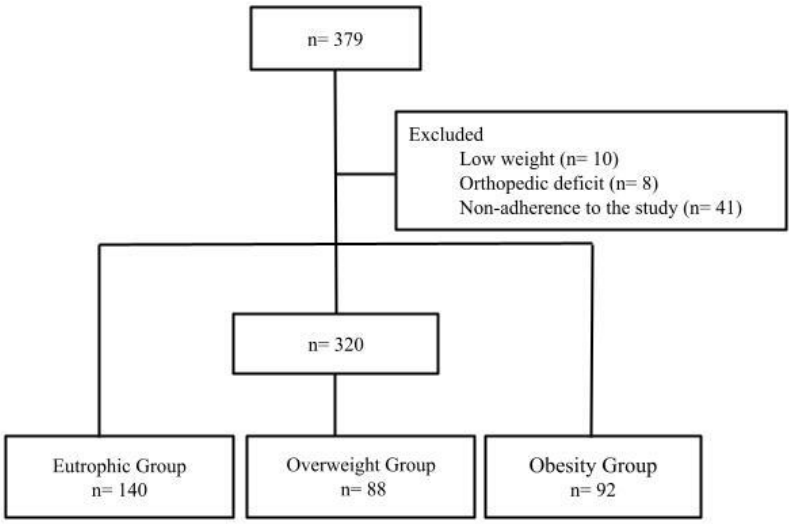

Figure 1. Study participant selection flowchart.

Hip circumference (HC) was measured in the region with the largest perimeter between the waist and thigh, and WHR was calculated as the ratio of WC to WH[15]. FEV_1 was obtained through digital spirometry (MicroLoop MK8® Care Fusion, Germany) performed by asking the individual to perform maximum inspiration up to total lung capacity (TLC), followed by forced expiration up to the residual volume, which was the best of three curves obtained under the acceptability criteria of the Brazilian Society of Pulmonology and Tisiology[16] and the American Thoracic Society and European Respiratory Society[17]. Predicted values were expressed as described by Knudson et al.[18].

Statistical analysis

Data were expressed as absolute frequencies, means, and standard deviations or as medians and interquartile ranges, depending on their distribution characteristics.

Intergroup comparisons were performed using the Kruskal-Wallis test with Dunn's post hoc test, and associations were measured using the Spearman Correlation test ($p \leq 0.05$), using the Statistical Package for the Social Sciences software (version 23.0).

RESULTS

The sample eligible for the study comprised 379 schoolchildren, with 10 individuals excluded for being underweight, 8 individuals having an orthopedic deficit, and 41 individuals who did not comply with the study. Thus, the final sample evaluated was composed of 320 students, stratified according to BMI classification in EG (n=140), OWG (n=88), and OG (n= 92) screened in 24 public schools and private companies in the municipality of Santa Cruz do Sul, RS (Figure 1). Municipal and state schools in urban and rural areas, as well as public and private schools, were tabulated by region, with the selection of schools determined by a random table. Table 1 lists the anthropometric characteristics of the analyzed sample.

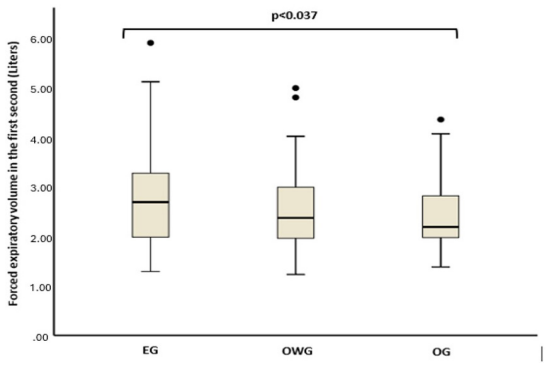

Figure 2. The behavior of the forced expiratory volume in the first second of the forced vital capacity curve in the evaluated groups.

A difference was evident between groups OG and EG (2.20 L vs. 2.71 L; p=0.037) (Figure 2). Regarding WHR, a significant difference was observed between EG (0.78 cm) and OG (0.85 cm) ($p<0.001$) and between OWG (0.80 cm) and OG (0.85 cm) ($p<0.001$) (Figure 3).

A significant, inverse, and moderate correlation was observed between WHR and FEV_1 in the EG ($p<0.001$, r= -0.448) (Figure 4) and in the OWG ($p<0.001$, r= -0.421), whereas in the OG, there was a significant, inverse, and weak correlation ($p<0.002$, r= -0.325) (Figure 4). There was no correlation between WC and FEV_1.

