ORIGINAL RESEARCH

SYSTEMIC HYPERTENSION, DIABETES MELLITUS, AND DYSLIPIDEMIA IN RELATION TO BODY MASS INDEX: EVALUATION OF A BRAZILIAN POPULATION

Cintia Cercato, Márcio Corrêa Mancini, Ana Maria Carvalho Arguello, Vanessa Quintas Passos, Sandra Mara Ferreira Villares and Alfredo Halpern

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OBJECTIVE: To determine the prevalence of systemic hypertension, diabetes mellitus, hypercholesterolemia, and hypertriglyceridemia in a Brazilian population in relation to body mass index.

METHOD: Retrospective evaluation of 1213 adults (mean age: 45.2 ± 12.8; 80.6% females) divided into groups according to body mass index [normal (18.5 - 24.4 kg/m^2); overweight (25 - 29.9 kg/m^2); grade 1 obesity (30 - 34.9 kg/m^2); grade 2 obesity (35 – 39.9 kg/m^2), and grade 3 obesity (≥ 40 kg/m^2)]. The prevalence of hypertension, diabetes mellitus, hypercholesterolemia, and hypertriglyceridemia were analyzed in each group. The severity of cardiovascular risk was determined. High-risk patients were considered those reporting 2 or more of the following factors: systemic hypertension, HDL ≤ 35 mg/dL, total cholesterol ≥ 240 mg/dL, triglycerides ≥ 200 mg/dL when HDL ≤ 35 mg/dL, and glycemia ≥ 126 mg/dL. Moderate-risk patients were those reporting 2 or more of the following factors: systemic hypertension, HDL ≤ 45, triglycerides ≥ 200 mg/dL, and total cholesterol ≥ 200 mg/dL.

RESULTS: The prevalence of systemic hypertension, diabetes mellitus, hypertriglyceridemia, and low HDL-cholesterol levels increased along with weight, but the prevalence of hypercholesterolemia did not. The odds ratio adjusted for gender and age, according to grade of obesity compared with patients with normal weight were respectively 5.9, 8.6, and 14.8 for systemic hypertension, 3.8, 5.8, and 9.2 for diabetes mellitus and 1.2, 1.3, and 2.6 for hypertriglyceridemia. We also verified that body mass index was positively related to cardiovascular high risk ($P < .001$)

CONCLUSION: In our population, cardiovascular risk increased along with body mass index.

KEY WORDS: **Cardiovascular risk factors. Obesity. Body mass index. Diabetes mellitus. Systemic hypertension.**

Cardiovascular diseases are a major cause for mortality in our country.[1] Quite a number of epidemiological studies have reported a clear correlation between obesity and cardiovascular risk factors.[2-4] This correlation has become quite relevant since the prevalence of obesity has been increasing significantly in Brazil.[5] Data from the National Health and Nutrition Survey *(Pesquisa Nacional de Saúde e Nutrição – PNSN)* show that about 40% of Brazilian adult population is overweight to some degree.[6]

People who are overweight are predisposed to higher cardiovascular risk, especially because obesity is closely associated with other factors, such as systemic hypertension (SH), glucose intolerance, diabetes mellitus (DM), and dyslipidemia.[7-10] Other studies have shown that obesity is an independent risk factor for the occurrence of atherosclerosis.[11]

Obesity is defined as the excess of body fat in relation to lean mass. The body mass index (BMI) is a simple, reproducible measurement commonly used to classify adults as overweight or obese. BMI provides good correlation with body fat index. Many studies have demonstrated the impact of BMI in a given population: the higher a person's BMI, the higher their cardiovascular risk.[2-4,7-10,12] In Brazil, how-

From the Obesity and Metabolic Diseases Group, Department of Endocrinology and Metabology, Hospital das Clínicas, Faculty of Medicine, University of São Paulo - São Paulo/SP, Brazil.
E-mail: ccercato@ig.com.br
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ever, there are few publications to show the correlation between BMI and cardiovascular risk factors.[13-15]

The present study was aimed at investigating the prevalence of major cardiovascular risk factors in a Brazilian population and at subdividing that population into high, moderate, and low cardiovascular risk categories according to obesity level based on BMI data.

