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Sugar-sweetened beverages consumption and BMI in Mexican adolescents. Mexican National Health and Nutrition Survey 2006

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Abstract

Objective. To evaluate the association between the consumption of sugar-sweetened beverages (SSBs) and body mass index (BMI) in Mexican adolescents. **Material and Methods.** We analyzed the data of 10 689 adolescents (ages 10 to 19 years old) who participated in the Mexican National Health and Nutrition Survey 2006 (ENSANUT 2006). Consumption of SSBs (i.e. sodas, fruit beverages and sugar beverages) was evaluated by means of a semi-quantitative food frequency questionnaire. BMI was calculated (kg/m^2). **Results**. Mean age was 13.8 ± 2.7 years. Fifty percent were females. Mean BMI was 21.7 ± 4.5. Thirty percent of adolescents were overweight or obese. Ninety percent of adolescents consumed at least one SSB during the 7 days before the interview. The median consumption of SSBs was 0.89 portion per day. Multiple-linear regression analysis showed that for each portion of sodas consumed, a 0.17-point increase in BMI was observed in boys after adjusting for confounders (95% *CI*; 0.02-0.32, *p* 0.03). Positive interactions of SSB consumption with age and time watching TV were observed in boys. **Conclusions**. Consumption of sodas was positively associated with BMI in Mexican boys.

Key words: beverages; body mass index; overweight; obesity; adolescents; Mexico

Jiménez-Aguilar A, Flores M, Shamah-Levy T. Consumo de bebidas azucaradas y su relación con el IMC en adolescentes mexicanos. Encuesta Nacional de Salud y Nutrición 2006. Salud Publica Mex 2009;51 supl 4:S604-S612.

Resumen

Objetivo. Examinar la asociación entre el consumo de bebidas refrescantes azucaradas (BRA) y el índice de masa corporal (IMC) en adolescentes mexicanos. **Material y métodos.** Se analizaron datos de 10 689 adolescentes (10 a 19 años de edad) de la Encuesta Nacional de Salud y Nutrición 2006 (ENSANUT 2006). El consumo de bebidas refrescantes azucaradas (BRA: refrescos, bebidas de fruta y bebidas endulzadas) se evaluó con un cuestionario semicuantitativo de frecuencia de consumo de alimentos. Se calculó el índice de masa corporal (kg/m^2). **Resultados**. La media de edad fue de 13.8 ± 2.7 años. El 50.4% fueron mujeres. La media de IMC fue de 21.7 ± 4.5. Un 30% de los adolescentes presentó sobrepeso u obesidad. El 90% de los adolescentes consumieron al menos una BRA en los 7 días previos a la encuesta, con una mediana de 0.89 porciones/día. El análisis de regresión lineal mostró que por cada porción consumida de refrescos, el IMC en los adolescentes varones aumentó 0.17 unidades, después de ajustar por variables confusoras (*IC* 95%: 0.02, 0.32, *p*= 0.03). Se observaron interacciones entre el consumo de BRA con la edad y el tiempo viendo televisión en los varones adolescentes. **Conclusiones**. El consumo de refrescos se asoció positivamente con el IMC en varones adolescentes mexicanos.

Palabras clave: bebidas; índice de masa corporal; sobrepeso; obesidad; adolescentes; México

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The prevalence of overweight and obesity have dramatically increased in Mexico.[1] The most recent Mexican National Health and Nutrition Survey (ENSANUT 2006) found that one out of three adolescents is overweight or obese.[2]At the same time an increase in consumption of sugar-sweetened beverages (SSBs) –such as sodas, fruit beverages and sweet-flavored drinks– has been observed. Mexico is the second largest consumer of soft drinks, after the US.[3] According to data from National Income-Expenditure Surveys (NIES) household expenditure on soft drinks has risen by 37.2% between 1986 and 1998.[1] At present, beverages contribute a fifth of all calories consumed by Mexicans. Because of this increase, recent Mexican guidelines suggest that energy from beverages must not exceed 10% of the recommendations of total energy.[4]

Recent evidence has shown that a high consumption of SSBs was associated with body weight gain and obesity in different populations.[5] In Mexico, there is scarce information about this problem.

