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The potential of central obesity antropometric indicators as diagnostic tools

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ABSTRACT

Objective

It has been suggested that the indicators of centralized obesity, namely by waist-to-hip circumference ratio (WHR) and waist circumference (WC), express different metabolic disorders. Thus, a study was conducted in order to verify the diagnostic potential of the relationship between these two measures and social, behavioral, and biological determinants of centralized obesity.

Methods

Two hierarchical multiple regression models were applied to a 1,042 subject sample from the city of São Paulo, southeastern Brazil, in order to evaluate relationships between indicators and determinants for centralized obesity. Clinical, biochemical/laboratory, and behavioral surveys were carried out using standardized questionnaires. Evaluation included blood pressure, anthropometric measurements, and waist and hip circumference measurements.

Results

WHR was significantly associated with low stature and strongly related to socioeconomic level; this was not the case with WC. Both WHR and WC were strongly associated with age, sex, and sedentary lifestyle. Women were at greater risk of centralized obesity then men: OR=5.04 and 7.27 for WHR and WC, respectively. WHR was significantly associated with alterations indicative of metabolic syndrome: hypertension and low levels of HDL-cholesterol. WC was significantly associated with hypertension alone. Both indicators were strongly associated with the concomitant presence of two or more alterations related to metabolic syndrome. Unlike WHR, WC was associated with hypercholesterolemia.

Conclusions

WHR was more closely associated with socioeconomic factors, past malnutrition, and alterations indicative of metabolic syndrome than WC, which was more closely associated with risk factors for cardiovascular and arteriosclerotic diseases.

Keywords

Obesity. Anthropometry. Body weights and measures. Socioeconomic factors. Risk factors.

INTRODUCTION

Several studies published in the last decade confirm the importance of body fat distribution in the etiology of obesity-related metabolic diseases, first suggested by Reaven.[3,4]

Fat accumulation around the abdominal region is characteristic of visceral abdominal obesity, which is more severe a risk factor for heart disease and glucose-insulin homeostasis derangement than generalized obesity. It is associated, as well, to hypertension, dyslipidemia, fibrinolysis, acceleration of the arteriosclerotic process, and psychosocial factors. The concomitant presence of centralized obesity and one or more of the above mentioned metabolic diseases characterizes the metabolic syndrome.[3-6]

In addition to biological factors, there are other socio-environmental factors which act upon the etiology of centralized obesity.[3] Velásquez et al,[12] in a study that used the same population as the present one, showed an association between centralized obesity and low stature, suggesting that past malnutrition may be a risk factor for this type of obesity in adult age. Viggiano[13] (2001), also studying the same population, found an association between glycemic alterations and abdominal obesity. Baker[1] (1993) shows that children with growth deficit are more likely to develop obesity, non-insulin-dependent diabetes, and cardiovascular disease. On the other hand, Marinho[7] (2002), in an analysis of intra-familiar nutritional state distribution, found that moderate to severe levels of malnutrition in children and adolescents are related to low maternal stature associated with obesity.

Visceral abdominal fat aggregation can be measured precisely through computerized tomography. This method, however, is unfeasible when dealing with population-wide studies, which employ anthropometric indicators for centralized obesity diagnosis.

Anthropometric indicators most used are the ratio between waist and hip circumference measures, or waist-to-hip ratio (WHR) and waist circumference (WC).

Due to its greater repeatability, WC has been considered as the better indicator for abdominal obesity, in comparison with WHR.[5,10,16] However, according to Björntorp[3] (1997), these two indicators contain different information concerning metabolic disorders associated to centralized obesity. WC would be a better indicator of visceral adiposity, being strongly related to arteriosclerotic heart disease. On the other hand, WHR, which contains a measure of the gluteus region – with its various muscular tissues, the main regulators of systemic-insulin sensitivity – would be more closely associated with insulin resistence.[3] Due to the importance of these two indicators of central obesity to population-based studies, the present paper is aimed at verifying the hypothesis proposed by Björntorp,[3] as well as at evaluating the diagnostic potential of these indicators: whether WHR and WC are interchangeable, or whether they contain information which are complementary.

Thus, we intend to analyze the relationships between centralized obesity indicators WHR and WC and socioeconomic, behavioral, and biological factors found in the etiology of this disorder.

