

# Soft drink consumption and body mass index in Brazilian adolescents: National Adolescent Student Health Survey

*Consumo de refrigerantes e índice de massa corporal em adolescentes brasileiros: Pesquisa Nacional de Saúde do Escolar*

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**ABSTRACT:** *Objective:* To estimate the association between soft drink consumption and body mass index (BMI) in eutrophic and overweight adolescents. *Methods:* We used data from the National Adolescent Student Health Survey (Pesquisa Nacional de Saúde do Escolar - PeNSE) of 2009. The dependent variable (outcome) was the tertiles of BMI score (zBMI), and the main independent variable (exposure) was the consumption of sugar-sweetened soft drinks. The models included age, school type, home goods and services score, and maternal schooling as adjustment variables. We estimated the association between exposure and outcome by using multinomial regression models, stratified by gender, and eutrophic and overweight subgroups. *Results:* 23.8% of the adolescents evaluated were overweight, and 21.7% reported consuming soft drinks daily. For eutrophic boys, those who consumed soft drinks had a greater chance of being in higher zBMI tertiles than non-consumers. For overweight adolescents, both male and female, soft drink consumption was associated with a lower chance of being in the highest tertile of zBMI score. *Conclusion:* The results show the possibility of reverse causality between consumption of sweetened soft drinks and zBMI in the overweight adolescents group. For eutrophic male adolescents, soft drink consumption can potentially increase the chances of having higher zBMI, which reinforces the need for measures to significantly reduce the consumption of this beverage.

**Keywords:** Adolescents. Soft drinks. Cross-sectional studies. Obesity.

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**RESUMO:** *Objetivo:* Estimar a associação entre consumo de refrigerantes e o índice de massa corporal (IMC) em adolescentes eutróficos e com excesso de peso. *Métodos:* Foram utilizados dados da Pesquisa Nacional de Saúde do Escolar (PeNSE) de 2009. Considerou-se como variável de desfecho os tercís do escore de IMC (zIMC) e como variável de exposição principal, o consumo de refrigerantes adoçados com açúcar. Idade, tipo de escola, escore de bens e serviços do domicílio e escolaridade materna foram incluídos nos modelos como variáveis de ajuste. Modelos de regressão multinomial, estratificados por sexo e pelos subgrupos de eutrofia e de excesso de peso foram utilizados para estimar a associação entre exposição e desfecho. *Resultados:* Dos adolescentes avaliados, 23,8% apresentaram excesso de peso e 21,7% relataram o consumo de refrigerantes diariamente. Nos meninos eutróficos, o consumo de refrigerantes esteve associado à maior chance de estar nos tercís mais altos de zIMC comparados aos não consumidores. Já nos adolescentes com excesso de peso, tanto do sexo masculino quanto feminino, o consumo de refrigerantes esteve associado à menor chance de estar no tercil mais alto de escore zIMC. *Conclusão:* Os resultados evidenciam a possibilidade de causalidade reversa entre o consumo de refrigerantes adoçados e zIMC no grupo de adolescentes com excesso de peso. Nos adolescentes eutróficos do sexo masculino, o consumo de refrigerantes pode, potencialmente, aumentar as chances de ter zIMC mais alto, o que reforça a necessidade de medidas visando à ampla redução do consumo dessa bebida.

*Palavras-chave:* Adolescentes. Refrigerantes. Estudos transversais. Obesidade.

## INTRODUCTION

Adolescent overweight and obesity are important public health problems. They relate to other morbidities that can persist until adulthood, including metabolic disorders that increase the risk of cardiovascular diseases and diabetes<sup>1</sup>.

The causes of overweight are complex, involving the joint action of genetic, environmental, and behavioral factors<sup>2</sup>. This change in nutritional status deserves attention, as it has been growing in several countries and all age groups<sup>3,4</sup>.

Concomitant with the overweight and obesity epidemic, soft drink consumption increased globally. In Brazil, the Household Budget Survey found variations of up to 400% in soft drink consumption between 1975 and 2003<sup>5</sup>. Almost at the same time, sweetened soft drinks have become popular in both the United States and Europe, with an increase not only in frequency of consumption but also in portion size<sup>6</sup>.

