RESEARCH ARTICLE

Waist circumference and its association with cardiovascular risk factors in obese children and adolescents

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ABSTRACT

Background. It has been demonstrated that indirect indicators of adiposity such as body mass index are associated with metabolic disorders including cardiovascular risk factors. The objective of this study was to evaluate the association of body mass index (BMI) and waist circumference (WC) with cardiovascular risk factors in obese children and adolescents.

Methods. We carried out a cross-sectional study in 115 obese children and adolescents (BMI > +2.0 SD). Weight, height and WC were measured. Blood pressure (BP), serum lipid profile, glucose and insulin were determined and HOMA-IR index was calculated. The correlation between BMI and WC with biochemical parameters and BP was identified; multivariate models were performed to evaluate the association of BMI and WC with cardiovascular risk factors.

Results. Mean age of the subjects was 9.75 ± 3.1 years. A significant positive correlation of BMI and WC with BP, insulin and HOMA-IR was identified. In multivariate models, both BMI and WC showed an association with these alterations.

Conclusions. In obese children and adolescents, both WC and BMI are associated with alterations in BP, insulin and HOMA-IR.

Key words: obesity, abdominal obesity, cardiovascular risk factors, children and adolescents.

INTRODUCTION

Obesity and overweight in children and adolescents is considered a public health problem worldwide because of its high prevalence as well as its association with different comorbidities. Among these are metabolic disorders that include cardiovascular risk factors (CRF).[1,2]

It has been pointed out that cardiovascular diseases in obese adults are as a result of atherogenic lipid accumulation and inflammatory changes associated with excess adipose tissue through the production of hormones, peptides and other molecules that affect cardiovascular function.[3] It has also been speculated that abdominal fat deposits release greater quantities of free fatty acids and proinflammatory cytokines than subcutaneous fat; therefore, accumulation of abdominal fat is associated with a greater cardiovascular risk.[4]

It has been demonstrated in children and adolescents that some indirect indicators of adiposity such as body mass index (BMI) are associated with the presence of these alterations. However, BMI has its limitations because its increase may be related to an increase in fat-free mass and its relationship with fat varies according to age, gender and degree of sexual maturity.[5,6] Therefore, since the end of the 1990s it has been pointed out that measurement of waist circumference (WC) as an indicator of abdominal fat may be a better CRF predictor.[7,8]

The majority of studies including some performed in our country have described these alterations in open populations that include children with normal weight,

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Received for publication: 1-25-13
Accepted for publication: 6-6-13

overweight and obesity. These reports indicate that the frequency of alterations increases as the values of BMI and WC increase, particularly in cases of overweight and obesity.[9,10] The inclusion of children with normal weight and overweight may be a disadvantage in the identification of these associations because the moderate increase of BMI does not necessarily indicate an excess of fat and, therefore, may not be associated with CRF.[6,11] In this way it has been noted that for these cases measurement of the WC could be an alternative for predicting metabolic and cardiovascular risk.[6]

The study of children and adolescents with obesity in whom high BMI values are invariably associated with an excessive accumulation of adipose tissue would allow to better assess the possible contribution of abdominal adiposity in the prediction of CRF.[12] Therefore, this study was carried out in a group of obese children and adolescents with the purpose of determining if abdominal obesity evaluated by measuring the WC is associated with CRF.

SUBJECTS AND METHODS

A cross-sectional study was conducted with 115 patients who were seen at the Clinic for the Care of Children and Adolescents with Obesity, Division of Pediatrics, Hospital Civil de Guadalajara Dr. Juan I. Menchaca (HCG-JIM) during the period from January 2009 to January 2012. All patients of either gender who presented for the first time for consultation were included. Subjects had to demonstrate exogenous obesity and had to be accompanied by one parent. HCG-JIM is an institution that cares for an open population, the majority being medium-low and low socioeconomic status. In all cases a physician carried out the clinical history and physical examination. Blood pressure measurement was done in triplicate by trained professionals with standardized procedures with a mercury sphygmomanometer using a cuff appropriate according to the size of the patient's arm. The measurements were compared with the values adjusted for age, gender and height published by the National Program of Education for High Blood Pressure in the U.S. The presence of pre-hypertension was considered when there were values between 90 and 94% and hypertension was considered at ≥95%.[13] Anthropometric measurements, weight, height and WC were performed by nutritionists trained for this purpose and in accordance with international techniques.[14] For measurement of weight we used a scale (SECA model 701021994) with accuracy of 100 g; height with a height rod (SECA model 240). WC was determined with the subject standing in front of the examiner with the arms at the sides, feet together, barechested. The edge of the iliac crest and the last rib were located and the halfway point of the distance between these two points was marked. At that point the measurement was done using a 0.6-mm wide metallic tape.[15] With the data obtained, anthropometric indices for height according to age and BMI were calculated. Obesity was diagnosed when the BMI was > +2.0 SD for age and gender according to the WHO reference standards.