The objective of the present study is to examine the association between consumption of SSBs and body mass index (BMI) in Mexican adolescents using data from the ENSANUT 2006.

Material and Methods

This is a cross-sectional, observational study based on data of adolescents who participated in the 2006 Mexican National Health and Nutrition Survey (ENSANUT 2006). The methods for this survey have been described in detail elsewhere.[2]

Briefly, the ENSANUT 2006 was a probabilistic survey with a complex, stratified sampling design, carried out between October 2005 and May 2006. The ENSANUT 2006 is representative of four regions (north, center, south and Mexico City)* and of rural (< 2 500 population) and urban (≥ 2 500 population) areas in the Mexican Republic. It obtained information from 48 304 households.‡

For determining sample size it was considered that the minimum interest prevalence should have an accuracy of 8.1%. It was also considered that state estimators obtained through the survey should have a 25% maximum relative error, a 95% confidence interval, a 20% non response rate, and a design effect of 1.7, determining a sample size of at least 1 476 households by state. A subsample corresponding to a third of the whole sample was selected for dietary information.[2]

The study sample was limited to adolescents (boys and girls 10 to 19 years old) who had dietary data. Prior to the interview, informed consent was obtained from the family head and from the adolescent. Protocol was reviewed and approved by the Ethics, Bio-safety and Research Committees at the National Institute of Public Health (INSP).

Dietary information. Trained personnel conducted an adapted version of the food-frequency semi-quantitative questionnaire (FFSQ), for its application in digital format; found in the Procedure Handbook for Nutrition Projects, published by the INSP.[6] The questionnaire included 101 food and beverage items classified into 14 groups. Data were entered into HP Compaq nx 6120 and Dell Latitude D510 laptop computers. Personnel from the INSP developed and validated the electronic questionnaires for input of data into the Fox Pro program version 7.

Non beverages energy. Dietitians converted the reported consumptions into grams or ml of food and beverages items. Energy from sources other than SSBs was then calculated using a comprehensive database compiled from diverse sources.* For data cleanup, observations with an energy intake less than 500 kcal or more than 7 000 kcal were eliminated. [7]

Consumption of sugar-sweetened beverages. The standard portion of beverages was a 240 ml glass. The FFSQ collected information about the consumption of sodas, fruit drinks, sugar beverages and diet beverages. Participants were asked for the numbers of days (never, one, two to four, five to six, and seven days), times a day (one, two to three, four to five, and six times per day), and total of glasses consumed for each beverage during a seven-day period before the interview. We obtained the total consumption of each beverage from the number of servings per day. The consumption of diet beverages was categorized as low or high intake with respect to the median of its distribution.

* The regions were established according to the definition by INEGI (National Institute of Statistics, Geography and Informatics): north (Baja California, Baja California Sur, Coahuila, Chihuahua, Durango, Nuevo Leon, Sonora and Tamaulipas), center (Aguascalientes, Colima, Guanajuato, Jalisco, Mexico (excluding urbanized municipalities and localities adjacent to Mexico City), Michoacan, Morelos, Nayarit, Queretaro, San Luis Potosi, Sinaloa, and Zacatecas), Mexico City (including the Federal District and urbanized municipalities in the State of Mexico), and south (Campeche, Chiapas, Guerrero, Hidalgo, Oaxaca, Puebla, Quintana Roo, Tabasco, Tlaxcala, Veracruz and Yucatan).

‡ A household unit was defined as all persons who usually sleep in the same house and benefit from a common income, whether or not they are connected by kinship.

* Safdie M, Barquera S, Porcayo M, Rodríguez S, Ramírez C, Rivera J, *et al.* Bases de datos del valor nutritivo de los alimentos. Compilación del Instituto Nacional de Salud Pública, 2004. (Unpublished document).

Body mass index. Standardized interviewers[8,9] took measurements of weight with a portable electronic scale (Tanita) with a precision of 100 g. Height was obtained with a Dynatop stadiometer, with a capacity of 2 meters and an accuracy of 1 mm.

