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Obesity and Cardiovascular Risk Factors in Adolescents Attending Public Schools

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Abstract

Background: Overweight in adolescence is a risk factor for the development of cardiovascular diseases in adulthood.

Objective: To study the association of cardiovascular risk factors (CRF) in overweight and normal-weight adolescents of both genders aged from 14 to 19 years, attending public schools.

Methods: Case-control study including 163 overweight and 151 normal-weight adolescents. Multiple logistic regression analysis was used to evaluate the associations between overweight and CRF (lipid profile, blood pressure and baseline insulin level). A set of CRF was defined for each individual, ranging from 0 (no risk factors) to 6 (all risk factors present).

Results: Overweight adolescents (body mass index > 85th percentile) presented a higher frequency of CRF in comparison to the normal-weight group. The CRF associated with overweight were HDLc ≤ 35 mg/dl (OR = 3.41; CI: 1.24-9.38), triglycerides ≥ 150 mg/dl (OR = 3.04; CI: 1.01-9.13), abnormal baseline insulin levels > 15 μU/ml (OR = 8.65; CI: 4.03-18.56) and abnormal blood pressure (OR = 3.69; CI: 1.76-7.72). Among overweight adolescents, 22.09% had more than three risk factors, whereas this percentage dropped to 6.12% among normal-weight adolescents.

Conclusion: Overweight adolescents presented risk factors for cardiovascular diseases. The need for programs and policies targeted at the diagnosis and treatment of this condition is pointed out in order to reduce the risks of morbidity and mortality in adulthood. (Arq Bras Cardiol 2010; 95(2): 200-206)

Key words: Obesity; risk factors; adolescents; disease prevention.

Introduction

The increase in the incidence of obesity among children and adolescents is considered a worldwide public health problem. In the United States, estimates of the National Health and Nutrition Examination Survey (NHANES IV) showed that, in the age range between 12 and 19 years, overweight increased from 14.8% to 18.3% among boys, and from 14.8% to 16.4% among girls[1]. In Brazil, according to the last national survey conducted, in the age range between 10 and 19 years, the prevalence of overweight was 18.0% in boys and 15.4% in girls[2].

Although genetic factors predispose to the development of obesity, several studies have pointed out environmental and behavioral factors such as the lack of physical activity[3], more time spent watching television[4], and increased intake of fast food[5] as determinants of its increasing incidence.

Overweight in childhood increases the chances of obesity in adulthood. Deshmukh-Taskar et al[6] first analyzed weight and height of participants in the Bogalusa Heart Study during their childhood, from 9 to 11 years of age, and then again from 19 to 35 years of age. They observed that of the 841 individuals in the last BMI quartile, 61.9% had remained in this position in adulthood.

Overweight is an important risk factor for cardiovascular diseases. Although the clinical manifestations of these diseases occur in adulthood, studies have demonstrated that comorbidities such as dyslipidemias, hypertension and insulin resistance may be present in childhood and adolescence[7,8], and are responsible for the increased risk of morbidity and mortality in adulthood[9,10].

Few studies correlating obesity with cardiovascular risk factors have been conducted among adolescents in developing countries, particularly in Brazil. However, according to the World Health Organization's report[11], children and adolescents from low socioeconomic levels are as exposed to obesity and cardiovascular risk factors as their peers from high socioeconomic levels. For the development of more efficient clinical prevention and intervention programs, studies targeted at this population are necessary.

The objective of the present study was to evaluate the

association between obesity and cardiovascular risk factors in adolescents.

Materials and methods

The study analyzed two databases in the city of São Paulo, the first one collected in 2002, and the second in 2006. The first one resulted from a case-control study in which a trained team of nutritionists and pediatricians performed anthropometric measurements of 1,420 adolescents aged from 14-19 years, representing 98.68% of all students enrolled in a public school for the selection of cases (overweight adolescents) and controls (normal-weight adolescents).

Sixteen adolescents (1.12%) refused to be evaluated and three (0.21%) could not be reached after three attempts. The groups were matched for age, gender, puberty stage (Tanner - breasts and genitals ≥ 4)[12] and socioeconomic level. The definition of overweight and normal weight was based on Must et al's criterion[13].

The adolescents were weighed and measured during the physical education classes. After being considered eligible to participate in the study, they were invited to come to school with their parents or guardians in order to receive information on the objectives of the research and give informed consent.

