Cardiovascular Risk Factors in Adolescents: Biological and Behavioral Indicators

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Objective

To provide descriptive information and investigate to what extent behavioral risk factors for cardiovascular diseases are associated with biological risk factors in the young population.

Methods

The sample included 452 adolescents (246 girls and 206 boys) between 15 and 18 years of age selected in a high school in the city of Londrina, Paraná. Risk factors of a behavioral nature were analyzed as regards insufficient physical activity, excessive intake of fat and cholesterol and smoking. As biological risk factor indicators we used overweight, high arterial pressure levels, and adverse concentration of serum lipids and lipoproteins.

Results

Approximately 20% of the girls and 16% of the boys presented at least one biological risk factor for development of cardiovascular diseases. Overweight was significantly associated with excessive intake of fats, while elevated arterial pressure was related to sedentary lifestyle and smoking. Excessive intake of fat and cholesterol indicated increased risk of undesirable concentrations of serum lipids and lipoproteins. The risk associated with altered blood pressure and serum lipids and lipoprotein was increased two-fold in smokers when compared with nonsmokers.

Conclusion

The results reinforce the need for interventions targeted at the adoption of a healthy lifestyle, including the regular practice of physical exercise, appropriate dietary patterns, and abstention from smoking as of an early age.

Key words

Blood pressure, serum lipids-lipoproteins, overweight, physical activity, dietary patterns, smoking.

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Although there is a slight declining trend in deaths, dysfunctions associated with the cardiovascular system are one of the major causes of morbidity and mortality in industrialized countries[1]. In Brazil, it is estimated that cardiovascular diseases (CVDs) account for approximately 20% of the deaths from known causes in subjects over twenty years of age[2].

The literature presents strong evidence that CVDs manifested in adulthood result from a complex interaction between a variety of risk factors that may have originated in childhood and adolescence[3-5]. Therefore, those young people who may eventually present risk factors tend, as they grow old, to be more predisposed to the onset of an atherosclerotic process and to the consequent development of CVDs

Therefore, trying to detect the presence of risk factors early in youth enables the planning and implementation of preventive intervention programs targeted at reducing the likelihood of the manifestation of CVD in adulthood.

Characteristics of risk factors which predispose subjects to CVDs are traditionally identified as being of a biological nature such as the amount of body fat, the serum lipid and lipoprotein profile and the blood pressure levels. However, since we are dealing with young subjects at a stage in life where they acquire and incorporate behaviors which are difficult to change in the future, it is prudent to analyze not only the biological risk factors in an isolated manner but also those risks of a behavioral nature such as practice of physical activity, eating habits and smoking[6-8].

Information available as to the incidence and aggregation of behavioral and biological risk factors which predispose to CVDs in adolescents are relatively scarce. Upon consulting the Brazilian literature, we verified that studies with such objective are rare or even inexistent. Therefore the objective of this study was to (a) provide descriptive information regarding the risk factors for CVDs observed in a representative sample of adolescents; and (b) establish the extension to which behavioral risk factors may be associated with biological risk factors in the young population.

Methods

To develop this study we used information included in the database built from the research project called "Physical Activity, Diet Composition and Risk Factors which Predispose to Cardiovascular Diseases in Adolescents", which includes male and female adolescents between fifteen and eighteen years of age[9].

The research project focused on school students regularly enrolled in high school at Colégio de Aplicação, associated with the State University of Londrina, state of Paraná. We decided to include subjects which frequented only this school because of the longitudinal characteristics of the study (experimentation with health promotion educational programs with interventions on diet and practice of physical exercise), and because of its representativity in the universe of high school students in the municipality of Londrina, Paraná.

The study's intervention protocols were approved by the Research Ethics Committee of the State University of Londrina and complied with the rules established by Resolution 196/96 of the National Health Council about research involving human subjects. Subjects were included in the study when they were willing to participate in the experiment and upon authorization by their parents or legal guardian. To this effect, all students enrolled in the 2003 school year, together with their parents or guardians were contacted and informed about the nature and objectives of the study. Of the 518 students enrolled, 452 (87%) agreed to participate in the study (Table 1).

Table 1 – Number of subjects analyzed in the project "Physical Activity, Diet composition and Risk Factors for Cardiovascular Diseases in Adolescents"

Age	Girls	Boys	Total
15 years	52	42	94
16 years	75	61	136
17 years	64	56	120
18 years	55	47	102
15 – 18 years	246	206	452

As additional information on the sample analyzed in the study we highlight that, based on the socioeconomic criteria used to classify the families of the students which included information such as the level of schooling of the family head, their housing conditions, the possession of household goods, cars and number of servants[10], we observed that 22% of the subjects were included in the lower socioeconomic level; 27% in the higher level and 51% in intermediary levels. As regards the classification criteria regarding sexual maturity as suggested by Tanner[11], 10% of the girls analyzed presented breast development equivalent to stage 3; 61% to stage 4 and 29% to stage 5. Among the boys, 49% were in stage 4 as regards pubic hair and the remaining 51% were in stage 5.

