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Original article

Waist circumference in children and adolescents correlate with metabolic syndrome and fat deposits in young adults

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SUMMARY

Background & aims: To determine the relevance of waist circumference (WC) measurement and monitoring in children and adolescents as an early indicator of overweight, metabolic syndrome (MS) and cardiovascular problems in young adults in comparison with visceral and subcutaneous adiposity.
Methods: A cohort study with 159 subjects (51.6% female) started in 1999 with an average age of 13.2 years. In 1999, 2006 and 2008 weight, height, and WC were evaluated. In 2006 blood samples for laboratory diagnosis of MS were added. In 2008 abdominal computed tomography (ACT) to quantify the fat deposits were also added.
Results: The WC measured in children and adolescents was strongly correlated with body mass index (BMI) measured simultaneously. A strong correlation was established between WC in 1999 with measures of WC and BMI as young adults. WC strongly correlated with fat deposits in ACT. The WC in 1999 expressed more subcutaneous fat (SAT), while the WC when young adults expressed strong correlation with both visceral fat (VAT) and SAT. The correlation of WC with fat deposits was stronger in females. WC and not BMI in 1999 was significantly higher in the group that evolved to MS.
Conclusions: The WC in children and adolescents was useful in screening patients for MS. WC expressed the accumulation of abdominal fat; especially subcutaneous fat.

1. Background & aims

In recent decades the prevalence of obesity is increasing in many countries around the world. This fact is of concern because excess body fat, especially abdominal fat, is directly related to changes in lipid profile. It is also associated with increased blood pressure and hyperinsulinemia, which are considered risk factors for developing chronic diseases such as diabetes mellitus type 2 and cardiovascular diseases. However, the question now is how many of these changes are already present in obese children and adolescents. European studies on cardiovascular risk had already shown in the 80's that abdominal obesity would be a better predictor of cardiovascular disease than body mass index (BMI).[1]

Data from the Bogalusa Heart Study allowed cutoff points of BMI and waist circumference (WC) in children and adolescents for cardiovascular disease risk.[2] Also using data from four British cohort studies (over 9000 patients), BMI and WC were good parameters to access risk of obesity and its consequences.[3]

The BMI has been routinely used in clinics and as an evaluation tool in public health for decades to identify individuals and populations at risk of future cardiovascular disease and diabetes. However, in recent years, the BMI has been criticized as a measure of risk because it reflects both fat mass and lean body mass, and because it is not possible to discriminate the distribution of fat.[4] There is a growing body of evidence suggesting that abdominal fat is more important as a risk factor for cardiovascular and metabolic disease than is general adiposity.[5] The mechanisms by which abdominal fat contributes to the risk of these diseases are not fully understood. The visceral adipose tissue is a very active metabolic element of abdominal fat, and probably plays a fundamental role in this process.[6]

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The aim of our study was to determine the importance of monitoring the measure of WC in a cohort of children and adolescents as a screening tool for metabolic syndrome (MS) in young adults. We compared WC in 1999 with the diagnostic of MS as young adults (2006) and deposits of fat in the abdominal computed tomography (ACT) scan and blood pressure in 2008.

2. Materials and methods

We conducted a cohort study, longitudinal, observational, descriptive and analytical, with cross-cutting interventions. The cohort involved children and adolescents (7–18 years old) residing in Veranópolis, South of Brazil in 1999, both from urban and rural areas, with at least one parent alive. Veranópolis is a city with a population predominantly of white Caucasians, originally from Italy, Europe, internationally known for its high longevity. The sample was obtained from a representative and random choice of the age group investigated. Exclusion criteria was[1]: with a history of any chronic diseases or coagulopathy[2]; with acute pathology, such as infectious diseases[3]; in oral anti-coagulant therapy and oral contraceptives[4]; pregnant or females with delayed menstruation.

The study was carried out on cross-cutting assessments: (1999) personally identifiable information was collected; anthropometric data (weight, height, and WC) was collected in all three assessments; (2006) blood was collected for measurement of triglycerides, serum total cholesterol, LDL and HDL and blood glucose; (2008) ACT was also performed. All assessments were made by the same team of professionals.

Standardized protocols were used to anthropometric parameters[7]: weight, height, WC. WC was obtained from the narrowest point between the lower edge of the cage framework and the iliac crest using a flexible tape measure, but not elastic. We calculated the Z score of height, weight, WC and BMI using reference values of mean and standard deviation for each of them by age, thus standardizing the sample.[8–11]

Cutoff points determined by Katzmarzyk et al.[2] were used for cardiovascular risk and the criteria for De Ferranti et al.[12] for diagnosis of MS.