METHOD

The study population was made up of 1213 individuals who sought assistance at our hospital. Out of those, 292 nonobese patients (BMI < 30 kg/m^2) sought clinical services for a regular check up; 921 obese patients who came to the Endocrinology Obesity Service were seeking treatment for their overweight conditions. The records of all patients who were assisted from 1997 through 2001 were reviewed retrospectively. Only those with complete data on the variables used in the present study were included. A total of 978 female patients (80.6%), and 235 male patients (19.4%) were studied, with a mean average age of 45.2 ± 12.8 years. The higher number of female patients in the study is due to the fact that more women seek assistance for treating obesity than do men.

BMI – calculated as body weight in kilograms divided by height in square meters – was used to group patients as being normal weight (18.5 - 24.4 kg/m^2), overweight (25 - 29.9 kg/m^2), mildly obese (grade 1: 30 - 34.9 kg/m^2), moderately obese (grade 2: 35 – 39.9 kg/m^2), and severely obese (grade 3: ≥ 40 kg/m^2), following World Health Organization criteria (Table 1).[16]

Data on systemic hypertension, DM, and lipid metabolic alterations were accessed for each patient from medical records. Plasma glucose, total cholesterol, HDL-C, and triglycerides were determined by an automated enzymatic method (Cobas Integra Plus equipment using commercial kits from Roche Diagnostic System Inc., Texas).

System hypertension was defined—following the Joint National Committee[17]—as systolic blood pressure (sBP) ≥ 140 mm Hg, and diastolic blood pressure (dBP) ≥ 90 mm Hg, or having a report on the use of hypertension drugs in the patient´s records. The methodology used to measure blood pressure was auscultatory. The Obesity Outpatient Unit at our hospital uses special blood pressure equipment for obese patients to adjust to the larger arm circumference.

Diabetes mellitus was defined as the presence of a fasting glucose level of ≥ 126 mg/dL, as suggested by the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus,[18] or having a report of the use of insulin or the administration of oral hypoglycemic drugs in the patient's records.

Hypercholesterolemia was considered to be the presence of a total cholesterol level over 200 mg/dL. Hypertriglyceridemia was defined as a triglyceride level greater than 150 mg/dL, following the criteria as in *Summary of the Third Report of the National Cholesterol Education Program* (NCEP, 2001).[19]

In the present study, in addition to carrying out an analysis on the prevalence of cardiovascular risk factors for each obesity level, cardiovascular severity risk was also evaluated. In order to do so, the study population was divided into 3 cardiovascular risk categories by using criteria as suggested by Leite et al. in 2002[20]:

A) Moderate risk—2 or more of the following factors are present: total cholesterol ≥ 200 mg/dL, HDL £ 45 mg/dL, triglycerides ≥ 200 mg/dL, plasma glycemia ≥ 126 mg/dL, sBP ≥ 140 mm Hg, and dBP ≥ 90 mm Hg.

B) High risk—2 or more of the following criteria are present: total cholesterol ≥ 240 mg/dL, HDL ≤ 35 mg/dL, triglycerides ≥ 200 mg/dL, and HDL ≤ 35 mg/dL, plasma glycemia ≥ 126 mg/dL, sBP ≥ 140 mm Hg and dBP ≥ 90 mm Hg.

C) Low risk: when patients did not present any or presented only 1 of the factors for moderate or high risk.

Statistics analysis was carried out using the EPI-Info software program. For the continuous variables, the analysis was carried out through mean and mean deviation calculation. For classification purposes, absolute and percentile frequencies of variables were calculated. For comparative analysis, the chi-square and Student *t* tests were used to determine differences significance between ratios and means respectively. For the purpose of comparing mean values among independent groups, 1-way analysis of variance was used. When testing proved significant, the Bonferroni adjustment test was used for group comparisons (in

Table 1- Obesity level classification based on body mass index – World Health Organization's criteria /1998.

Body Mass Index (kg/m^2)	World Health Organization Classification
<18.5	Low weight
18.5-24.9	Normal
25-29.9	Overweight
30-34.9	Obesity – Grade 1 (mild)
35-39.9	Obesity – Grade 2 (moderate)
≥40	Obesity – Grade 3 (severe)

groups of 2). A logistic regression model was used to assess the correlation between BMI—irrespective of any other variable—and high cardiovascular risk. All tests were carried out at the 5% significance level.

RESULTS

The population under study was made up of 1213 individuals, with 80.6% being females. Population demographics can be found in table 2. There was a significant difference between groups in relation to age and gender. Individuals in the normal-weight and overweight groups were made up of older patients, mostly males.

