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Rates of Obesity and Obesogenic Behaviors of Rural Appalachian Adolescents: How Do They Compare to Other Adolescents or Recommendations?

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Abstract

Background: To better understand the unique challenges of Appalachians, community-based studies are needed to establish benchmark rates. This study compares obesity rates and obesogenic behaviors among Appalachian adolescents to other adolescent populations or clinical recommendations.

Methods: This study was conducted in 11 Appalachian schools. Body mass index, body mass index percentile, and body fat percentage were measured using a Tanita DC-430U analyzer. Physical activity was measured using Actigraph wGT3X-BT accelerometers. Sugar-sweetened beverage consumption was self-reported. Pearson's correlations, independent t tests, and multivariate analyses with tests of between-subject effects were conducted.

Results: Mean ($n = 345$) age was 15.23 ($SD = 1.02$) years. Appalachian adolescents were extremely obese (13.1%) by more than double that of national adolescent rates. Nearly 29% of males and over 55% of females were at increased cardiovascular risk. Only 15% were moderately active for at least 60 minutes a day, but only for 1 day per week. Mean afterschool sedentary time was 4.75 hours. Only 2.1% recorded vigorous activity for a minimum of 10 minutes at 1 day per week. Nearly all regularly consumed sugar-sweetened beverages.

Conclusion: Obesogenic health disparities were evident in Appalachia. Rates of obesogenic factors among Appalachian adolescents exceed national rates. Appalachian adolescents were far less active, and extreme obesity is a major health concern.

Keywords

accelerometry; body composition; guidelines and recommendations; health behavior; physical activity

Adolescence is considered a time of optimal health. However, during adolescence, it is important to establish health behaviors, especially dietary choices and physical activity (PA) because these patterns have been shown to carry into adulthood.^{1,2} Obesity is well established as a risk factor for diabetes, cardiovascular disease, and certain cancers^{3–5}; these conditions contribute to the leading causes of preventable death.^{6–8} Among preventable causes of obesity and its comorbid conditions are lack of PA, increased sedentary behaviors, and not meeting the recommended dietary guidelines.^{5,9–11} Personal health behaviors that contribute to obesity are often referred to as obesogenic.

Obesogenic behaviors have been found to be related to weight status in nationally representative adolescent samples⁵ and have been explored in smaller regional samples focusing on younger school-aged children.^{12–14} Adolescents have been studied for PA patterns and sedentary time.^{2,5,9,15} These studies focused on national rates or relied on small samples. They may not reveal unique trends within subpopulations. Obesogenic behaviors among adolescents who live in Appalachia have not been fully explored.

Persons living in Appalachia are shaped by a unique regional culture that is characterized by isolation and taking care of their own.^{16,17} Appalachians value their community, kinship and social ties, self-reliance, work ethic, and loyalty.^{17,18} They often have a distrust of outsiders and of the formal health care system.^{19,20} Furthermore, rural Appalachia has environmental, economic, and social characteristics that influence health problems.⁸ Reduced educational opportunities and high unemployment have led to economic instability and persistent poverty, which is associated with poorer health outcomes.^{16,21} Appalachian children have less overall access to health care compared with other children, regardless of insurance status.¹⁶ Furthermore, health care utilization is lower for Appalachians even when care is available, possibly due to the lack of financial means to pay for copayments or coinsurance.^{16,17} Appalachians also report a lack of cultural competence from health care providers as a barrier to seeking care.¹⁷ Consequently, Appalachians suffer disproportionately from poorer overall health.