Risk factors predisposing to cardiovascular diseases were analyzed using biological and behavioral indicators. As regards biological indicators, we used information on the body mass index, blood pressure at rest, and the serum concentration of circulating lipids and lipoproteins. As regards behavioral indicators, we obtained information on the levels of physical activity, composition of diet and tobacco consumption.

The body mass index was calculated considering the ratio between body weight and the height square (kg/m^2). To determine the height, we used a stadiometer with a scale of 0.1 cm, and to verify the body weight we used a scale with a definition of 100g, based on the methodology presented by Gordon et al[12]. In compliance

with reference values for age and gender suggested in the literature[13], we considered overweight the adolescents with a BMI ≥ 25 kg/m^2.

The levels of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using the auscultation method with the help of a mercury sphygmomanometer, with cuffs of the appropriate size to fit the arms of the adolescents. With the subjects seated, the blood pressure was measured in the left arm after a minimum rest of five minutes. The value of the SBP corresponded to Korotkoff's Phase 1 and the DBP corresponded to Korotkoff's Phase 4, or the disappearance of the sounds. The blood pressure was measured twice, and the mean value of both was considered for the analysis. According to the criteria established by the 3rd Brazilian Consensus on Hypertension[14], those adolescents who had SBP ≥ 140 mmHg and DBP ≥ 90 mmHg were considered as having elevated blood pressure.

The concentrations of serum lipids and lipoproteins were ascertained by means of 10 ml venous blood samples collected from the elbow fold following a 10-12 hour fast, between 7 am and 8 am. The serum was immediately separated by centrifugation, and the concentration of triglycerides (TG), total cholesterol (TC) and its fractions [low-density lipoproteins (LDL-C) and high-density lipoproteins (HDL-C)] were ascertained. The total serum cholesterol was ascertained using the cholesterol oxidase/peroxidase enzymatic method in a spectrophotometer. HDL-C was measured using the reactive precipitation method, and the LDL-C was estimated using the formula proposed by Friedewald et al[15]. Serum triglycerides were ascertained using the glycerol enzymatic method. The reference values employed to define a lipid and liproproteic profile for atherogenic risk complied with those proposed for adolescents in the Brazilian Consensus on Dyslipidemias[16]: TG ≥ 130 mg/dl, TC ≥ 200 mg/dl, LDL-C ≥ 130 mg/dl and HDL-C ≤ 35 mg/dl.

To estimate the levels of physical activity we used a retrospective self-report tool to record daily activities (by the subjects themselves) as proposed by Bouchard et al[17]. Accordingly, everyday activities are classified within a *continuum* with 9 categories according to estimates regarding the average calorie consumption of human activities: (1) resting in bed; (2) activities carried out while seated; (3) light activities carried out while standing; (4) activities which require light walks (< 4 km/hour); (5) light manual work; (6) active leisure activities and recreational sports; (7) moderate manual work; (8) active leisure activities and recreational sports of moderate intensity; and (9) intense manual work and practice of competitive sports.

The retrospective tool was filled out by the adolescents themselves in four days of the same week, two in the middle of the week (between Monday and Friday) and two on weekends (Saturday and Sunday). For calculation purposes, we used the weighted average comprising the two days in the middle of the week and of the weekend. For better management, the day was divided in 96 periods of 15 minutes each. The subjects received instructions and recommendations to identify the type of activity classified between the categories 1 and 9 carried out in each 15-minute period during the 24 hours of the day. A list of examples of typical everyday activities included in the different categories was presented to the adolescents in an attempt to facilitate the completion of the tool. The subjects were also instructed to take additional notes if an activity had not been included in the list specifically developed to this end.

With this information in hand, we established the time spent by each subject in the different categories of physical activity. We considered the time spent in categories 6 to 9 (average energy expenditure > 4.8 Mets) as an indicator of moderate-to-intense physical activity (MIPA). The time spent in categories 3 to 5 (average energy expenditure between 2.3 and 3.3 Mets) as an indicator of low-intensity physical activity (LIPA); and in the categories 1 and 2 (energy expenditure < 1.5 Mets) as an indicator of physical inactivity (PI). Additionally, based on calorie references suggested by the developers of the measuring tool used[17], we resorted to estimates of energy expenditure per kilogram of body weight relative to the activities carried out during the day (kcal/kg/day) as an indicator of the habitual practice of physical activity (PA). This procedure was validated for use with adolescents by the doubly labeled water method[18]. According to the proposal of Cale[19], we considered as physically underactive those adolescents who presented DE ≤ 37 kcal/kg/day.

