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Anthropometry and physical activity level in the prediction of metabolic syndrome in children

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Abstract

Objective: To evaluate the effectiveness of anthropometric measures and physical activity level in the prediction of metabolic syndrome (MetS) in children.
Design: Cross-sectional study with children from public and private schools. Children underwent an anthropometric assessment, blood pressure measurement and biochemical evaluation of serum for determination of TAG, HDL-cholesterol and glucose. Physical activity level was calculated and number of steps per day obtained using a pedometer for seven consecutive days.
Setting: Viçosa, south-eastern Brazil.
Subjects: Boys and girls (*n* 187), mean age 9·90 (SD 0·7) years.
Results: Conicity index, sum of four skinfolds, physical activity level and number of steps per day were accurate in predicting MetS in boys. Anthropometric indicators were accurate in predicting MetS for girls, specifically BMI, waist circumference measured at the narrowest point and at the level of the umbilicus, four skinfold thickness measures evaluated separately, the sum of subscapular and triceps skinfold thickness, the sum of four skinfolds and body fat percentage.
Conclusions: The sum of four skinfolds was the most accurate method in predicting MetS in both genders.

Keywords
CVD
Child
Receiver-operating characteristic curve

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Metabolic syndrome (MetS) can be considered as a clustering of cardiovascular risk factors and type 2 diabetes. In adults, diagnosis of MetS requires the presence of at least three of the following factors: central obesity, dyslipidaemia (low HDL-cholesterol (HDL-C) and hypertriacylglycerolaemia), hypertension and hyperglycaemia. However, there is no consensus regarding the diagnosis of MetS in children[1]. Some of the criteria used have been based on the recommendations of the National Cholesterol Education Program – Adult Treatment Panel III, with appropriate adjustments and specific cut-off points for age and gender[2–4].

For the diagnosis of metabolic risk and the components of MetS, biochemical evaluation has been more commonly used in clinical practice; however, this is invasive, requires trained personnel and is costly. In contrast, anthropometry has been reported as an important tool for both clinical practice and population studies, including the identification and prediction of metabolic risk[5–9].

In the context of epidemiological studies, several have reported gender differences for percentage body fat[10], waist circumference (WC)[11], insulin resistance (by homeostatic model assessment, HOMA-IR)[10] and MetS[12] in children. Moreover, gender differences have also been reported following an intervention programme designed to control insulin resistance[13] and after a follow-up of 6·6 years for trends of MetS in children[14]. The biochemical and anthropometric changes and differential response to intervention programmes between boys and girls suggest the need for separate analyses.

It is widely acknowledged that lifestyle factors (hours of screen viewing, level of physical activity) influence predictors of the MetS[15,16]. For example, regular physical activity plays a fundamental role in the prevention and management of obesity, hypertension, dyslipidaemia and insulin resistance[17]; however, data regarding the relationship between physical activity level (PAL) and the prediction of MetS in children remain scarce. The present

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study evaluated the effectiveness of anthropometry and PAL in the prediction of MetS in children.

Materials and methods

Study design and participants

The present cross-sectional study was conducted in a sample comprising 187 children (106 girls, 56·7 %) of mean age 9·90 (SD 0·7) years. To calculate the minimum sample size we employed the equation proposed by Lwanga and Lemeshow[18]. Considering the total number of 1049 students in the age group studied, the population total of 72 220, a standard error of 5 % with a 95 % confidence interval, eight schools (25 % of the thirty-two schools with 5th graders) were randomly selected. All 5th-grade students in each school were invited to participate in the study, and 74·8 % consented with authorization from their parents.

The sample comprised schoolchildren from the urban area of Viçosa, a university town in south-eastern Brazil with a population of ~72 220 inhabitants and an area of 299 km^2. The Human Development Index is 0·809, and the index of development of basic education is 5·7 (a score of 6·0 corresponds to a quality of education system comparable to that in developed countries). The service sector is the main component of the local economy and the Gross Domestic Product is $US 4320 per capita.

Procedures

Children underwent a comprehensive anthropometric protocol and blood pressure evaluation after the study was approved by the Ethics in Human Research Committee of the Federal University of Viçosa and parental consent was given. Children were provided instructions regarding the completion of a physical activity recall questionnaire and survey questions regarding socio-economic status and lifestyle were completed by parents. Participants also received instructions regarding the necessity to fast for 12 h in preparation for the collection of blood. All children received instruction on wearing a pedometer prior to wearing it for seven consecutive days.