Previous research has shown that residents from rural areas report higher rates of obesity and lower rates of PA.^{8,22} In studies conducted in Appalachian Ohio, self-report reveals that 37% of high school aged students reported engaging in moderate PA for 5 days of the week, and 13% engaged in vigorous activity for 3 days within the past week.²³ Youth residing in Appalachian Ohio who met the PA guidelines did so primarily outside of organized sports or physical education classes.²³ Only 14% met the guidelines through organized sports, and 12% met the guidelines through physical education classes.²³

In rural Appalachia, more residents also lack resources for preventive care²⁴ and healthful behaviors, such as recreational facilities, organized sports, or neighborhoods for PA.²⁵ To better understand the unique challenges of the rural Appalachian region, community-based studies are needed to establish benchmark rates.⁶ The purpose of this study was to describe rates of obesity and obesogenic behaviors among rural Appalachian adolescents. The research questions were as follows:

1. How do the rates of body mass index (BMI), BMI percentile for age and gender BMI%, and percentage of body fat among rural Appalachian adolescents compare to national rates or clinical recommendations?
2. How do daily PA behaviors compare to the United States daily PA guidelines for adolescents?
3. Are daily PA behaviors related to BMI, BMI%, or body fat percentage?
4. How do sugar-sweetened beverage (SSB) consumption behaviors compare to other adolescents residing in the United States?
5. Are SSB consumption behaviors related to BMI, BMI%, or body fat percentage?

A large proportion of the students (70%–100%) who attend the participating schools receive free breakfast and lunch programs, and the remaining students receive reduced pricing on school meals. Consequently, with the exception of SSBs, daily dietary choices are more limited for the adolescents participating in this study. However, beverage choice is a lifestyle behavior that adolescents have more control over in their daily lives. Because of the demographic profile of our sample, we focus our dietary questions on SSB behaviors. For each of these questions, gender differences were examined.

Methods

This study is a secondary analysis of a larger group-randomized controlled trial being conducted in 11 rural Appalachian high schools in southern Ohio. Pearson's correlations, independent t tests, and multivariate analyses with tests of between-subject effects were conducted. Effect sizes (ES) were calculated using Cohen's *d* to also measure the magnitude of the treatment effect. ES accounts for large sample sizes and large degrees of freedom. When SDs were not similar, Glass' delta technique was performed to calculate ES; if sample sizes were not similar, Hedges' *g* was used to calculate ES. Small ES was defined as <0.2 , medium ES = 0.3 to 0.5, large ES = 0.6 or above. The level of significance was set at $P = .05$.

Sample and Procedure

A systematic sample was drawn from schools meeting the following criteria: (1) located in a rural Appalachian county, (2) county-level obesity rates where schools were located were similar to other counties of included schools, and (3) at least half (50%) or more of students were on a free or reduced lunch program. From these criteria, a sample of adolescents ($n = 345$) in grades 9 to 12 was recruited. Baseline data were used for this study. Prior to data collection, adolescent written assent and parental permission were obtained. The study was approved by the Human Subjects Committee at the host institution and each school. The study is registered on [ClinicalTrials.gov](https://clinicaltrials.gov) (ID number: NCT02329262).

Measures

BMI for Age and Gender.—BMI is a proxy measure for nutritional status and is highly correlated with many different components of body weight, including lean mass, skeletal muscle mass, fat mass, and bone mass, yet BMI cannot distinguish between these different

components.²⁶ However, studies have found a strong link between BMI and percentage of body fat.^{26,27} In research, BMI remains the most commonly used measure to assess general body composition.²⁶ Using the Tanita DC-430U Body Composition Analyzer, BMI was calculated for age and gender. The Tanita portable professional grade BIA analyzer has been found to be valid and reliable in estimating BMI and the percentage of body fat in adolescents when compared with dual-energy X-ray absorptiometry (DXA).^{26–28}

Height was obtained by having the adolescent stand without shoes on a portable stadiometer facing forward. The individual's age, gender, and height were entered into the body composition analyzer for calculations. Participants stood on the body composition analyzer without shoes or socks, with their feet on the measuring pads and their hands directed down the side of their legs.