Information on dietary composition was obtained from dietary records. The subjects received a tool with instructions and recommendations to identify every bit of food eaten, including beverages, with their respective estimated portion sizes (home measures), in four days of the same week, two in the middle of the week (between Monday and Friday) and two on the weekend (Saturday and Sunday). For calculation purposes, we used the weighted average of the two midweek days and two weekend days. With this information in hand, we determined the average proportion of the energy supply/day from the intake of total fat (FAT_{total}) and saturated fat ($FAT_{saturated}$), and the average quantity/day of cholesterol intake (mg/day). The caloric equivalent and the nutritional proportions of foods were established using the System for Support to Nutrition Decisions software, version 2.5, designed by the IT Center of the Paulista School of Medicine of the Federal University of São Paulo[20]. The adequacy of diet indicators was analyzed following the recommendations of the American Academy of Pediatrics[21]. The consumption of total fat ≤ 30%, saturated fat ≤ 10% and cholesterol ≤ 300 mg/day was considered as adequate.

As regards smoking, the habit was identified upon analyzing the answers to a question made specifically to this end. The question "you are a smoker" was presented to the adolescents with five options of answer: (a) no,

I have never smoked; (b) no, but I used to smoke; (c) yes, I occasionally smoke; (d) yes, I smoke at least once a week; and (e) yes, I smoke on a daily basis. Those adolescents who reported smoking once a week or daily were considered as smokers.

The information was statistically treated using the computerized package *Statistical Package for the Social Science* (SPSS), version 12.0. The analysis of continuous variables was carried out using the procedures of descriptive statistics and later, to identify any differences between the genders, we used Student's "*t*" test. Categorical variables (proportion of frequency according to the cut-off points considered) were analyzed using contingency tables involving chi-square (χ^2) tests to identify statistical differences between the genders. The extent to which the indicators related to physical activity, dietary composition and tobacco consumption may be associated with overweight and with imperiling levels of blood pressure and of serum lipids and lipoproteins was established using *Odds Ratio* (OR) estimates by using analysis of binary logistic regression. We adopted a 95% confidence interval.

Results

Statistical information regarding the variables analyzed are shown in Table 2. As regards biological indicators associated with risk factors for CVDs when comparing BMI mean values, there are no differences between the genders that may be pointed out statistically. However, we observe DBP and SBP mean values significantly higher among the boys. As to the serum concentrations of lipids and lipoproteins, the results indicate mean values which are statistically higher among the girls for most of the components analyzed. Mean TG concentrations have shown to be similar in both genders.

As regards the behavioral indicators associated with risk factors for CVDs, estimates as to the PA, equivalent to physical activity carried out throughout the day and the average time spent in LIPA and MIPA indicated differences which are statistically significant between the genders. However, girls and boys alike remained physically inactive for approximately twenty hours/day. On average the boys dedicated four times more time of the day to MIPA than the girls (45.13 as compared with 12.46 min/day; p = 0.000). Results as to dietary composition also revealed statistical differences between the genders. The mean values found indicate that boys presented significantly higher intake of fat and cholesterol, and higher calorie supply/day as compared to the girls.

The proportions of adolescents who presented biological and behavioral indicators considered as risk factors for CVDs are shown in Table 3. Behavioral risk factors were the ones that presented the highest prevalence. With this respect, the girls presented an insufficient rate of physical activity (PA ≤ 37 kcal/kg/day) which was statistically higher than the boys' rate (55.4 as compared with 41.9%; p = 0.006). Excessive intake of total fat and saturated fat did not present significant differences between the genders; however, they showed to be the risk behavioral indicators more frequently observed. Statistically speaking (p = 0.000), a higher proportion of

Table 2 – Values of mean, standard deviation and "t" statistics for the information associated with risk factors for cardiovascular diseases

	Girls (n = 246)	Boys (n = 206)	"t" Test	p < t
Biological Indicators				
BMI (kg/m2)	21.11 ± 2.81	21.37 ± 3.17	0.924	ns
DBP (mmHg)	71.41 ± 8.61	73.86 ± 7.91	3.126	0.002
SBP (mmHg)	109.47 ± 9.56	118.63 ± 10.20	9.84	0
TC (mg/dl)	146.23 ± 23.36	134.32 ± 23.21	5.414	0
HDL-C (mg/dl)	52.52 ± 12.14	46.44 ± 6.77	6.402	0
LDL-C (mg/dl)	77.70 ± 22.66	72.14 ± 20.88	2.692	0.008
TG (mg/dl)	80.00 ± 35.71	81.49 ± 37.17	0.434	ns
Physical Activity				
PA_{total} (kcal/kg/day)	36.63 ± 2.22	37.70 ± 3.32	4.082	0
PI (min/day)	1199.33 ± 105.18	1204.39 ± 117.56	0.483	ns
LIPA (min/day)	233.05 ± 103.01	199.13 ± 109.57	3.387	0
MIPA (min/day)	12.46 ± 3.48	45.13 ± 7.21	65.509	0
Dietary Indicators				
ES_{total} (kcal/kg/day)	34.34 ± 14.34	39.94 ± 12.95	4.37	0
FAT_{total} (%)	32.86 ± 6.92	34.17 ± 6.98	4.72	0
$FAT_{saturated}$ (%)	18.18 ± 2.81	19.61 ± 3.65	4.702	0
Cholesterol (mg/day)	295.06 ± 108.95	356.42 ± 125.08	5.573	0