Of the 340 adolescents eligible to the study, 77 refused to participate. Of the remaining 263, 4 were excluded due to the diagnosis of hypothyroidism, made after clinical examination and determination of thyroid hormone levels. Finally, of the 259 adolescents, 83 were defined as cases (overweight with body mass index (BMI) equal to or greater than the 85th percentile) and 176 as controls (normal weight with BMI higher than the 5th percentile and lower than the 85th percentile).

Since the data analysis of the 2002 case-control study showed a low statistical power for the estimation of risk factors for obesity in adolescents[4], we decided to increase the number of cases by including only overweight adolescents. The second database comprised only adolescents above the 95th percentile, according to the criterion proposed by Must et al[13]. For this purpose, in 2006 four public schools located in the same region as that of the 2002 study were chosen. Of the total of 2,663 students enrolled in those schools, 144 (5.04%) could not be reached after three attempts, and 189 (7.09%) refused to be evaluated. Of the 150 overweight adolescents, 124 were eligible for the study, since 26 of them did not meet the study inclusion criteria, because they were older than 19 years of age or were already undergoing weight loss therapy. Of the 124 individuals eligible for the study, 42 (33.87%) refused to participate and two (1.61%) dropped out of school after the first anthropometric assessment.

The sample then comprised 80 overweight adolescents. In order to identify occasional selection biases, the BMI distribution by gender of the 80 adolescents included in the study was compared to that of adolescents who had dropped out of the study; no statistically significant difference was observed between them.

The total sample of both databases comprised 339 adolescents, 163 of whom were overweight and 176 were normal weight. For the analyses, 25 adolescents had a z score for height-for-age ≥ -2.0 and were excluded; thus, the final sample included 314 adolescents (163 cases and 151 controls).

All procedures described below (anthropometric measurements and biochemical tests) were exactly the same used in data collection in 2002 and in 2006.

Information on family history for cardiovascular diseases, including first and second-degree ancestors, and use of medications was obtained by means of a questionnaire that had been validated and pre-tested in the pilot study; this questionnaire was administered by trained nutritionists and pediatricians. Variables regarding family history were codified as yes (presence of the disease) or no (absence of the disease).

The anthropometric measurements (weight and height) were taken according to standardized procedures[14]. Height was measured in an anthropometer (Alturexata™) to the nearest centimeter, and weight was measured in a digital scale (Kratos™ model Línea) to the nearest 0.05 kg.

Blood pressure was measured by a duly trained physician using a mercury sphygmomanometer (Tycos™) with cuffs that fit the individual's arm circumference. Systolic blood pressure (Korotkoff phase I) and diastolic blood pressure (Korotkoff phase V) were measured three times at 5-minute intervals, in the right arm, considering the mean of the three measurements[15,16].

Prehypertension was defined as systolic and diastolic blood pressure values between the 90th and 95th percentiles for age, gender and height. Hypertension was defined as blood pressure levels above the 95th percentile[15]. Prehypertension and hypertension values were grouped into risk categories.

Blood samples were collected by venipuncture in the morning, after a 12-hour fasting, for determination of total cholesterol (TC), LDLc, HDLc, triglycerides, and baseline insulin. LDL-cholesterol levels were estimated according to Friedewald's equation[17], when triglyceride levels were below 400 mg/dl. Levels of TC > 170 mg/dl, LDLc > 110 mg/dl, HDLc < 35 mg/dl, triglycerides > 150 mg/dl, and baseline insulin > 15 μU/ml were considered as risks for cardiovascular diseases[18,19].

The study was approved by the Research Ethics Committee of *Universidade Federal de São Paulo*, after all the adolescents and guardians had given informed consent.

Univariate and bivariate statistical analyses were carried out with calculations of the proportions of individuals exposed to different risk factors in the overweight group and in the normal weight group, with the respective odds ratios (OR) and 95% confidence intervals (CI). Multiple logistic regression analysis was used to examine the associations between the nutritional status and cardiovascular risk factors. Variables with significant associations ($p < 0.05$) in the bivariate analysis were included in the multiple logistic regression analysis[20].

Finally, a set of cardiovascular risk factors was defined as the number of conditions (prehypertension and hypertension, abnormal TC, LDLc, HDLc, triglyceride and baseline insulin levels) present in each individual, ranging from 0 (absence of all conditions) to 6 (presence of all the conditions mentioned).