As a result, in the last decade, large epidemiologic studies have begun to investigate the relationship between soft drink consumption and overweight in various populations<sup>7,8</sup>, an association credited to both the amount of sugar in these beverages and how they negatively affect the mechanisms of satiety. There is evidence that consumption of these beverages leads to a greater risk of gaining body weight, while solid foods suppress the appetite for longer. In addition, due to their high glycemic index, sweetened drink consumption can result in a chronic state of hyperglycemia and hyperinsulinemia, leading to a possible weight gain and body fat accumulation<sup>10</sup>.

Despite the biological plausibility of the association between soft drink consumption and overweight, results are still controversial<sup>11</sup>. These conflicting results could be a consequence of various methodological issues, including the cross-sectional design, which does not allow assessment of the relationship of causality<sup>12</sup>.

In cross-sectional studies, exposure might operate distinctly on the outcome in different categories of nutritional status and gender. Thus, the purpose of the present study was to evaluate cross-sectional associations between sugar-sweetened soft drink consumption and body mass index (BMI), stratified by gender, and in eutrophic and overweight adolescents' subgroups.

## **METHODS**

### **SURVEY DATA AND STUDY POPULATION**

This study was carried out with data from the National Adolescent Student Health Survey (Pesquisa Nacional de Saúde do Escolar - PeNSE), held in 2009. Briefly, PeNSE is a population survey conducted with ninth-grade students from public and private elementary schools in the Brazilian territory, aimed at investigating risk factors and adolescent health protection. The research included students from all 26 state capitals and the Federal District.

The PeNSE 2009 sample consisted of 60,973 adolescents, of whom 2,002 participants were excluded due to lack of credible BMI information for their age (Z-scores lower than -5 or higher than +5), as proposed by the World Health Organization for the assessment of nutritional status in children and adolescents aged 5 to 19 years<sup>13</sup>. Later, we excluded another 1,703 adolescents since their weight was low. Therefore, the final sample of this study comprised 57,268 Brazilian students.

### **SAMPLE AND DATA COLLECTION**

The sample was designed to represent the population of ninth grade students from public and private elementary schools in Brazilian state capitals and the Federal District, based on the 2007 school census information. The selection occurred in two stages: selection of schools through a systematic sampling with probability proportional to the number of schools in the cities; and selection of classes, with all adolescents from each one of them answering the questionnaire of the study, thus, eliminating the need for a third stage.

We calculated the sample to estimate the proportion of characteristics of interest in each geographic stratum (26 state capitals and the Federal District), with a maximum error of 3% and 95% confidence interval.

Personal digital assistant (PDA) was used for data collection. The device had the self-administered structured questionnaire, divided into thematic modules: sociodemographic characteristics, eating habits, body image, physical activity, smoking, use of alcohol and other drugs, oral health, sexual behavior, violence, accidents, and safety.

In addition to the questionnaire they filled, the adolescents had their weight and height measured at school, while wearing light clothes, barefoot, and with no jewelry or other objects that could interfere with weight. The individuals stepped on an electronic platform scale, with capacity for 150 kg and sensitivity of 100 grams to calculate the weight. To measure the height, the adolescent stood in a stadiometer, with graduation marked in millimeters and a maximum height of 200 centimeters, in an upright position, with feet together, and heels touching the wall.

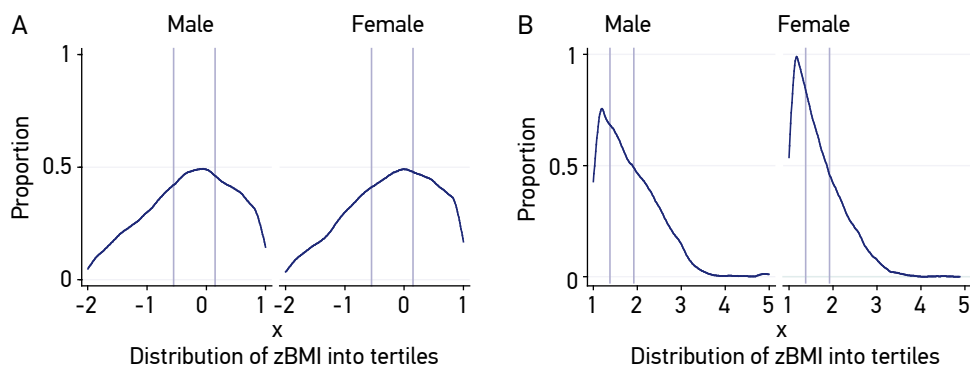
More details on the methodology adopted in the survey were reported in previous publications<sup>14,15</sup>.