BMI – body mass index; DBP – diastolic blood pressure; SBP – systolic blood pressure; TC – total cholesterol; TG – triglycerides; PA_{total} – total physical activity; PI – physical inactivity; LIPA – low-intensity physical activity; MIPA – moderate-to-intense physical activity; ES_{total} – energy supply; FAT_{total} – total fat; $FAT_{saturated}$ – saturated fat

Table 3 – Proportion (%) of adolescents who presented risk factors for cardiovascular diseases: biological and behavioral indicators

	Girls	Boys	χ^2 Test	p < t
Biological Indicators				
BMI (≥ 25 kg/m²)	16.5	18.6	0.213	ns
DBP (≥ 90 mmHg)	10.2	8.1	0.366	ns
SBP (≥ 140 mmHg)	9.7	8.8	0.027	ns
TC (≥ 200 mg/dl)	12.9	5.6	6.084	0.015
HDL-C (≤ 35 mg/dl)	1.6	4.4	2.224	0.045
LDL-C (≥ 130 mg/dl)	9.0	4.8	7.538	0.006
TG (≥ 130 mg/dl)	9.5	8.1	0.126	ns
Behavioral Indicators				
PA (≤ 37 kcal/kg/day)	55.4	41.9	7.644	0.006
FAT_{total} (≥ 30 %)	63.7	71.0	2.383	ns
$FAT_{saturated}$ (≥ 10 %)	57.4	62.1	0.842	ns
Cholesterol (≥ 300 mg/day)	24.8	50.0	29.716	0.000
Smoker (%)	15.1	20.7	4.152	0.034

BMI – body mass index; DBP – diastolic blood pressure; SBP – systolic blood pressure; TC – total cholesterol; TG – triglycerides; PA – physical activity; FAT_{total} – total fat; $FAT_{saturated}$ – saturated fat

boys (50%) presented intake of dietary cholesterol ≥ 300 mg/day as compared with girls (24.8%). The proportion of smokers was also significantly higher among boys (20.7 as compared with 15.1; p = 0,034).

When using the reference values suggested by the Brazilian Society of Cardiology[16], we verify that serum concentrations of lipids and lipoproteins associated with increased risk for CVD were common in approximately 2%-13% of the girls studied. Among the boys, the proportion of risk varied between 4% and 8%. Additionally, between 8% and 10% of both male and female adolescents selected for the study showed adverse blood pressure levels, which suggests that an eventual indication of hypertension is not an uncommon phenomenon in adolescence. Significant differences which indicate a higher proportion of girls with adverse serum lipoprotein levels were identified when both genders were compared as regards TC (12.9 as compared with 5.6%; p = 0.015) and its fractions - HDL-C (1.9 as compared with 4.4%; p = 0.045) and LDL-C (9.0 as compared with 4.4%; p = 0.006). The differences relative to the proportion of girls (9.5%) and boys (8.1%) that present high TG values were not statistically evidenced.

Table 4 describes the proportion of adolescents analyzed that presented multiple risk factors concurrently. Approximately 20% of the girls and 16% of the boys showed to have at least one biological risk factor related to the development of CVDs. The co-occurrence of two and three potential biological risk factors was identified in 16% and 3% of the girls and in 12% and 3% of the boys respectively. Significant differences between boys and girls were verified only as regards the lower proportion of girls who did not present at least one biological risk factor (59.1 as compared with 68.5%; p = 0.049). As regards the risk factors related to behavioral indicators, only approximately 10% of the adolescents failed to present at least one of the five risk behaviors selected in the study and which may eventually predispose to the onset of CVDs. The girls presented proportions of increasing magnitude and up to the combined presence of three behavioral risk factors, whereas the boys showed a balanced distribution of the proportion of co-occurrence of the five behavioral risk factors considered. Statistical differences indicating higher proportions among boys were identified as regards the co-occurrence of four or more behavioral risk factors (21 as compared with 10.1%; p = 0.003).

