



Obesity anthropometric indicators associated with cardiometabolic risk in Portuguese children and adolescents

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ABSTRACT

The purpose of this study was to determine the association between cardiometabolic risk with body mass index and skinfold independently or in combination in youth. This cross-sectional study comprised a convenience sample of 450 children and adolescents (255 girls), aged 10 to 18 years old. Indicators of body composition were measured, and hemodynamic assessment completed. The association between body mass index and/or sum of skinfolds and cardiometabolic risk (z score of the sum of triglycerides/high density lipoprotein cholesterol, waist circumference, and mean blood pressure), was calculated using Generalized Linear Models Regression. The results showed that youngsters classified as overweight or obese with the highest skinfold measurements had the strongest association with cardiometabolic risk ($\beta > 2.60$; IC 95%: 2.25–3.0) when compared with those exhibiting normal skinfold thickness ($\beta > 1.78$; IC 95%: 1.30–2.20). Body mass index was most strongly associated with cardiometabolic risk ($\beta > 1.78$; IC 95%: 1.3–2.2), in comparison to skinfold thickness, which was associated to a lesser extent ($\beta > 0.41$; IC 95%: 0.34–0.49). Results of this cross-sectional study indicate that body mass index is more strongly associated with cardiometabolic risk than skinfold thickness. However when these two measures of overweight/obesity are combined, prediction of cardiometabolic risk is further improved. It is therefore important that public health professionals consider both body mass index and sum of skinfolds to better predict cardiometabolic risk in overweight and obese youth. Implications for future research include the use of longitudinal designs and inclusion of children from other racial/ethnic groups.

1. Introduction

Overweight and obesity in children and adolescents continues to be a public health concern (Faenza et al., 2016). This is particularly the case as obesity is considered the primary cause of cardiometabolic comorbidities (Faenza et al., 2016; Cook et al., 2003). Alongside prevention of obesity, ensuring good cardiometabolic health in children and youth is a key public health priority. However, approximately 10% of adolescents already show clustering of three or more cardiometabolic (CM) abnormalities (Cook et al., 2003). In addition, one form of CM risk cluster, namely the metabolic syndrome, has been recognized as a robust indicator of cardiovascular problems in adulthood and early diagnosis is a priority for prevention of later cardiometabolic disease (Juonala et al., 2011; Popkin et al., 2013).

Anthropometric assessment has been widely used to screen children and youth for CM risk, principally because of their low-cost, ease of administration and non-invasive nature (Groeneveld et al., 2007; Andersen et al., 2015; Griffiths et al., 2013). Body mass index (BMI) is the most widely used such anthropometric index in epidemiological studies to determine metabolic risk (Andersen et al., 2015; Faenza et al., 2016; Barlow and Expert Committee, 2007; Cole et al., 1995; Sardinha et al., 2016). However, although BMI appears to be related to total body composition, use of BMI is not without problems as it is unable to distinguish fat and lean mass and its usefulness has been questioned (Barlow and Expert Committee, 2007; Sardinha et al., 2016). There are also several other anthropometric and body composition variables such as high percentage of fat, visceral fat and abdominal adipose tissue accumulation as well as other specific tissue fat

Abbreviations: CM, cardiometabolic; BMI, body mass index; SKF, skinfolds; WC, waist circumference; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; TG, triglycerides; OW/OB, overweight/obese; ESKF, average of skinfolds; SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure; WHtR, waist-to-height ratio

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accumulation that have been associated with CM risk (Bosch et al., 2015; Neovius et al., 2009). Consequently, the use of different anthropometric indicators, either alongside or instead of BMI, such as skinfolds (SKF) and waist circumference (WC), might provide complementary information to better screen for CM risk in children and youth. Furthermore, these aforementioned methods are recognized as adequate to determine CM risk (Taylor and Hergenroeder, 2011; Aristizabal et al., 2015).

The association between CM risk and overweight/obesity (OW/OB) is not simple and trying to distinguish which solitary anthropometric measure of obesity might be best associated with CM risk in children and youth may not be as effective as understanding if combining anthropometric measures might be better associated with CM risk. Indeed, in prior studies, different anthropometric methods showed differential associations with key indices of cardiometabolic health including high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), total cholesterol, triglycerides (TG) and C-reactive protein (Gracia-Marco et al., 2015). Further, Samouda et al. (2015) showed that complementing anthropometric measures of regional adiposity with BMI Z scores could improve the prediction of CM risk factors in youth. It is therefore reasonable to hypothesize that a sum of BMI and SKF could be a more effective indicator of overall adiposity in children and youth. However, few studies to date have examined if this might be the case. This study sought to determine the association between CM risk with BMI and SKF independently or in combination in youth.

