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Differences in Male and Female Adolescents From Various Racial Groups in the Relationship Between Insulin Resistance–Associated Parameters With Sugar-Sweetened Beverage Intake and Physical Activity Levels

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Abstract

Objective—To describe racial and gender differences in insulin resistance–associated parameters due to sugar-sweetened beverage (SSB) intake and physical activity (PA) levels in the adolescent population.

Methods—Data from individuals aged 12 to 19 years from the National Health and Nutrition Examination Survey during the years 1999–2004 were analyzed. SSB intake and PA levels were evaluated in Non-Hispanic whites, Non-Hispanic blacks, and Mexican Americans. Outcome measures included measurements of insulin sensitivity, lipids, blood pressure, waist circumference, and body mass index.

Results—Multivariate linear regression analyses showed that anthropometric measurements, metabolic parameters, and indices of insulin resistance differed among the racial groups. Moreover, within each of these racial groups, they differed between the sexes.

Conclusions—The differing relationships between insulin resistance–associated parameters and SSB intake and PA levels among racial groups and between the sexes illustrate the importance of race and gender in the investigation of diseases such as obesity and metabolic syndrome.

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Declaration of Conflicting Interests

The author(s) declared no conflicts of interest with respect to the authorship and/or publication of this article.

Keywords

sugar-sweetened beverage; physical activity; NHANES; insulin resistance; metabolic syndrome; obesity

Introduction

The increasing prevalence of obesity, insulin resistance, and the metabolic syndrome (a group of conditions associated with insulin resistance, including hypertension, atherogenic dyslipidemia, central adiposity, impaired glucose metabolism, and a prothrombotic and proinflammatory state) in the pediatric population is a global health issue. Moreover, these conditions in childhood may be antecedents to adult disease.^{1–6} Thus, the long-term public health consequences of these disorders in children and adolescents—with respect to both premature morbidity and mortality—are significant.

Although an individual's genetic composition may predispose them to disorders of weight management or insulin sensitivity,^{7–9} environmental factors also undoubtedly contribute to these conditions' development. Specifically, 2 lifestyle behaviors associated with obesity, insulin resistance, and the metabolic syndrome are (a) high levels of sugar-sweetened beverage (SSB) intake^{10–16} and (b) low levels of physical activity (PA).^{17–23} Dietary modifications and regular exercise are thus 2 recommendations typically given by pediatricians to children and adolescents either at risk for or currently diagnosed with these disorders.

In a study of US adolescents aged 12 to 19 years participating in the National Health and Nutrition Examination Survey (NHANES) during the years 1999–2004, we previously reported that increased SSB intake was independently associated with a higher homeostasis model of insulin resistance (HOMA-IR), systolic blood pressure (SBP), waist circumference (WC), and body mass index (BMI) percentile for age and gender and lower high-density lipoprotein cholesterol (HDL-C) concentrations; alternatively, increased PA levels were independently associated with a lower HOMA-IR, low-density lipoprotein cholesterol (LDL-C) concentrations, and triglyceride (TG) concentrations and higher HDL-C concentrations.²⁴ Furthermore, we reported that decreased SSB intake and increased PA levels modified each other's effects on lowering HOMA-IR and TG concentrations and raising HDL-C concentrations.²⁴

However, our previous study evaluated the adolescents from the NHANES cohorts in aggregate and was not designed to reveal any potential differences among the various racial groups studied.²⁴ Thus, given that differences among individuals of various racial backgrounds may exist with respect to insulin resistance–associated metabolic parameters and anthropometric measurements associated with SSB intake and PA levels, we reevaluated the NHANES data to address this hypothesis. Herein, we report the racial and gender differences in insulin resistance–associated parameters due to SSB intake and PA levels among Non-Hispanic whites, Non-Hispanic blacks, and Mexican Americans using data from US adolescents participating in NHANES during the years 1999–2004.

Patients and Methods

Study Design and Population

The NHANES is conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention, and is designed to monitor the health and nutritional status of the US civilian, noninstitutionalized population. Since 1999, NHANES has been planned and conducted as a continuous annual survey, and data are released in 2-year periods (e.g., 1999–2000, 2001–2002). A nationally representative sample is selected annually using a stratified multistage probability cluster sample design;²⁵ oversampling Mexican Americans and black individuals, adolescents aged 12 to 19 years, persons aged 60 years and older, low-income white individuals, and pregnant women permit more precise estimates for these groups. This report is based on data obtained from NHANES 1999–2000, 2001–2002, and 2003–2004. The NHANES protocol was approved by the NCHS Institutional Review Board (IRB), and written informed consent was obtained from all participants aged 18 years and older; for participants younger than 18 years of age, written informed assent was obtained in addition to parent or guardian consent. This study was approved by the IRB at the University of California, Davis.