The extent to which behavioral risk factors (insufficient levels of physical activity, excessive intake of fat and cholesterol and smoking) were associated with biological risk factors (overweight, imperiling levels of blood pressure and of serum lipids and lipoproteins) was estimated using binary logistic regression analysis. OR values originating from statistical calculations are presented in Table 5. The

Table 4 – Proportion (%) of adolescents who had co-occurring risk factors for cardiovascular diseases

	Biological Indicators					Behavioral Indicators				
	None	1	2	3	≥ 4	None	1	2	3	≥ 4
Girls	59.1	20.4	16.3	2.7	1.5	9.5	20.9	33.5	25.9	10.1
Boys	68.5	16	11.6	2.9	1	10.5	18.5	26.6	23.4	21
χ^2 Test	3.873	1.168	1.669	0.025	0.003	0.038	0.27	2.209	0.254	9.574
p < t	0.049	ns	ns	ns	ns	ns	ns	ns	ns	0.003

Table 5 – Odds Ratio between biological and behavioral indicators associated with risk factors for cardiovascular diseases in adolescents

		Physical Activity Insufficient	Excessive Intake			Smoking
			Fat $_{Total}$	Fat $_{Saturada}$	Cholesterol	
BMI	Girls	1.17 (0.94 – 1.41)	1.64 (1.32 – 1.98)	1.57 (1.28 – 1.88)	1.19 (0.98 – 1.37)	0.86 (0.71 – 0.99)
	Boys	1.06 (0.83 – 1.31)	2.17 (1.81 – 2.58)	1.93 (1.65 – 2.24)	1.21 (0.99 – 1.37)	0.91 (0.69 – 1.11)
DBP	Girls	1.80 (1.63 – 2.01)	1.14 (0.96 – 1.29)	1.17 (0.94 – 1.36)	1.11 (0.90 – 1.30)	1.86 (1.56 – 2.14)
	Boys	1.89 (1.50 – 2.16)	1.10 (0.90 – 1.28)	1.41 (1.07 – 1.77)	0.84 (0.69 – 0.98)	1.99 (1.65 – 2.31)
SBP	Girls	1.91 (1.66 – 2.16)	1.62 (1.31 – 1.89)	1.24 (1.05 – 1.41)	1.36 (1.19 – 1.53)	2.27 (1.85 – 2.71)
	Boys	1.90 (1.64 – 2.12)	1.27 (1.02 – 1.48)	1.74 (1.51 – 1.99)	1.15 (0.94 – 1.32)	2.41 (2.01 – 2.85)
TC	Girls	1.04 (0.85 – 1.26)	1.93 (1.66 – 2.17)	2.42 (2.04 – 2.81)	1.72 (1.49 – 1.98)	2.33 (1.98 – 2.70)
	Boys	0.92 (0.73 – 1.13)	1.61 (1.42 – 1.83)	1.91 (1.61 – 2.25)	1.50 (1.26 – 1.71)	1.79 (1.40 – 2.15)
HDL-C	Girls	1.13 (0.87 – 1.35)	0.62 (0.51 – 0.70)	0.74 (0.59 – 0.88)	0.66 (0.49 – 0.80)	2.27 (1.85 – 2.71)
	Boys	0.96 (0.76 – 1.18)	0.48 (0.39 – 0.56)	0.44 (0.31 – 0.55)	0.56 (0.40 – 0.70)	1.91 (1.46 – 2.34)
LDL-C	Girls	0.87 (0.64 – 1.08)	1.82 (1.55 – 2.05)	2.52 (2.15 – 2.80)	1.51 (1.30 – 1.74)	2.79 (2.40 – 3.20)
	Boys	0.63 (0.44 – 0.85)	1.49 (1.31 – 1.69)	1.61 (1.30 – 1.88)	1.23 (1.01 – 1.48)	2.65 (2.34 – 2.98)
TG	Girls	1.10 (0.88 – 1.29)	1.88 (1.68 – 2.12)	2.64 (2.27 – 2.99)	2.47 (2.15 – 2.83)	2.65 (2.25 – 3.02)
	Boys	0.98 (0.72 – 1.26)	1.60 (1.43 – 1.81)	1.78 (1.52 – 2.04)	1.61 (1.39 – 1.86)	2.56 (2.17 – 2.99)

BMI – body mass index; DBP – diastolic blood pressure; SBP – systolic blood pressure; TC – total cholesterol; TG – triglycerides

results found indicate that excessive intake of total fat and saturated fat were the behavioral indicators which presented the highest association with overweight among male and female subjects alike in this study. Based on OR values, we estimate that, statistically speaking, girls who showed excessive intake of total fat (OR = 1.64; 95% CI 1.32-1.98) and saturated fat (OR = 1.57; 95% CI 1.28-1.88) had respective 64% and 57% more chances of being overweight. For boys, those who presented excessive intake of total fat (OR = 2.17; 95% CI 1.81-2.58) and saturated fat (OR = 1.93; 95% CI 1.65-2.24) presented, in approximated values, twice the chance of being overweight. Excessive intake of cholesterol, smoking and insufficient physical activity were not significantly associated with overweight.

Insufficient physical activity and smoking were the behavioral indicators which had the highest association with imperiling levels of blood pressure especially in the case of SAP. Excessive intake of fat and cholesterol presented lower association with elevated blood pressure although, in the specific case of SAP, OR values were statistically significant. Girls (OR = 2.27; 95% CI 1.85-2.71) and boys (OR = 2.41; 95% CI 2.01-2.85) who smoked presented twice the predisposition to elevated SAP that their non-smoking counterparts. As regards the practice of physical activity, girls (OR = 1.91; 95% CI 1.66-21.16) and boys (OR = 1.90; 95% CI 1.64-2.12) who had insufficient physical activity had 90% more chances of presenting SAP values ≥ 140 mmHg.