All statistical analyses were carried out using the STATA software release 8.0[21].

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Results

A total of 163 overweight adolescents (mean age of 16.01 years; 42.3% boys) and 151 normal-weight adolescents (mean age of 16.2 years; 45.0% boys) participated in the study. The frequencies and odds ratios (OR) with respective 95% confidence intervals for the variables related to the risk factors are shown in Table 1.

Overweight adolescents were proven to have higher frequencies of cardiovascular risk factors in comparison to the group of normal-weight adolescents. Approximately 15.0% of the overweight adolescents had low HDLc levels (crude OR = 4.17). The frequency of abnormal triglyceride levels was 11.04% (crude OR = 3.62). As regards baseline insulin, 38.65% had abnormal levels in comparison to 5.96% of the normal-weight adolescents (crude OR = 9.94). Prehypertension or hypertension were present in 26.99% of the overweight adolescents (crude OR = 4.15).

No differences were observed between the groups in relation to family history of cardiovascular diseases.

The odds ratios adjusted for cardiovascular risk factors between the two groups are shown in Table 2. The cardiovascular risk variables associated with overweight were HDLc (OR = 3.41; CI: 1.24-9.38), triglycerides (OR = 3.04; CI: 1.01-9.13), abnormal blood pressure (OR = 3.69; CI: 1.76-7.72) and abnormal baseline insulin (OR = 8.65; CI: 4.03-18.56).

Table 1 - Frequencies (%) and odds ratios (OR) with their respective 95.0% confidence intervals (CI) for the variables related to cardiovascular risk factors in adolescents from 14 to 19 years of age enrolled in public schools in the city of São Paulo - Brazil

Variables	Overweight			Normal weight			Crude OR (95% CI)	p
	n	Yes		n	Yes			
		n	%		n	%		
Cardiovascular risk factors								
Total cholesterol ≥ 170 mg/dl	163	55	33.74	151	52	34.43	0.96 (0.60 - 1.54)	0.897
LDLc ≥ 110 mg/dl	163	45	27.61	151	32	21.19	1.41 (0.84 - 2.38)	0.188
HDLc ≤ 35 mg/dl	163	24	14.72	151	6	3.97	4.17 (1.65 - 10.51)	0.002
Triglycerides ≥ 150 mg/dl	163	18	11.04	151	5	3.31	3.62 (1.31 - 10.02)	0.013
Baseline Insulin ≥ 15.0 µU/ml	163	63	38.65	151	9	5.96	9.94 (4.72 - 20.91)	0.000
Presence of prehypertension or hypertension	163	44	26.99	147	12	8.16	4.15 (2.09 - 8.24)	0.000
Blood pressure								
Systolic								
Abnormal (> 90th percentile)	163	30	18.40	147	3	2.04		0.000
Hypertension (≥ 95th percentile)		16	9.82		1	0.68		
Prehypertension (≥ 90th percentile and < 95th percentile)		14	8.59		2	1.36		
Normal (< 90th percentile)		133	81.60		144	97.96		
Diastolic								
Abnormal (> percentile 90)	163	32	19.63	147	10	6.80		0.004
Hypertension (≥ 95th percentile)		11	6.75		3	2.04		
Prehypertension (≥ 90th and < 95th percentile)		21	12.88		7	4.76		
Normal (< 90th percentile)		131	80.37		137	93.20		
Positive family history								
Myocardial infarction mother	154	2	1.30	147	4	2.72	0.45 (0.08 - 2.50)	0.364
Myocardial infarction father	151	12	7.95	144	14	9.72	0.80 (0.35 - 1.79)	0.591
Early CV event* - woman (< 55 years)	155	2	1.29	148	0	0	0	0
Early CV event* - man (<65 years)	150	4	2.67	145	7	4.83	0.54 (0.15 - 1.88)	0.344

*p < 0.05 Chi-square test. *CV - cardiovascular.*

Table 2 - **Multiple logistic regression analysis with odds ratio (OR) adjusted for cardiovascular risk factors in overweight adolescents and normal-weight adolescents from 14 to 19 years of age enrolled in public schools of the city of São Paulo - Brazil**

Variables (n = 310) Cardiovascular risk factors	Adjusted OR (95.0% CI)	p*
HDLc ≤ 35 mg/dl	3.41 (1.24 - 9.38)	0.010
Triglycerides ≥ 150 mg/dl	3.04 (1.01 - 9.13)	0.048
Baseline insulin ≥ 15.0 μU/ml	8.65 (4.03 - 18.56)	0.000
Blood pressure (prehypertension + hypertension)	3.69 (1.76 - 7.72)	0.000

*$p < 0.05$.