Body mass index was calculated as the weight in kilograms divided by the height in meters squared. BMI data were considered valid when they were between 10 and 58 units.[2] The classification of overweight and obesity was done in accordance with age and sex-specific BMI cut points recommended by the International Obesity Task Force (IOTF).[2,10] The 15th percentile of NCHS' weight-for-age z-scores was used to identify individuals with low weight.[11]

Socieconomic status. An indicator of socioeconomic status (SES) was constructed using a principal components analysis.[12,13] It included variables related to housing conditions (such as flooring and roofing materials), home appliances (including refrigerators, stoves, washing machines, TV sets, radios, videoplayers, telephones, and computers) and number of rooms (other than bathrooms, kitchens and corridors). The first component accounted for 46% of the total variance. The standardized factor was divided into tertiles.

TV viewing. To estimate TV viewing time, we used the Mexican students questionnaire (CAINM) developed following the format of the Youth Activity Questionnaire (YAQ). The CAINM was previously validated among adolescents in Mexico City and the results show that the questionnaire was valid (adjusted r= 0.51, disattenuated r= 0.69, $p< 0.05$) and that it had an acceptable reproducibility (r= 0.53, $p< 0.05$) to estimate TV-viewing time.[14] The questionnaire was administered directly to the adolescents. It asked about the number of hours a week they spent watching TV, including weekends. The total number of hours per week spent watching TV was estimated. This variable was divided into categories in accordance with criteria by the American Academy of Pediatrics.[15]

Sex and age. Sex and age was obtained by the survey team.

Presence of menarche. Presence of menarche was obtained by interviews and used as an indicator of sexual maturation in girls.[16]

Data Analysis. Descriptive statistics (medians, 25th and 75th percentiles) of servings per day of SSBs were obtained. Median intakes of SSBs across biological and socioeconomic categories were compared. Differences between categories were obtained by median regressions.

To assess the relationship between consumption of SSBs and BMI, linear regression models were developed. After examination of multi-collinearity, beverages as servings consumed per day were included simultaneously as independent variables (sodas, fruit drinks and sugar beverages). The variable SSBs as a group was tested in another model.

We sequentially adjusted for sets of variables that might confound the association between SSBs and BMI: non-beverage energy, diet drinks, region (urban or rural), age, SES, and time watching TV. Models were stratified by sex, and for female adolescents presence of menarche was included.

Two-way interaction terms were tested in the linear regression models for consumption of SSBs and age, and for TV-viewing and menarche.

Sampling weights (expansion factors) were calculated as the inverse of the selection probability for each individual, accordingly to the sampling scheme used.[2] All calculations were weighted by expansion factors and adjusted for sampling (clustering) effects using the SVY STATA 9.0 module (Stata Corporation, TX, USA)* for complex surveys. A statistically significant level of 0.05 was used.

Results

A total of 10 884 observations met the inclusion criteria, but 195 were eliminated due to implausible energy intake values. Thus, we analyzed data from 10 689 individuals, representative of up to 10 million adolescents in Mexico.

The comparison between subjects included and excluded from analysis showed no significant differences with respect to age, sex or BMI ($p > 0.05$).

Fifty percent of the subjects were female adolescents. The mean age was 13.8 ± 2.7 years. More than 30% of the male adolescents were in the group of 13 to 15 years, and nearly 30% of the females were in the oldest age group (16 to 19 years). Mean BMI was 21.4 ± 4.4. On average, female adolescents had a higher BMI and a higher prevalence of overweight in relation to males ($p< 0.05$). The greater proportion of adolescents had a low SES (49.9%). Adolescents were concentrated in the center (39.8%) and southern (40.6%) regions of the country. The greater proportion of adolescents lived in urban areas (57.5%). The average time watching TV was 7.5 ± 5.5 h/w. Fifty-two percent of adolescents watched TV less than seven hours a week. A higher proportion of female adolescents watched TV for more than 21 hours a

* Stata Corp. Intercooled Stata 9.2 College Station Texas, USA, 2006.