As regards lipids and lipoproteins, OR values reveal that smoking and excessive intake of saturated fat were the behavioral indicators which contributed the most to worrisome changes in the serum levels of this type of fat. Smoking girls or those who eat an excessive amount of saturated fat have 2.3 (CT – OR = 2.33; 95% CI 1.98-2.70) to 2.8 (LDL-C – OR = 2.79; 95% CI 2.40-3.20) more chances of having an atherogenic profile of serum lipids and lipoproteins. As for boys, OR values were slightly reduced and yet were still significant, statistically speaking. According to the outline established for the logistic regression, the smallest OR values were found between LDL-C values ≥ 130 mg/dl and insufficient physical activity and HDL-C values ≤ 35 mg/dl and the excessive intake of fat and cholesterol. However, reduced concentrations of HDL-C were significantly associated with smoking (girls – OR = 2.27; 95% CI 1.85-2.71; and boys – OR = 1.91; 95% CI 1.46-2.34).

Discussion

Studies available in the literature seek to describe estimates regarding the prevalence of risk factors for CVD in the young population. However, while some of these studies have focused solely on biological indicators[22-28]; others focus only on information about behavioral indicators which are aggressive to cardiovascular health[29-31]. This study, in addition to providing descriptive information for both biological and behavioral aspects observed in a sample of adolescents, tried to establish

to what extent selected behavioral indicators may be associated with biological indicators which are considered risks indicators for the onset and progression of CVDs.

As regards biological risk factors for CVDs, differences between the genders regarding average BMI values, blood pressure and serum concentrations of lipids and lipoproteins observed in the study are consistent with trends found in the literature. Indications found in previous publications point to the sexual dimorphism observed in the levels of blood pressure and of serum lipids and lipoproteins, which can be explained by hormonal changes typical of each gender and that occur close to puberty. The higher production of estrogen in girls in this period should contribute temporarily to a higher serum concentration of TC and its fractions, whereas the higher production of testosterone in boys is related to higher levels of blood pressure[32,33]. In the beginning of adulthood, however, the lipoproteic pattern that accounts for the higher incidence of CVD among men as compared to women is already established. The literature we consulted suggests that any relation that there might be between the level of TG and the gender is not accurate. Some studies found higher levels among boys[27,34-36], while others, in agreement with the results observed in this study, did not find differences that may be statistically relevant between male and female adolescents[23-26,28].

In comparison with other studies, if, on the one hand the adolescents analyzed here present mean values for biological risk factors for CVDs which are similar to the ones of other studies carried out in Latin American countries[22,26,37], Africa[23] and Asia[38,39], on the other hand important differences are observed when we compare them with the results of studies with European subjects[24,27,28,33,36,40] and with North American subjects[25,35] of the same age. Although we found some studies with Brazilian young people[41-44], differences regarding the composition of samples impede comparisons with the results observed in this study. We believe that the differences regarding biological attributes relating to risk factors for CVDs can be attributed, to a large extent, to multiple environmental factors defined by geoclimatic, economic, social and cultural characteristics which modulate the expression of the genetic potential.

As concerns the proportion of adolescents who presented information of a biological nature indicative of risk for CVD, specifically as regards the BMI, we verified that in comparison with the results of epidemiological surveys involving different segments of the young population in Brazil[45,46], a smaller proportion of adolescents in the study was classified as overweight (16.5% of the girls and 18.6% of the boys). However, despite these results, there is reason for concern since excess weight in childhood and adolescence tends to persist in adulthood. Estimates suggest that only one out of five adolescents who are overweight tends to reduce and maintain weight within the expected limits in adulthood[47]. Programs to reduce and control weight in adolescence seem to be efficient to a very limited extent, acting on the supposition that those adolescents who are overweight will continue to be overweight into adulthood.

With this regard, we should emphasize that overweight is not considered as an immediate biological risk factor for the onset and progression of CVDs. However, in general, a compromised cardiovascular profile in adulthood is accompanied by excess weight which is established and maintained in childhood and adolescence[48,49]. Therefore, by adopting actions to control weight in young people, we can potentially minimize the occurrence of other known risk factors at more advanced ages.

As to blood pressure values, it is worth highlighting that higher levels, which were identified in one out of ten adolescents analyzed, should not necessarily indicate the presence of hypertension. In this case, to verify hypertension, we recommend that abnormally high blood pressure values should be confirmed at two or more different occasions within a determined period of time[50]. However, longitudinal follow ups have shown that those adolescents with high levels blood pressure tend to maintain high pressure values and to be diagnosed as hypertensive later in adulthood[51]. Echocardiographic studies with young people showed a continuous increase in the thickness of the left posterior ventricular wall in parallel with increasing levels of blood pressure[52]. Therefore, changed levels of blood pressure in adolescence are evidence that immediate therapeutic intervention may be required to prevent hypertension in the future.

