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Comparing percentages and ranks of adolescent weight-related outcomes among U.S. states: Implications for intervention development

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Abstract

Understanding statistical differences in states' percentages and ranks of adolescents meeting health behavior guidelines can guide policymaking. Data came from 531,777 adolescents (grades 9–12) who completed the Youth Risk Behavior Surveillance System survey in 2011, 2013, or 2015. We measured the percentage of adolescents in each state that met guidelines for physical activity, fruit and vegetable (F&V) consumption, and healthy weight status. Then we ranked states and calculated the ranks' 95% CI's using a Monte Carlo method with 100,000 simulations. We repeated these analyses stratified by sex (female or male) or race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic/Latino, or other). Pearson's and Spearman's correlation coefficients examined consistency in the percentages and ranks (respectively) across behaviors and subgroups. Meeting the physical activity and F&V consumption guidelines was relatively rare among adolescents (25.8% [95% CI=25.2%–26.4%] and 8.0% [95% CI=7.6%–8.3%], respectively), while meeting the healthy weight guideline was common (71.5% [95% CI=70.7%–72.3%]). At the state level, percentages of adolescents meeting these guidelines were statistically similar; states' ranks had wide CI's, resulting in considerable overlap (i.e., statistical equivalence). For each behavior, states' percentages and ranks were moderately to highly correlated across adolescent subgroups (Pearson's $r=0.33$ – 0.96 ; Spearman's $r=0.42$ – 0.96), but across behaviors, only F&V

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consumption and healthy weight were correlated (Pearson's $r=0.34$; Spearman's $r=0.37$). Adolescents in all states could benefit from initiatives to support cancer prevention behaviors, especially physical activity and F&V consumption. Programs in states that ranked highly on all assessed health behaviors could be adapted for dissemination in lower-performing states.

Keywords

adolescent health; cancer prevention; geographic disparities; physical activity; fruit and vegetable consumption; healthy weight; nutrition; body mass index; overweight/obesity; energy balance

Health behaviors related to energy balance, including physical activity and dietary intake, contribute to undue morbidity and mortality.^{1,2} Several types of cancer have been linked to poor physical activity³ and diet (including low fruit and vegetable (F&V) consumption).⁴ Overweight and obesity are closely related to these health behaviors⁵ and also have been associated with increased cancer risk.⁶ These behaviors each cause 2–3% of all cancers diagnosed in high-income countries such as the United States.⁷

Healthy People 2020 sets objectives for these behaviors based on guidelines from public health organizations, but many people in the U.S., including adolescents, fail to reach these objectives.⁸ In 2015, for example, 16% of high school students were overweight and another 14% were obese.⁹ Health during adolescence sets a foundation for health trajectories throughout the lifetime.^{10,11} For example, BMI during childhood is positively correlated with BMI during adulthood.¹¹ In addition, health behaviors during adolescence may confer independent risks for chronic disease beyond health behaviors during adulthood^{10,12}, although this evidence is mixed.¹¹

Adolescent physical activity, diet, and overweight/obesity vary not only by important sociodemographic factors such as sex and race/ethnicity⁹, but also by contextual factors such as social norms¹³ and the built environment.¹⁴ Striking differences in these behaviors have emerged across states.^{9,15} As noted above, nationally, 14% of high school students were obese in 2015, but this percentage ranged almost two-fold across states, from 10% in Montana to 19% in Mississippi.⁹

Comparing and ranking states on their performance on health indicators may motivate policies and programs to improve public health^{16,17}, but often such ranks ignore error in estimates derived from survey data.^{18–20} This practice can lead to over-interpretation of ranks that do not differ statistically.^{19,21} Our study aimed to examine the percentages of cancer-preventing energy balance indicators among adolescents across states and to evaluate differences in their ranks, using several years of population-based data.