METHODS

Population

The present study used data from the survey Doenças cardiovasculares ateroscleróticas, dislipidemias, hipertensão, obesidade e diabetes melito em população da área metropolitana de São Paulo (Arteriosclerotic heart diseases, dislipidemias, hypertension, obesity, and diabetes mellitus in a São Paulo metropolitan area population), carried out in 1990-91 in the city of Cotia, in the metropolitan area of São Paulo City, in southeastern Brazil.[9] This was a cross-sectional study which analyzed population groups from five "study areas" defined according to socioeconomic and geographical criteria, including central and peripheral regions of the city. The sample included 1,047 subjects of both sexes, ages 20 years or older.

Details concerning methodology and data collection can be found in a previously published article (Martins et al,[9] 1993).

Three surveys consisting of direct interviews were conducted. Standardized questionnaires were used.

1. Clinical survey: blood pressure/anthropometric measurements and personal/family clinical history with emphasis on the presence of cardiovascular events (myocardial infarction, unstable angina, myocardial revascularization through surgery or angioplasty, cerebrovascular accident).

2. Biochemical and laboratory survey: serum levels of total cholesterol, HDL-cholesterol, LDL-cholesterol, glucose, and triglycerides.

3. Sociodemographic and behavioral interview: included data concerning age, income, place of birth, occupation, position, proprietorship, number of employees, schooling, sex, and lifestyle (alcohol drinking, smoking, sedentary lifestyle).

Data collection instruments

Data collection employed, among others, the following clinical, biochemical, and behavioral evaluation instruments:

Arterial pressure, measured using a standard Hg sphygmomanometer, relating systolic pressure to the first signs of Korotkoff sounds, and diastolic pressure to their disappearance (Korotkoff phase V). In seated position, three consecutive arterial pressure measurements were performed on the left arm at five-minute intervals. Mean value was registered and subjects were classified as normotensive or hypertensive. Because the survey was aimed at investigating cardiovascular disease, arterial pressure in obese and elderly patients was measured with the subject lying down and then seated, and on both arms.

Anthropometric measurements – included weight, height, hip and waist circumference measures. Height was measured in meters, with subject standing barefoot, in erect position, looking towards the horizon, with back and back of the knee touching the wall. A nonelastic tape measure, affixed to the wall at 50cm from the floor and a triangle were employed. Weight was measured in kilograms, using Filizola-type scales, with 150kg maximum weight and 100g precision. Subjects, in light clothing and without shoes, were weighed by an interviewer trained to avoid mistakes, who kept her eyes below reading angle so as to record the subject's weight, which was rounded to the closest integer.

Waist – measured in cm, using a nonelastic tape measure, at the midpoint between iliac crest and outer face of last rib.

Hip – measured in cm, using a nonelastic tape measure, at the point of greatest perimeter between hips and buttocks.

Blood glucose was measured through fingertip lancing, using Hemoglukotest tapes.

After clinical-biochemical-laboratory survey, individual interviews were conducted using a standardized questionnaire for the collection of demographic, socioeconomic, and behavioral information, and of data on personal and family heart, kidney, and other disease history.[9]

Demographic and socioeconomic data included, among others: sex, age, marital status, city and state of birth, time residing in the city, position at work, schooling, and individual/family income of each subject.

Behavioral data referred to certain lifestyle components, such as smoking, alcohol drinking, and sedentary lifestyle.[9]

Smoking was evaluated according to four aspects: smoker, nonsmoker, number of cigarettes/day, duration of smoking habit.

Alcohol drinking was analyzed by means of the CAGE questionnaire, aimed at the early detection of alcoholism, designed by Ewing and Rouse, in 1970. It includes four questions related to the habit of drinking and other more general questions aimed at facilitating interview flow.[8]

Physical activity was estimated based on an hourly average derived form subjects' daily energy expenditure, evaluated by means of six questions aimed at identifying daily activities performed by the subject at work, during free time, and at home.