Anthropometry

Body weight was assessed with an electronic digital scale (Lumina-02550; Plenna, São Paulo, Brazil) with a precision of 100 g and height was measured using a portable 2-m anthropometer (Rigor e Técnica, Viçosa, Brazil) with gradations of 0·1 cm. Children were measured wearing light clothes and without shoes following standardized procedures[19]. BMI was calculated as weight (in kilograms) divided by the square of height (in metres) and children were classified as overweight or obese, according to criteria established by Cole *et al.*[20].

WC was measured after normal expiration using a flexible and non-elastic 2-m tape (Sanny, São Paulo, Brazil). All measurements were carried out in triplicate and the average recorded. Measurements were taken at the following anatomic landmarks: (i) at the narrowest point of the waist between the iliac crest and the ribs (WC1) and (ii) at midpoint between the iliac crest and the lower rib (WC2), as recommended by the WHO[15]; and (iii) at the level of the umbilicus (WC3), as recommended by the *Anthropometric Standardization Reference Manual*[21]. The conicity index was calculated from measurements of WC, weight and height, according to a formula proposed by Valdez[22]. The purpose of this index was to assess body fat distribution for which cut-off points are not available in children.

Triceps (TST), subscapular (SST), suprailiac (SuST) and biceps (BST) skinfold thicknesses were measured according to standardized techniques using a Lange skinfold calliper (Cambridge Scientific Instruments, Cambridge, MA, USA) which exerts a constant pressure of 10 g/m^2. All measurements were taken on the right side of the body with three non-consecutive replicates of each measurement[23] which were subsequently averaged. The sum of two skinfolds (TST + SST; Σ2ST) and the sum of four skinfolds (TST + SST + SuST + BST; Σ4ST) were also calculated.

The equations proposed by Slaughter *et al.*[24] were used to calculate percentage body fat (%BF) and children were classified according to the categories of adiposity proposed by Lohman[25].

Blood pressure

Blood pressure was measured using a sphygmomanometer according to standardized approaches[26]. Only children whose systolic or diastolic blood pressure values exceeded the 90th percentile (according to height, gender and age) in three different measurements were diagnosed with high blood pressure.

Socio-economic status and lifestyle survey

Parents received a survey developed specifically for the present study, with eighteen closed questions regarding socio-economic status, lifestyle factors and sedentary behaviour.

Physical activity level

A 3 d physical activity diary (two weekdays and one weekend day) was completed[27]. Activities were classified according to metabolic equivalents of task (MET) into light (≤3·9 MET), moderate (>4 and ≤6·9 MET), vigorous (≥7 MET) and moderate-to-vigorous (>4 MET) intensity. Children who accumulated at least 60 min of moderate-to vigorous-intensity physical activity (MVPA) per day achieved the recommendation for a healthy lifestyle[28].

All children wore a pedometer (DX 8897; Pulse Rate Pedometer, Hong Kong, China) and the average number of steps per day was derived across seven consecutive days.

Blood collection and analyses

After 12 h of fasting, blood samples were collected and immediately processed. Serum was analysed using the enzymatic colorimetric method to determine HDL-C, TAG and glucose on an automated haematology analyser (Cobas Mira Plus; Roche, Rotkreuz, Switzerland).

Metabolic syndrome

In the current study, MetS was diagnosed according to the presence of three or more of the following criteria: (i) TAG ≥100 mg/dl; (ii) HDL-C <50 mg/dl; (iii) glucose ≥110 mg/dl; (iv) WC ≥75th percentile for age and sex; and (v) blood pressure (diastolic or systolic) >90th percentile adjusted for age, height and sex. The cut-off points adapted to the age of the population studied were chosen according the criteria of de Ferranti *et al.*[2].

Statistical analysis

Analyses were performed using the statistical software package SPSS version 17·0 for Windows. The continuous variables were described by means of measurements with central and dispersion tendency, including mean, standard deviation, median, and minimum and maximum values. The categorical variables were described in percentage values.

All variables were tested for normality by the Kolmogorov–Smirnov test. Student's t test was used to compare the means of independent variables with parametric distribution and the Mann–Whitney test was used for the variables having non-parametric distribution. $P < 0·05$ was considered for statistical significance. The Kruskal–Wallis test with Dunn's *post hoc* test was selected for comparison among the groups on non-parametric distribution.

Measures of association between MetS, lifestyle and biochemical variables were obtained by the χ^2 test and odds ratios with their 95 % confidence intervals are presented.

