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ORIGINAL ARTICLE

Association between Cardiovascular Risk in Adolescents and Daily Consumption of Soft Drinks: a Brazilian National Study

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Abstract

Background: Cardiovascular risk in adolescence is a public health problem that has grown along with the increase in soft drink consumption.

Objective: To investigate the association between cardiovascular risk factors and daily consumption of soft drinks in Brazilian adolescents.

Methods: We conducted a cross-sectional, national, school-based study of 36,956 Brazilian adolescents aged 12 to 17 years. Daily soft drink consumption was estimated using a 24-hour dietary recall. Cardiovascular risk was categorized as overweight, obesity, hypertension, hyperglycemia, and dyslipidemia. The survey command of Stata 14.0® was used to analyze data from a complex sample. The chi-square test was used to assess differences in soft drink consumption and other variables in the descriptive analysis. The odds ratio of cardiovascular risk factors and their respective 95% confidence intervals were estimated, considering sociodemographic and behavioral variables in the Mantel-Haenszel model. Statistical significance was set at $p < 0.05$.

Results: Daily consumption of soft drinks was common among adolescents. A daily serving ≥ 450 mL was significantly associated with overweight and hypertension. Results associated with the consumption of regular soft drinks show the possibility of reverse causality. Consumption of diet soft drinks in adolescence should be considered a cardiovascular risk factor.

Conclusion: Daily consumption of soft drinks can be understood as a relevant risk factor in the epidemiological scenario. Improper eating habits are multifactorial in nature and need to be better understood in the context of adolescent health and further explored in national surveys.

Keywords: Adolescent; Dietary Sugars, Food and Beverages; Cardiovascular Diseases; Risk Factors; Control and Sanitary Supervision of Foods and Beverages; Healthy Surveys.

Introduction

Cardiovascular disease (CVD) is a leading cause of death in Brazil, accounting for approximately 20% of all deaths in individuals over 30 years of age.[1] Unhealthy diets and physical inactivity are the main contributors to overweight and obesity, identified as major risk factors for chronic noncommunicable diseases (NCDs).[2]

Surveillance and monitoring of risk factors are effective actions to tackle NCDs. Dietary habits influence the growth and development of individuals, and they seem to vary with sex, age, culture, ethnicity, and socioeconomic status. Unhealthy eating habits and high consumption of soft drinks are common during adolescence, but food choices vary among adolescents.[3]

Both the frequency and amount of soft drink consumption have increased worldwide. In Brazil, the Household Budget Survey found variations of up to 400% in the consumption of soft drinks from 1975 to 2003.[4] When analyzing high-risk behaviors for CVD during adolescence, data from the Brazilian National School Health Survey showed that 27.2% (95% confidence

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interval [CI], 26.1%-28.4%) of the adolescents surveyed consume soft drinks 5 or more days per week.[5]

Limiting soft drink consumption can contribute to reducing weight gain and associated chronic diseases, such as cardiometabolic diseases. Public policies have been adopted to promote health and to reduce soft drink consumption especially in childhood and adolescence, but compensation mechanisms have limited the benefits of these actions.[6-8]

Early interventions have been successful in reducing CVD with the potential to change the current epidemiological scenario.[9] Adolescent exposure to unhealthy habits, such as high consumption of soft drinks, is associated with increased cardiovascular risk and greater lifetime accumulation of exposure. Cardiovascular risk factors include overweight and obesity, dyslipidemia, hypertension, insulin resistance, sedentary lifestyle, and atherogenic diet.[10]

Great human potentialities are developed during adolescence and may have repercussions in adulthood. A better understanding of risk factors common to this age group can strengthen public policies and guide more effective health actions for changes in the epidemiological profile. Therefore, this study aimed to investigate the association between cardiovascular risk factors and daily consumption of soft drinks in Brazilian adolescents.

Methods

This study analyzed data from the Brazilian Study of Cardiovascular Risks in Adolescents (ERICA), whose methodological approach was based on conglomerate sampling, minutely described in preliminary studies.[11,12]

We conducted a cross-sectional, multicenter, national, school-based study that covers the population of adolescents aged 12 to 17 years enrolled in public or private schools in Brazilian municipalities with more than 100,000 inhabitants.