## DEPENDENT, INDEPENDENT, AND OTHER VARIABLES OF INTEREST

We categorized the BMI – the dependent variable of this study – into tertiles based on Z-score distribution (zBMI). For the eutrophic adolescents subgroup, the first tertile ranged from -1.99 to -0.55 Z-score; the second, from -0.55 to 0.15 Z-score; and the third, from 0.15 to 0.99 Z-score. For overweight adolescents, the first tertile ranged from 1.00 to 1.38 Z-score; the second, from 1.38 to 1.92 Z-score; and the third, from 1.92 to 4.99 Z-score (Figures 1A and 1B).

The main independent variable in this study was the frequency of sugar-sweetened soft drink consumption (does not consume, consumes 1 to 2 days a week, consumes 3 to 4 days a week, consumes 5 to 6 days a week, and consumes daily).

Adjustment variables were: age ( $\leq 13$  years, 14 years, 15 years, and  $\geq 16$  years), school type (public and private), home goods and services score (first, second, and third tertile), and maternal schooling (without instruction or incomplete elementary school, complete



zIMC: escore Z do índice de massa corporal.

Figure 1. Distribution of body mass index Z-score into tertiles: (A) eutrophic adolescents (first tertile = -1.99 to -0.55; second tertile = -0.55 to 0.15; third tertile = 0.15 to 0.99) and (B) overweight adolescents (first tertile = 1.00 to 1.38; second tertile = 1.38 to 1.92; third tertile = 1.92 to 4.99).

elementary school or incomplete high school, complete high school or incomplete higher education, higher education).

The construction of home goods and services score considered if the household had TV, fridge, stove, microwave, washing machine, landline telephone, cell phone, DVD player, computer, car, bathroom inside the house, and a housecleaner on five or more days a week. Each item received a weight equivalent to the frequency of goods owned or presence of service, which was added up to obtain the final score and analyzed in tertile distribution, with the first tertile referring to a lower number of home goods and services.

Since 18.4% of the adolescents evaluated by PeNSE did not know the maternal schooling, this variable underwent a process of imputation. This process comprised the identification of auxiliary variables, capable of predicting the years of education of the mother. The imputation of missing values was performed by estimating the average value after categorizing data into 20 groups based on gender, school type, and region variables.

## DATA ANALYSIS

We carried out a descriptive analysis for all variables – dependent, main independent, and adjustment –, followed by a bivariate analysis between soft drink consumption and zBMI tertiles, and estimates of odds ratio (OR) and its confidence intervals of 95% (95%CI). Multinomial logistic regression models, stratified by gender, were estimated separately for each subgroup of adolescents – eutrophic and overweight – and adjusted for potential confounding variables.

The Statistical Software for Professionals version 12 (StataCorp, Texas, United States) performed all analyses, considering the complex sample design.

## ETHICAL ASPECTS

The National Committee for Ethics in Research of the Ministry of Health approved PeNSE 2009. The research followed ethical standards, with voluntary participation of adolescents, and all information, both from students and the school, are confidential and not identified.

## RESULTS

Out of the 57,268 adolescents included in this study, 52.85% were females, and 21.69% reported consuming soft drinks daily. The overall overweight prevalence was 23.81% (95%CI 23.07 – 24.56%), and it was statistically higher in males (25.07%; 95%CI 23.84 – 26.29% versus 22.70%; 95%CI 21.84 – 23.55%;  $p = 0.0015$ ).

Table 1 presents the characteristics of adolescents stratified by gender, and according to zBMI tertiles in eutrophic and overweight adolescents' subgroups.

Table 1. Characteristics of adolescents, according to body mass index tertiles in eutrophic and overweight subgroups.