DISCUSSION

This study evaluated the association between FEV_1 and WHR in overweight and obese schoolchildren and showed that FEV_1 was inversely correlated with WHR in children and adolescents, regardless of body weight. Furthermore, obese students had lower FEV_1 than normal-weight students. The sample comprised 60.6% female

Table 1 – Sample characteristics and anthropometric data.

	EG	OWG	OG	p-value
	(n=140)	(n=88)	(n=92)	
Male sex (%)	53 (37.9)	38 (43.2)	35 (38)	0.692
Age (years)	12 (10-14)	11 (9-14)	10 (9-12)	<0.001[a]
Ethnicity (%)				
Caucasian	113 (73.6)	58 (65.9)	60 (65.2)	0.304
Grizzly	23 (16.4)	22 (25)	23 (25)	0.188
Afrodescendant	14 (10)	8 (9.1)	9 (9.8)	0.974
Body mass (Kg)	44.05 ± 13.48	49.80 ±14.19	58.07 ±17.41	<0.001[b]
Stature (cm)	1.52 ±0.18	1.48 ±0.13	1.48 ±0.13	0.096
BMI (Kg/m^2)	18.35 (17.02-20.30)	21.50 (19.80-24.21)	26.06 (23.80 - 28.42)	<0.001[c]
WC (cm)	62.30 (58-67.65)	68.10 (62-73.30)	77 (72-84)	<0.001[c]
HP (cm)	82 (71.50-89.25)	86 (77-96)	91 (83-99)	<0.001[c]
WHR (cm)	0.78 (0.73-0.82)	0.80 (0.76-0.83)	0.85 (0.80-0.89)	<0.001[a;b]

EG: Eutrophic Group; OWG: Overweight Group; OG: Obesity Group; BMI: body mass index; WC: waist circumference; HP: hip circumference; WHR: waist-to-hip ratio. Data expressed as frequency, mean, and standard deviation or median and interquartile range. [a]significant difference between EG and OG (p<0.05). [b]significant difference between OWG and OG (p<0.05). [c]significant difference between the three groups (EG, OWG, OG) (p<0.05).

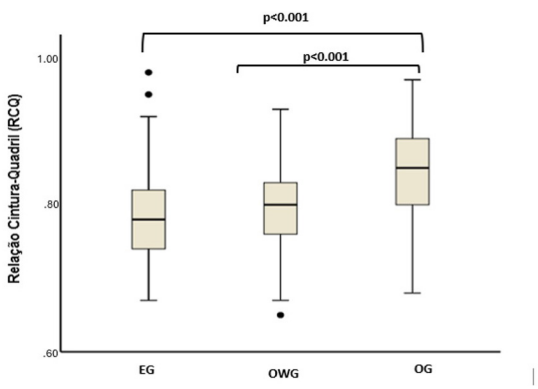

Figure 3. The waist-to-hip ratio in the evaluated groups.

students, with 40% of the participants being overweight or obese. Abdelkarim et al.[19] emphasize that overweight and obesity have been considered by the World Health Organization as an important public health challenge. It is estimated that around 42.4 to 51.8 million children and adolescents (20-25%) are overweight or obese in Latin America[20]. In Brazil, over three decades, the prevalence of obesity reached approximately 8.2% of the child and adolescent population[21]. According to the IBGE, one in every three Brazilian children aged between 5 and 9 years is overweight[22]. From this perspective, the Food and Nutrition Surveillance System (2019) demonstrated that 16.33% of children between 5 and 10 years old are overweight and 9.38% are obese. Regarding adolescents, 18% are overweight and 9.53% are obese[23]. Passos and collaborators[24] in a study carried out in Pelotas (RS), evaluated 335 children between 6 and 10 years old, of both sexes and from private schools, and showed that, of the total sample, 49.3% were eutrophic, 26% were overweight, 15% were obese and 9.7% were severely obese.

The WHR is an anthropometric indicator used to assess cardiovascular risk and is useful in detecting central obesity in a simple, effective, and low-cost way. Studies recommend the use of anthropometric measurements as an appropriate assessment method, with the WHR being an indicator of good sensitivity and reproducibility[13,25,26]. The present study showed that overweight and obese individuals had a WHR of 0.80 and 0.85, respectively, which classifies them as having low cardiovascular risk.

Pereira et al.[27] evaluated the association between body fat measurements and BMI in female adolescents and concludedthat the WHR was less sensitive for estimating the percentage of body fat (%BF) associated with WC.