Materials and Methods

Data source

Data came from the Youth Risk Behavior Surveillance System (YRBSS), a biennial, school-based survey coordinated by the Centers for Disease Control and Prevention (CDC) to monitor adolescent health behaviors.²² YRBSS surveys representative samples of students in

grades 9–12 in each state using a three-stage clustered sampling design.²³ In states with 60% response rates, YRBSS staff produce survey weights to account for student non-response and to increase generalizability of the findings.²³

The present study analyzed data from 531,777 respondents in the 2011, 2013, and 2015 YRBSS surveys to estimate state-specific percentages of adolescent energy balance behaviors. Forty-seven states completed a YRBSS survey with an adequate response rate during at least one of these years (see Supplementary Table S1 for sample sizes across years and subgroups).²²

Measures

We measured adherence to behavioral guidelines⁸ about physical activity, F&V consumption, and weight status among adolescents. State YRBSS surveys used the items quoted below or slight variations.

Physical activity—The Physical Activity Guidelines for Americans from the U.S. Department of Health and Human Services (DHHS) recommend that adolescents engage in at least 60 minutes of aerobic physical activity per day.²⁴ YRBSS survey items read: “During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?”²³ We coded respondents as meeting the guideline if they were active for at least 60 minutes during 7 of the past 7 days.

F&V consumption—The Dietary Guidelines for Americans, 2015–2020, from the U.S. DHHS recommend that adolescents eat at least two servings of fruits and three servings of vegetables every day.²⁵ Six YRBSS survey items assessed F&V consumption; all items began with “During the past 7 days, how many times did you...” and finished with “drink 100% fruit juices such as orange juice, apple juice, or grape juice?,” “eat fruit?,” “eat green salad?,” “eat potatoes?,” “eat carrots?,” and “eat other vegetables?”²³ YRBSS staff calculated the number of servings of fruits and vegetables respondents ate per day. We coded respondents as meeting the guideline if they consumed the recommended amount of fruits and vegetables.

Four states did not include comparable survey items on F&V consumption (Delaware, Hawaii, Maine, and New York); thus analyses of this outcome are restricted to 43 states.²³

Weight status—The CDC recommends that adolescents maintain a normal weight, defined as below the 85th percentile of age- and sex-specific BMI.²⁶ YRBSS respondents self-reported height and weight (biologically-implausible responses for height or weight were recoded to missing), and YRBSS staff calculated their BMI percentile.²³ We coded respondents as meeting the guideline if they were below the 85th percentile of age- and sex-specific BMI.

Other variables—Respondents self-reported their sex (male; female; or missing). In addition, they self-reported their race and ethnicity, which YRBSS classified as non-Hispanic white, non-Hispanic black, Hispanic/Latino, other, or missing. Respondent state came from YRBSS records.

Statistical analysis

First, we calculated the percentage of respondents adhering to each of the guidelines described above for the overall population, by demographic subgroup, and by state. We used chi-squared tests to compare the percentages of adolescents meeting these guidelines across subgroups. Scatterplots depict the observed percentages and 95% confidence intervals (CI's) for states' adherence to each behavioral guideline. As a supplementary figure, we include choropleths to depict the states' adherence levels.

Next, we ranked states according to their observed percentages and estimated the error around the ranks via a Monte Carlo method to generate simultaneous CI's for each state's rank for each indicator.^{19,27} This approach used 100,000 replications assuming a normal distribution of percentages across states. For each replication, we simulated the percentage of adolescents meeting each guideline in each state given the observed percentage and standard error. Then we ranked the states in each replication and calculated each state's median rank and the 95% CI. We iteratively compared each state to all other states to examine their ranks. Scatterplots depict the ranks and associated CI's for states' adherence to each behavioral guideline. To gain further understanding of how these patterns vary by adolescent subgroups, we repeated these analyses stratifying by adolescent sex and by adolescent race/ethnicity.

Finally, we examined the consistency in percentages and ranks across subgroups and outcomes to estimate the similarity of these behaviors for different subgroups; marked differences in percentages and ranks could indicate states' failure to address a given behavior for a given subgroup. We used Pearson's correlation coefficients to measure the association between percentages and Spearman's rank correlation coefficients to measure the association between ranks for the overall population compared to each of the subgroups (female; male; non-Hispanic white; non-Hispanic black; Hispanic/Latino; other race/ethnicity). In addition, for the overall population, we examined pairwise comparisons between physical activity, F&V consumption, and healthy weight guidelines; similarities in percentages and ranks could indicate a common cause underpinning engagement in these behaviors that could be examined in future research.