Body Fat Percentage.—Using standardized body fat ranges for children,²⁸ body fat percentage was measured as the amount of body fat as a proportion of body weight. Proportion for age and gender was calculated by the Tanita DC-430 Body Composition Analyzer. The body fat percentage is estimated by the DXA method using the bioelectrical impedance analysis method.²⁹ DXA is the best individual method to measure body composition.²⁶ DXA is the most stable method utilized to provide the population-specific reference curves for classifying excess body fat in adolescents.²⁹ When used in community-based studies, the Tanita portable body composition analyzer has demonstrated acceptable accuracy for estimating percentage of body fat when compared with DXA in pediatric and adolescent samples.²⁸ For the DXA method, standard measurement modes were selected to obtain the most reliable results.^{30,31}

BMI Percentile for Age and Gender.—BMI percentile measurements are used in clinical practice and public health research as indicators of growth trajectory, growth abnormality, and growth variability.²⁶ Percentiles describe growth patterns over time and allow one to rank individuals relative to others based on age and gender.²⁶ Using the Centers for Disease Control and Prevention (CDC) calculator, each participant's date of birth, gender, day of data collection, weight to the nearest one-eighth pound, and height in feet and inches to the nearest one-eighth inch were entered. Using sex-specific CDC guidelines for age, “underweight” was defined as below the fifth percentile; “healthy weight” was between the 25th and 85th percentile; “overweight” between the 85th and 95th percentile; “obese” was above the 95th percentile; and “extremely obese” was at or above the 120th percentile.^{32,33} Using data from 6 countries, these BMI cutoffs have been found to be statistically equivalent to adult cutoffs for classifying weight status.^{34,35}

PA Behaviors.—Participants wore an Actigraph wGT3X-BT³⁶ accelerometer for 7 consecutive days (1 wk). Readings were obtained from 2 PM to 11 PM during school days and 7 AM to 11 AM on nonschool days. At a minimum, participants had to wear the device for 4 hours (recording activity) during school days and 6 hours during nonschool days. If those thresholds were not met, the data were excluded. Data were used to estimate time spent in sedentary, light, moderate, and vigorous activity. Using the cut point validations established from Freedson et al³⁷ with accelerometers worn on the hip, the following cut points were used to designate activity intensity categories: vigorous activity—3961 counts

per minute,^{38–40} moderate activity—1535 to 3961 counts per minute,³⁸ light activity—100 to 1534 counts per minute,³⁸ and sedentary behavior—fewer than 100 counts per minute.^{38–41} Two or more hours of 0 counts indicates that the device was not worn and was excluded from analysis.⁴¹ The Actigraph accelerometer has been found to most accurately classify all activity categories compared with the Actical device when used with children and adolescents.⁴²

SSB Consumption.—A serving of SSB was defined as 8 ounces. Participants were provided with pictures of 12-ounce soda cans, 20-ounce soda, 32-ounce “Big Gulp,” and a 2-liter soda. For each size, estimated servings were provided. With these visual cues, daily intake during the past 4 weeks was reported by responding to the following questions: (1) “I drink sweetened drinks (pop, sweet tea, flavored coffee drinks, sport drinks, fruit drinks) ___ days per week” and (2) “On the days that I drink sweetened drinks, I usually drink (how many) servings of sweet drinks per day.” Content and predictive validity of these questions have been demonstrated with adolescents residing in rural and Appalachian regions.^{43,44}

Sociodemographic Variables.—Questions assessing gender, age, race/ethnicity, grade in school, and household structure were used to describe the sample.

Results

Most participants were white (89.4%), followed by American Indian/Native American (9.3%). See Table 1 for a demographic description of the sample. Participants ranged in age from 14 to 18 years old, with the mean age being 15.23 (SD = 1.023) years. The sample was 52% female. Owing to the recruitment criteria of the main randomized controlled trial study, the majority of the sample were either in the ninth (50.3%) or 10th (28.9%) grade. Students in either ninth or 10th grade were recruited to participate in the intervention arm of the main study. Students enrolled in a health course of a participating teacher at comparison schools were recruited for participation. Most students enrolled in health courses at the comparison schools were also in either ninth or 10th grade.