All patients had laboratory tests done including glucose, insulin and lipid profile. Glucose and lipid concentrations (total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C) and triglycerides (TG) were quantitatively determined with the SYNCHRON® system. For insulin concentration, the Access Ultrasensitive Insulin Beckman Coulter device was used. Chemiluminescence immunoassay was done for the determination of the quantitative levels of insulin in serum and plasma. Total cholesterol concentrations of ≥200 mg/dl, LDL-C ≥130 mg/dl, HDL-C ≤40 mg/dl, TG ≥150 mg/dl, glucose ≤100 mg/dl and insulin ≥20 were considered normal. With the values of the concentrations of glucose and insulin the HOMA-IR was calculated (model for the evaluation of glucose homeostasis): (glucose/18) x (insulin/22.5) where values >3.8 were considered as indicators of insulin resistance.[16,17]

Statistical analysis

Descriptive statistics were carried out for the study variables: the analysis of correlation (Pearson) between the values of the BMI and the WC with the values of systolic blood pressure (SBP), diastolic blood pressure (DBP), TC, LDL-C, HDL-C, TG, glucose, insulin and HOMA-IR index. Multivariate models were performed adjusted for age and gender, taking the profile variables of lipid profile, glucose, insulin, HOMA-IR and blood pressure as dependent variables and BMI and WC as independent variables; $p < 0.05$ was considered as significant. The study was carried out with the authorization of the study subjects and their parents and with the approval of the Ethics and Research Committee of the hospital.

RESULTS

There were 115 patients included, 60% males and 40% females. The average age was 9.75 ±3.1 years. The average ages of the father and mother were 40.4 and 37.5 years, respectively. With respect to family history, 95.7% reported history of obesity in the parents or in some family members and 74.3% of diabetes mellitus. In all cases the values of weight and height of the mother were obtained, with which the BMI was calculated; 50% were obese (BMI ≥30) and 31.1% were overweight (BMI 25-29.9). Two of the mothers and one father reported having type 2 diabetes mellitus. The average birth weight was 3312 ±648 g. In 13.2% a history of being a pre-term product was reported.

The averages of the anthropometric values, blood pressure and biochemical variables according to gender (Table 1) are shown. Only BMI values were significantly higher in males. Altered values for glucose were identified in 7% of subjects, insulin in 32.5%, HOMA-IR 36%, TC in 13.9%, HDL-C in 48.7%, LDL-C in 10.4%, TG in 46.1%, SBP in 7.3% and DBP in 3.7%.

The values of correlations of BMI and WC with the biochemical variables and blood pressure are shown in Table 2. The correlations were positive and significant in the cases of the values of SBP and DBP, insulin and HOMA-IR, both for BMI and WC. HDL values showed a negative correlation with WC. In cases of insulin and HOMA-IR, the coefficients of correlation were higher with the WC.

Due to the correlation between BMI and WC values (r =0.79), the multivariate models adjusted for age and gender were conducted separately with BMI and WC as independent variables. In both cases they remained associated with the values of the DBP, insulin and HOMA-IR but not so with SBP and HDL values. In all cases, WC explains a greater variability of the CRF that showed association, but the strength of association was similar and significant in both cases (WC and BMI) (Table 3).

DISCUSSION

The presence of obesity in children and adolescents has become one of the health problems of highest prevalence worldwide. Its association with CRF from early stages of life is worrisome and considered to be the beginning of the process of atherosclerosis, which will determine the development of cardiovascular disease in the adult.[18] Therefore, having anthropometric indicators that are associated with the presence of these disorders is of interest and would allow for identification of individuals at risk. The majority of studies in this regard have concluded that both BMI and the WC are associated with CRF and WC may be a better predictor of the risk of its presence, particularly in adults.[6,19,20]

Table 1. Anthropometric and biochemical characteristics and blood pressure in obese children and adolescents

	Males (*n* = 69)		Females (*n* = 46)	
Variable	Average	SD	Average	SD
Age (years)	9.6	3.0	9.9	1.3
BMI (Z)*	4.0	1.6	3.3	0.9
Height index/age (Z)	0.9	1.0	0.6	1.1
WC (cm)	88.3	11.7	86.1	12.2
Glucose (mg/dl)	86.8	10.0	85.2	11.3
Insulin (μIU/ml)	16.7	11.8	17.2	10.6
HOMA-IR	3.6	2.8	3.7	2.5
TC (mg/dl)	161.8	32.2	165.8	31.0
HDL-C (mg/dl)	36.8	9.8	34.9	9.7
LDL-C (mg/dl)	93.2	25.1	97.9	27.8
TG (mg/dl)	158.9	106.4	163.8	70.4
SBP (mmHg)	105.0	12.1	101.0	13.3
DBP (mmHg)	61.3	10.2	63.0	10.1

SD, standard deviation; BMI, body mass index; WC, waist circumference; HOMA-IR, homeostasis model assessment-estimated insulin resistance; TC, total cholesterol; HDL-C, high-density lipoproteín cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglycerides; SBP, systolic blood pressure: DBP, diastolic blood pressure. *p = 0.005 (Student t test; males *vs.* females).