Non-daily activities were evaluated based on mean weakly energy expenditure. Total energy expenditure [TEE], as a multiple of the baseline metabolic rate, was estimated based on the number of hours spent at work, resting, on leisure activities, and at home, multiplied by factors related to the energy expenditure involved with the performance of each activity (FAO/WHO/UNU, 1985).[11]

The level of physical activity in relation to a daily average of total energy expenditure, as a multiple of baseline metabolism rate [BMR] was divided into three categories: mild, moderate, and intense.

Statistical analysis

Due to the inclusion of risk factors of different nature – demographic, socioeconomic, behavioral, and biological – we chose to use two hierarchical analysis models, as proposed by Victora et al. (1996).[13]

In order to analyze how distal and proximal determinants of centralized obesity are associated with the indicators of this morbidity, the analysis model (Figure 1) was carried out using multiple regression based on stepwise forward selection.

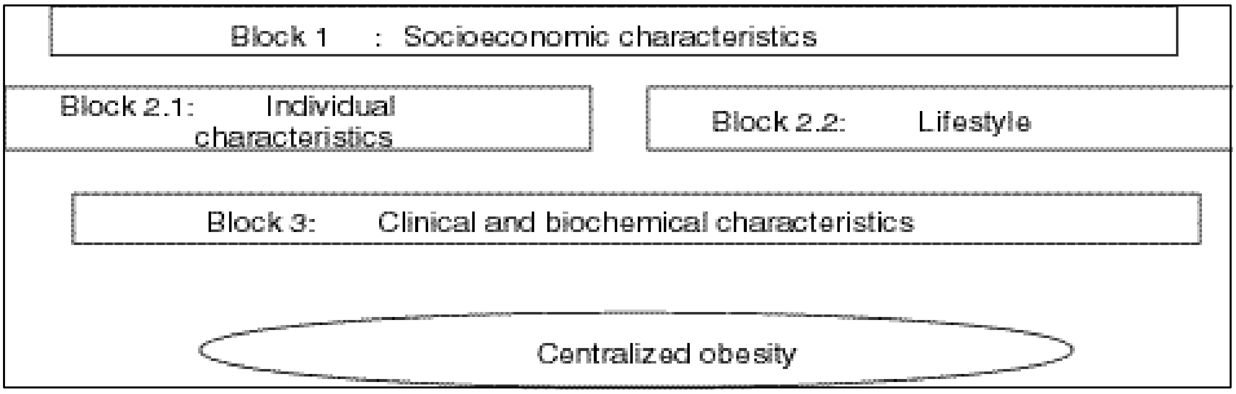

Figure – Hierarchical analysis model.

Before building each model, univariate analyses were carried out in order to estimate crude odds ratios (cOR) and their respective 95% confidence intervals, using Epi-Info v. 6.02 software. MULTLR software was used for non-conditional hierarchic multiple logistic regression analysis.

All variables with p levels < 0.20 in univariate analysis were included in the model. In each block, variables with p levels < 0.05, those which best adjusted the model, and those which represented blocks were kept in the model.

Model I refers to variables associated with WHR, and model II to those associated with WC.

Hierarchical analysis models I and II were constructed according to the framework presented in Figure 1.

Dependent variables include centralized obesity indicators WHR and WC.

Block 1 – socioeconomic characteristics –variables schooling (SCH) and gross family income (FI).

SCH was divided into two categories: SCH > fourth grade elementary =0, and SCH = fourth grade elementary =1.

FI was also divided into two categories: FI = 10 minimum wages (MW) =0, and < 10 MW =1.

Block 2.1 – individual characteristics –variables age (20-39=0; 40-59=1; 60 or more =3), sex (male =0; female =1), and height (m) (>1.60=0; =1.60=1(men) and >1.50=0; =1.50=1(women)).

Block 2.2 – lifestyle, ascribed to the same hierarchical level as individual characteristics for dealing with individual subjects – variables smoking (SK) (no =0; yes =1); alcohol drinking (AD) (no =0; yes =1); and sedentary lifestyle (no =0; yes =1).

Block 3 comprised indicators of the following metabolic disorders:

Dyslipidemia: total cholesterol (TC) (mg/dl): <200 mg =0 and =200 =1; HDL cholesterol (HDL)[10] mg/dl: >40 =0 and =40=1; triglycerides (TR) mg/dl: <150 =0 and =150 =1.[10]

Glycemic alterations (GL): glucose mg/dl : <110 =0 and =110=1[10]

Hypertension (HP): systolic pressure <140 =0 and =140=1 or diastolic pressure <90 =0 and =90=1.