Obesity is recognized as a low-grade inflammatory state that can influence lung function. In a systematic review developed by Hegewald et al.[28], obesity in adults reduced lung volumes and capacities compared with normal-weight individuals. Reductions in TLC, FVC, and FEV_1 were the most representative findings, suggesting the presence of arestrictive breathing pattern. In our study, an inverse association was observed between FEV_1 and WHR. Pasic et al.[29] evaluated 60 asthmatic children aged 5–15 years who were allocated into normal weight, overweight, and obesity groups and showed that obesity in asthma can increase airflow restrictions with a reduction in FEV_1 and FVC, concluding that FEV_1 in eutrophic asthmatic individuals was significantly higher than that in obese asthmatic individuals. Udomittipong et al.[30] identified that obese children aged 8 to 15 years showed a decrease in FEV_1 compared with normal-weight children.

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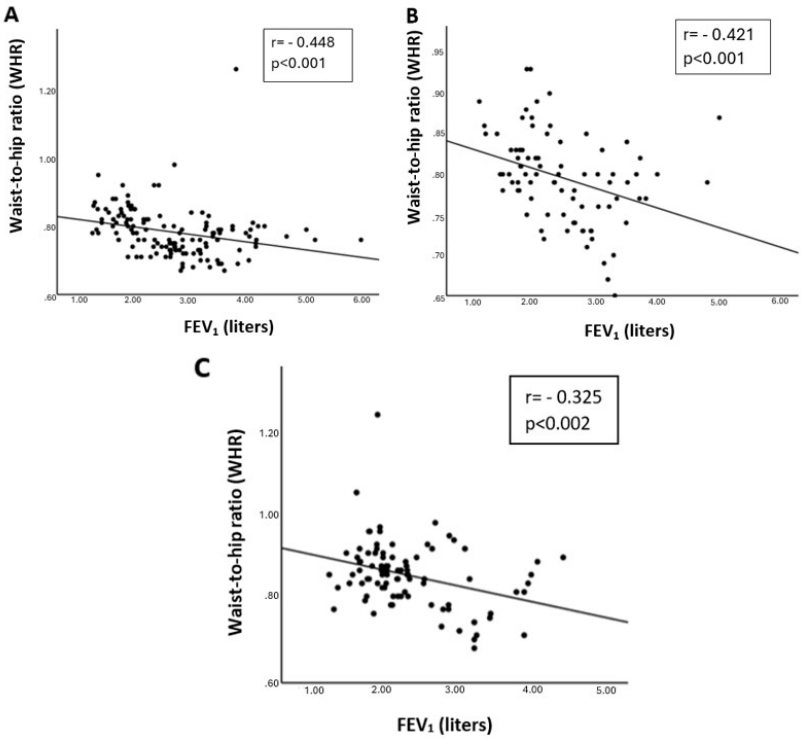

Figure 4. Association between forced expiratory volume in the first second of forced vital capacity (FVC) and waist-hip ratio in the Eutrophic Group (A), Overweight Group (B), and Obesity Group (C).

In this study, there was an inverse and weak correlation between FEV_1 and WHR ($p<0.002$; $r=-0.325$) in the OG, which is contrary to the findings of Boran et al.[31], who evaluated 80 obese children and adolescents aged between 7 and 15 years, with no correlation between anthropometric measurements and FEV_1. However, Ulger et al.[32], when evaluating the lung function of 38 children and adolescents with exogenous obesity and 30 healthy children and adolescents aged between 9 and 15 years, showed a strong correlation between BMI, WHR, and lung volumes (FVC, FEV_1, and peak expiratory flow). In a study by Satapathy et al.[33], a significant reduction in FEV_1 was evidenced in obese and overweight children when compared with the control group aged 6 to 14 years, and an inverse correlation was also observed between lung volumes (FEV_1 and FVC) and BMI and WHR.

It should be noted that the present study presented some limitations, such as the fact that the outcomes were not stratified by the sex of the children and adolescents analyzed, since the distribution of fat occurs differently between the sexes,being of the gynoid type (accumulation of tissue adipose tissue on the buttocks, thighs, and hips) in females and the android type (accumulation of adipose tissue in the abdomen, waist and trunk) in males[34].

Furthermore, the use of WHR in children and adolescents as an anthropometric measure to assess body fat distribution may be interfered with by rapid changes in pelvic width due to sexual maturation.

CONCLUSION

Obese students had lower FEV_1 compared with normal-weight individuals, with an inverse association between lung volume and WHR independent of body weight classification.

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