Table I
CHARACTERISTICS OF ADOLESCENTS. MEXICO, ENSANUT 2006

Characteristic	*National*	*Males* %	*Females* %
Population size*	100.0	49.6	50.4
Age, (years)			
10 to 12	36,3	36,0	36,5
13 to 15§	35,1	37.3	33.0
16 to 19§	28,6	26.7	30.5
Menarche			
Yes	-	-	70,8
No	-	-	29,2
Body weight			
Normal	64,5	64,3	64,6
Underweight‡	7,2	9.0	5.5
Overweight§	20,4	18.9	21.9
Obesity	7,9	7,8	8,0
Socioeconomic status			
Low	49,9	49,7	50,2
Medium	30,7	30,2	31,3
High	19,3	20,1	18,5
Region			
North	12,8	13,0	12,5
Center	39,8	39,8	39,9
Mexico City	6,8	6,9	6,6
South	40,6	40,3	41,0
Area			
Urban	57,5	57,3	57,7
Rural	42,5	42,7	42,3
Time watching TV, hrs/wk			
< 7	52,0	52,5	51,5
≥ 7 to< 14	33,6	34,1	33,1
≥ 14 to 21	12,2	11,7	12,7
> 21§	2,2	1.7	2.7
Mean (SD)			
Age, years	13.8 (2.7)	13.8 (2.6)	13.9 (2.7)
BMI‡	21.4 (4.4)	21.1 (4.3)	21.7 (4.5)
Menarche, years	-	-	12.1 (1.2)
Time watching TV, h/w	7.5 (5.5)	7.4 (5.4)	7.7 (5.6)

* National sample size:10 689 Expansion factor: 10 029 247; Male sample size: 5 298 Expansion factor: 4 971 124 Female sample size: 5 391 Expansion factor: 5 058 123

‡ Significant difference between males and females (p< 0.001 adjusted in a lineal regression model or in a logistic regression model)

§ Significant difference between males and females (p< 0.05 adjusted in a lineal regression model or in a logistic regression model)

week as compared to males ($p< 0.05$). The average age at menarche was 12.1 ± 1.2 years and 70.8% of the females already had it (Table I).

During the seven days prior to the survey, 77.2% of the adolescents consumed sodas, 39.7% consumed

Table II
NUMBER OF SERVINGS PER DAY OF SUGAR-SWEETENED BEVERAGES,* BY DIFFERENT CHARACTERISTICS OF ADOLESCENTS. MEXICO, ENSANUT 2006

		Percentile	
Characteristic	*Median*	*25*	*75*
National	0.89	0.43	1.96
Sex			
Males	1.00‡	0.43	2.07
Females	0.86§	0.36	1.71
Age, (years)			
10 to 12	0.79‡	0.29	1.50
13 to 15	1.00§	0.43	2.00
16 to 19	1.00§	0.43	2.08
Menarche			
Yes	0.89‡	0.43	1.88
No	0.68§	0.29	1.43
Body weight			
Normal	0.86‡	0.40	1.93
Underweight	0.86‡	0.29	1.71
Overweight	1.00§	0.43	2.00
Obesity	0.89#	0.43	2.00
Socioeconomic status			
Low	0.64‡	0.17	1.43
Medium	1.02§	0.43	2.14
High	1.21#	0.51	2.50
Region			
North	1.21‡	0.57	2.50
Center	1.00§	0.43	2.07
Mexico City	1.00§	0.43	2.00
South	0.67#	0.14	1.45
Area			
Urban	1.07‡	0.43	2.14
Rural	0.64§	0.15	1.43
Time watching TV, hrs/wk			
< 7	0.79‡	0.29	1.57
≥ 7 to< 14	1.00§	0.43	2.08
≥ 14 to 21	1.07#	0.43	2.33
> 21	1.00§	0.43	2.14

* Servings consumed 7 days prior to the survey
Categories with a common superscript (‡§#) are not statistically distinguishable from one category to another at the $p= 0.05$ level. (Adjusted in a lineal regression for medians)

fruit beverages and 27.7% consumed sugar beverages. Ninety percent consumed one or more SSBs. On average, a somewhat higher percentage of male adolescents consumed sodas (79%) compared to females (75.5%) ($p< 0.01$). Moreover, approximately 91% of males and 89% of females ($p< 0.05$) consumed one or more SSBs (data not shown).

