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Abdominal circumference as an indicator of clinical and laboratory parameters associated with obesity in children and adolescents: comparison between two reference tables

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Abstract

Objective: To evaluate the sensitivity and specificity of two pediatric abdominal circumference reference tables to detect abnormally high body mass index, total cholesterol, fasting blood insulin and leptin levels, and homeostasis model assessment values.

Methods: A total of 624 male and female subjects, with ages ranging from 7 to 18 years, were evaluated. All children were recruited from two public schools. Venous blood samples were collected for determination of fasting plasma insulin, glucose, leptin, and total cholesterol levels. Weight, height and abdominal circumference were assessed according to internationally accepted guidelines. Contingency tables were constructed, comparing the presence or absence of increased abdominal circumference, according to cutoff points established by Taylor et al. and Freedman et al., with the presence or absence of abnormal values in the laboratory tests.

Results: Sensitivity values were consistently higher for the table by Taylor et al., whereas the table by Freedman et al. showed greater specificity. Positive predictive values were quite low in general, and were only relevant for body mass index.

Conclusions: Results indicate that the table by Taylor et al. is best for screening purposes, as it identifies individuals at higher risk of presenting abnormal test results. On the other hand, the reference table by Freedman et al. is more suitable for clinical practice, as it could be used to replace laboratory measurements, such as blood insulin or leptin levels, which may not be available at all sites.

J Pediatr (Rio J). 2007;83(2):181-185: Abdominal circumference, obesity, adolescent, dyslipidemias, insulin resistance, leptin.

Introduction

Child and adolescent obesity has reached epidemic proportions worldwide.[1] While in recent years the main concern associated with obesity in children has been the high risk of obesity during adulthood, there is currently growing concern about the consequences of obesity during childhood.[2] Recent studies have demonstrated that problems such as atherosclerotic plaques, glucose intolerance, non-insulin dependent diabetes mellitus, dyslipidemia, hypertension, hyperleptinemia, among others, are also

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present in children and adolescents, especially in those who are obese.[3] Such information, however, is often disregarded in pediatric nutrition practice, especially because of the difficulties associated with access to laboratory tests, which are frequently expensive or even unavailable, and also because of the lack of adequate international standards for establishing syndromic diagnosis, such as metabolic syndrome.[4]

In adults, the measurement of abdominal circumference is accepted as an important tool for assessing the risk of underlying pathologic conditions, especially atherosclerosis.[5] For children and adolescents, however, the scarcity of long-term prospective studies does not allow the simple extrapolation of these findings.[6] In addition, the fact that this measurement presents some degree of variation, due to physical growth, demands that cutoff points, when existing, be different for each age group.[7] Two studies are important in this respect. In 1999, with data from the Bogalusa Heart Study, Freedman et al.[8] assessed the relationship between abdominal circumference and blood insulin and lipid levels in 2,996 subjects from 5 to 17 years. Considering the risk of abnormal blood test results, they produced a reference table with cutoff points based on the 90th percentile of the sample distribution. In 2000, Taylor et al.[9] published a study with 580 children and adolescents with ages between 3 and 19 years aimed at validating the abdominal circumference measurement as an indicator of central adiposity, using the dual energy X ray absorptiometry (DEXA) as the gold standard for measuring adiposity. The authors developed a reference table with cutoff points for abdominal circumference, defined as the 80th percentile of the sample.

The aim of the present study is to comparatively evaluate the sensitivity and specificity of two reference tables for detecting abnormally high body mass index (BMI), total cholesterol, blood insulin and leptin levels, and homeostasis model assessment (HOMA) values.

Methods

The study was carried out in two public schools in the district of Bonfim Paulista, located 6 kilometers from Ribeirão Preto (southeast Brazil) and administratively subordinated to this city. In a cross sectional design, anthropometric measures, personal data and venous blood samples were taken at a single occasion. A total of 624 children and adolescents were evaluated, both male and female, with ages ranging from 7 to 18 years (84 to 215,9 months). Initially, all the 1,200 students enrolled at the two schools were considered for inclusion in the study. Exclusion criteria were the following: refusal to participate in the study (240); unsigned consent form from parents/guardians (306); ongoing treatment for any medical condition (18); inadequate conditions for anthropometric measurements, such as use of prosthesis, cast, physical handicap, etc. (12). The research was approved by the Research Ethics Committee of the Universidade de Ribeirão Preto, on October 20th, 2003, as described in the memorandum ComÉt/ no. 94/2003.