Characteristics	Eutrophic					
	Male (%)			Female (%)		
	First tertile	Second tertile	Third tertile	First tertile	Second tertile	Third tertile
Soft drink consumption (days a week)						
Does not consume	37.03	31.85	31.12	31.24	30.82	37.93
1 to 2	35.32	32.69	31.99	31.68	30.85	37.47
3 to 4	34.01	33.90	32.09	30.69	33.34	35.97
5 to 6	30.17	36.79	33.04	32.66	32.57	34.76
Daily	33.19	34.68	32.13	31.59	34.22	34.18
Age (years)						
≤ 13	27.87	34.35	37.78	28.54	31.63	39.84
14	33.28	33.99	32.73	31.80	32.76	35.45
15	36.14	33.63	30.23	33.04	33.39	33.57
≥ 16	40.56	34.34	25.10	36.63	30.69	32.68
School type						
Public	35.47	34.12	30.41	32.54	32.19	35.27
Private	26.65	33.62	39.74	27.42	33.22	39.37
Goods and services score						
First tertile	35.16	33.79	31.06	31.33	32.79	35.87
Second tertile	36.13	33.83	30.04	32.96	31.37	35.67
Third tertile	30.99	34.36	34.65	30.50	32.95	36.55
Maternal schooling						
Without instruction or incomplete elementary school	37.00	35.54	27.46	33.44	31.64	34.92
Complete elementary school or incomplete high school	34.80	33.54	31.66	31.77	32.89	35.34
Complete high school or incomplete higher education	31.63	34.72	33.64	30.46	32.23	37.31
Complete higher education	30.62	31.29	38.09	28.24	33.38	38.37

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Table 1. Continuation.

Characteristics	Overweight					
	Male (%)			Female (%)		
	First tertile	Second tertile	Third tertile	First tertile	Second tertile	Third tertile
Soft drink consumption (days a week)						
Does not consume	29.81	29.47	40.71	33.41	35.42	31.16
1 to 2	27.33	30.50	42.18	33.15	32.81	34.04
3 to 4	24.43	34.55	41.01	35.90	38.26	25.85
5 to 6	31.43	31.60	36.97	42.57	31.77	25.65
Daily	35.07	28.51	36.42	37.19	34.57	28.23
Age (years)						
≤ 13	26.42	31.81	41.76	33.93	36.35	29.73
14	29.99	30.65	39.36	36.87	34.83	28.30
15	30.96	31.34	37.70	36.73	32.34	30.93
≥ 16	30.35	31.76	37.89	36.93	30.75	32.33
School type						
Public	30.03	31.04	38.93	35.97	34.03	30.00
Private	27.34	31.46	41.20	35.92	36.71	27.36
Goods and services score						
First tertile	31.82	30.93	37.26	35.27	35.88	28.85
Second tertile	28.59	33.96	37.45	39.52	34.16	26.32
Third tertile	27.66	29.77	42.57	33.87	34.27	31.85
Maternal schooling						
Without instruction or incomplete elementary school	30.91	35.27	33.81	34.73	35.38	29.89
Complete elementary school or incomplete high school	27.72	28.38	43.90	35.51	33.23	31.26
Complete high school or incomplete higher education	30.57	32.34	37.09	36.73	35.74	27.53
Complete higher education	27.88	30.60	41.53	37.08	33.91	29.01

Eutrophic male adolescents who consumed soft drinks three or more days a week had a higher chance of being in the second tertile of zBMI than non-consumers. These associations were present before and after the adjustment for age, school type, goods and services score, and maternal schooling. Soft drink consumption related to a greater chance of the adolescent being in the third tertile of zBMI, but only in the category of consumption for five or six days a week, the association remained after adjustments. For eutrophic girls, there was no relationship between soft drink consumption and zBMI (Table 2).

Overweight male adolescents who consumed soft drinks five or more days a week had a lower chance of being in the third tertile of zBMI than non-consumers. For overweight girls, consumption of soft drinks for three or more days a week also related to a lower chance of being in the third tertile of zBMI. The associations remained before and after adjustments, for both males and females (Table 3).

Table 2. Odds ratio and confidence interval of 95% for tertiles of body mass index Z-score and frequency of soft drink consumption in the eutrophic adolescents group.