The data were collected between March 2013 and December 2014. A total of 1251 schools in 124 Brazilian municipalities were selected, for a total sample of 36,956 adolescents with complete data from a self-report questionnaire, 24-hour dietary recall (24-HDR), and physical and biochemical examinations. The sample is representative of the population of Brazilian adolescents at the national and regional levels, for the capital cities and the Federal District.

Food consumption was estimated based on 24-HDR data, collected using ERICA-REC24h, a computer-based direct data collection platform. The software was developed from a database consisting of 1626 food items, including preparation methods and units of predefined serving sizes. The database was developed by the Brazilian Institute of Geography and Statistics and used in the 2008-2009 National Diet Survey.[13,14] Reported foods that were not included in ERICA-REC24h were incorporated by the researchers.

Beverages reported by the adolescents in 24-HDRs were divided into 6 groups: flavored dairy drinks, soy-based beverages, juices and fruit drinks, regular soft drinks, diet soft drinks, and other (beverages that did not fit any of the previous groups).[15]

Participants' sex, age group, and Brazilian region were treated as sociodemographic variables. Eating habits (calories consumed daily and the percentage of sugar in the diet) and sedentary lifestyle (screen time > 2 hours/day) were treated as behavioral variables.

Cardiovascular risks were investigated by anthropometric assessment, blood pressure measurement, and biochemical blood tests using fasting blood samples.[16-18] Cardiovascular risk factors in adolescence were defined as follows: overweight and obesity, classified according to body mass index; hypertension, when systolic or diastolic blood pressure corresponded to the 95th percentile or higher; hyperglycemia, defined as fasting blood glucose ≥ 126 mg/dL; and dyslipidemia, defined as total cholesterol ≥ 170 mg/dL, LDL-cholesterol ≥ 130 mg/dL, HDL-cholesterol < 45 mg/dL, and/or triglycerides ≥ 130 mg/dL. Sex, age, geographic region, and screen time (> 2 hours/day) were used as adjustment variables.

Statistical analysis

Data were analyzed in Stata 14.0®, and the effect of sample design and expansion based on sample weight were considered by using the *survey* command. A 95% CI was adopted, and the level of statistical significance was set at $p < 0.05$.

The chi-square test was used to assess the association between variables in the descriptive analysis. For inferential analyses, soft drink consumption was categorized by using the median daily consumption of regular soft drinks (450 mL) as a cutoff point. The odds ratio of cardiovascular risk was calculated by associating soft drink consumption with

sociodemographic and behavioral adjustment variables in the Mantel-Haenszel model.

The study met the ethical requirements of the Declaration of Helsinki and was approved by the Research Ethics Committee of the Institute for Studies in Collective Health at the Federal University of Rio de Janeiro (Process 45/2008). Only adolescents who agreed in writing and whose guardians signed the informed consent form participated in the study. The confidentiality and anonymity of the participants were preserved in this study.

Results

The consumption of sugar-sweetened beverages was high among adolescents attending schools in Brazilian cities with more than 100,000 inhabitants. The mean age of the participants was 14.7 years (range, 12 to 17 years), and 60% were female. Geographic region was a determinant of soft drink consumption (p = 0.000).

As shown in Table 1, beverages in the groups 'juices and fruit drinks,' 'regular soft drinks,' and 'flavored dairy drinks' were the most frequently reported in the 24-HDR by Brazilian adolescents. As measured by the median, the highest daily servings were found in the groups 'regular soft drinks' (450 mL) and 'juices and fruit drinks' (300 mL). Flavored dairy drinks, soy-based beverages, and diet soft drinks had values of 240 mL/day.

The ratio of the amount of added sugar to the total daily energy value, in calories, was checked for the different groups. The groups 'regular soft drinks' and 'juices and fruit drinks' had a ratio of 8.06% and 6.78%, respectively. Diet soft drinks do not contain sugar, which is why the ratio was zero. Daily servings of sugar-sweetened beverages were high and often positively correlated with daily energy (calorie) increase in adolescents, probably because of the added sugar from these drinks (Table 1).

Table 2 presents the distribution of sociodemographic, behavioral, and cardiometabolic characteristics of adolescents in the ERICA study according to the consumption of regular and diet soft drinks. Only 1.06% (n = 391) of the sample reported consuming diet soft drinks in the 24-HDR. In contrast, 45.21% (n = 16,708) reported consuming regular soft drinks. The consumption of soft drinks varied according to the different independent variables (Table 2).