Prior to collecting biological material, participants and their legal guardians were informed about the project, both orally and through an informed consent, by which permission was granted for collecting blood samples. All participants were instructed to follow a 12-hour fasting; blood samples were taken in the morning, at the participating schools. Two 4 mL tubes of blood, without additives, were collected; samples were taken to the laboratory within 2 hours, for processing and biochemical and hormonal analyses. Transportation was made in insulated boxes. The biological material was centrifuged in a Bio Eng BE 4000 centrifuge for 5 min at 3,500 rpm, between 1 and 2 h 30 min after blood collection (to allow blood clotting). After centrifugation, the serum was separated and divided into three aliquots of 500 µL. Measurement of insulin was performed in one of the aliquots on the same day of the collection. Blood glucose was assessed enzymatically with the hexokinase method, using the automatic analyzer Cobas Mira Plus (Roche). Serum insulin levels were determined by chemiluminescence (Immulite, DPC-Medlab). Leptin values were measured by a sandwich enzyme-linked immunosorbant assay, using an ELISA Organon reader. Total cholesterol was measured with an enzymatic kit (CHOD-PAP), on a Cobas Mira Plus (Roche) analyzer. HOMA was calculated using the equation proposed by Wallace & Matthews[10]: blood glucose (mol/dL) x blood insulin (µUI/mL) / 25. Weight and height were measured according to the recommendations by Cameron.[11] Abdominal circumference was measured at the level of an imaginary horizontal line at the midway region between the lowest rib margin and the iliac crest.[12]

To evaluate the predictive value of the abdominal circumference measurement as an indicator of obesity-associated metabolic abnormalities, contingency tables were constructed. In these, the presence or absence of an increased abdominal circumference – according to the criteria established by Taylor et al. and Freedman et al. – was compared against the presence or absence of high values of BMI, total cholesterol, blood insulin and leptin, and HOMA. The cutoff point for fasting blood glucose level was set at 100 mg/dL.[13] A high BMI was defined according to the guidelines of the National Center for Health Statistics (NCHS) as a BMI above the 85th percentile.[14] High total cholesterol was defined as greater than 170 mg/dL, according to the III Brazilian Guidelines on Dyslipidemias and Guidelines for the Prevention of Atherosclerosis.[15] The upper limit of normality for blood insulin and leptin and HOMA was calculated based on the mean plus two standard deviations (SD) of the values

obtained for the 624 participants, grouped in 12 month age groups, as these values present large variation according to age group.

Results

Cutoff points are presented in Table 1. Using the values proposed in this table, 143 (22.9%) individuals were identified with BMI above the 85th percentile; 167 (26.8%) with high cholesterol levels; 27 (4.3%) with hyperinsulinemia; 21 (3.4%) with high HOMA index; and 31 (5.0%) with hyperleptinemia.

Comparative results are shown in Table 2. From the 30 pairs of results analyzed, sensitivity values were consistently higher for the table by Taylor et al.; using this reference table, BMI, insulin, HOMA and leptin values showed high sensitivity (varying between 70.4 and 80.7); the same was not found for total cholesterol, which presented very low sensitivity (24.6).

Specificity values were consistently higher for the reference table by Freedman et al., varying from 91.9 to 99.6; the lowest specificity was for total cholesterol. Specificity results obtained with the values suggested by Taylor et al. were also high (ranging from 79.6 to 94.6), but did not surpass the results obtained with the values proposed by Freedman et al.

Positive predictive values were generally low, with the exception of BMI. Negative predictive values were consistently high, with slight advantage to the table by Taylor et al.

False-positive results were consistently low, especially for the table by Freedman et al., which showed a maximal value of 8.1. False-positive results for Taylor et al. varied between 5.4 and 20.8. False-negative results were found more frequently when using the values proposed by Freedman et al. (range 45.2-88).

Global test coefficient values were similar for both reference tables, with slightly higher results for the table by Taylor et al. in regard to BMI, insulin, leptin and HOMA values.

Discussion

The present study aimed at assessing if the measurement of abdominal circumference, analyzed according to two different reference tables, can indicate the presence of clinical and laboratory abnormalities associated with obesity, which generally require more complex methods. Taking into consideration the technical advantages and feasibility of abdominal circumference measurement,[16,17] this method could constitute an alternative for screening patients at risk. With this goal, as a screening method, higher sensitivity values are desirable.[18] In this sense, the table by Taylor et al. showed marked superiority, reaching sensitivity levels above 70 for all the parameters assessed, with the exception of total cholesterol, for which sensitivity was low with both tables tested. Accordingly, in other studies, total cholesterol levels were not associated with abdominal adiposity.[6]