Abdominal CT exams were performed on the same day of the anthropometric measurement. The examinations were acquired with HiSpeed CT® scan equipment (GE, Milawukee, USA). Patients were positioned supine with feet facing the inside of the machine, and then focused the cuts on the umbilicus. We obtained only one cut in each patient, for reducing the radiation (about 2.3 mGy per examination). The images were obtained with 120 kVp, 100 mAs, field of view (FOV) of 36–40 cm, thickness 10 mm, tilt table, cut from 1 s, matrix 515 × 512, with filter and window to share moles. The images were acquired in DICOM 3.0® protocol and stored for later analysis. Data analysis was performed using manipulation by the computer program “Image J 1.45S”® (free download at internet)”. The analyses were done by two radiologists blinded to clinical and anthropometric data of patients. Initially, the images were manipulated so that only densities between (−190) to (−30) Hounsfield units were analyzed (defined densities for fat by set-ups of literature.[13] It was initially designed the outer contour (abdominal perimeter), and it was calculated by the computer in mm^2 the total fat of the abdomen (TF). It was then designed the outline of the inner portion of the abdomen, following the inner edge of the interface between the muscle wall and the underlying fat. The psoas muscles were also excluded. The value obtained was termed internal or visceral fat (VAT). The difference between the values of total fat and internal fat was termed external or subcutaneous fat (SAT).

2.1. Statistical analysis

Data was entered into a spreadsheet in Microsoft Office Excel 2007®, and subsequently exported to the analysis in SPSS-18.0®. To compare quantitative variables with symmetrical distribution, we used the Student *t* test for independent samples and those whose distribution was skewed by the Mann–Whitney test. Categorical variables were associated by Chi-square test with Yates correction. Quantitative variables were correlated by Pearson correlation coefficient. It was considered a significant level of 5%.

2.2. Ethical aspects

The research project was approved by the Scientific Committee of the Medical School, and by the Research Ethics Committee of PUCRS, Brazil, for their implementation, in accordance with Resolution No. 196/96 of the National Board of Health. All participants who agreed to participate in this study were required to sign the consent form at each stage in 1999, 2006 and 2008, if they were under the age of 18, consent was signed by the parents.

3. Results

159 children and adolescents were enrolled in this study. In 1999, during the first survey, the average age was 13.2 ± 2.2 years and 51.6% were females. This and other characteristics of the population are in Table 1.

WC in 1999 showed a very strong correlation with BMI in the same year ($r = 0.917$, $p < 0.001$), as well as when it was compared with BMI in 2006 and 2008 ($r = 0.685$, $p < 0.001$ and $r = 0.545$, $p < 0.001$ respectively). WC in 1999 showed a strong correlation with WC in 2006 and 2008 ($r = 0.631$, $p < 0.001$ and $r = 0.619$ $p < 0.001$ respectively). No differences were seen regarding gender.

Table 1
Anthropometric and laboratory characteristics of the study population in the three times of observation.

	1999	2006	2008
	n = 159	*n* = 159	*n* = 159
Age, years	13.2 ± 2.6	20.7 ± 2.6	22.7 ± 2.6
Sex, *n*(%)	–	–	–
Male	77 (48.4)	–	–
Female	82 (51.6)	–	–
Weight, Kg	53.3 ± 15.3	67.6 ± 14.6	71.1 ± 15.6
Zweight	0.5 (−0.1 a 1.3)	0.15 (−0.3 a 0.8)	0.36 (−0.2 a 0.9)
Height, m	1.6 ± 0.1	1.7 ± 0.1	1.7 ± 0.1
Zheight	0.22 (−0.5 a 0.8)	−0.12 (−0.7 a 0.4)	−0.05 (−0.5 a 0.6)
BMI, Kg/m²	21.4 ± 3.9	23.5 ± 3.8	24.3 ± 3.9
ZBMI	0.43 (0.1 a 1.3)	0.19 (−0.3 a 0.7)	0.4 (−0.2 a 0.9)
WC, cm	72.7 ± 11.1	77.1 ± 10.1	84.1 ± 10.6
ZWC	0.1 (−0.2 a 0.7)	−0.55 (−1 a −0.1)	−0.37 (−0.9 a 0.3)
VAT, cm²	–	–	52 (37 a 80)
SAT, cm²	–	–	229 (146 a 319)
TF, cm²	–	–	280 (190 a 397)
SBP, mmHg	109.6 ± 11	119.1 ± 15	130.5 ± 18
DBP, mmHg	68.1 ± 7	72.1 ± 13.5	78.7 ± 13.3
HDL, mg/dL	–	53.1 ± 10.8	–
Trigl, mg/dL	–	81 (61 a 109)	–
Gluc, mg/dL	–	87.9 ± 16.5	–

Data presented in mean ± sd or median (P25 a P75); and for categorical variables *n*(%). Zweight = Z score for weight; Zheight = Z score for height; BMI = body mass index; ZBMI = Z score for BMI; WC = waist circumference; ZWC = Z score for waist circumference; VAT = visceral fat at abdominal CT scan; SAT = subcutaneous fat at abdominal CT scan; TF = total fat at abdominal CT scan; SBP = systolic blood pressure; DBP = diastolic blood pressure; HDL = serum HDL cholesterol; Trigl = serum triglycerides; Gluc = serum glucose.