Participants

The NHANES protocol consists of a home interview performed by a trained interviewer, followed by a visit to an examination center, where participants undergo physical examinations, provide blood and urine samples, and complete additional questionnaires. The details of the participant examinations and laboratory assessments are available on the NHANES website.²⁵ For our study, only data from participants aged 12 to 19 years were analyzed; individuals were excluded from analyses if they were pregnant and/or used steroids, blood glucose regulators, insulin, other antidiabetic agents, growth hormone, or sex hormones. Based on information derived from the NHANES questionnaire, subjects were classified as non-Hispanic white, non-Hispanic black, Mexican American, other/ multiracial, or other/Hispanic. Given the low number of NHANES participants in the “other/multiracial” and “other/Hispanic” categories (369 and 480, respectively), only the “non-Hispanic white,” “non-Hispanic black,” and “Mexican American” participants were included in the statistical analyses.

Measurements

Outcome variables included glucose levels, insulin levels, HOMA-IR measurements, total cholesterol (TC) levels, HDL-C levels, LDL-C levels, TG levels, SBP, diastolic blood pressure (DBP), WC, and BMI percentile for age/gender (per the NCHS references).²⁶ HOMA-IR ($[\text{fasting glucose (mM/L)} \times \text{fasting insulin } (\mu\text{U/mL})]/22.5$),²⁷ LDL-C, and TG results are limited to those who had completed at least an 8-hour fast. Mean WC is presented as the least squares mean controlling for age and gender.

Definitions

Sugar-sweetened beverage information was obtained through a 24-hour dietary recall interview. (In NHANES 2003–2004, the 24-hour recall was assessed on 2 separate days; the

first day was an in-person interview comparable to the previous NHANES study periods primary interview mode, whereas the second day was a telephone interview 3 to 10 days later. For consistency in the methodology of data collection among the study periods, only the first day of the NHANES 2003–2004 24-hour recall was used in our analyses.) Sugar-sweetened beverages were defined as caloric soft drinks, colas, sugar-sweetened fruit drinks, or other SSBs; pure fruit juices and diet soft drinks were not included.²⁴ SSB intake in grams (g) for each reported beverage was divided by 250 g (a serving equivalent; approximately 8 ounces [oz] or a cup of beverage) and summed for each adolescent. Units of SSB intake are defined as the number of SSB serving equivalents per day. Physical activity information was obtained during the interview questionnaire. Levels of PA were determined based on the following equation: (the mean number of times a subject did activity per day) $\times$ (the average duration of each time in minutes) $\times$ (the metabolic equivalent [MET] score).^{24,28,29}

Statistical Analysis

Statistical analyses were performed with SUDAAN, version 9.0 (Research Triangle Institute, Research Triangle Park, NC) using techniques appropriate for the complex NHANES survey design. All of the analyses used the NHANES-provided sampling weights that were calculated to take into account unequal probabilities of selection resulting from the sample design, nonresponse, and planned oversampling of selected subgroups, so that results are representative of the US community-dwelling population. Dietary and activity variables were analyzed as continuous variables. Multivariate linear regression analyses were performed to determine independent associations between each outcome variable and the number of serving equivalents of SSBs consumed and/or the levels of PA after adjusting for age, gender, race, and energy intake (kcal). Analyses involving female subjects were adjusted for the occurrence or not of menarche. Testing for correlation using an interaction term was done to ensure that the assumption of independence between variables was not violated in these analyses. Additional analyses, including interaction terms were also conducted to determine if there were racial or sex differences in the extent to which SSB intake and/or PA affected the outcome variables included in this study. All *P* values are 2-sided and statistical significance was established a priori at $\alpha = .05$.