Soft drink consumption was significantly associated with overweight, obesity, and hypertension (p < 0.05), as shown in Tables 3 and 4. Adolescents who consumed more regular soft drinks had a lower odds ratio for overweight, obesity, and hypertension (Table 3). The odds ratio for overweight, obesity, and hypertension increased with increasing servings of diet soft drinks (Table 4). The distribution of associations remained constant after adjustments.

Discussion

Data from the 2017-2018 Brazilian Household Budget Survey show that soft drinks are the beverages with the highest average daily per capita consumption in Brazil (67.1 g/day). The average daily per capita soft drink consumption in the South is twice as high as in the North and Northeast.[19]

Considered a marker of an unhealthy dietary pattern, soft drink is a beverage made from carbonated water

Table 1 – Description, median (mL) and ratio (%) between added sugar and the total energy value of beverages reported in the 24-HDR[1] by Brazilian adolescents. ERICA[a], Brazil, 2013-2014

Beverage group	Description	N	%[b]	Median (mL)	Ratioc (%)
Flavored dairy drinks	Dairy drinks sweetened with artificial or natural flavors, and fermented milk	7,341	9.38	240	2.75
Soy-based beverages	Soy milk and soy-based beverages	124	0.19	240	2.75
Juices and fruit drinks	Natural and processed fruit juices	20,462	24.12	300	6.78
Regular soft drinks	Sugar-sweetened soft drinks	16,708	20.72	450	8.06
Diet soft drinks	Diet and light soft drinks	391	0.46	240	0.00
Other	Other beverages consumed by adolescents reported in the 24-HDR	36,953	45.14	1005	9.40

[1] 24-HDR: 24-hour dietary recall. [a] Data extracted from the database of the 2013-2014 Brazilian Study of Cardiovascular Risks in Adolescents; [b] Sample effect considered in the analysis; [c] Ratio (%) = added sugar from the beverage group (kcal/day)/total energy value (kcal/day).

Table 2 – Association between daily soft drink consumption and independent variables in Brazilian adolescents. ERICA[a], Brazil, 2013-2014

Variable	Regular soft drinks		Diet soft drinks	
	n (%)	p-value[b]	n (%)	p-value[b]
Do not consume	20,248 (54.79)		36,565 (98.94)	
Consume	16,708 (45.21)		391 (1.06)	
Sex				
Female	9,882 (26.74)	0.00	227 (0.61)	0.43
Male	6,826 (18.47)		164 (0.44)	
Age group				
12-14 years	7,823 (21.17)	0.00	185 (0.50)	0.54
15-17 years	8,885 (24.04)		206 (0.56)	
Brazilian macro-regions				
North	2,937 (7.95)	0.00	52 (0.14)	0.00
Northeast	5,047 (13.66)		92 (0.25)	
Southeast	3,956 (10.70)		131 (0.35)	
South	2,282 (6.17)		59 (0.16)	
Central West	2,486 (6.73)		57 (0.15)	
Screen time				
≤ 2 hours/day	6,155 (16.65)	0.00	130 (0.35)	0.03
> 2 hours/day	9,204 (52.42)		230 (0.62)	
Do not know	1,349 (3.65)		31 (0.08)	
Total energy in 24-HDR[1]				
≤ 2000 kcal/day	6,483 (17.54)	0.00	185 (0.50)	0.27
2000-3000 kcal/day	5,957 (16.12)		137 (0.37)	
≥ 3000 kcal/day	4,268 (11.55)		69 (0.19)	
Added sugar[c]				
≤ 5% total energy/day	8,151 (22.06)	0.00	274 (0.74)	0.00
> 5% total energy/day	8,557 (23.15)		117 (0.32)	
Cardiovascular risk				
Overweight				
Yes	4,078 (11.03)	0.00	133 (0.36)	0.00
No	12,630 (34.18)		258 (0.70)	
Obesity				
Yes	1,287 (3.48)	0.00	47 (0.13)	0.00
No	15,421 (41.73)		344 (0.93)	
Hypertension				
Yes	1,464 (3.96)	0.04	47 (0.13)	0.04
No	15,244 (41.25)		344 (0.93)	
Hyperglycemia				
Yes	516 (1.40)	0.37	18 (0.05)	0.06
No	16,192 (43.81)		373 (1.01)	
Dyslipidemia				
Yes	13,022 (35.24)	0.30	314 (0.85)	0.30
No	3,686 (9.97)		77 (0.21)	