Frequency of consumption (days a week)	Male		Female	
	OR (95%CI)		OR (95%CI)	
	Not adjusted	Adjusted*	Not adjusted	Adjusted*
Second tertile				
Does not consume	1.00	1.00	1.00	1.00
1 to 2	1.52 (0.92 – 2.52)	1.55 (0.93 – 2.59)	1.02 (0.54 – 1.93)	0.99 (0.52 – 1.91)
3 to 4	<b>1.65 (1.02 – 2.67)*</b>	<b>1.66 (1.01 – 2.71)*</b>	1.12 (0.60 – 2.11)	1.08 (0.56 – 2.08)
5 to 6	<b>2.06 (1.24 – 3.43)*</b>	<b>2.08 (1.24 – 3.48)*</b>	1.05 (0.56 – 1.99)	1.01 (0.52 – 1.95)
Daily	<b>1.65 (1.01 – 2.70)*</b>	<b>1.68 (1.01 – 2.77)*</b>	1.14 (0.62 – 2.13)	1.10 (0.58 – 2.10)
Third tertile				
Does not consume	1.00	1.00	1.00	1.00
1 to 2	<b>1.76 (1.01 – 3.06)*</b>	1.73 (0.97 – 3.07)	1.18 (0.72 – 1.94)	1.11 (0.67 – 1.85)
3 to 4	<b>1.83 (1.04 – 3.22)*</b>	1.72 (0.95 – 3.09)	1.16 (0.70 – 1.92)	1.08 (0.65 – 1.81)
5 to 6	<b>2.29 (1.33 – 3.93)*</b>	<b>2.12 (1.21 – 3.74)*</b>	1.04 (0.62 – 1.74)	0.97 (0.57 – 1.64)
Daily	<b>1.87 (1.08 – 3.23)*</b>	1.75 (0.99 – 3.08)	1.08 (0.66 – 1.79)	1.02 (0.61 – 1.70)

OR: odds ratio; 95%CI: confidence interval of 95%; \*adjusted for age, school administrative dependence, goods and services score, and maternal schooling; body mass index reference category: first tertile.



## DISCUSSION

About a quarter of adolescents included in this study were overweight and more than a fifth reported consuming sugar-sweetened soft drinks daily. We observed different relationships between the consumption of this beverage and zBMI in eutrophic and overweight individuals.

The overweight prevalence was similar to the one reported by the Household Budget Survey conducted in 2008-2009<sup>3</sup>, the same period of this edition of PeNSE. In Brazil, overweight prevalence increased approximately 4% between 2003 and 2009<sup>3</sup>. Populations of young people who live in high-income countries, such as the United States, have been presenting significant increases in overweight prevalence as well. Between 1999 and 2015, there was a linear and considerable rise in overweight (10.6 to 13.9%) and obesity (from 14.1 to 16.0%) prevalence<sup>16</sup>.

Table 3. Odds ratio and confidence interval of 95% for tertiles of body mass index Z-score and frequency of soft drink consumption in the overweight adolescents group.

Frequency of consumption (days a week)	Male		Female	
	OR (95%CI)		OR (95%CI)	
	Not adjusted	Adjusted*	Not adjusted	Adjusted*
Second tertile				
Does not consume	1.00	1.00	1.00	1.00
1 to 2	0.87 (0.36 – 2.12)	0.76 (0.31 – 1.89)	0.86 (0.30 – 2.45)	0.84 (0.31 – 2.27)
3 to 4	1.07 (0.45 – 2.57)	0.94 (0.38 – 2.30)	0.93 (0.33 – 2.64)	0.88 (0.33 – 2.37)
5 to 6	0.65 (0.27 – 1.57)	0.57 (0.23 – 1.42)	0.60 (0.21 – 1.77)	0.59 (0.21 – 1.61)
Daily	0.65 (0.27 – 1.54)	0.57 (0.23 – 1.40)	0.79 (0.27 – 2.29)	0.76 (0.27 – 2.10)
Third tertile				
Does not consume	1.00	1.00	1.00	1.00
1 to 2	0.52 (0.26 – 1.05)	0.49 (0.23 – 1.02)	0.59 (0.30 – 1.17)	0.59 (0.29 – 1.20)
3 to 4	0.54 (0.27 – 1.08)	0.49 (0.24 – 1.03)	<b>0.43 (0.21 – 0.86)*</b>	<b>0.42 (0.20 – 0.88)*</b>
5 to 6	<b>0.39 (0.19 – 0.82)*</b>	<b>0.36 (0.17 – 0.77)*</b>	<b>0.36 (0.18 – 0.74)*</b>	<b>0.36 (0.17 – 0.77)*</b>
Daily	<b>0.36 (0.17 – 0.75)*</b>	<b>0.33 (0.15 – 0.72)*</b>	<b>0.42 (0.20 – 0.87)*</b>	<b>0.41 (0.19 – 0.86)*</b>

OR: odds ratio; 95%CI: confidence interval of 95%; \*adjusted for age, school administrative dependence, goods and services score, and maternal schooling; body mass index reference category: first tertile.