Results

Participant Characteristics

The total number of adolescents in the NHANES 1999–2004 cohort was 6967; the mean age of the participants was 15.5 years; 51.1% of the participants were male, and 48.9% of the participants were female (Table 1). The racial distribution of the participants was as follows: 62.1% non-Hispanic white, 14.8% non-Hispanic black, 10.9% Mexican American, and 12.2% other races (including Hispanic and multiracial subjects). For statistical purposes, only the non-Hispanic white, non-Hispanic black, and Mexican American participants were evaluated in this study. In addition, 442 individuals (~6% of the entire cohort) were excluded from analyses because of pregnancy and/or the use of steroids, blood glucose regulators, insulin, other antidiabetic agents, growth hormone, or sex hormones.

Metabolic Parameters and Anthropometric Measurements Associated With SSB Intake and PA Levels in Non-Hispanic Whites

In non-Hispanic whites, increased SSB intake was associated with a higher HOMA-IR, TG, WC, and BMI percentile for age/gender and a lower HDL-C, whereas increased PA levels were associated with a lower HOMA-IR, LDL-C, TG, and WC and a higher HDL-C (Table 2). However, the associations differed between the sexes. In females, increased SSB intake was associated with a higher HOMA-IR, TG, SBP, and WC and a lower HDL-C, whereas increased PA levels were associated with a decreased TC, TG, and WC. In males, increased SSB intake was associated with an increased BMI percentile for age/gender and a decreased HDL-C, whereas increased PA levels were associated with a decreased HOMA-IR and LDL-C.

Metabolic Parameters and Anthropometric Measurements Associated With SSB Intake and PA Levels in Non-Hispanic Blacks

In non-Hispanic blacks, increased SSB intake was associated with a higher HOMA-IR, TG, and WC and a lower HDL-C, whereas increased PA levels were associated with a higher HDL-C and a lower DBP and WC (Table 3). As was the case with non-Hispanic whites (Table 2), the associations also differed between the sexes. In females, increased SSB intake was associated with a higher WC, whereas increased PA levels were not associated with any significant changes in the parameters measured. In males, increased SSB intake was associated with a higher HOMA-IR, LDL-C, TG, and WC and a lower HDL-C, whereas increased PA levels were associated with an increased HDL-C and decreased WC.

Metabolic Parameters and Anthropometric Measurements Associated With SSB Intake and PA Levels in Mexican Americans

In Mexican Americans, increased SSB intake was associated with a lower HDL-C and a higher BMI percentile for age/gender, whereas increased PA levels were associated with a lower HOMA-IR and TG and a higher HDL-C (Table 4). As was found with both non-Hispanic whites and blacks (Tables 2 and 3, respectively), the associations also differed between the sexes. In females, increased SSB intake was not associated with any significant changes in the parameters measured, whereas increased PA levels were associated with a lower HOMA-IR and WC. In males, increased SSB intake was also not associated with any significant changes in the parameters measured, whereas increased PA levels were associated with an increased BMI percentile for age/gender.

Discussion

In these nationally representative samples of US adolescents, we found that the relationships between insulin resistance-associated parameters and SSB intake and PA levels differed between non-Hispanic whites, non-Hispanic blacks, and Mexican Americans. Specifically, SSB intake was negatively associated with HDL-C in each group studied; however, it was positively associated with (a) HOMA-IR, TG, WC, and BMI percentile for age/gender in non-Hispanic whites, (b) HOMA-IR, TG, and WC in non-Hispanic blacks, and (c) only BMI percentile for age/gender in Mexican Americans. Alternatively, increased PA levels were positively associated with HDL-C in each group studied; however, they were negatively

associated with (a) HOMA-IR, LDL-C, TG, and WC in non-Hispanic whites, (b) DBP and WC in non-Hispanic blacks, and (c) HOMA-IR and TG in Mexican Americans. Within each of the racial groups studied, the relationships between insulin resistance-associated parameters and SSB intake and PA levels also differed between the sexes.