Descriptive Results of BMI, BMI Percentile, and Body Fat Percentage

Body mass index ranged from 12.4 to 58.6. See Table 2 for health outcomes by gender. Over 20% (22.2%) of the participants had BMIs between 25 and 29.9 for age and gender. About 70% had BMIs ranging between 30.0 and 39.9 for age and gender. Many (4.5%) had BMIs ranging from 40.0 to 58.6, indicating clinical concerns for extreme obesity.

Body Fat Percentage and BMI Percentile.—Body fat percentage ranged from 5.5% to 56.8%, with the mean being 27.14% (SD = 10.36) of total body weight. Male body fat percentage (n = 160) ranged from 5.5% to 48.1%, with a mean of 21.26% (SD = 9.1). Female body fat percentage (n = 173) ranged from 16.1% to 56.8%, with a mean of 32.75% (SD = 8.2).

Body mass index percentiles ranged from 1 to >120, with the average percentile being 73 (healthy weight status). Although most of the sample (51.2%) had BMI percentiles indicating healthy weight status, 16% of participants were classified as overweight, with

BMI percentiles ranging from 85 to 94.9. Nearly one-third of participants were either obese or extremely obese, with 16.5% being classified as obese and 13.1% being classified as extremely obese. Although the mean BMI percentile was slightly higher in females (73.6, SD = 25.4) compared with males (72.8, SD = 26.9), the difference was not significant ($P = .79$). The BMI percentile results differ slightly from the BMI results; the BMI percentile results indicate a higher prevalence of adolescent obesity and extreme obesity than identified with the BMI values.

How Do the Rates of BMI, BMI Percentile for Age and Gender (BMI%), and Percentage of Body Fat Among Appalachian Adolescents Compare to National Rates or Clinical Recommendations?

About 30% of the adolescents were extremely obese. This rate is more than double the rate of other adolescent populations. Our rural Appalachian males' extreme obesity rate (13%) was more than double the rate of male adolescent populations of similar age (5.9%).³² According to 2011–2014 National Health and Nutritional Examination Survey (NHANES) data, the overall rate of extreme obesity was 7.8%, with females slightly higher (8%) compared with males (7.7%).³¹ Nationally, rates of extreme obesity were lower among non-Hispanic adolescents compared with other adolescent populations, with males having the lowest rate (5.9%). In our sample, the rural Appalachian adolescent extreme obesity rates were disproportionately high regardless of gender. Comparatively, 2011–2014 NHANES data report the prevalence of obesity among adolescents was 20.1% for white males and 21% for females.³² Our rural Appalachian sample had lower rates of obesity, with 18.9% for males and 14.4% for females. The gender difference in obesity prevalence is notable compared with national findings.

Dwyer and Blizzard⁴⁵ have proposed body fat percentages of 20% for males and 30% for females based on cardiovascular risk, specifically hypertension and dyslipidemia for adolescents. Based on these clinical recommendations, over 45% of the rural Appalachian males and over 55% of the females exceed this threshold. Williams et al⁴⁶ identified a body fat percentage threshold of 25% regardless of gender as increasing risk for hypertension and lipoproteins among adolescents. Using the 25% threshold, nearly 29% of rural Appalachian males and over 55% of rural Appalachian females are at increased cardiovascular risk.

Laurson et al⁴⁶ estimated the body fat percentile curves for US adolescents using skinfold measures from NHANES IV data. They found that the mean body fat percentage for 15-year-old males was 15.6%. The Appalachian male mean body fat percentage was 21.26%. These results are consistent with another study³⁵ that estimated body fat percentage using DXA scans. This study reported mean body fat percentage for 15-year-old males ranged from 21.3% to 23.2%.⁴⁷ Likewise, Laurson et al⁴⁷ reported a mean body fat percentage of 25.5% for 15-year-old girls, and Ogden et al⁴⁸ reported a mean body fat percentage range of 31.7% to 34.3% for 15-year-old girls. In this study, the mean body fat percentage for females was 32.75%. See Table 3 for mean body fat percentage of sample by age and gender compared with US adolescents.