Major cardiovascular risks based on BMI can be found in table 3. An increase in the prevalence of systemic hypertension, DM, hypertriglyceridemia, and low HDL-cholesterol in relation to increasing BMI was clear. No association was found between hypercholesterolemia or higher LDL-cholesterol levels and higher BMI. The risk factors most clearly associated with being overweight or obese were systemic hypertension and DM.

The risk for an overweight or obese individual for developing systemic hypertension, DM, hypertriglyceridemia, and hypercholesterolemia for each grade of BMI when compared to normal weight individuals can be found in table 4. An analysis was carried out after age and gender adjustment as a result of group differences. Systemic hypertension and DM risks were significantly higher in individuals whose BMI was greater than 30 kg/m^2. Individuals who are se-

Table 2 - Population demographics based on body mass index.

Characteristics	Body Mass Index (kg/m^2)					*P*
	18.5 - 24.9 n = 111	25 - 29.9 n = 181	30 - 34.9 n = 296	35 - 39.9 n = 265	≥ 40 n = 360	
Gender F / M (%)	66.7 / 33.3	64.1 / 35.9	83.1/16.9	85.7 / 14.3	87.5 / 12.5	< 0.001*
Age (years)	48.9 ± 10.2	50.7 ± 9.5	43.8 ± 13.2	44.0 ± 13.3	43.4 ± 13.4	< 0.05*
Body Mass Index (kg/m^2)	22.4 ± 1.6	27.6 ± 1.4	32.7 ± 1.5	37.4± 1.5	47.5 ± 7.6	< .001**
Abdominal circumference (cm)	80.4 ± 7.1	92.9 ± 7.5	99.5 ± 7.1	108.2 ± 7.7	125.2 ± 14.2	< .001**

* Bonferroni's test: normal and overweight show no difference. Mild, moderate, and severe obesity have no difference between them. The difference can be found between normal and overweight versus obesity groups. ** Bonferroni's test: all groups differ when compared to one another

Table 3 - Cardiovascular risk factors based on body mass index.

Risk factor	Body Mass Index (kg/m^2)					*P**
	18.5 - 24.9 n = 111	25 - 29.9 n = 181	30 - 34.9 n = 296	35 - 39.9 n =2 65	≥ 40 n = 60	
Systemic Hypertension (%)	18.9	24.9	45.3	53.6	63.3	.001
DM (%)	4.5	11.1	12.5	17.7	24.4	.001
Hypertriglyceridemia (%)	26.1	32.6	31.8	35.1	40.3	.046
Hypercholesterolemia (%)	54.0	58.6	56.8	51.7	50.3	.29
Glycemia (mg/dL)**	96.6 ± 38.3	103.6 ± 40.4	100.6 ± 29.3	109.6 ± 46.2	113.1 ± 50.7	.001
Triglycerides (mg/dL)**	120.9 ± 78.7	136.1 ± 81.2	145.1 ± 115.8	148.1 ± 148.9	158.8 ± 96.9	.02
Total Cholesterol (mg/dL)**	207.2 ± 41.0	209.3 ± 44.1	210.3 ± 45.9	204.2 ± 42.5	205.2 ± 50.5	.47
HDL-Cholesterol (mg/dL)**	52.6 ± 13.3	48.7 ± 13.7	46.8 ± 12.5	45.5 ± 11.3	45.1 ± 10.1	.001
LDL-Cholesterol (mg/dL)**	131.1 ± 34.3	133.9 ± 39.6	135.6 ± 40.4	129.7 ± 34.6	128.0 ± 41.1	.12

* one-way analysis of variance ** Mean ± standard deviation

Table 4 - Comorbidity risk based on body mass index adjusted for gender and age.

Risk Factor	Body Mass Index (kg/m^2)				
	18.5 -24.9 OR (CI 95%)	25 - 29.9 OR (CI 95%)	30 - 34.9 OR (CI 95%)	35 - 39.9 OR (CI 95%)	≥ 40 OR (CI 95%)
Systemic hypertension	1	1.3 (0.7 - 2.4)	5.9 (3.3 - 10.3)	8.6 (4.9 - 15.4)	14.8 (8.3 - 26.2)
DM	1	2.5 (0.9 - 6.9)	3.8 (1.4 - 10.1)	5.8 (2.2 - 15.3)	9.2 (3.6 - 23.7)
Hypercholesterolemia	1	1.1 (0.7 - 1.8).	1.3 (0.9 - 2.1)	1.1 (0.7 - 1.7)	1.0 (0.7 - 1.6)
Hypertriglyceridemia	1	1.2 (0.8 - 2.3)	1.2 (0.7 - 2.3)	1.3 (0.9 - 2.4)	2.6 (1.3 - 4.5)

OR: Odds ratio; CI: Confidence interval.

verely obese also reported a significant risk for developing hypertriglyceridemia.