In general, and consistent with our previous findings,²⁴ increased SSB intake and decreased PA levels were associated with adverse metabolic parameters in each population studied. However, the information from this study is unique in that it demonstrates that the significance of the associations varies depending on the race and gender of the individuals. For example, whereas SSB intake is significantly associated with many insulin resistance-associated parameters (HOMA-IR, HDL-C, TG, SBP, and WC) in non-Hispanic white female adolescents, it is only associated with a few parameters (HDL-C and BMI percentile for age/gender) in non-Hispanic white male adolescents. In contrast, SSB intake is significantly associated with more insulin resistance-associated parameters in non-Hispanic black male adolescents (HOMA-IR, HDL-C, LDL-C, TG, and WC) than female adolescents (WC). Furthermore, and somewhat surprising given the large sample sizes, SSB intake had no significant associations with indices of insulin resistance in either female or male Mexican American adolescents when the sexes were analyzed separately. With respect to exercise, PA levels were associated with TC, TG, and WC in non-Hispanic white adolescent females, but HOMA-IR and LDL-C in non-Hispanic white adolescent males. Alternatively, in adolescent non-Hispanic blacks, PA levels had no significant associations with indices of insulin resistance in females but were associated with HDL-C and WC in males. Furthermore, in adolescent Mexican Americans, PA levels were associated with HOMA-IR and WC in females but BMI percentile for age/gender in males.

Although cross-sectional studies cannot show causality between exposure and outcome, they can nonetheless provide useful associations that can be applied clinically; thus, this study is important in that it provides health care providers a predicted outcome in insulin resistance-associated parameters in male and female adolescents from various racial groups if SSB intake and PA levels are modified. For example, based on our data, a reduction in SSB intake in the adolescent population may be expected to yield the greatest positive impact with respect to indices of insulin resistance in non-Hispanic white females and non-Hispanic black males. Alternatively, an increase in PA levels in the adolescent population may be expected to yield a positive impact with respect to indices of insulin resistance in non-Hispanic white and black adolescent males, whereas in females they may be expected to yield a positive impact in non-Hispanic whites and Mexican Americans. A detailed investigation into the reasons for these differences is beyond the scope of this study, and although not evaluated in this study because of sample size considerations, the associations of SSB intake and PA levels on indices of insulin resistance in other racial subgroups is also important and warrant further investigation. However, our findings nevertheless underscore the importance of race and gender in the evaluation of multifactorial diseases, and reinforce the importance of considering race, gender, and culture in treatment recommendations and patient management.

Previous studies have suggested that SSBs negatively affect metabolism and energy homeostasis,³⁰ and the consumption of SSBs has been implicated in many^{10,11,15,16,30,31} but

not all^{32,33} studies to be a contributing factor to the increased incidence and prevalence of overweight and obesity. Furthermore, the odds of a pediatric patient becoming obese—and therefore at risk for developing the metabolic syndrome—has been reported to increase by ~60% for each additional SSB serving per day,¹² and individuals who consume a large portion of their daily energy intake with SSBs are reported to have increased body weight, increased fat mass, dyslipidemia, and high blood pressure.^{34,35} However, as our study suggests, the association of SSB intake with clinical and metabolic parameters differs depending on the race and gender of the subject studied.

Alternatively, PA causes more of its metabolic-changing effects by its action on skeletal muscle, and regular exercise induces long-term changes within the skeletal muscle that improve whole-body insulin sensitivity.^{36–38} Although there have been fewer epidemiological studies regarding the association of PA levels with overweight and obesity in children, data from large adult studies^{39,40} have convincingly shown the metabolic benefits of increased exercise. Moreover, a recent study in adolescents showed that moderate physical activity was positively related to improved glucose metabolism and resting energy expenditure.⁴¹ Yet as our study shows, the association between exercise with clinical and metabolic parameters also differs depending on the race and gender of the subject studied.

Our group has previously reported that increased SSB intake is associated with an increased HOMA-IR, SBP, WC, and BMI percentile for age/gender and decreased HDL-C, whereas increased PA levels are associated with a decreased HOMA-IR, LDL-C, and TG and increased HDL-C in the pediatric population.²⁴ However, that study was not designed to reveal any potential differences among racial groups and between the sexes in the relationship between insulin resistance–associated parameters with SSB intake and PA levels. The results reported herein are thus not only novel but also demonstrate that differences do exist between racial groups and between the sexes with respect to the relationship of SSB intake and PA levels with indices of insulin resistance. Our results also demonstrate that BMI can be decreased or increased in subjects as a result of increased exercise, an observation most likely due to the weight differences of fat and muscle.