At the national level, the daily median consumption of SSBs was 0.89 (percentile 25: 0.43, p75: 1.96). Median SSB consumption was higher for male adolescents than for females ($p< 0.001$). Median SSB consumption was higher among older adolescents (13 to 19 years) compared to the youngest adolescents (10 to 12 years). In general, overweight adolescents consumed more SSBs compared to adolescents who had a normal weight. The consumption of SSBs was positively associated with SES. A higher consumption of SSBs was observed in the northern region and in urban areas ($p< 0.05$). Adolescents who already had menarche consumed, on average, more SSBs than those who had not yet had it ($p< 0.05$). Adolescents who watched less than 7 hrs of TV per week consumed less SSBs ($p< 0.05$) (Table II).

For male adolescents, the unadjusted analysis showed that consumption of sodas was positively associated with BMI. For each serving of soda consumed, BMI increased 0.54 units (95% CI: 0.39-0.70, $p< 0.001$), whereas consumption of fruit drinks and sugar beverages were not significantly associated with BMI. It was noted that before adjusting for non-beverage energy the coefficient related to the consumption of soft drinks decreased (β= 0.16, 95% CI: 0.01-0.31, $p= 0.04$), while after adjustment for non-beverage energy the coefficient increased slightly (β= 0.17, 95% CI: 0.02-0.32, $p= 0.03$). None showed significant associations between consumption of fruit drinks and sugar beverages with BMI before or after adjusting for non-beverage energy. After adjusting for non-beverage energy, the consumption of all SSBs were not significantly associated with BMI in male adolescents (β= 0.06, 95% CI: -0.04-0.17, $p= 0.25$) (Table III).

In female adolescents, the unadjusted model showed that for every serving of soda consumed, BMI increased 0.19 units (95% CI: 0.03-0.35, $p= 0.03$). For fruit drinks and sugar beverages, no significant associations were observed. The adjusted analysis showed that before and after adjusting for non beverages energy, no drink studied, including the set of SSBs was significantly associated with BMI in females (Table III).

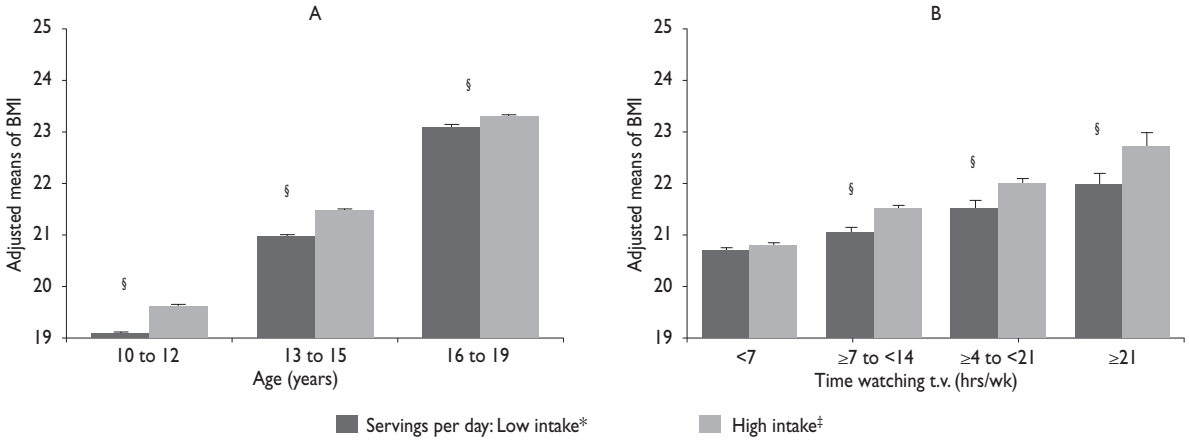
Figure 1 presents the adjusted mean BMI for male adolescents derived from the regression models that included interaction terms between the consumption of SSBs and age, and between the consumption of SSBs and TV-viewing time. In panel A, it is observed that in each age group, males with a higher consumption of SSBs had a higher BMI compared to those with a lower consumption of SSBs ($p< 0.05$).