When the population was divided into cardiovascular risk categories, according to the criteria of Leite et al.,[20] as BMI increased so did the percentage of patients at high cardiovascular risk, while low cardiovascular risk decreased (Figure 1). Through the logistic regression model, BMI proved to be significantly correlated to high cardiovascular risk ($P < .001$).

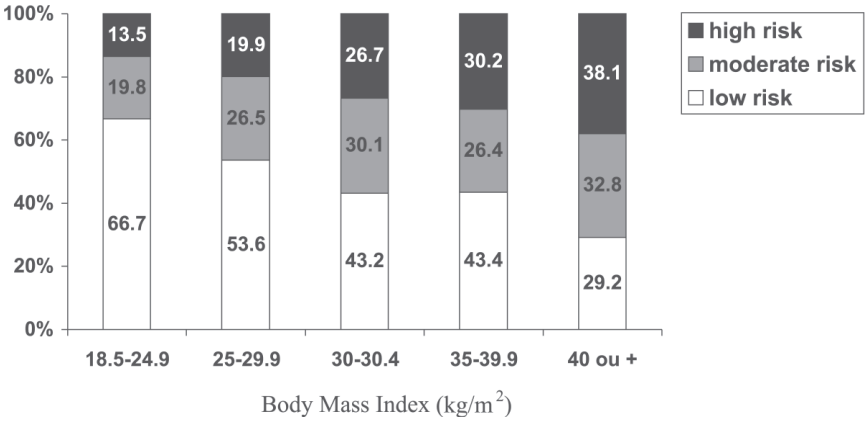

Figure 1 - Cardiovascular risk categories and body mass index . Chi-square test $P < .001$.

DISCUSSION

The present study was undertaken to examine the prevalence of major risk factors for atherosclerotic cardiovascular diseases associated with obesity level based on BMI. Additionally, risk factors were aggregated to subdivide the population into high, moderate, and low cardiovascular risk.

A clear association was detected between increased BMI values and systemic hypertension, which was consistent with previous reports in literature. Most epidemiological studies show that obesity is a strong independent risk factor for systemic hypertension.[21,22] As early as 1987 while studying hypertension precursors in young adults, Framingham researchers demonstrated that 78% of systemic hypertension cases in males and 65% of hypertension cases in females could be a direct result of obesity[23]. In Brazil, Gus et al. [14] have demonstrated that BMI was the anthropometric measurement that presented the most consistent association with systemic hypertension, both in males and females. Carneiro et al.[13] demonstrated that body fat distribution is also a very important determinant of arterial hypertension.

Other studies in the literature have demonstrated that the relative risk of developing type 2 DM increases exponentially with increased BMI[24,25]. Recent publications include data from over 84,000 women who participated in the Nurses' Health Study, demonstrating obesity to be a major risk for the onset of diabetes. Women who reported BMI over 35 kg/m^2 were shown to be 39 times more likely to developing diabetes compared with those who were normal weight[24]. In our population, individuals who were moderately obese (BMI between 35 and 39.9 kg/m^2) and severely obese (BMI $\geq$ 40 kg/m^2) were respectively at 5.8 and 9.2 times higher risk of developing DM compared with those who reported normal BMI.

As for plasma lipids, the present study revealed that higher levels of triglycerides and reduced HDL-cholesterol levels were associated with obesity. However, the study did not reveal any association between elevated levels of total cholesterol or LDL-cholesterol and obesity. Those data are consistent with reported findings that the major dyslipidemia associated with obesity is a mild to moderate increase in triglycerides and a decrease HDL-cholesterol.[26,27] Such alterations are usually associated with small, dense LDL particles that are more atherogenic since they have lower affinity with LDL receptors, closer binding to arterial wall proteoglycans, and higher susceptibility to oxidation.[28] Previous studies have demonstrated that an increased BMI is associated with reduction in LDL particle size.[27,29] Therefore, although no increase in LDL-cholesterol level was found in association with obesity in the population under study, small, dense LDL particles may have increased, since obesity was shown to be associated with higher triglyceride levels and lower HDL-cholesterol levels.