Dependent variables were defined according to standards proposed by WHO (1997):[14]

1 – Abdominal obesity: (men) waist/hip circumference ratio (WHR) =1,00; (women) WHR =0,85.

2 – Abdominal obesity: (men) waist circumference (WC) =94 cm ; (women) WC =80 cm.

RESULTS

Univariate analysis was carried out between the dependent variable and the variables in each block. Variables included in the model were those significantly associated with the dependent variable (p=0.05), those which contributed to model improvement, or those representing blocks.

Block 1 included socioeconomic indicators schooling and income. Due to the interaction between these two variables, they were replaced by a dummy, as seen in Table 1. Table 1 also presents associations between WHR and individual lifestyle factors age, sex, low stature, and sedentary lifestyle, which are controlled by socioeconomic level, i.e., variables in Block 2 are controlled for those in Block 1. Sex, age, and sedentary lifestyle were strongly related to WHR. Low stature, which had produced a significant association in univariate analysis due to its strong correlation with socioeconomic level, lost statistical significance, although with a borderline p-value (p=0.055).

Table 1 – Individual lifestyle factors associated with waist-to-hip ratio, controlled for socioeconomic level.

Variable	Category	OR	Adj. OR; 95%CI	P*
Block 1				
Income/schooling interaction				
	0- SCH=0 FI=0	1.00		
	1- SCH=1 FI=1	2.50	1.24; 5.06	0.011
	2- SCH=0 FI=1	2.05	1.23; 3.41	0.005
	3 – SCH=1 FI=0	0.91	0.51; 1.63	0.751
Block 2				
Age				
	20-39 = 1	1.00		
	40-59 = 2	3.18	2.29; 4.41	<0.000
	60+ =3	5.56	3.42; 9.37	<0.000
Sex				
	Male = 0	1.00		
	Female = 1	5.09	3.68; 7.03	<0.000
Physical activity				
	Intense/moderate = 0	1.00		
	Mild =1	1.64	1.33; 202	<0.000
Low stature				
	No = 0	1.00		
	Yes = 1	1.60	0.99; 2.62	0.055

*Wald's test descriptive level.

OR Odds ratio

In the final model (Table 2, which presents associations between WHR and metabolic disorders controlled for Blocks 1 and 2, associations with age, sex, and sedentary lifestyle were highly significant; socioeconomic level (income/schooling interaction) maintained its statistical significance. Among variables related to metabolic alterations, triglycerides and glycemia, when isolated – event verified in only 10% of cases –, had no statistically significant association. The concomitant presence of two or more of these alterations was strongly associated with WHR. Blood cholesterol, on the other hand, was not significantly associated with WHR.

Table 2- Final model- Clinical and biochemical factors associated with waist-to-hip ratio, controlled for socioeconomic, individual, and lifestyle factors.

Variable	Category	OR	Adj. OR; 95%CI	P*
Block 1				
Income/schooling interaction				
	0- SCH=0 FI=0	1.00		
	1- SCH=1 FI=1	2.13	1.00; 4.68	0.050
	2- SCH=0 FI=1	1.70	0.94; 3.07	0.081
	3- SCH=1 FI=0	0.87	0.44; 1.74	0.704
Block 2				
Age				
	20-39 = 1	1.00		
	40-59 = 2	2.39	1.69; 3.37	<0.000
	60+ =3	4.03	2.37;6.84	<0.000
Sex				
	Male = 0	1.00		
	Female = 1	5.19	3.63; 7.41	<0.000