How do Daily PA Behaviors Compare to the United States Daily PA Guidelines for Adolescents?

Rural Appalachian adolescents are not meeting the recommended daily PA requirements of 60 minutes of moderate or vigorous physical activity (MVPA) every day.⁴⁹ Table 4 presents days of MVPA. Only 15% of rural Appalachian adolescents were moderately active for at least 60 minutes for 1 day. Two days of moderate activity were assessed by 6.8%. No students were measured with 7 days of moderate activity. Only 2.1% of the students were assessed with vigorous activity for 1 day in the past week. Compared with other adolescents, our results indicate that rural Appalachian adolescents are far less active. According to the CDC, 27.1% of high school students self-reported that they had participated in at least 60 minutes per day of PA on all 7 days before the survey.⁴⁹ Rural Appalachian teens in our sample were assessed with MVPA for at least 60 minutes less than 1 day per week (0.7 d [SD = 1.16]). In addition, rural Appalachian adolescents averaged 4.75 hours of sedentary time after school per day.

During the school week, participants averaged 23.13 minutes (SD = 18.7) of MVPA per day. Males were significantly more active than females during school days, averaging 26.32 minutes (SD = 19.8) of MVPA, whereas females averaged only 19.93 minutes (SD = 17.3; $t = 3.11$, $df = 325$, $P = .002$). The ES was 0.32, indicating a medium gender effect on MVPA. These results fall well below the recommendations of at least 60 minutes per day. There was no difference in MVPA levels between weekdays and weekend days ($t = .782$, $df = 317$, $P = .43$). The ES was <0.1 , supporting no effect on MVPA based on weekend days. On weekend days, the rural Appalachian adolescents averaged 22.59 minutes (SD = 26.44) of daily MVPA. Males were more physically active on weekends. Males averaged 25.05 minutes (SD = 27.33) of MVPA. Females averaged only 19.38 minutes (SD = 25.04) of MVPA on weekend days.

Are Daily PA Behaviors Related to BMI, BMI%, or Body Fat Percentage?

Weekly MVPA was negatively related to body fat percentage ($r = -.199$, $P = .001$). As MVPA increased, body fat percentage decreased. When examined separately, vigorous PA ($r = -.289$, $P = .001$) was more strongly related to body fat percentage than moderate PA ($r = -.12$, $P = .001$). In total, weekly MVPA explained approximately 4% of the variance in body fat percentage ($r^2 = .0399$). In combination, weekly MVPA was not related to BMI ($r = -.05$, $P = .36$) or BMI percentile ($r = .008$, $P = .89$). However, when examined alone, weekly vigorous PA was negatively related to BMI ($r = -.147$, $P = .001$). Weekly sedentary time was related to BMI ($r = .129$, $P = .02$) and percentage of body fat ($r = .126$, $P = .02$). As sedentary time increased, BMI and percentage of body fat also increased. Weekly sedentary time was not related to BMI percentile ($r = .039$, $P = .48$). Weekly sedentary behaviors explained $<2\%$ of the variance in either BMI or percentage of body fat.

How do SSB Consumption Behaviors Compare to Other Adolescents Residing in the United States?

About 30% percent of the rural Appalachian adolescents consumed SSBs for 7 days per week. Over half (52.5%) consumed SSBs for 5 or more days per week. Only 5.6% of adolescents abstained from SSBs. For nonabstainers, on average 2.87 (SD = 2.8) daily

servings were consumed. Most adolescents (56.1%) reported consuming between 1.5 and 3 daily servings.

Gender differences were found with SSB consumption. Males consumed more SSB servings, whereas females consumed SSBs more days of the week. Males drank 3.2 servings per day compared with females, who drank 2.6 servings ($t = 2.24$, $df = 319$, $P = .07$). The ES was 0.196, indicating a small gender effect on servings of SSBs. Females drank SSBs more days per week compared with males, but the difference was not significant ($t = 1.29$, $df = 321$, $P = .19$). Females drank SSBs for 4.2 days of the week, and males drank SSBs for 3.8 days. The ES was 0.15, indicating a small effect of weekly consumption rate based on gender. Although they are not significant, these trends are noteworthy.