Importantly, the finding that the absolute values of the beta coefficients from our multivariate linear regression analyses were consistently smaller for the PA analyses than for the SSB analyses does not diminish the significance of exercise and its relationship with insulin resistance–associated parameters; rather, it is a reflection of the methodology used. SSB intake was defined as the number of SSB serving equivalents a subject consumed per day, whereas PA levels were defined as: (the mean number of times a subject did activity per day) $\times$ (the average duration of each time in minutes) $\times$ (the MET score).²⁴ As would be expected from its determination from multiple variables, a much wider range of PA levels were calculated in the study population than SSB intake levels, influencing the effect of a single unit incremental change on the outcome. However, based on our model, even a small increase in daily exercise by an individual (eg, increasing the mean number of times a subject engaged in physical activity from 2 to 3 per day, and increasing the average duration of physical activity from 10 to 15 minutes) would have a profound effect on their calculated

PA level (increasing it by 225%), leading to larger changes in the outcome variables than would be expected by the small value of the beta coefficient.

Our study also has several important limitations. First, as mentioned above, all we are able to report are associations between exposure (SSB intake and PA levels) and outcome (insulin resistance–associated parameters) as opposed to causality since our study is cross-sectional. Second, since the pubertal status of the subjects was not documented in the NHANES periods that we studied, we are unable to adjust our analyses for the subjects' degree of sexual maturation. Third, studies such as ours that use questionnaire data have inherent limitations: (a) the recall method is subject to inaccuracy and bias, especially with behaviors such as dietary habits⁴² and levels of exercise²⁸ and (b) an individual's dietary habits and levels of exercise can vary greatly from one day to the next, limiting the reliability of short-term recall on long-term patterns. However, given that overweight subjects often underreport their levels of energy intake⁴² and less active adolescents often overestimate their degree of physical fitness,²⁸ we can have confidence in our results since these biases would be expected to diminish rather than enhance our ability to find significant associations between SSB consumption and PA levels with insulin resistance–associated measures.

Conclusion

In summary, we report that the relationships between insulin resistance–associated metabolic parameters and anthropometric measurements with SSB intake and PA levels differ between non-Hispanic whites, non-Hispanic blacks, and Mexican Americans and between the sexes. Specifically, in our study, although SSB intake was significantly associated with many insulin resistance–associated parameters in non-Hispanic white female adolescents, it was only associated with a few parameters in non-Hispanic white males. Alternatively, in the adolescent non-Hispanic black population, the converse was found. Furthermore, no significant associations were found in either female or male Mexican American adolescents when the sexes were analyzed separately. In contrast, PA levels were significantly associated with indices of insulin resistance in both female and male non-Hispanic white and Mexican American adolescents, although the parameters that were significant differed between the races and sexes. Alternatively, in the non-Hispanic black adolescent population, significant differences were only found in males. These findings thus illustrate the importance of race and gender in the investigation of disease processes, and may have important implications for the prevention and treatment of insulin resistance and the metabolic syndrome among individuals of different ethnicities.

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Table 1

Characteristics of US Adolescents Aged 12 to 19 Years: NHANES 1999–2004 Cohorts

Characteristic	NHANES			
	1999–2000	2001–2002	2003–2004	1999–2004
Participants, n	2308	2417	2242	6967
Mean age (years)	15.4	15.5	15.4	15.5
Gender (%)				
Male	51.5	50.6	51.1	51.1
Female	48.5	49.4	48.9	48.9
Race/ethnicity (%)				
Non-Hispanic white ^a	56.8	63.8	64.9	62.1
Non-Hispanic black ^a	14.9	13.9	15.7	14.8
Mexican American ^a	13.0	9.0	11.1	10.9
Other races ^b	15.3	13.3	8.3	12.2

Abbreviation: NHANES, National Health and Nutrition Examination Survey.

^a Racial/ethnic groups evaluated in this study.^b Other races category includes “Other/Multiracial” (5.3% of the NHANES 1999–2004 cohort) and “Other/Hispanic” (6.9% of the NHANES 1999–2004 cohort).

Table 2

Multivariate Linear Regression Analyses Evaluating the Relationship Between SSB Intake and PA Levels With Insulin Resistance–Associated Metabolic Parameters and Anthropometric Measurements, NHANES 1999–2004 Adolescent Population, Non-Hispanic White