Cut-off points for the variables analysed were suggested through the use of receiver-operating characteristic (ROC) curves. The optimal cut-offs were determined by finding the values that allowed the best balance between sensitivity and specificity. The statistical significance of each analysis was assessed by the area under the ROC curve (AUC) and by the inferior limit of the 95 % confidence interval being higher than 0·5[29].

Results

Anthropometry

Table 1 shows the anthropometric characteristics of the children. Significant differences ($P < 0·05$) were observed between boys and girls for all four skinfolds, the sums of skinfolds (Σ2ST, Σ4ST) and %BF.

Physical activity level

The number of steps per day did not differ significantly ($P > 0·05$) between genders, with boys recording a median of 5952 steps/d (range 807–31 459 steps/d) and girls a median of 4906 steps/d (range 387–20 803 steps/d). On the other hand, time spent in MVPA differed significantly ($P < 0·05$) between genders: median (range)

Table 1 Anthropometric, biochemical and blood pressure parameters for 5th-grade girls and boys (*n* 187; mean age 9·90 (SD 0·7) years), Viçosa, south-eastern Brazil

	Girls					Boys				
	n	Mean	SD	Median	Range	*n*	Mean	SD	Median	Range
Weight (kg)	106	35·05	8·1	33·0	23·2–59·5	81	35·10	9·4	32·4	22·6–60·1
Height (m)	106	1·40	0·7	1·4	1·3–1·6	81	1·39	0·7	1·4	1·3–1·6
BMI (kg/m^2)	106	17·56	2·9	16·9	13·7–29·1	81	17·75	3·6	16·5	13·3–28·7
WC1 (cm)	106	59·80	6·8	57·7	51·0–82·5	81	61·28	8·5	59·0	51·3–88·0
WC2 (cm)	106	62·10	8·3	59·4	50·4–93·5	81	62·20	9·2	59·7	52·0–93·2
WC3 (cm)	106	65·21	8·7	62·5	53·2–90·7	81	64·26	10·4	61·2	44·2–94·9
Conicity index	106	1·14	0·1	1·1	1·0–2·0	81	1·14	0·1	1·1	0·9–1·4
TST (mm)	106	16·74*	7·2	14·8	4·8–38·7	81	14·41	8·4	12·0	4·0–41·3
BST (mm)	106	9·52*	4·6	7·3	3·0–22·0	81	8·19	6·0	6·0	3·0–31·3
SuST (mm)	106	14·95*	11·1	10·5	4·0–52·5	81	11·78	11·0	7·5	3·0–59·0
SST (mm)	106	11·50*	7·8	8·0	4·0–35·3	81	10·33	8·7	7·0	4·0–40·0
Σ2ST (mm)	106	28·20*	13·9	28·2	9·8–67·3	81	24·74	16·6	18·7	8·0–76·3
Σ4ST (mm)	106	52·73*	28·5	41·9	18·7–140·3	81	44·69	32·9	32·0	14·0–166·7
%BF	106	22·18*	6·1	21·1	9·3–31·5	81	18·93	6·7	17·8	7·3–31·3
TAG (mg/dl)	84	72·65	34·3	62·0	40·0–227·0	57	60·77	18·2	57·5	41·0–120·0
HDL-C (mg/dl)	84	57·12	10·4	57·0	31·0–84·0	57	55·54	9·2	56·0	32·0–75·0
Glucose (mg/dl)	84	77·87	5·0	77·0	60·0–89·0	57	79·18	5·5	78·5	70·0–96·0
SBP (mmHg)	106	110·17	10·2	110·0	90·0–140·0	81	107·03	9·8	108·0	90·0–140·0
DBP (mmHg)	106	73·51	7·5	70·0	60·0–100·0	81	72·25	7·5	70·0	56·0–100·0

WC1, waist circumference taken at the narrowest point of the waist, between the iliac crest and the ribs; WC2, waist circumference taken at the midpoint between the iliac crest and the lower rib; WC3, waist circumference taken at the level of the umbilicus; TST, triceps skinfold thickness; BST, biceps skinfold thickness; SuST, suprailiac skinfold thickness; SST, subscapular skinfold thickness; Σ2ST, sum of two skinfolds (TST + SST); Σ4ST, sum of four skinfolds (TST + SST + SuST + BST); %BF, percentage body fat; HDL-C, HDL-cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure.
*Significant differences between genders, Mann–Whitney test ($P < 0·05$).