Rural Appalachian adolescents are exceeding national estimates of SSB consumption for teenagers. The 2015 Youth Behavior Risk Survey⁵⁰ found that 7% of high school students drank SSBs 3 or more times per day. In this study, nearly 33% reported drinking at least 3 servings a day. Data from the NHANES estimates that almost 2/3 of youth consume at least 1 SSB on a given day.⁵¹ In this study, nearly all adolescents (95.4%) reported consuming at least 1 SSB.

Are SSB Consumption Behaviors Related to BMI, BMI%, or Body Fat Percentage?

Daily SSB servings was related to BMI ($r = .11$, $P = .04$) and BMI percentile ($r = .12$, $P = .03$) but was not related to percentage of body fat ($r = .041$, $P = .44$). The number of days per week that SSBs were consumed was not related to any body composition variables of interest: BMI ($r = .08$, $P = .14$), BMI percentile ($r = .007$, $P = .90$), and percentage of body fat ($r = .104$, $P = .05$). The effects of SSB consumption behaviors on BMI and percentage of body fat were greatest for females compared with males. Between-subjects effects for SSB consumption behaviors on body fat mass were not significant ($F = 2.761$, $df = 5$, $P = .07$). Regardless of gender, SSB consumption behaviors explained a very small percentage of the variance for BMI and body fat percentage in this rural Appalachian adolescent sample.

Discussion

This study supports the importance of understanding health needs and disparities within subpopulations. Adolescents residing in rural Appalachia suffer from poorer health at earlier ages. Health disparities related to obesogenic health behaviors were evident. Reliance on national data that describe obesity-related factors among adolescents would fail to reveal unique factors facing rural Appalachian Americans, classified nationally as “lower risk, such as white adolescents.”

Although the majority of our sample had just entered ninth grade (50%), our results indicate that a high rate of rural Appalachian adolescents are obese, with many being extremely obese. Rural Appalachian females disproportionately exceed body composition clinical recommendations for cardiovascular disease risk. Results indicate that rural Appalachian adolescents are at higher risk for hypertension and dyslipidemia compared with other adolescents. This study reveals that measurement of body composition provides essential information on the health of adolescents. For health professionals targeting cardiovascular

disease and obesity among adolescents, gathering body composition measurements are important health indicators.

Compared with national prevalence rates, rural Appalachian adolescent males are disproportionately represented as extremely obese. The risks of reduced life span and comorbidities are increased with extreme obesity.⁵² A BMI over 40 kg/m² is estimated to reduce life expectancy by 6.5–13.7 years in adults.⁵² Comorbidities such as heart disease, type 2 diabetes mellitus, and certain cancers increase as BMI increases.^{52,53} Illness and early death from earlier acquisition of these comorbidities is a serious concern in the rural Appalachian region. Finding high prevalence rates of extreme obesity poses important clinical and public health challenges.

Although disproportionately poor health outcomes prevalent within rural Appalachia are affected by broader environmental factors, our results show that personal health behaviors are important. The rates of obesity and extreme obesity in early adolescence suggest that obesogenic behaviors such as lower PA, increased sedentary behavior, and increased SSB consumption within rural Appalachia occur at earlier ages. Previous studies have found that these behaviors typically occur in older adolescent populations.^{2,5,54} The strength of association between obesogenic behaviors and obesity is likely to strengthen with the transition to adulthood.

We found that young adolescents did not meet the recommended PA guidelines of 60 minutes a day of MVPA. For those who engaged in PA, the activity time was less than 30 minutes. Our sample averaged less than 1 day of MVPA per week. About 74% of the students had no days of moderate activity and 98% had 0 days of vigorous activity. In addition, they averaged 4.75 hours of sedentary time per day. A recent study by Li et al⁵⁵ found similar results to our findings among a high school sample (n = 561) that was tracked over 4 years of high school. Using the Actigraph accelerometers to measure MVPA over 7 consecutive days, Li et al⁵⁵ reported that less than 9% of 10th-grade students were meeting PA guidelines, students were active less than 30 minutes per day, and sedentary activity level was related to BMI. However, Li et al⁵⁵ did not differentiate between moderate PA and vigorous PA, and their sample was much more diverse, with less than 40% white.