Table III
RELATIONSHIP BETWEEN NUMBERS OF SERVINGS CONSUMED PER DAY OF THE STUDIED BEVERAGES AND THE BODY MASS INDEX OF THE ADOLESCENTS. MEXICO, ENSANUT 2006*

	Unadjusted				*Before non beverage energy adjustment*				*After non beverage energy adjustment*			
Beverages	β*(BMI)*	*95% CI*		*p*	β*(BMI)*	*95% CI*		*p*	β*(BMI)*	*95% CI*		*p*
Males												
Sodas	0.54	0.39	0.70	0.00	0.16	0.01	0.31	0.04	0.17	0.02	0.32	0.03
Fruit drinks	-0.01	-0.18	0.17	0.95	-0.09	-0.25	0.08	0.29	-0.08	-0.24	0.09	0.35
Sugar beverages	0.11	-0.06	0.29	0.21	0.02	-0.19	0.23	0.85	0.03	-0.19	0.24	0.81
Sugar-sweetened beverages‡	0.29	0.18	0.39	0.00	0.05	-0.05	0.16	0.32	0.06	-0.04	0.17	0.25
Females												
Sodas	0.19	0.03	0.35	0.03	-0.11	-0.27	0.06	0.22	-0.07	-0.23	0.10	0.44
Fruit drinks	-0.03	-0.20	0.15	0.76	-0.14	-0.30	0.03	0.10	-0.09	-0.25	0.07	0.28
Sugar beverages	0.02	-0.23	0.27	0.88	-0.08	-0.31	0.15	0.51	-0.04	-0.27	0.20	0.77
Sugar-sweetened beverages‡	0.09	-0.02	0.20	0.11	-0.11	-0.22	0.00	0.05	-0.07	-0.18	0.04	0.23

* All beverages were included simultaneously in each sex-specific mixed model, which was adjusted for diet drinks, age, socioeconomic characteristics (SES and area), time watching TV, and presence of menarche only in girls

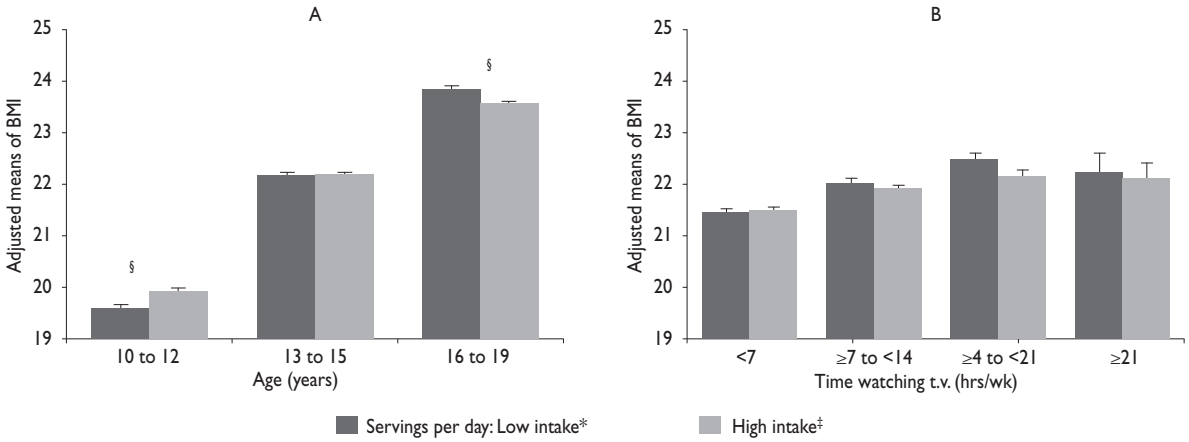
‡ Sugar-sweetened beverages were tested in another sex-specific mixed model, which was adjusted for diet drinks, age, socioeconomic characteristics (SES and area), time watching TV, and presence of menarche only in girls



A. Adjusted means by diet drinks, non beverage energy, age, socioeconomic characteristics (SES and area), time watching TV and the interaction between SSBs and age in a lineal regression model (*p* value's interaction= 0.02)
B. Adjusted means by diet drinks, non beverage energy, age, socioeconomic characteristics (SES and area), time watching TV and the interaction between SSBs and time watching TV in a lineal regression model (*p* value's interaction= 0.15)

* Low intake: 10 to 12y= 0.00, 0.83 serv/d; 13 to 15y= 0.00, 0.02 serv/d; 16 to 19y= 0.00, 1.24 serv/d
‡ High intake: 10 to 12y= 0.86, 8.57 serv/d; 13 to 15y= 1.03, 12.00 serv/d; 16 to 19y= 1.29, 11.30 serv/d
§ Significant difference between low and high intake of SSBs (*p*< 0.05 adjusted in a lineal regression model)