Physical activity				
	Intense/moderate = 0	1.00		
	Mild =1	2.08	1.37; 3.16	<0.000
Low stature				
	No = 0	1.00		
	Yes = 1	1.49	0.89; 2.47	0.127
Block 3				
Metabolic alteration interaction				
	0-HP=0 TR=0 GL=0 HDL=0	1.00		
	1-HP=1 TR=0 GL=0 HDL=0	1.86	1.09; 3.22	0.024
	2-HP=0 TR=1 GL=0 HDL=0	2.31	0.78; 6.82	0.131
	3-HP=0 TR=0 GL=1 HDL=0	2.53	0.64; 10.77	0.181
	4-HP=0 TR=0 GL=0 HDL=1	1.65	1.00; 2.75	0.050
	5- 2 concomitant alterations	2.48	1.53; 4.04	<0.000
	6- 3 concomitant alterations	3.21	1.82; 5.68	<0.000
	7- 4 concomitant alterations	6.97	1.97; 24.67	0.003
Total cholesterol				
	< 200 mg/dl= 0	1.00		
	≥200 mg/dl=1	1.17	0.85; 1.61	0.335

* Wald's test descriptive level.

Proceeding with hierarchical analysis, Table 3 shows the association between WC and variables related to individual and lifestyle factors, controlled for socioeconomic level. The association between sex and WC was highly significant: women were at a sevenfold risk of abdominal obesity, as defined by this indicator, when compared to men. Sedentary lifestyle was significantly associated with WC; smoking, alone or associated with alcohol drinking, had a protective effect.

Table 3 - Individual lifestyle factors associated with waist circumference, controlled for socioeconomic level.

Variable	Category	OR	Adj. OR; 95%CI	P*
Block 1				
Income/schooling interaction				
	0- SCH=0 FI=0	1.00		
	1- SCH=1 FI=1	1.50	0.92; 2.45	0.102
	2- SCH=0 FI=1	1.44	0.67; 2.03	0.596
	3- SCH=1 FI=0	1.06	0.73; 2.79	0.287
Block 2				
Age				
	20-39 = 1	1.00		
	40-59 = 2	3.25	2.27; 4.46	<0.000
	60+ =3	4.27	2.71; 7.67	
Sex				
	Male = 0	1.00		
	Female = 1	7.27	4.81; 10.99	<0.000
Physical activity				
	Intense/moderate = 0	1.00		
	Mild =1	1.40	1.11; 1.76	0.004
Smoking/alcohol drinking interaction				
	0- SM=0 AD=0	1.00		
	1- SM=0 AD=1	0.61	0.17; 2.22	0.453
	2- SM=1 AD=0	0.59	0.41; 0.86	0.007

	3- SM=1 AD=1	0.21	0.05; 0.90	0.040

* Wald's test descriptive level.

Alcohol drinking alone was not associated with waist circumference.

The final model, shown in Table 4, presents the associations between WC and metabolic variables, controlled for socioeconomic level (Block 1), individual conditions, and lifestyle (Block 2). Variables age, sex, degree of physical activity, hypertension alone, two or more concomitant metabolic alterations, and hypercholesterolemia maintained their statistical significance.

Table 4 - Final model- Clinical and biochemical factors associated with waist circumference, controlled for socioeconomic, individual and lifestyle factors.

Variable	Category	OR	OR aj. 95%	P*
Block 1				
Income/schooling interaction				
	0- SCH=0 FI=0	1.00		
	1- SCH=1 FI=1	1.49	0.86; 3.76	0.118
	2- SCH=0 FI=1	1.40	0.82; 2.40	0.217
	3- SCH=1 FI=0	0.98	0.53; 1.80	0.944
Block 2				
Age				
	20-39 = 1	1.00		
	40-59 = 2	1.69	1.20; 239	0.002
	60+ =3	2.02	1.16; 3.52	0.013
Sex				
	Male = 0	1.00		
	Female = 1	6.54	4.64; 9.27	<0.000
Physical activity				
	Intense/moderate = 0	1.00		
	Mild =1	1.50	1.02; 2.19	0.037
Smoking/alcohol drinking interaction				
	0- SM=0 AD=0	1.00		
	1- SM=0 AD=1	0.63	0.52; 2.94	0.628
	2- SM=1 AD=0	0.31	0.19; 1.67	0.306
	3- SM=1 AD=1	0.62	0.33; 1.27	0.621
Block 3				
Metabolic alteration interaction				
	0-HP=0 TG=0 GL=0 HDL=0	1.00		
	1-HP=1 TG=0 GL=0 HDL=0	2.57	1.34; 4.92	0.003
	2-HP=0 TG=1 GL=0 HDL=0	2.99	0.91; 9.85	0.071
	3-HP=0 TG=0 GL=1 HDL=0	1.90	0.38; 7.48	0.493
	4- HP=0 TG=0 GL=0 HDL=1	1.34	0.72; 2.51	0.357
	5- 2 concomitant alterations	3.49	1.96; 6.21	<0.000
	6- 3 concomitant alterations	7.21	3.74; 13.92	<0.000
	7- 4 concomitant alterations	9.90	2.77; 35.31	<0.000
Total Cholesterol				
	<200 mg/dl	1.00		
	≥200 mg/dl	1.58	1.11; 2.25	0.011