[1] 24-HDR: 24-hour dietary recall. [a] Data extracted from the database of the 2013-2014 Brazilian Study of Cardiovascular Risks in Adolescents; [b] Chi-square test; [c] The World Health Organization (2015) states that greater health benefits can be achieved if the daily consumption of sugar is reduced to 5% of the calories ingested

Table 3 – Association between cardiovascular risk and daily consumption[a] of regular soft drinks in Brazilian adolescents. ERICA[b], Brazil, 2013-2014.

Cardiovascular risk	OR[1] (95% CI)	p-value	OR[2] (95% CI)	p-value	OR[3] (95% CI)	p-value
Overweight	0.93 (0.90-0.96)	0.00	0.93 (0.90-0.95)	0.00	0.93 (0.90-0.95)	0.00
Obesity	0.94 (0.89-0.98)	0.00	0.93 (0.89-0.98)	0.00	0.93 (0.89-0.97)	0.00
Hypertension	0.95 (0.91-0.99)	0.04	0.95 (0.91-0.99)	0.03	0.95 (0.91-0.99)	0.03
Hyperglycemia	1.01 (0.94-1.09)	0.66	1.01 (0.94-1.09)	0.69	1.01 (0.94-1.09)	0.73
Dyslipidemia	0.99 (0.96-1.02)	0.67	0.99 (0.96-1.02)	0.93	0.99 (0.96-1.02)	0.75

OR: odds ratio (p>0.05); 95% CI: 95% confidence interval.
[a] Serving ≥ 450 mL; bData extracted from the database of the 2013-2014 Brazilian Study of Cardiovascular Risks in Adolescents; [1] Analysis adjusted for sex and age group (12-14 years and 15-17 years); [2] Analysis adjusted for Brazilian macro-region; [3] Analysis adjusted for screen time > 2 hours/day.

Table 4 – Association between cardiovascular risk and daily consumption[a] of diet soft drinks in Brazilian adolescents. ERICA[b], Brazil, 2013-2014.

Cardiovascular risk	OR[1] (95% CI)	p-value	OR[2] (95% CI)	p-value	OR[3] (95% CI)	p-value
Overweight	1.27 (1.11-1.44)	0.00	1.25 (1.09-1.42)	0.00	1.26 (1.10-1.43)	0.00
Obesity	1.37 (1.11-1.68)	0.00	1.34 (1.09-1.65)	0.00	1.35 (1.10-1.66)	0.00
Hypertension	1.26 (1.03-1.53)	0.02	1.24 (1.02-1.52)	0.02	1.22 (1.01-1.49)	0.03
Hyperglycemia	1.21 (0.87-1.70)	0.24	1.20 (0.86-1.66)	0.27	1.20 (0.86-1.67)	0.27
Dyslipidemia	1.10 (0.96-1.26)	0.14	1.12 (0.98-1.29)	0.08	1.13 (0.98-1.29)	0.07

OR: odds ratio (p>0.05); 95% CI: 95% confidence interval.
[a] Serving ≥ 450 mL; bData extracted from the database of the 2013-2014 Brazilian Study of Cardiovascular Risks in Adolescents; [1] Analysis adjusted for sex and age group (12-14 years and 15-17 years); [2] Analysis adjusted for Brazilian macro-region; [3] Analysis adjusted for screen time > 2 hours/day.

that typically contains substances such as sodium, carbohydrates, and especially sugar.[20] Most Brazilian adolescents consume this beverage daily, and factors such as sex, age, and sedentary lifestyle are pointed out as determinants of unhealthy dietary behavior, varying according to geographic region.[21,15]

Liquid calories do not produce the same level of satiety as solid calories, and the consumption of soft drinks is often associated with excessive calorie intake and increased risk of obesity.[6,22] The World Health Organization recommends that sugar consumption should be reduced to 5% of the calories ingested daily, but consuming diet soft drinks, as a substitute for regular soft drinks, has also been associated with cardiovascular risk and should be considered in the development of public health policies.[23,24]

The association between sugar-sweetened beverages and chronic diseases is complex and can be confused by several factors.[25] Ambrosini *et al.*,[26] identified that the daily serving size of soft drinks influenced the increase in cardiometabolic risk, overweight, and obesity in girls. Among boys, there was a reduction in HDL-cholesterol levels, regardless of weight gain. All adolescents, both female and male, who increased their intake to more than 325 mL/day showed increased triglyceride levels.