In the case of this study, all patients were obese with BMI averages that exceeded the 3.0 SD in males as in females, and most had abdominal obesity. This fact is important because abdominal obesity carries an additional risk that is identified through the measurement of BMI.

The positive correlation of BMI and WC with blood pressure, insulin and HOMA-IR with higher values in the last two with WC suggests that even in obese subjects the risk of these disorders increases with the increased accumulation of fat in the abdominal region. The results (with the exception of SBP) were confirmed in multivariate models adjusted for age and gender in which the WC explains greater variability of the CRF, although the strength of the association was similar for both measurements. These results are consistent with reports indicating that in obese adolescents with a similar BMI, insulin sensitivity is lower in those with increased abdominal fat.[21,22]

Table 2. Correlation coefficients[a] of WC and BMI with blood pressure and biochemical variables

	BMI	WC
BMI (kg/m^2)	–	0.79*
WC (cm)	0.79*	–
SBP (mmHg)	0.32**	0.32**
DBP (mmHg)	0.39*	0.41*
Glucose (mg/dl)	0.14	0.16
Insulin (μU/ml)	0.48*	0.58*
HOMA-IR	0.46*	0.55*
TG (mg/dl)	0.05	0.09
TC (mg/dl)	0.06	0.08
HDL-C (mg/dl)	-0.14	-0.19***
LDL-C (mg/dl)	0.16	0.07

[a]Pearson correlation coefficient.
HOMA-IR, homeostasis model assessment-estimated insulin resistance; BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglycerides; TC, total cholesterol; HDL-C: high density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.
*$p < 0.001$; **$p < 0.01$; ***$p < 0.05$

Studies similar to the present one have identified the usefulness of the measurement of the waist circumference in patients with obesity. Raman et al. when they studied 121 African-American overweight or obese children or adolescents (BMI >85th percentile) and identified an independent association of WC with DBP and HDL-C.[23] Bassali et al. reported an increased risk of abnormal HDL values, insulin and TG levels associated with WC in 188 obese children (7-11 years).[12] Moreover, in another study conducted in Korea in 175 adolescents who were overweight or obese who were evaluated for abdominal and subcutaneous fat using computed tomography, the association of abdominal fat was identified between blood pressure, insulin, HOMA-IR, HDL-C and TG.[24] Janssen et al. evaluated data from the Bogalusa Heart Study in 2597 children and adolescents aged 5-18 years. They concluded, similar to this work, that both anthropometric variables predict CRF.[25]

Differences in the magnitude and variables associated with abdominal obesity may correspond to differences in the ages of the subjects of study, ethnic differences, environmental aspects or differences among study designs. However, the findings that point to increased cardiovascular risk in obese children and adolescents and with excess abdominal fat are consistent.

A limitation of this study was having a group of subjects who attended a hospital for treatment and who are not representative of obese children and adolescents in the community. Also, there was lack of national data on the distribution of WC to establish appropriate cut-off points and to determine the presence of abdominal obesity as the basis for risk prediction. For this reason it would be important to have WC reference values for our population.

In conclusion, abdominal obesity is associated with metabolic and cardiovascular risk factors; however, in this

Table 3. Multiple regression analysis adjusted by age and gender to evaluate the role of BMI and WC in regard to DBP, insulin and HOMA-IR values

	DBP			Insulin			HOMA-IR		
	Coeff	95% CI	*p*	Coeff	95% CI	*p*	Coeff	95% CI	*p*
BMI	0.62	0.15; 1.09	<0.01	0.80	0.29; 1.31	<0.001	0.18	0.05; 0.30	<0.001
R^2		0.20			0.30			0.27	
WC	0.33	0.11; 0.56	<0.01	0.49	0.25; 0.72	<0.001	0.11	0.05; 0.16	<0.001
R^2		0.20			0.36			0.32	

Coeff, β coefficients adjusted by age and gender; R^2, coefficient of determination adjusted for each model; HOMA-IR, homeostasis model assessment-estimated insulin resistance; DBP, diastolic blood pressure; BMI, body mass index; WC, waist circumference; 95% CI, 95% confidence interval.

study it was not possible to identify an independent effect of BMI according to its high correlation. The strength of association of BMI and WC with CRF was similar; therefore, the two measurements can be considered for the evaluation of obese children and adolescents. The excess of abdominal fat evaluated using the WC appears to be a more sensitive indicator of alterations in insulin metabolism, for which reason it has been considered in the diagnosis of metabolic syndrome in adolescents.[26] Measurement of WC is relatively simple. It is desirable that it be systematically incorporated into the evaluation of overweight and obesity in children and adolescents.

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