	Overall Sample Size	SSB Intake, B (SE) ^a			PA Level, B (SE) ^b		
		Overall	Female	Male	Overall	Female	Male
HOMA-IR ^c	669	0.06 (0.02) ^d	0.08 (0.03) ^d	0.06 (0.03)	–0.0004 (0.0001) ^d	–0.0001 (0.0001)	–0.0005 (0.0002) ^d
TC (mg/dL)	1461	0.03 (0.33)	–0.01 (0.51)	0.10 (0.41)	–0.003 (0.002)	–0.01 (0.002) ^d	–0.002 (0.003)
HDL-C (mg/dL)	1461	–0.53 (0.11) ^d	–0.83 (0.18) ^d	–0.38 (0.11) ^d	0.001 (0.0005) ^d	0.001 (0.001)	0.001 (0.001)
LDL-C (mg/dL) ^c	676	0.17 (0.40)	0.10 (0.83)	0.14 (0.41)	–0.01 (0.002) ^d	–0.005 (0.004)	–0.01 (0.002) ^d
TG (mg/dL) ^c	679	1.91 (0.89) ^d	3.89 (1.56) ^d	1.16 (1.06)	–0.01 (0.004) ^d	–0.01 (0.004) ^d	–0.01 (0.005)
SBP (mm Hg)	1573	0.17 (0.11)	0.44 (0.17) ^d	0.02 (0.11)	–0.0003 (0.0004)	–0.001 (0.001)	–0.0002 (0.001)
DBP (mm Hg)	1573	–0.01 (0.09)	0.06 (0.20)	–0.05 (0.11)	0.0002 (0.0005)	0.001 (0.001)	–0.0003 (0.001)
WC (cm)	1585	0.49 (0.13) ^d	0.83 (0.24) ^d	0.29 (0.15)	–0.002 (0.001) ^d	–0.002 (0.001) ^d	–0.002 (0.001)
BMI percentile	1596	1.08 (0.21) ^d	0.95 (0.48)	0.90 (0.29) ^d	–0.0005 (0.001)	–0.001 (0.002)	–0.001 (0.002)

Abbreviations: NHANES, National Health and Nutrition Examination Survey; SSB, sugar-sweetened beverage; PA, physical activity; HOMA-IR, homeostasis model assessment of insulin resistance; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglyceride; SBP, systolic blood pressure; DBP, diastolic blood pressure; WC, waist circumference; BMI, body mass index; SE, standard error.

^a B (SE) are for the number of serving equivalents of SSBs consumed per day adjusting for the amount of physical activity performed per day, age, gender, and energy intake (in kilocalories).

^b B (SE) are for the sum of the mean number of times a participant did activity per day $\times$ the average duration of each time $\times$ the metabolic equivalent score of the activity adjusting for the number of serving equivalents of SSBs consumed per day, age, gender, and energy intake (in kilocalories).

^c Fasting subsample.

^d $P < .05$.

Table 3

Multivariate Linear Regression Analyses Evaluating the Relationship Between SSB Intake and PA Levels With Insulin Resistance Associated Metabolic Parameters and Anthropometric Measurements, NHANES 1999–2004 Adolescent Population, Non-Hispanic Black

	Overall Sample Size	SSB Intake, B (SE) ^a			PA Level, B (SE) ^b		
		Overall	Female	Male	Overall	Female	Male
HOMA-IR ^c	797	0.12 (0.05) ^d	0.17 (0.14)	0.09 (0.04) ^d	−0.0002 (0.0001)	−0.0002 (0.0002)	−0.0002 (0.0001)
TC (mg/dL)	1819	0.36 (0.35)	−0.29 (0.55)	0.65 (0.41)	−0.0005 (0.001)	0.001 (0.001)	−0.001 (0.001)
HDL-C (mg/dL)	1818	−0.33 (0.10) ^d	−0.32 (0.18)	−0.32 (0.13) ^d	0.001 (0.0003) ^d	0.001 (0.0005)	0.002 (0.0004) ^d
LDL-C (mg/dL) ^c	803	0.61 (0.47)	−0.34 (0.64)	1.24 (0.54) ^d	−0.002 (0.001)	−0.0001 (0.001)	−0.003 (0.001)
TG (mg/dL) ^c	804	2.25 (1.01) ^d	0.63 (0.93)	3.15 (1.47) ^d	−0.001 (0.001)	0.0003 (0.002)	−0.002 (0.002)
SBP (mm Hg)	1924	0.10 (0.12)	0.05 (0.19)	0.11 (0.15)	−0.0003 (0.0003)	−0.001 (0.001)	−0.0002 (0.0003)
DBP (mm Hg)	1924	0.02 (0.11)	0.01 (0.16)	0.02 (0.14)	−0.001 (0.0005) ^d	−0.001 (0.001)	−0.001 (0.001)
WC (cm)	1952	0.48 (0.14) ^d	0.57 (0.24) ^d	0.41 (0.20) ^d	−0.001 (0.0004) ^d	−0.001 (0.001)	−0.001 (0.0005) ^d
BMI percentile	1959	0.37 (0.26)	0.74 (0.46)	0.19 (0.34)	−0.001 (0.001)	−0.0001 (0.001)	−0.0002 (0.001)