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Table 2 Cut-off points for predictors of MetS in 5th-grade boys (*n* 81), Viçosa, south-eastern Brazil

	Cut-off point	SENS (%)	SPEC (%)	PPV (%)	NPV (%)
Anthropometric					
Conicity index	>1·16	100	45·1	12·5	100
Σ4ST (mm)	>68·8	100	82·3	30·8	100
Non-anthropometric					
Number of steps/d	7872	100	78·2	22·0	100

MetS, metabolic syndrome; Σ4ST, sum of four skinfolds (triceps + subscapular + suprailiac + biceps); SENS, sensitivity; SPEC, specificity; PPV, positive predictive value; NPV, negative predictive value.

of 105 min/d (0–390 min/d) and 15 min/d (0–360 min/d) for boys and girls, respectively.

Only 13·6 % of girls and 14·5 % of boys achieved the American recommendation of 11 000 and 13 000 steps/d, respectively[30], and 36·7 % of girls and 68·1 % of boys met the recommended 60 min of daily MVPA[28].

Biochemical variables and blood pressure

None of the participants had impaired fasting glucose, 24·1 % of the children had HDL-C levels below the recommended level, 10·6 % had hypertriacylglycerolaemia and 14·4 % recorded high blood pressure. For all biochemical variables and blood pressure, no significant between-gender differences were found ($P > 0·05$; see Table 1).

Metabolic syndrome

MetS was found in 8·5 % of the children. In respect of the five components of MetS (TAG, HDL-C, glucose, WC and blood pressure), 53·2 % of children showed normal values in all measures while 26·2 % had at least one component, 12·1 % had two components, 6·4 % had three, and 2·1 % had four or more components of MetS.

The prevalence of overweight and obesity was 15·0 % and 5·9 %, respectively, with boys showing a higher obesity prevalence (8·6 %) than girls (3·8 %).

For girls, hypertriacylglycerolaemia and high %BF were significantly associated with MetS (OR = 31·3; 95 % CI 5·43, 179) and (OR = 6·23; 95 % CI 1·03, 48·3), respectively. For boys, significant associations were found for MetS and hypertriacylglycerolaemia (OR = 47·0; 95 % CI 3·68, 599) and MetS and low HDL-C (OR = 34·5; 95 % CI 2·80, 413). There was no significant association between screen time (hours in front of a television and computer) and MetS.

Predictors of the metabolic syndrome

Anthropometric indices presented in Table 1 were tested as predictors of MetS in both genders. For boys, the AUC was significant for conicity index (AUC = 0·737; 95 % CI 0·520, 0·955) and Σ4ST (AUC = 0·897; 95 % CI 0·785, 0·963). Weight, height, BMI, WC, the four skinfolds assessed separately, Σ2ST and %BF were ruled out as predictors of MetS in boys. Cut-off points for anthropometric measures were suggested for boys that showed the best balance between sensitivity and specificity (Table 2).

Table 3 Area under the ROC curve of anthropometric predictors of MetS in 5th-grade girls (*n* 106), Viçosa, south-eastern Brazil

Anthropometric index	AUC	SE	95 % CI
BMI (kg/m^2)	0·754*	0·084	0·590, 0·919
WC1 (cm)	0·683*	0·086	0·516, 0·852
WC3 (cm)	0·709*	0·095	0·522, 0·896
TST (mm)	0·737*	0·104	0·633, 0·826
BST (mm)	0·674*	0·109	0·566, 0·770
SuST (mm)	0·667*	0·109	0·559, 0·764
SST (mm)	0·708*	0·107	0·601, 0·800
Σ2ST (mm)	0·733*	0·105	0·628, 0·822
Σ4ST (mm)	0·908*	0·070	0·827, 0·959
%BF	0·788*	0·065	0·660, 0·916

ROC, receiver-operating characteristic; MetS, metabolic syndrome; AUC, area under the curve; WC1, waist circumference taken at the narrowest point of the waist, between the iliac crest and the ribs; WC3, waist circumference taken at the level of the umbilicus; TST, triceps skinfold thickness; BST, biceps skinfold thickness; SuST, suprailiac skinfold thickness; SST, subscapular skinfold thickness; Σ2ST, sum of two skinfolds (TST + SST); Σ4ST, sum of four skinfolds (TST + SST + SuST + BST); %BF, percentage body fat.
*Significant AUC, inferior limit to the 95 % CI greater than 0·5.

For girls, anthropometric measures including BMI, WC1, WC3, four skinfolds assessed separately, Σ2ST, Σ4ST (higher AUC = 0·908) and %BF (Table 3) were useful for the prediction of MetS, and cut-off points were proposed for these measures (Table 4).