The present study also showed a high frequency of soft drink consumption. Due to lack of information, it was not possible to estimate the volume of soft drinks consumed. However, a recent national survey revealed high consumption of sugar-sweetened drinks, such as juices, soft drinks, and refreshments, during adolescence — an average of 122 mL per day, more than twice the average consumed by adults and seniors in Brazil<sup>17</sup>.

Sugary drinks have been perceived as the main contributor to the increase in total calorie consumption, with possible weight gain<sup>18</sup> and emergence of metabolic changes<sup>19-22</sup>. In this study, a relevant finding was the positive association between soft drink consumption and higher categories of zBMI among male adolescents with BMI in the range of values considered normal.

The relationship between sugary drink consumption and weight gain could be explained by the fact that liquid foods satiate less than solid ones due to lack of chewing, cephalic phase of less pronounced ingestion, faster gastric emptying, and cognitive factors, which influence energy compensation in control of food intake<sup>9</sup>. Besides the physical condition of the food, sugary drinks have a high glycemic index, which leads to a chronic state of hyperglycemia and hyperinsulinemia, with a potential increase in weight and body fat<sup>10</sup>. Another important aspect worth mentioning is that, over time, soft drinks can replace or significantly reduce the consumption of other beverages such as milk<sup>23</sup>, tea, water, or other lower-calorie drinks.

There was no association between soft drink consumption and zBMI categories for eutrophic girls. This result is similar to the data from a multinational study conducted by Katzmarzyk et al.<sup>24</sup>, which also observed a positive association between sugar-sweetened soft drink consumption and zBMI for boys living in low- and middle-income countries and lack of association between girls. Usually, female adolescents tend to be more concerned with health and beauty issues compared to boys<sup>25</sup>. In addition, they might be more sensitive to body perception, even before reaching overweight, which could result in a decrease in food consumption. At the same time, it is possible that girls underestimate soft drink consumption in comparison to male adolescents, in the same way that women have a higher prevalence of underreporting food intake<sup>26</sup>.

Thus far, we are not aware of studies that assessed the association between soft drink consumption and zBMI in eutrophic and overweight adolescents' groups separately. This strategy can assist in finding a better perception of the relationship between exposure and outcome in a cross-sectional study, which could facilitate the understanding of reverse causality, that is, the decrease in soft drink consumption after weight gain. In this scenario, it is not surprising that the results of the association between soft drink consumption and zBMI are inverse for the overweight adolescents subgroup, both for males and females. Therefore, we believe that, due to the lack of temporality, it is possible to invert the association. In this regard, adolescents in major overweight

categories could have adopted measures to reduce weight, among them the decrease in consumption of sugar-sweetened soft drinks.

It is also worth considering the possibility of information bias, which can contribute to the negative association between soft drink consumption and zBMI among overweight individuals. Studies show that, in general terms, obese people tend to underestimate their dietary intake<sup>26,27</sup>, and it is possible that this group has reported a frequency of soft drink consumption lower than the real one.

Considering the limitations inherent to the cross-sectional design, which hinders the establishment of causal inferences, it would be ideal to have a dietary evaluation prior to the assessment of the nutritional status of adolescents in prospective studies. However, studies of this type with a representative sample are not available in developing countries, yet.

Strong points of the study include having as a basis a sample of adolescents with national representation, and the outcome, zBMI, using measurements of weight and height. Furthermore, we believe that the strategy of adopting BMI partitions may have helped in a better understanding of the association between exposure and outcome.

## CONCLUSION

In conclusion, these results show high overweight prevalence and high soft drink consumption, which potentially relate to categories with greater zBMI for eutrophic male adolescents. Measures to significantly reduce soft drink consumption can represent one of the main strategies in pursuit of a healthier diet and decrease in the consumption of sugar. On the other hand, this study shows that overweight Brazilian adolescents might be realizing that it is important to reduce the consumption of sugary drinks, which could result in a lower intake or a greater underreport of soft drink consumption in this group. We believe that the simultaneous measurement of exposure and outcome may explain the distinct relationships between the consumption of this beverage and zBMI in different categories of nutritional status and gender, indicating the need for longitudinal studies.

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