FIGURE 1. ADJUSTED MEANS OF BMI IN MALES ADOLESCENTS, BY SUGAR-SWEETENED BEVERAGES TYPE AND AGE AND TIME WATCHING TV. MEXICO, ENSANUT 2006



A. Adjusted means by diet drinks, non beverage energy, age, socioeconomic characteristics (SES and area), time watching TV, menarche and the interaction between SSBs and age in a lineal regression model (*p* value's interaction= 0.07)
B. Adjusted means by diet drinks, non beverage energy, age, socioeconomic characteristics (SES and area), time watching TV, menstruation, and the interaction between SSBs and time watching TV in a lineal regression model (*p* value's interaction= 0.89)

* Low intake: 10 to 12y= 0.00, 0.85 serv/d; 13 to 15y= 0.00, 1.00 serv/d; 16 to 19y= 0.00, 0.92 serv/d
‡ High intake: 10 to 12y= 0.86, 7.50 serv/d; 13 to 15y= 1.01, 11.35 serv/d; 16 to 19y= 0.93, 10.71 serv/d
§ Significant difference between low and high intake of SSBs (*p*< 0.05 adjusted in a lineal regression model)

FIGURE 2. ADJUSTED MEANS OF BMI IN FEMALES ADOLESCENTS, FOR SUGAR-SWEETENED BEVERAGES TYPE, AGE AND TIME WATCHING TV. MEXICO, ENSANUT 2006

In panel B, it is observed that in the category of 7 hrs of TV per week, there were no significant differences between male adolescents with a lower consumption of SSBs compared to males with a higher consumption of SSBs ($p > 0.05$), while in the categories of more than 7 hrs of TV per week it was observed that males with a greater consumption of SSBs had a higher BMI compared to those with a lower consumption of SSBs ($p< 0.05$) (Figure 1).

Figure 2 presents the adjusted mean BMI for girls resulting from the regression models that included interaction terms between the consumption of SSBs and age, and between the consumption of SSBs and TV-viewing time. In panel A, it is observed for the group of female adolescents 10 to 12 years old that the BMI was higher in those who had a higher consumption of SSBs compared to those who had a lower consumption of SSBs ($p< 0.05$). The oldest females (16 to 19 years) who had a higher intake had a BMI lower than those who had a lower consumption of SSBs ($p< 0.05$). In panel B, it is observed in the categories of more than 7 hrs of TV per week that the females who had a greater consumption of SSBs had a lower BMI with respect to those who had a lower consumption of SSBs, but the differences were not significant ($p > 0.05$) (Figure 2).

Through a regression model that included the interaction term between consumption of SSBs and the presence of menarche (interaction term: β= -0.24, 95% CI: -0.46 -0.01, $p= 0.04$) it was noted that female adolescents who had already presented menarche and had a higher consumption of SSBs had a lower BMI (22.7, *SE*= 0.03) with respect to those who had a lower intake of SSBs (22.9, *SE*= 0.03) ($p< 0.05$). Female adolescents who had not yet presented menarche and who had a higher consumption of SSBs had a higher BMI (19.3, *SE*= 0.04) than those who had a lower intake of SSBs (19.1, *SE*= 0.03) ($p< 0.05$) (data not shown).

Discussion

We analyzed the relationship between consumption of sugar-sweetened beverages (SSBs) and BMI in a sample of adolescents who participated in a nationally representative Mexican survey (ENSANUT 2006).

The results showed that consumption of sodas were positively associated with BMI for male adolescents, after adjusting for potential confounders. Moreover, positive interactions of SSB consumption with age and TV-viewing time were observed in males. Giammattei *et al*. showed a similar interaction between SSB consumption with TV-viewing time, finding a significant positive association in adolescents between BMI with hours of television watched per evening and daily soft drink consumption ($p< 0.05$).[17]

Among female adolescents, no significant associations were found. This finding is consistent with previous studies, which have shown more consistent associations in males compared to females. However, the results are quite diverse.[18,19]

It is important to mention that the results in female adolescents with respect to age group show a different direction than expected; we observed that in the oldest group of females (16 to 19 years), those who had a higher intake had a lower BMI compared with those females who had a lower consumption of SSBs ($p< 0.05$). This situation could be due to reverse causation, since it is possible that the oldest group of females has a greater concern about body weight than the youngest group. Thus, female adolescents 16 to 19 years with a greater BMI tended to consume less SSBs than those 16 to 19 years who had a lower BMI.