Sample weights were used to obtain population estimates that accounted for student nonresponse²³, and design information was incorporated to calculate standard errors accounting for the complex survey design.²⁰ Below, we present unweighted frequencies and weighted percentages. Analyses were conducted in SAS version 9.3 (Cary, NC) with an alpha value of .05.

Results

Across survey years, 531,777 adolescents participated in YRBSS. Of these, about half were female (48.8%) and half male (50.7%) (0.5% missing). More than half of participants were non-Hispanic white (52.5%), with smaller groups of non-Hispanic blacks (15.3%), Hispanics/Latinos (21.2%), or other race/ethnicity (8.5%) (2.5% missing).

Meeting the adolescent physical activity guideline

Altogether, 491,093 participants from 47 states reported their physical activity, and 25.8% (95% CI=25.2%–26.4%) of adolescents met this guideline (Table 1). Meeting this guideline was higher among males than females ($\chi^2=16,568$, $p<.0001$) and among non-Hispanic whites than other races/ethnicities ($\chi^2=989$, $p<.0001$).

Across states, the percentage of adolescents meeting this guideline ranged from 20.2% (Utah) to 34.6% (Oklahoma) (Table 2, Figure 1A). Thus, Oklahoma was ranked first (1, 95% CI=1–1) and Utah last (47, 95% CI=43–47). The CI's for the percentages and ranks of meeting the physical activity guideline overlapped for many states. For example, the CI for California's rank, 25th (8–42; Supplementary Table S2), overlapped 33 other ranks.

In stratified analyses, states' percentages and ranks for meeting physical activity guidelines across subgroups were fairly consistent. Percentages in the overall population were correlated with those observed in subgroups (females: $r=0.84$; males: $r=0.93$; non-Hispanic white: $r=0.88$; non-Hispanic black: $r=0.54$; Hispanic/Latino: $r=0.62$; other race/ethnicity: $r=0.65$; all $p<.05$). Similarly, ranks were correlated for the overall population versus subgroups (females: $r=0.84$; males: $r=0.91$; non-Hispanic white: $r=0.88$; non-Hispanic black: $r=0.45$; Hispanic/Latino: $r=0.63$; other race/ethnicity: $r=0.63$; all $p<.05$) (Supplementary Table S2). For example, Oklahoma was ranked in the top five states for meeting the physical activity guideline, and Utah in the bottom three, across most subgroups.

Meeting the adolescent F&V consumption guideline

Altogether, 488,149 participants from 43 states reported their F&V consumption, and 8.0% (95% CI=7.6%–8.3%) of adolescents met this guideline (Table 1). Meeting this guideline was higher among males than females ($\chi^2=387$, $p<.0001$) and varied by race/ethnicity ($\chi^2=665$, $p<.0001$).

Across states, the percentage of adolescents meeting this guideline ranged from 4.2% (Wisconsin) to 12.6% (Colorado) (Table 2, Figure 1B). Thus, Colorado was ranked first (1, 95% CI=1–8) and Wisconsin last (43, 95% CI=41–43). The CI's for the percentages and ranks of meeting the F&V consumption guideline overlapped for many states. For example, the CI for Connecticut's rank, 22nd (14–33; Supplementary Table S3), overlapped 18 others.

In stratified analyses, states' percentages and ranks for meeting F&V consumption guidelines across adolescent subgroups were fairly consistent. Percentages in the overall population were highly correlated with those observed in subgroups (females: $r=0.92$; males: $r=0.94$; non-Hispanic white: $r=0.95$; non-Hispanic black: $r=0.75$; Hispanic/Latino: $r=0.70$; other race/ethnicity: $r=0.67$; all $p<.05$). Similarly, ranks were highly correlated for the overall population versus subgroups (females: $r=0.90$; males: $r=0.92$; non-Hispanic white: $r=0.94$; non-Hispanic black: $r=0.59$; Hispanic/Latino: $r=0.68$; other race/ethnicity: $r=0.62$; all $p<.05$) (Supplementary Table S3). For example, Colorado was ranked in the top four states for meeting the F&V consumption guideline, and Wisconsin in the bottom two, across most subgroups.