Frequency distribution of cardiovascular risk factors is shown in Figure 1. Of the overweight adolescents, 23.08% had more than three risk factors in comparison to only 6.12% of the normal-weight adolescents.

Discussion

The strategy adopted in this study - increasing the number of overweight individuals and the severity of obesity after four years of the original data collection from the case-control study - proved effective to increase the power for the identification of risks with a better statistical accuracy. Despite the better accuracy to estimate the risks, limitations inherent to all case-control studies remain, regarding the difficulties to determine the time sequence of the line of causality investigated and the recall biases.

This is even more evident when the small number of publications addressing cardiovascular risks in adolescents is considered, which makes the results of the present study especially relevant, since it includes adolescents who remained obese even after their pubertal growth spurt. Most

of the studies published on adolescents include broader age ranges and do not assess the pubertal development, a criteria that is mandatory when the nutritional status of adolescents is evaluated.

The findings of the present study are consistent with those of other studies that correlated cardiovascular risks to obesity in children and adolescents from Germany, United States, Korea and France[7,22-24].

In this study, 14.72% of the overweight adolescents presented with low HDLc levels in comparison to only 3.97% of the normal-weight adolescents. Considering the same cut-off point, Reinehr et al[22] found an 18.0% rate among 1,004 German overweight adolescents, whereas Kim et al[24] observed low HDLc levels in 14.4% of the 76 Korean overweight adolescents. Although both studies considered broad age groups, the proportions of abnormal HDLc levels was similar to those found in the present study, showing that this metabolic disorder is concomitant to the increase in fat mass.

On the other hand, the frequencies of increased triglyceride levels found in the two studies mentioned were higher than the 11.04% found in the present study, i.e., 20.0% in the German study, and 35.1% in the Korean study[22,24].

We observed that 26.99% of the overweight adolescents presented with prehypertension or hypertension. Similar results were also found in developing countries. In a study conducted by Chiolero et al[25] in the Republic of the Seychelles, of the 15,612 children and adolescents from 5 to 16 years of age analyzed, the prevalence of hypertension in the obese group was 25.0% and 33.2% for boys and girls, respectively.

When the systolic and diastolic blood pressure levels were analyzed separately, the frequencies of prehypertension and hypertension were 9.82% and 6.75% for the group of overweight adolescents, in comparison to 0.68% and 2.04% among normal-weight adolescents. Rao et al[26] studied 2,223 Indian adolescents from 9 to 16 years of age of both genders using BMI as the diagnostic criterion for obesity and observed
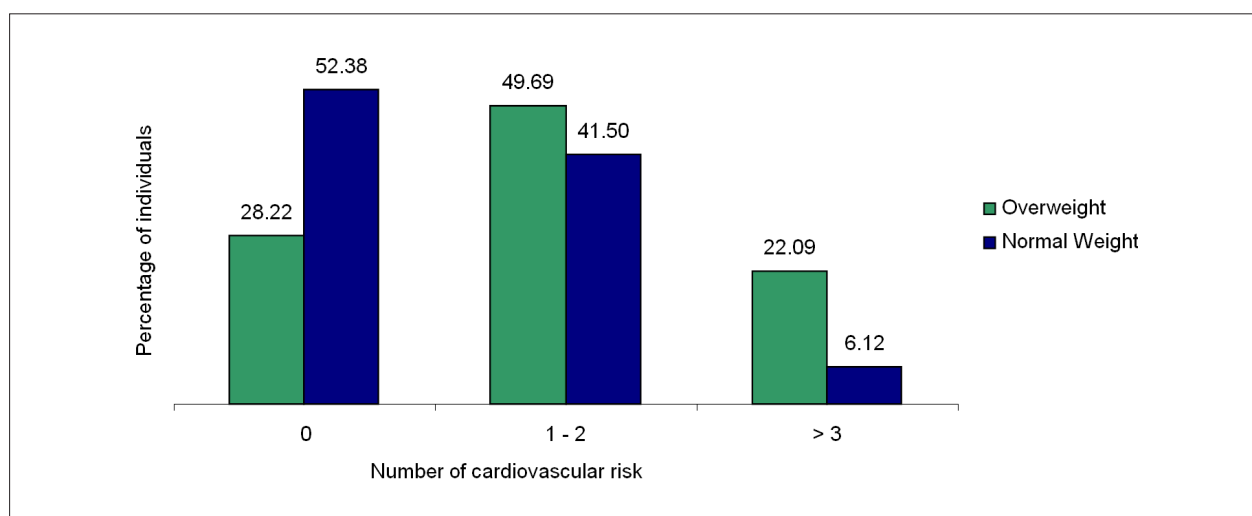