In addition to examining each of the major risk factors individually against BMI, assessment of the severity level of cardiovascular risks by aggregating all those factors and subdividing the population into high, moderate, and low cardiovascular risk categories was attempted. To reach such categorization, criteria as suggested by Leite et al.[20] were used. The population under study showed BMI and high cardiovascular risk to be significantly associated. The data are compatible with findings reported in the literature of higher myocardium infarction risk and cardiovascular mortality in obese individuals.[3,4,9]

In the present study we analyzed just the major risk factors for coronary heart disease, i.e., blood pressure, total cholesterol, triglycerides, and diabetes. However, part of the relationship between obesity and cardiovascular risk could be mediated by newly identified risk factors. One of these is insulin resistance and its companion,

hyperinsulinemia. Several hypotheses have been proposed for a causative link between insulin resistance (or hyperinsulinemia) and cardiovascular risk.[30,31] Second, obese individuals typically carry a proinflammatory state that may predispose them to acute coronary syndromes. This state is characterized by elevations of serum high-sensitivity C-reactive protein (hs-CRP); in fact, increased levels of hs-CRP reflect high cytokine levels that may render otherwise stable atherosclerotic plaques vulnerable to plaque rupture[32]. Previous studies have demonstrated that obesity is associated with elevations of hs-CPR[33,34]. An excess of adipose tissue apparently secretes increased amounts of several cytokines that underlie the proinflammatory state.[34,35] Other studies are necessary to investigate these emerging risk factors in a Brazilian population.

We conclude that BMI assessment in a Brazilian population has demonstrated that increasing levels of obesity are associated with a higher prevalence of systemic hypertension, DM, and hypertriglyceridemia, as well as reduced HDL-cholesterol levels. These results are consistent with those reported in the literature and, taken together, are proof that obesity is clearly associated with a profile of unfavorable risks for cardiovascular disease, thus emphasizing the importance of prevention and treatment of obesity.

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RESUMO

CERCATO C e col. Hipertensão arterial, diabetes melito e dislipidemia de acordo com o índice de massa corpórea: estudo em uma população Brasileira. **Rev. Hosp. Clín. Fac. Med. S. Paulo 59**(3): 113-118, 2004.

OBJETIVO: Determinar prevalência de hipertensão arterial, diabete melito, hipercolesterolemia e hipertrigliceridemia em uma população brasileira de acordo com grau de obesidade.

MÉTODO: Estudo retrospectivo em 1213 adultos (média de idade: 45,2 ± 12,8 anos; 80,6 % sexo feminino) em grupos de acordo com índice de massa corpórea (normal:18,5-24,4 Kg/m2; sobrepeso 25-29,9 Kg/m2; obesidade classe1: 30-34,9 Kg/m2; classe 2: 35-39,9 Kg/m2 ; classe 3:³ 40 Kgm2). Analisamos presença de hipertensão arterial, diabete melito, hipercolesterolemia e hipertrigliceridemia em cada grupo. Determinamos severidade do risco cardiovascular, considerando risco alto pacientes com 2 ou mais dos seguintes fatores: hipertensão arterial, HDL ≤ 35mg/dl, colesterol total ≥240mg/dl, triglicérides ≥200mg/dl quando HDL ≤ 35mg/dl e glicemia ≥126mg/dl; risco moderado aqueles com 2 ou mais dos seguintes fatores: hipertensão arterial, HDL ≤ 45, triglicérides ≥200mg/dl e colesterol total ≥200mg/dl.

RESULTADOS: Houve aumento significativo da prevalência de hipertensão arterial, diabete melito, hipertrigliceridemia, HDL-colesterol baixo, porém não houve maior prevalência de hipercolesterolemia. O odds ratio, ajustado para idade e sexo, para obesidade em relação aos indivíduos de peso normal foi 5,9, 8,6 e 14,8 para hipertensão; 3,8, 5,8 e 9,2 para diabete melito e 1,2, 1,3 e 2,6 para hipertrigliceridemia. Após estabelecer severidade do risco cardiovascular, verificamos que o índice de massa corpórea se correlacionou de forma significativa com alto risco cardiovascular (p< 0.0001).

CONCLUSÃO: Em nossa população, observamos aumento do risco cardiovascular com aumento do índice de massa corpórea.

UNITERMOS: **Fatores de risco cardiovascular. Obesidade. Índice de massa corpórea. Diabetes melito. Hipertensão arterial sistêmica.**

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