Abbreviations: NHANES, National Health and Nutrition Examination Survey; SSB, sugar-sweetened beverage; PA, physical activity; HOMA-IR, homeostasis model assessment of insulin resistance; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglyceride; SBP, systolic blood pressure; DBP, diastolic blood pressure; WC, waist circumference; BMI, body mass index; SE, standard error.

^a B (SE) are for the number of serving equivalents of SSBs consumed per day adjusting for the amount of physical activity performed per day, age, gender, and energy intake (in kilocalories).

^b B (SE) are for the sum of the mean number of times a participant did activity per day × the average duration of each time × the metabolic equivalent score of the activity adjusting for the number of serving equivalents of SSBs consumed per day, age, gender, and energy intake (in kilocalories).

^c Fasting subsample.

^d $p < .05$.

Table 4

Multivariate Linear Regression Analyses Evaluating the Relationship Between SSB Intake and PA Levels With Insulin Resistance Associated Metabolic Parameters and Anthropometric Measurements, NHANES 1999–2004 Adolescent Population, Mexican American.

	Overall Sample Size	SSB Intake, B (SE) ^a			PA Level, B (SE) ^b		
		Overall	Female	Male	Overall	Female	Male
HOMA-IR ^c	912	0.04 (0.04)	0.03 (0.07)	0.05 (0.04)	-0.0003 (0.0001) ^d	-0.0004 (0.0001) ^d	-0.0002 (0.0002)
TC (mg/dL)	2081	-0.10 (0.37)	-0.10 (0.42)	-0.04 (0.50)	-0.001 (0.001)	-0.002 (0.001)	-0.001 (0.002)
HDL-C (mg/dL)	2080	-0.30 (0.13) ^d	-0.37 (0.20)	-0.25 (0.15)	0.001 (0.0004) ^d	0.001 (0.001)	0.001 (0.001)
LDL-C (mg/dL) ^c	912	-0.28 (0.33)	-0.45 (0.49)	-0.20 (0.49)	-0.002 (0.001)	-0.002 (0.002)	-0.002 (0.001)
TG (mg/dL) ^c	918	1.16 (0.84)	0.87 (1.12)	1.07 (1.23)	-0.01 (0.003) ^d	-0.004 (0.004)	-0.01 (0.004)
SBP (mm Hg)	2192	0.12 (0.09)	0.01 (0.14)	0.16 (0.13)	-0.0001 (0.0004)	-0.001 (0.001)	0.001 (0.0005)
DBP (mm Hg)	2192	0.13 (0.12)	0.10 (0.18)	0.13 (0.18)	-0.0004 (0.0004)	-0.0002 (0.001)	-0.001 (0.0005)
WC (cm)	2197	0.23 (0.16)	-0.08 (0.22)	0.40 (0.26)	-0.001 (0.001)	-0.002 (0.001) ^d	-0.0002 (0.001)
BMI percentile	2209	0.59 (0.29) ^d	0.21 (0.55)	0.76 (0.49)	0.002 (0.001)	-0.001 (0.001)	0.003 (0.002) ^d

Abbreviations: NHANES, National Health and Nutrition Examination Survey; SSB, sugar-sweetened beverage; PA, physical activity; HOMA-IR, homeostasis model assessment of insulin resistance; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglyceride; SBP, systolic blood pressure; DBP, diastolic blood pressure; WC, waist circumference; BMI, body mass index; SE, standard error.

^aB (SE) are for the number of serving equivalents of SSBs consumed per day adjusting for the amount of physical activity performed per day, age, gender, and energy intake (in kilocalories).

^bB (SE) are for the sum of the mean number of times a subject did activity per day $\times$ the average duration of each time $\times$ the metabolic equivalent score of the activity adjusting for the number of serving equivalents of SSBs consumed per day, age, sex, and energy intake (in kilocalories).

^cFasting subsample.

^d $p < .05$.