The number of steps per day was an accurate predictor of MetS, acting as a protective factor in boys (AUC = 0·891; 95 % CI 0·736, 0·971). Cut-off points with the best balance between sensitivity and specificity for protection against MetS are shown in Table 2. However, the number of steps per day by girls and the time spent in MVPA for both genders were not accurate in predicting MetS.

Discussion

The present study proposes a simple, easily applied, reproducible and low-cost alternative for the prediction of MetS in children. Currently, there is no consensus regarding the most appropriate anthropometric, haemodynamic and biochemical parameters to diagnose MetS in children. Accordingly, the present study sought to elucidate the accuracy of anthropometric parameters to diagnose the MetS.

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Table 4 Cut-off points for anthropometric predictors of MetS in 5th-grade girls (*n* 106), Viçosa, south-eastern Brazil

Anthropometric index	Cut-off point	SENS (%)	SPEC (%)	PPV (%)	NPV (%)
BMI (kg/m^2)	>19·2	50	78·75	19·0	94·0
WC1 (cm)	>56·0	100	40·00	14·3	100
WC3 (cm)	>63·8	75	61·25	16·2	96·1
TST (mm)	>14·8	100	53·75	17·8	100
BST (mm)	>8·2	75	56·25	14·6	95·7
SuST (mm)	>8·3	100	45·00	15·4	100
SST (mm)	>7·6	100	48·75	16·3	100
Σ2ST (mm)	>22·6	100	52·50	17·4	100
Σ4ST (mm)	>72·0	100	82·50	36·4	100
%BF	>25·7	75	71·25	20·7	96·6

MetS, metabolic syndrome; WC1, waist circumference taken at the narrowest point of the waist, between the iliac crest and the ribs; WC3, waist circumference taken at the level of the umbilicus; TST, triceps skinfold thickness; BST, biceps skinfold thickness; SuST, suprailiac skinfold thickness; SST, subscapular skinfold thickness; Σ2ST, sum of two skinfolds (TST + SST); Σ4ST, sum of four skinfolds (TST + SST + SuST + BST); %BF, percentage body fat; SENS, sensitivity; SPEC, specificity; PPV, positive predictive value; NPV, negative predictive value.

Σ4ST was the main anthropometric predictor of MetS in boys and girls (AUC = 0·897 and AUC = 0·908, respectively) and showed cut-off point values with sensitivity and specificity above 80 %. It is worth noting that the closer to 1·0 is the AUC, the more accurate and the higher the power of a diagnostic test.

Σ2ST was accurate in only girls (AUC = 0·733). Freedman *et al.*[5] reported that Σ2ST had lower accuracy than BMI in predicting cardiovascular risk factor components of MetS, in agreement with data from the present study (Table 4).

Several studies have emphasized the relationship between TST and %BF[31–35]; however, studies investigating the power of TST to predict MetS remain scarce. Our results demonstrated that all individual skinfold thickness measures predict MetS in girls. Among these, TST is more accurate (AUC = 0·737; 95 % CI 0·633, 0·826; sensitivity = 100 %, specificity = 53·75 %) with a cut-off point of 14·8 mm. Sardinha *et al.*[32] reported that TST is also efficient in predicting %BF in 10–11-year-old girls (against the gold standard of dual energy X-ray absorptiometry) and obtained an AUC of 0·96 (95 % CI 0·87, 0·99; sensitivity = 79 %, specificity = 100 %) with a cut-off point of 21 mm. Moreover, this cut-off point predicts increases in total cholesterol and LDL-cholesterol (sensitivity = 83·3 %, specificity = 78·7 %) for 11-year-old Brazilian boys[36]. Given this evidence, measurement of TST is an important indicator of cardiovascular risk factors and should be included in both scientific research and the clinical monitoring of children.

In the present study, the cut-off point suggested for %BF in the prediction of MetS in girls was 25·7 % (sensitivity = 75 %, specificity = 71·25 %), a value similar to the one proposed by Lohman[31] to classify girls with moderately high %BF (%BF ≥25 %). Thus, %BF >25 % for girls seems to be confirmed as a key value in increasing the risk for developing MetS.