Comparisons with results observed in other studies as to the proportion of adolescents who presented inadequate levels of blood pressure and serum lipids and lipoproteins should be carried out in a careful manner due to possible differences associated with the cut-off points considered. However, as regards blood pressure levels, it is worth highlighting that the adolescents analyzed here showed more favorable proportions than the adolescents analyzed in European[24,36] and North American[25,35] studies, but similar proportions in relation to the studies carried out in countries of Latin America[37], Asia[38,39], Africa[23] and Brazil[53,54].

As regards serum lipid and lipoprotein concentrations, and in agreement with results of other studies[22-28], the girls presented a proportion of impairment which is significantly higher for the concentrations of TC and of the LDL-C fraction. Reduced levels of HDL-C fraction, less frequent in both male and female subjects, which appears to be typical of the young population, was the only biological risk factor where the boys presented a proportion which is significantly higher than the girls'. These findings have a significant impact when we think of data from necropsies of young people who died during prospective studies. It was possible to verify that the adverse profile of serum lipids and lipoproteins in young bodies may be the cause of anatomic pathologic lesions in the coronary arteries and in the aorta, and is therefore defined as a strong predictor of CVD in adulthood. The presence of fatty streaks and fibrous plaques was related

especially to the changed levels of the HDL-C fraction and TG[55,56]. Therefore the control of lipid and lipoprotein serum levels should minimize the progression of any atherosclerotic process in adolescents and therefore reduce the future risk of occurrence of CVD.

It is important to highlight that, in this study, a significant proportion of the adolescents analyzed (40.9% of the girls and 31.5% of the boys) showed at least one biological risk factor for CVD, and approximately 50% of these adolescents had multiple risk factors combined. Under these circumstances and considering evidence that the biological risk factors identified in adolescence tend to persist in adulthood[57], we have to take into account that the greater the number of aggregated risk factors, the higher the probability of early onset and progression of CVD. Therefore, those subjects who presented isolated or co-occurring biological indicators above the cut-off points regarded as points of risk should be considered as possible candidates for CVD in the future. Only by doing longitudinal follow up of the adolescents considered as "at risk" will it be possible to confirm the presence of this condition in the future. However, although only a small part of these adolescents may eventually confirm this prognosis, this translates by itself into a significant number of adolescents for whom a predictive factor for CVD is identified in an early stage.

As regards behavioral indicators relating to the onset and progression of CVD, we verify that the results found are in agreement with trends presented by other studies, which indicate that boys are usually more active, but have dietary patterns which are linked to higher degrees of compromising than the girls[30,31]. Although methodological differences relating to measurement tools employed in the collection of data and to the criteria for interpreting information may affect comparisons with other studies, the results presented by the adolescents analyzed in this study indicate a higher proportion of sedentary lifestyle and atherogenic diet.

As regards smoking, in this study, smoking daily or at least once a week defined adolescents as smokers. By this definition, the proportion of boys who reported to be smokers was significantly higher than girls. In comparison with studies available in the literature that present epidemiological characteristics, these findings show a higher proportion of smoking male adolescents. Surveys carried out in other Brazilian regions[58,59], in industrialized countries[29-31] and in developing countries[37,60] reveal similar prevalence for both genders in the region of 15%.

The fact that only 9.5% of the girls and 10.5% of the boys did not present at least one compromised behavioral indicator stood out. This high aggregation of risk behavior was also observed in other studies[61], thus suggesting that a high proportion of adolescents with a sedentary lifestyle tend to have an unhealthy diet and smoke at the same time. These findings acquire great importance as regards the adoption of healthy habits throughout life in view of the evidence available in the literature which suggests that unhealthy behavior acquired and cultivated in childhood and adolescence is difficult to change and tends to persist in adulthood and beyond[62,63].

Analysis about the extent to which risk behaviors may be associated with biological risk factors for CVD in young populations should consider the role of genetic components in the variation of weight and of levels of blood pressure and of serum lipids and lipoproteins[64]. If we accept this premise, it is important to say that, in these cases, any changes observed in biological risk factors as a result of risk behaviors may depend on individual variations to manifest themselves; additionally, in theory, the expression is supposed to be less likely in adolescents than in adults.

Anyway, even in view of these limitations, the OR values found indicated associations between behavioral indicators and most of the biological risk factors for CVD selected in the study. The results found suggest that insufficient physical activity, represented in the study by PA $\leq$ 37 kcal/kg/day for both male and female subjects, may play a more important role in explaining increased levels of blood pressure. The adolescents who were physically less active showed 80% to 90% more chances of presenting impairment linked to blood pressure levels than their more active counterparts. However, in agreement with the results of other studies[35,36,39,65], in the set of cases studied in this paper, serum concentrations of lipids and lipoproteins considered as of risk and higher weight (BMI $\geq$ 25 kg/m^2) did not show to be significantly influenced by insufficient physical activity.