In general terms, the prevalence of overweight and obesity, consumption of different types of beverages, as well as the effect of the consumption of SSBs on BMI found in our study coincide with other studies. For example, Berkey *et al.* found that for male adolescents who increased their soda intake by ≥ 2 servings per day from the previous year gained weight (0.14 increase in BMI).[19] Ludwig *et al*. found at baseline consumption of SSBs that in the fully adjusted model, BMI increased by 0.18 for each serving consumed per day (95% CI: 0.09-0.27; $p= 0.02$).[8] Phillips *et al*. found that subjects in the third and fourth quartiles of percentage of calories from soda had BMI_z scores of 0.17 units higher, on average, than those of subjects in the fist quartile ($p< 0.001$).[20] In another study conducted among Mexican adolescents (10 to 19 years), the association between the consumption of SSBs and BMI was greater than that observed in this study. Denova *et al*. found that for each additional SSBs serving consumed daily, adolescents BMI increased by 0.33 ($p< 0.001$).[21]

The review by Malik[5] has confirmed the notion about a positive association between consumption of SSBs and weight gain in different populations. The biological plausibility of how the consumption of SSBs can influence body weight is still unknown. It has been suggested that the consumption of energy through liquid food tends to generate a lower sense of satiety as compared to the intake of solid foods, resulting in a higher consumption of food in subsequent meals and, therefore, a larger total energy consumption.[22] However, in our study we controlled for non-beverage energy intake and this did not affect the results. In one study among obese adolescents that compared satiety after

consuming the same amount of energy through liquid foods versus solid foods, no difference in satiety was observed.[23] Among other assumptions, it has been proposed that the sugars contained in the SSBs could prove addictive. A study in rats showed that after withdrawal of a sugar-rich diet, the animals showed qualitatively clear signs of dependence on sugars, similar to those presented in morphine and nicotine addiction, including teeth chattering and anxiety.[24] On the other hand, it is possible that consumption of SSBs is only one component of a feeding pattern that favors body weight gain, or perhaps a reflection of an "obesogenic" lifestyle. A relationship was tested in an intervention study aimed to reduce the consumption of SSBs by American adolescents, and a significant reduction of body weight was observed among overweight and obese adolescents regardless of lifestyle variables.[25]

The interpretation of our results should consider certain limitations. The most important limitation deals with the cross-sectional nature of our study, which does not allow for making causal inferences between consumption of SSBs and increased BMI. However, our results coincide with previous longitudinal studies that suggest a cause-effect association (that is, consumption of SSBs precedes and has a positive association with weight gain). Thus, one could rule out the idea of a reverse causality for male adolescents (being overweight or obese promotes the intake of SSBs).

Another limitation is related to the use of a FFSQ, which was not specifically designed for accurately measuring beverage intake. Moreover, the portion size was standardized as 240 ml, and it could be that the children were consuming larger portion sizes. If this were the case, our study could be underestimating beverage consumption in this population. The overall result would be an overestimation of the actual effect associated with the consumption of one portion of SSBs.

Some of the strengths of the present study consist of the use of a large, nationally representative sample of Mexican adolescents, as well as the use of standardized personnel and methods. Additionally, the subjects and interviewers were blinded to the hypothesis of the study. Finally, we controlled in the multivariate analyses for potential confounders.

In conclusion, there was a positive association between the consumption of sodas and BMI in a nationally representative sample of Mexican adolescents. However this association was observed in males only. While it is necessary to conduct further studies on the subject with longitudinal design, it is also important to take immediate actions in this regard, such as encouraging the decrease in consumption of SSBs, as well as promoting the consumption of plain water for preventing and controlling the epidemic of overweight and obesity in Mexico. The Secretary of Health has recently undertaken an effort in this regard when designing the "recommendations for beverages' consumption for a healthy lifestyle for the mexican population".

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