Figure 1 - *Prevalence of cardiovascular risk factors among overweight adolescents (N = 163) and normal-weight adolescents (N = 147), according to the presence of abnormal serum levels of total cholesterol, LDLc, HDLc, triglycerides and baseline insulin, as well as of prehypertension or hypertension. The adolescents had a score for cardiovascular risk factors from 0 (no conditions) to 6 (presence of all conditions).*

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that 22.2% of the boys had abnormal systolic blood pressure and 14.0% had abnormal diastolic blood pressure. In girls, they found 29.9% of abnormal systolic blood pressure and 7.1% of abnormal diastolic blood pressure.

In the multiple regression analysis, overweight adolescents were observed to have an approximately four-times higher chance of presenting abnormal blood pressure than normal-weight adolescents, even after adjustment for total cholesterol, triglycerides and baseline insulin.

Findings from the Bogalusa Heart Study showed that blood pressure levels above the 80th percentile during childhood were associated with an increased prevalence of elevated blood pressure during adulthood[10]. In a recent study on children and adolescents who participated in the National Health and Nutrition Examination Survey (NHANES), increased obesity, especially abdominal obesity, was observed to explain part of the tendency to elevated blood pressure levels, because there is an association between hypertension and hyperinsulinism[11].

Among overweight adolescents, 38.65% presented abnormal baseline insulin levels. A strong association between abnormal baseline insulin levels and overweight (OR = 8.65) was found in the multiple logistic regression analysis. Freedman et al[27] studied children and adolescents of the Bogalusa Heart Study using a more strict cut-off point for the diagnosis of obesity (the 95th percentile) and found an association of OR = 12.6 for baseline insulin.

Hyperinsulinemia is strongly associated with the intraabdominal adipose tissue[28]. As demonstrated by Reinehr et al[29] in a longitudinal study, hyperinsulinemia may be the central abnormality in obese children and adolescents, and this contributes to dyslipidemia. The physiological mechanism suggested for this process is that the intraabdominal fat has a high and intense metabolic activity, permitting the triglyceride depots concentrated in this region to be more easily mobilized to the blood stream, thus leading to an increased production of free-fatty acids and LDLc in the liver[30].

As regards the set of cardiovascular risk factors analyzed, the present study showed that 22.09% of the overweight adolescents had more than three risk factors at the same time in comparison to 6.12% of the normal-weight adolescents.

The presence of cardiovascular risk factors including dyslipidemia, hypertension and abnormal baseline insulin levels characterizes the metabolic syndrome[31-33] which, as demonstrated in this study, is present in this group of overweight adolescents from low-income families.

Although the clinical symptoms of cardiovascular diseases occur in adulthood, the atherosclerotic process starts in childhood, and overweight is one of its main determinants[34,35]. Evaluation of the nutritional status is, therefore, essential in the clinical practice, aiming at detecting and preventing obesity and the associated cardiovascular risk factors.

In addition to obesity, genetic factors may contribute to the development of the atherosclerotic process, in conjunction with other environmental aspects which the adolescents are exposed to, such as the use of drugs, cigarettes and oral contraceptives. Changes in lifestyle such as by encouraging physical activities and an adequate diet are key strategies for maintaining healthy weight[36].

In conclusion, risk factors for cardiovascular diseases such as low serum HDLc levels and abnormal triglyceride and baseline insulin levels, and the presence of prehypertension or hypertension are strongly associated with overweight. We point out the need for surveillance systems in developing countries that could identify overweight adolescents who should be included in obesity control and cardiovascular disease prevention programs aimed at reducing morbidity and mortality in adulthood.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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