* Wald's test descriptive level.

DISCUSSION

Centralized obesity indicators, represented by the relationship between WHR and WC, were differently associated to the various socioeconomic, behavioral, and biochemical factors that act upon the etiology of this disease.

Both indicators are related to sex, age, and degree of physical activity. This is consistent with associations widely demonstrated in the literature. The risk of centralized obesity increases with age, and is greater among women.

Concerning the relationship between these indicators and socioeconomic level, WHR was associated with the family income/schooling interaction and with family income alone. Waist circumference was associated with only with schooling in univariate analysis, loosing its significance when introduced into the model. It thus seems that the former is more evidently connected with poverty. The significant association found by Velásquez et al[12] (2000) between WHM and low stature in women in this predominantly poor population corroborates this hypothesis, suggesting past malnutrition as a risk factor for centralized obesity. Still in the same population, Viggiano[13] (2001) found an association between centralized obesity, low stature, and gycemic alterations. Marinho[7] (2002) found that moderate to severe malnutrition in children and adolescents is related to low maternal stature associated with obesity.

This evidence reinforces the hypothesis proposed by Baker et al[1] (1997), according to which children with growth deficit would have a greater probability of developing obesity, non-insulin-dependent diabetes, and cardiovascular disease. Metabolic adaptation in malnourished fetuses would be associated with changes in hormone secretion levels in both fetus and placenta. The persistence of changes in these levels, and in tissue sensitivity to hormones might provide the connection between infant malnutrition and obesity in adulthood.

On the other hand, WHR and WC were associated with lifestyle variables – alcohol drinking, smoking, and sedentary lifestyle – in different ways. Both indicators are strongly associated with sedentary lifestyle, confirming the results obtained in numerous surveys that associate these indicators with metabolic disorders that partake in the etiology of the metabolic syndrome and of arteriosclerotic cardiovascular disease.[2-5]

Smoking, alcohol drinking, and the interaction between these two variables were not significantly associated with WHM. On the other hand, smoking alone and the smoking/alcohol drinking interaction had a protective effect in relation to waist circumference, probably due to the loss of appetite caused by smoking. The interaction found between smoking and alcohol drinking is surely due to the fact that one habit induces the other: two-thirds of drinkers were also smokers in the population studied. It should be noted, however, that the association between smoking and cardiovascular disease has been thoroughly demonstrated in numerous studies. Hence the protective effect of smoking against weight gain, registered in the studied population (mean BMI among nonsmokers was significantly lower than that of smokers) and observed in day-to-day life in no way represents protection against cardiovascular risk.

Concerning metabolic alterations, the associations of WHR and of WC with dyslipidemia were dissimilar: the former was significantly related to low levels of HDL-cholesterol, and the latter, to hypercholesterolemia.

The metabolic disorders which constitute the metabolic syndrome are strongly associated among themselves, and were thus presented in interactive form in the hierarchical models. Two or more alterations occurred simultaneously in a large proportion (34%) of cases.

The significant relationships of hypercholesterolemia with WC alone, and of WHR with low levels of HDL-cholesterol corroborate the hypothesis that the former would constitute an indicator for arteriosclerotic cardiovascular disease, and the latter for insulin resistance.

There were few cases (10%) of isolated hypertriglyceridemia or hyperglycemia. Thus, the effect on WHR and WC of each of them per se could not be assessed.

WHR was more strongly related to socioeconomic factors, risk of past malnutrition, an alterations suggestive of metabolic syndrome than WC, more strongly associated with arteriosclerotic cardiovascular disease.

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