To our knowledge, the present study is the first to suggest a conicity index cut-off point as a predictor of MetS in Brazilian children. The conicity index was accurate in the prediction of MetS for boys only, with a cut-off point of 1·16 (AUC = 0·737; 95 % CI 0·520, 0·955). The conicity index predominantly assesses central fat that is highly correlated with components of the MetS[37]. However, as the conicity index was created for adults and with sex-specific cut-off points, its use in children has remained somewhat controversial. Taylor *et al.*[38] tested the accuracy of three anthropometric measures in predicting the percentage of central fat in children and adolescents (3–19 years old). The conicity index had lower accuracy (AUC = 0·81; 95 % CI 0·74, 0·88) compared with WC (AUC = 0·97; 95 % CI 0·95, 0·99) and greater accuracy in relation to the waist-to-hip ratio (AUC = 0·71; 95 % CI 0·62, 0·80). The median value for the conicity index was 1·16 and did not show the value of the cut-off point[38]. Alternatively, the conicity index is a simple and, in the absence of sophisticated equipment, can be used as a measure of body fat distribution in children[39].

The BMI is widely reported as a diagnostic tool for obesity. As an indicator of MetS in children, numerous cut-off points have been suggested for BMI: >97th percentile for age and sex[40–42]; ≥85th percentile[43]; and the cut-off point proposed by Cole *et al.*[20] to define overweight and obesity[44]. We suggest, for girls, a BMI cut-off point of 19·2 kg/m^2 (sensitivity = 50 %, specificity = 78·25 %), approaching the values of Cole *et al.* (BMI = 19·86 kg/m^2) and Conde and Monteiro (BMI = 18·63 kg/m^2)[45], a national reference for the diagnosis of overweight in 10-year-old girls. In a case–control study[46], only 12 % of the overweight/obese group were free of MetS risk factors in contrast to 83·9 % of normal-weight children. These findings underline the importance of BMI as a predictor of MetS risk.

As an indicator of MetS, WC is assessed with the largest number of methodological variations. Different points of measurement were detected and cut-offs points have varied: ≥85th percentile of the population studied[47] and ≥90th percentile for age and sex[42,43]. In the present study, two measurement sites were accurate in predicting

MetS in girls: WC1 and WC3, with cut-off points of 56·0 and 63·8 cm, respectively, in the prediction of MetS. WC3 was more accurate (AUC = 0·709) with a better balance between sensitivity and specificity compared with WC1 (AUC = 0·683).

Hirschler *et al.*[6] reported that WC3 correlated significantly with all components of MetS in children aged 6–13 years. Furthermore, they highlighted that children with abdominal obesity (>90th percentile of the sample) had increased risk for CVD and type 2 diabetes. In the current study, we observed that 10·1 % of children were >90th percentile for abdominal obesity (WC3 > 78·68 cm). On the other hand, when using the cut-off point suggested (WC3 > 63·8 cm) for the prediction of MetS, an estimated 38·7 % of children were at risk of MetS.

The current study is the first to suggest a cut-off point for the number of steps per day as a predictor of MetS in Brazilian boys. Use of this indicator suggested that 40 % of boys studied were protected from MetS based on attainment of the recommended cut-off point of 7872 steps/d (AUC = 0·891; 95 % CI 0·736, 0·971; sensitivity = 100 %; specificity = 78·12 %). The ROC curve analysis demonstrated better sensitivity and specificity with much lower values of steps/d compared with the American recommendation of 13 000 steps/d to achieve a minimum standard of health[30]. All children classified as having MetS achieved less than 7872 steps/d, indicating that this number of steps may be a critical marker of poor metabolic health.

There is an urgent need to establish criteria to facilitate the diagnosis of MetS in children and recommended cut-off points should be similar to those of adults to facilitate comparisons[3]. Current recommendations and cut-off points need to be developed and reviewed, particularly for WC, dyslipidaemia and hyperglycaemia.

Our data provide evidence for the incorporation of a comprehensive tool to be used by health workers and educators involved in health programmes for schoolchildren. As Brazil has a government-endorsed School Health Program target to evaluate students, the findings of the present study provide justification for the addition of a physical assessment to assist in the prediction of schoolchildren at risk of MetS.

The power of the results related to the anthropometric measures presented herein support their use in screening children at risk of poor metabolic health. Most importantly, a large number of children could be assessed inexpensively, those at risk diagnosed early, and referred to the appropriate professionals for assistance.

Conclusion

We conclude that, for both genders, Σ4ST was the most accurate method to predict MetS in children. Moreover, BMI and WC, already widely used in the diagnosis of MetS, were accurate in the prediction of MetS only in girls. PAL and the number of steps per day, however, were effective in the prediction of MetS in boys. Thus, monitoring of anthropometric measures and PAL is essential in the control and prevention of MetS in children.

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