2. Methods

2.1. Participants

This is a cross sectional study, using a quantitative approach, carried out as part of a longitudinal research project. The study comprise the follow up of different Portuguese schoolchildren and adolescents cohorts since 1998 until 2010 (Aires et al., 2010; Martins et al., 2009). A convenience sample, comprising 450 students (255 girls and 195 boys), aged 11–17 years old from two different schools in Porto-Portugal, participated in this study. Prior to data collection, schools approved the study protocol and informed written consent was obtained from the participants' parents/guardians. The Scientific Board of PhD Program in Exercise and health approved the project at Porto University (Portugal). The subjects signed consent forms and their identities were kept confidential. All study procedures were carried out following the Helsinki Declaration (World Medical Association, 2013).

The minimum sample size was calculated on G power software considering a statistical analysis to F tests family omnibus r^2 (a multiple regression), with a 0.05 to alpha error probability, and 0.95 to power test and a medium effect size F^2 Cohen of 0.20, suggesting a minimum sample size of 105 participants. The study was executed with a total date of 450 youths, stratified by gender.

2.2. Anthropometric measures

Height and mass were measured in all subjects who were dressed in lightweight clothing and after having breakfast. Body mass was measured to the nearest 0.10 kg, using an electronic weight scale (Seca 708 portable digital beam scale) and body height was measured to the nearest mm in bare or stocking feet with the participant standing upright against a Holtain Stadiometer. BMI was calculated as kg/m^2 . WC was measured to the nearest mm with a metallic tape at the superior border of the iliac crest.

Skinfolds were taken from the triceps, subscapular and medial calfing Harpenden Skinfold Calipers and following established protocols (Heyward, 1998). Each skinfold was measured twice consecutively, on the right side of the body. If measurements differed by $> 5\%$, a third measure was taken. To minimize errors in this evaluation, two

researchers (men measured boys; woman measured girls) with five years of experience in anthropometry measurements were responsible for this test in all procedures of this study. The average of three skinfolds (triceps, subscapular and midcalf) thickness measurements was calculated as a final value, determining the sum of skinfolds (ESKF).

2.3. Cardiometabolic risk factors

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured by an automated oscillometric sphygmomanometer (DINAMAP model BP 8800) using a standard technique (Duarte et al., 2000). The subjects were at rest, in sitting position, with the right arm at heart level. The first and second measurements were taken after 5 and 10 minute resting. The average of these two measurements was used for data analysis. Mean arterial pressure (MAP) was calculated as: $[(\text{SBP} - \text{DBP}) / 3] + \text{DBP}$.

For determination of HDL-C and TG, after 12–14 h of fasting, capillary whole blood samples were collected from the earlobe using a 35 μl lithium heparin-coated capillary tube and immediately assayed using the Cholestech LDX Analyzer (Cholestech Corporation- Hayward, CA, USA). TG and HDL-C values were used for determining the TG/HDL-C ratio (Giannini et al., 2011).

2.4. Statistical analyses

The data was evaluated using the Shapiro Wilk Normality Test and outliers were analyzed considering the box-plot for all variables. Descriptive analysis was expressed considering average and standard deviations. We separated all analyses by gender because we have previously found significant correlations between males, females and cardiometabolic variables (data not shown). WC, TG/HDL-C and MAP were continuous variables in the data base, so we tested Pearson's correlations among those variables. Results were considered significant when $p < 0.05$. After each variable (WC, TG/HDL-C and MAP) was transformed in standard deviation unit (Z score) in a descriptive statistic method, they were summed up in a new Z score, called Z Cardiometabolic Risk, which was used as a dependent variable in the next regression analysis.

BMI was categorized as normal weight or overweight and obese according to Cole et al. (1995) cut-points. Regarding ESKF, we used the 75 percentile adjusted by age and gender, to categorize the group at risk of being obese (P75). These methods were used based on previous data with the same population (Guerra et al., 2006). Using this data a new variable was created based on BMI and ESKF, comprising four categories: 1) No risk where both BMI and ESKF were classified as in the healthy zone; 2) risk zone according to ESKF ($p > 75$) and normal BMI; 3) risk zone according to BMI (overweight and obese) and normal ESKF and 4) risk aggregated, this category included those who were classified in the risk zone for both BMI and ESKF.

The association between body composition and cardiometabolic risk (dependent variable) was tested through different Generalized Linear Regression Models. We considered “Healthy” as the reference category to be compared to BMI or ESKF with BMI + ESKF regarding variance and strength of the association with the dependent variable (β coefficient). The best regression model was determined using the minor value of Akaike's and Bayesian's criteria. An alpha level of < 0.05 was considered for all analyses and all analysis was completed using the Statistical package for Social Sciences (SPSS) version 24.0 (IBM Corp, Armonk, NY).

3. Results

Table 1 shows continuous and categorical sample descriptive analysis. Homogeneity was observed in the average values of age, body mass, height, WC, TG/HDL-C, MPA and Z cardiometabolic risk. The occurrence of participants at risk with BMI + ESKF was higher than

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