In our study, soft drink consumption was negatively associated with overweight and hypertension in adolescents. A possible explanation for these results is the reverse causality effect, considering the cross-sectional design of the study, as restrictions on the consumption of sugar-sweetened beverages have been incorporated into recommendations for dietary changes to prevent cardiovascular risk.[22,23]

Replacing sugar-sweetened beverages by diet/light soft drinks has been pointed out as an alternative

to reduce sugar in the diet. Diet soft drinks are low-calorie beverages, but the artificial sweeteners in their composition can increase the storage of calories from other foods consumed. An increased consumption of diet soft drinks has been associated with increased risk of type 2 diabetes, CVD, and metabolic syndrome.[27] Also, diet soft drinks have more sodium than regular soft drinks, and the increased amount of sodium in the diet may be associated with higher blood pressure in adolescents who consume diet soft drinks than in those who consume regular soft drinks. This possibility should be considered by people on a recommended low-sodium diet.[28] Hypertension is strongly associated with adverse cardiovascular events, including heart failure, ischemic heart disease, and cerebrovascular diseases.[29]

It is important to highlight that the health-disease process is not associated simply with the presence or absence of a certain food in the diet, but rather with the set of foods consumed, their quantity and servings. Therefore, other independent pathways should be considered in the investigation of cardiovascular risk factors in adolescence.[25] For example, high screen time favors physical inactivity and greater consumption of obesogenic foods, in addition to causing distractions that interfere with the physiological signals of hunger and satiety. The media can negatively influence eating behaviors in adolescents, and high screen time contributes to both a sedentary lifestyle and excessive soft drink consumption.[30]

Regional specificities should be considered in the development of public policies aimed at promoting health and reducing cardiovascular risk in adolescents. It is known that the current epidemiological scenario is multifactorial and that social, demographic, and behavioral variables are associated with the development of cardiovascular risk factors in this population. Therefore, in-depth scientific studies on sociodemographic, behavioral, and epidemiological factors associated with soft drink consumption are essential, since the daily consumption of these beverages is high in adolescence. Associations between dietary habits and epidemiological risk factors need to be carefully observed.

One of the limitations of this study is the inability to establish a cause-and-effect relationship between soft drink consumption and cardiovascular risk, as the cross-sectional design makes it impossible to determine the time interval between the variables. However, there are few Brazilian population-based studies of adolescents on this topic with the amount of information provided in this study. The sample size and the standardization of methods and instruments used in data collection reinforce the reliability of the data reported in this study.

Conclusions

Population-based studies investigating the consumption of sugar-sweetened beverages using a 24-HDR are still incipient, and the association of regular and diet soft drinks with cardiovascular risk factors in adolescents was a relevant finding in the present study.

Brazilian adolescents who are overweight and have hypertension may be realizing the importance of reducing the consumption of regular soft drinks, resulting in lower intake or greater underreporting of soft drink consumption in this group. In contrast, adolescents consuming larger servings of diet soft drinks were at greater risk of being overweight, obese, and hypertensive.

These data highlight the need to expand scientific research and strengthen health actions focused on soft drink consumption among adolescents, considering the susceptibilities and specific characteristics of this population. Adolescents' consumption of sugar-sweetened beverages needs to be explored as an important cardiovascular risk factor for the Brazilian epidemiological scenario and should not be ignored in the development of public policies within the environments in which adolescents live.

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Author contributions

Conception and design of the research: Neves AFG, Vianna RPT. Acquisition of data: Neves AFG, Vianna RPT. Analysis and interpretation of the data: Neves AFG, Vianna RPT, Lopes MT. Statistical analysis: Neves AFG, Vianna RPT, Lopes MT. Writing of the manuscript: Neves AFG, Vianna RPT, Lopes MT. Critical revision of the manuscript for intellectual content: Neves AFG, Vianna RPT, Lopes MT.

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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Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Institute for Studies in Coletive Health (UFRJ) under the protocol number 45-2008, report number 01/2009. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consente was obtained from all participants included in the study.

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