Hortz et al²³ reported low rates of moderate and vigorous PA in a similar sample approximately 10 years ago in the same region, indicating little change in PA behaviors among youth over the past decade. Using a self-report instrument, high school students (n = 1024) from 15 schools estimated their levels of PA during the previous week. Hortz et al²³ found that only 37% of participants engaged in moderate PA for at least 5 days and only 13% reported vigorous activity. While the rates reported by Hortz et al are low, the rates reported in this study are much lower; this difference may be explained by the use of accelerometers versus self-report to measure PA.

Rural Appalachian adolescents lag behind other adolescent populations in meeting PA guidelines and subsequently suffer higher prevalence of obesity. Broader environmental factors including lack of recreational facilities, family and home responsibilities, and the lack of opportunity to engage in organized sports may contribute to the findings. Previous

studies have found that nearly one-fourth of youth residing in this region have relied on school-based opportunities such as organized sports or physical education to meet PA guidelines.²³ Consequently reductions in these school-based programs and curricula may further contribute to our findings.

Rural Appalachian adolescents consume more SSBs than recommended. Nearly all (94%) of the rural Appalachian adolescents consumed at least 1 SSB per day, with most consuming several servings per day, far more than other adolescent populations. Within this region, consumption of SSBs is socially acceptable and accounted for a large variance of BMI (34%) and percentage of body fat (54%). Although the relationship between SSB behaviors and health outcomes, including BMI and percentage of body fat, were significant but modest in this study, targeting SSB consumption behaviors may have a favorable effect on longer term obesity trends within the region. Affecting SSB behaviors are small, manageable changes that may net overall improvements in lifestyle behaviors and health outcomes.

Health programming to reduce SSB consumption among rural Appalachian teens has shown promise when using culturally acceptable approaches, including peer mentoring models that stress self-reliance and helping others in the community. Smith and Holloman⁴³ used a teen advisory approach that produced a significant and sustainable reduction in daily SSB consumption. Health programming should be tailored to meet the needs of adolescent subpopulations. To provide personalized interventions, gender differences must be understood and incorporated into health programs. Males and females seem to have different health behavior outcomes; females will need different health programming targets compared with males. Our findings show that males generally engaged in healthier behaviors compared with females. Males consumed fewer SSBs and were more physically active. Further understanding of gender differences in barriers, motivators, and, ultimately, health behaviors is important.

Many health professionals measure BMI as an indicator of obesity for health surveillance.⁶ Our results indicate that BMI was nearly identical for both genders. BMI does not fully capture an individual's body composition or cardiovascular risk. Measuring BMI and percentage of body fat provides a more complete analysis of the individual's adipose tissue and cardiovascular risk. Although adolescent girls are expected to have a higher percentage of body fat, results show that clinically the boys' composition indicates overfat status and the girls' results indicate obese status.^{27,30} This important clinical difference would not be uncovered by only measuring BMI.

The primary limitation of this study is the cross-sectional design that limits inferences about causal relations between obesogenic behaviors and PA or health outcome correlates. Another limitation is the reliance on self-report for SSB measures. However, studies have shown good correlations between dietary self-report and measured dietary intake. The strengths of this study include a large sample size, with participants from 11 schools, objectively measuring PA and sedentary behavior among an underrepresented adolescent population. An additional strength is objectively measuring BMI and body fat percentage using a body composition analyzer. Finally, we also calculated BMI percentiles for age and gender, thus providing a complete weight for age and gender profile. However, some results should be

viewed with caution because some relationships between variables are modest but significant. These modest results may be uncovering small effects or relationships that would have important clinical implications. One should also consider that some modest results may also be influenced by the large sample size of this study.