An important difference was noted for the sensitivity in detecting high BMI (above the 85th percentile). The chance of

Table 1 - Number of participants assessed in each age group and cutoff points used in this study

		Cutoff points							
				Insulin		HOMA		Leptin	
Age (months)	n (624)	BMI	Total cholesterol	Boys	Girls	Boys	Girls	Boys	Girls
84-119.9	155	P85	170	6.74	7.99	2.38	2.22	31.62	33.09
120-143.9	142	P85	170	14.5	15.06	3.39	3.43	40.87	42.41
144-167.9	155	P85	170	26.89	26.84	4.84	4.89	34.92	45.7
168-191.9	128	P85	170	14.53	16.11	4.28	4.59	33.58	52.43
192-216	44	P85	170	10.7	14.42	2.37	3.21	40.11	59.13

HOMA = homeostasis model assessment; BMI = body mass index.

detecting individuals with high BMI among those who actually have high BMI using the reference table by Taylor et al. is practically twice that of Freedman et al. Specificity values, on the other hand, were relatively high for both methods, and therefore they were both capable of correctly identifying individuals with BMI below the cutoff point. When observing the global test coefficient, the reference table by Taylor et al. appears to be more able to identify true results.

This study shows that, for detecting peripheral insulin resistance based on abdominal circumference measurement, fasting blood insulin or HOMA values yield similar results. In both cases, sensitivity levels were considerably higher for the reference table by Taylor et al., reinforcing its role as a screening method. Specificity values, in this case, were different; the reference values suggested by Freedman et al. were more specific, and proved to be more effective in identifying individuals without peripheral insulin resistance. Therefore, the global test coefficient was similar for both references.

In terms of sensitivity, the numbers suggested by Taylor et al. were markedly superior to those suggested by Freedman et al. for detecting hyperleptinemia, with less false-negative results, supporting this reference as an appropriate screening tool. The cutoff points suggested by Freedman et al. showed greater specificity, with less false-positive results; this profile suggests that this table may be more adequate for the individual evaluation of patients who present other indexes of peripheral insulin resistance and in whom it is reasonable to suspect hyperleptinemia, as well as in the absence of laboratory tests, which are still expansive and of limited availability.

Some limitations of the present study must be recognized. The most important is surely the cutoff points used for insulin, HOMA and leptin values, which were based on a statistical calculation (means + 2 SD) and not on "associated risk." This was motivated by the inexistence, until the present moment, of internationally validated cutoff points for these variables. Another limitation refers to the small number of variables investigated, as important markers – such as LDL-cholesterol, HDL-cholesterol, triglycerides, fibrinogen, polymerase chain reaction, uric acid, blood pressure, etc. – were left out of the study.

Despite these limitations, some important aspects must be emphasized, such as the high number of study participants and the investigation of parameters such as blood insulin and leptin levels in the whole sample. Generally, the study results indicate that the reference table by Taylor et al. is best for screening purposes, since it indicates individuals at higher risk of presenting laboratory abnormalities. On the other hand, the reference table by Freedman et al. is more adequate for clinical practice, and it can replace laboratory test that may be unavailable for

Table 2 - Performance of abdominal circumference measurement according to the cutoff points suggested by Taylor et al. and Freedman et al. for identifying laboratory abnormalities associated with abdominal adiposity in children and adolescents

	BMI n = 624		Total cholesterol n = 624		Insulin n = 624		HOMA n = 624		Leptin n = 624	
	Taylor	Freedman	Taylor	Freedman	Taylor	Freedman	Taylor	Freedman	Taylor	Freedman
Sensitivity	76.9	38.5	24.6	12	70.4	48.2	71.4	42.9	80.7	54.8
Specificity	94.6	99.6	79.2	91.9	80.4	92.6	79.9	92	81.3	93.3
PPV	80.9	96.5	30.2	35.1	14	22.8	11	15.8	18.4	29.8
NPV	93.2	84.5	74.2	74.1	98.4	97.5	98.8	97.9	98.8	97.5
False +	5.4	0.4	20.8	8.1	19.6	7.4	20.1	8	18.7	6.8
False -	23.1	61.5	75.4	88	29.6	51.9	28.6	57.1	19.4	45.2
Test coefficient	85.9	74.5	52.0	53.2	69.6	67.0	69.3	63.6	75.5	71.0

BMI = body mass index; HOMA = homeostasis model assessment; NPV = negative predictive value; PPV = positive predictive value.

physicians at some locations. We suggest that such a screening procedure, considering the magnitude of the problem of child obesity, be always performed, reinforcing the abdominal circumference measurement as a compulsory part of the pediatric examination.

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