In studies with adults, it was proven that sedentary lifestyle is a behavior that is clearly related to the onset and progress of CVD and of associated risk factors[66]. However, this association does not appear to be confirmed with the same degree of potentiality in young populations. We can also speculate that these differences may be partly due to metabolic adaptations related to the control of serum lipid and lipoprotein concentrations and weight induced by the habitual practice of physical activity, particularly in the bodies of young people, that are not yet biologically mature, and in adults. For example, in theory, it is assumed that adolescents may be more active in their everyday life, and for this reason, variations in serum concentrations and weight are not as sensitive as in adults. It may also be that the significant associations observed in adults are non-causal, and therefore there may be additional effects of other unknown variables which affect the relationship between physical activity-serum lipids and lipoproteins and physical activity-weight which are not yet clear for adolescents. This may suggest the concept that the impact of a sedentary lifestyle on the concentration of serum lipids and lipoproteins and on weight may take some time to be identified.

Dietary patterns with higher intake of fat and cholesterol had a significant impact on the subjects' risk of presenting excess weight, increased blood pressure values and an adverse lipid and lipoprotein profile. The OR values found prove that the extent of the association between atherogenic dietary patterns and biological risk factors selected in this study presented different magnitudes for each gender. Whereas among boys the excessive intake

of total and saturated fat was strongly associated with overweight, among the girls inadequate proportions of fats and cholesterol in diet composition played a more important role in relation to higher serum concentrations of lipids and lipoproteins. However, probably due to the close metabolic relationship between lipid and lipoprotein components, we verified that OR values observed in association with atherogenic dietary patterns for both male and female subjects were very similar. These findings are consistent with the results of studies of interventions which reduced the intake of saturated fat in the diet of young people and caused a sharper reduction in LDL-C and TG concentrations among girls[67].

The lower OR values observed between the high consumption of dietary cholesterol and the selected biological risk factors are consistent with weak associations found in studies involving adults[68], and confirm evidence that excessive intake of dietary cholesterol presents a weaker association with higher concentrations of serum lipids and lipoproteins than the excessive intake of total and saturated fat.

On analyzing the association between smoking and increased blood pressure values and an adverse lipid and lipoprotein profile, we verified that OR values were, in most situations, superior to two units. Therefore, in the set of cases studied here, being a smoking adolescent implies at least a two-fold increase in the likelihood of having blood pressure levels and serum lipid and lipoprotein concentrations suggestive of hypertension and dyslipidemia respectively. However, when it comes to the association between smoking and overweight, we verified that OR values were not statistically relevant which suggests that, for adolescents, smoking does not necessarily increase the risk of accumulating weight.

Despite the undisputed harmful effects of tobacco components to health in general, as has been evidenced in other studies [69,70], the evidence gathered in this study indicates a strong influence of smoking on biological risk factors for CVD in adolescents. Reversible effects associated with cardiovascular health as a consequence of abandoning smoking have been experimentally documented in adults[71]. In these cases, the benefits obtained are partly explained by favorable changes observed in the levels of arterial pressure and of serum lipids and lipoproteins. The question here is to identify the impact of abandoning smoking on the cardiovascular health of adolescents.

Considering the evidence of its strong association with atherogenic aggressions and the potential predisposition of young people to the acquisition of tobacco dependence, it is sensible to assume that the risk of smoking adolescents having CVD in adulthood is extremely high.

The concept that potential biological risk factors may appear early in young people and progress through several stages to cause CVD in adulthood and the confirmation provided by the findings, i.e., that biological risk factors may be equally affected in adolescence and adulthood in response to exposure to risk behavior emphasizes the importance of designing preventive actions targeted at the prevention and change of habits which are aggressive to the cardiovascular health of adolescents. In this respect, although the social and family environment may play a significant role in the development of behaviors which influence the healthy lifestyle adopted by young people, educational programs targeted at health education should be implemented in an attempt to help young people minimize the extraordinary impact of the media regarding their option for adopting the habit of engaging in sedentary activities for leisure and in their free time, the higher consumption of atherogenic foods, and smoking. Specialists are unanimous in suggesting that efforts to prevent and reduce risk behavior should be implemented during school years, when young people are especially prone to incorporate behavior which is aggressive to health into their everyday life and carry them into adulthood.

In this scenario, we highlight that restricting the access to inadequate diet and to tobacco and other harmful substances, and the compulsory practice of physical activity in physical education classes are very unlikely to prompt young people to take on healthy habits that will last their whole life. Health education programs should include pedagogical practices to help raise young people's awareness as to the harmful influence of risk behavior and to help them make their own decisions regarding the adoption of healthy and long lasting habits.

Potencial Conflict of Interest

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

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