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Table 1

Demographic Description of the Sample (n = 341)

Demographic variables	Number	Percent
Age, y		
14	95	28.5
15	111	33.3
16	84	25.2
17	40	12.0
18	3	0.9
Mean (SD) = 15.23 y (1.023)		
Gender		
Male	159	48.0
Female	172	52.0
Missing	2	
Grade in school		
9	167	50.3
10	96	28.9
11	58	17.5
12	11	3.3
Missing	1	
Race/Ethnicity		
White, not of Hispanic origin	288	89.4
American Indian or Native American	30	9.3
Black, not of Hispanic origin	15	4.7
Hispanic or Latino	3	0.9
Asian American, Pacific Islander	2	0.6
Household structure		
Lives with mother	272	80.2
Lives with father	222	65.5
Lives with at least 1 grandmother	61	18.0
Lives with at least 1 grandfather	48	14.2
Lives with foster parent or legal guardian	3	0.9

Table 2**Descriptive Results of Health Outcomes**

Variable	Total sample (N = 333)	percentage	Males (N = 159)	percentage	Females (N = 173)	percentage
BMI						
Underweight	(3)	0.9%	(1)	<0.01%	(2)	1.1%
Healthy weight	(180)	52.3%	(79)	49.7%	(66)	38.1%
Overweight	(57)	17.1%	(28)	17.6%	(57)	32.9%
Obese	(55)	16.5%	(30)	18.9%	(25)	14.4%
Extremely obese	(44)	13.1%	(21)	13.2%	(23)	13.3%

Health outcomes	Total N	Mean	SD	Range	Male N	Mean	SD	Female N	Mean	SD
BMI	334	25.78	6.82	12.4–58.6	160	25.79	7.07	173	25.82	6.6
BMI percentile	333	73.01	26.2	1.0–>99.0	159	72.62	27.1	173	73.71	25.38
Percentage of body fat**	334	27.11	10.4	5.5–56.8	160	21.09	9.15	173	32.75	8.19

Abbreviation: BMI, body mass index. Note: Underweight defined as sex-specific percentile <5%; healthy weight is defined as sex-specific percentile between 5 and 84.9; obese is defined as 5th sex-specific percentile; extreme/morbid obese is defined as 120th sex-specific percentile. US Centers for Disease Control and Prevention (CDC)

BMI-for-age Growth Charts.

* Gender differences at $P = .001$.

** Gender differences at $P = .02$.

Table 3

Mean Body Fat Percentage of Sample by Age and Gender Compared with US Adolescents

Gender (current study N)	Age	Mean BF%*	Ogden et al ⁴⁸ est.**	Laurson et al ⁴⁷ est.***
Male (n = 38)	14	20.23	24.52	16.6
Male (n = 54)	15	21.69	22.28	15.6
Male (n = 47)	16	22.28	23.4	15.5
Male (n = 21)	17	18.41	22.6	16.1
Female (n = 59)	14	32.78	32.51	24.0
Female (n = 56)	15	33.78	33.07	25.5
Female (n = 35)	16	30.91	34.23	26.2
Female (n = 20)	17	33.48	33.8	27.0

Abbreviation: BF%, body fat percentage; DXA, dual-energy X-ray absorptiometry; est., estimate

* Estimates obtained using Tanita DC 430-U Body Composition Analyzer in a school setting.

** Estimates obtained using whole-body DXA scans during 1999–2004 National Health and Nutritional Examination Survey; average for whole age group reported on table.

*** Estimates obtained by skinfold thickness from National Health and Nutritional Examination Survey IV data.

Table 4

Frequency Distribution: Days of Moderate and Days of Vigorous Activity

Days of activity	Frequency of moderate activity	Percent moderate activity	Frequency of vigorous activity	Percent of vigorous activity
0	251	74	332	97.9
1	51	15	7	2.1
2	23	6.8	0	0
3	8	2.4	0	0
4	5	1.5	0	0
5	1	3	0	0