Meeting the adolescent healthy weight status guideline

Altogether, 490,919 participants from 47 states reported on their weight status, and 71.5% (95% CI=70.7%–72.3%) of adolescents met this guideline (Table 1). Meeting this guideline was higher among females than males ($\chi^2=2,589$, $p<.0001$) and varied by race/ethnicity ($\chi^2=5,249$, $p<.0001$).

Across states, the percentage of adolescents meeting this guideline ranged from 66.4% (Kentucky) to 82.0% (Colorado) (Table 2, Figure 1C). Thus, Colorado was ranked first (1, 95% CI=1–2) and Kentucky last (45, 95% CI=40–47; tied with two other states). The CI's for the percentages and ranks of meeting the healthy weight guideline overlapped for many states. For example, the CI for North Dakota's rank, 24th (15–30; Supplementary Table S4), overlapped 14 others.

In stratified analyses, states' percentages and ranks for meeting healthy weight guidelines across adolescent subgroups were fairly consistent. Percentages in the overall population were correlated with those observed in subgroups (females: $r=0.96$; males: $r=0.93$; non-Hispanic white: $r=0.84$; non-Hispanic black: $r=0.47$; Hispanic/Latino: $r=0.33$; other race/ethnicity: $r=0.53$; all $p<.05$). Similarly, ranks were correlated for the overall population versus subgroups (females: $r=0.96$; males: $r=0.92$; non-Hispanic white: $r=0.82$; non-Hispanic black: $r=0.53$; Hispanic/Latino: $r=0.42$; other race/ethnicity: $r=0.50$; all $p<.05$) (Supplementary Table S4). For example, Colorado was ranked in the top two states for meeting the healthy weight guideline, and Kentucky in the bottom seven, across most subgroups.

Across behavioral indicators, states' percentages and ranks were not highly correlated. States that had high percentages for the F&V consumption guideline tended to also have high percentages for the healthy weight guideline ($r=0.34$), but the associations were smaller for the physical activity and F&V consumption guidelines ($r=-0.02$) and for the physical activity and healthy weight guidelines ($r=-0.09$). Similarly, states that were ranked highly for F&V consumption tended to also rank highly for healthy weight ($r=0.37$), but the associations were smaller for physical activity and F&V consumption ($r=-0.06$) and for physical activity and healthy weight ($r=-0.07$).

Conclusions

Among more than half a million adolescents, we found considerable statistical overlap in states' percentages and ranks of meeting guidelines for cancer prevention behaviors (physical activity, F&V consumption, and weight status). Overall, meeting guidelines for physical activity and F&V consumption was rare, but meeting healthy weight guidelines was more common. While ranking states on these indicators may galvanize public health action around a particular prevention behavior^{16,17}, statistically, many states had equivalent ranks. Ranking smaller geographic areas (e.g., counties) with correspondingly smaller population and survey sample sizes would be prone to even more uncertainty. Rankings for each behavior were similar for the overall population and subgroups defined by sex; lower (but still statistically-significant) correlations observed for the overall population and subgroups defined by race/ethnicity could be explained by the smaller sample sizes. Additional

research is needed to examine potential differences in adolescent cancer prevention behaviors across states to support interventions to improve these patterns.

These findings indicate that adolescents in all states would benefit from interventions to promote cancer prevention behaviors. States' percentages and ranks for meeting guidelines were correlated only for F&V consumption and healthy weight. Some state-level conditions may similarly underpin these two behaviors (and therefore interventions may be able to target both simultaneously), but independent interventions may be needed for other adolescent health behaviors. Notably, Colorado was ranked first overall for F&V consumption and healthy weight, and sixth for physical activity. Future research should explore (1) the reliability of inter-state rankings on these health behaviors and (2) the characteristics of states with especially high performance on all three adolescent health indicators to understand which policies or programs can be implemented in other states.

However, at least four study limitations should be acknowledged when interpreting these findings. First, several states (and Washington, D.C.) were absent from this analysis.²³ The consequence is that the range of ranks did not extend to 50 or 51, and none of the states can be designated as "best" or "worst," even if they had the best or worst performance in this dataset. Second, due to differences in YRBSS sampling schemes and the availability of data, state sample sizes were quite variable and not necessarily what one would expect based on population.²² If sampling procedures had been identical across states, the CI's would have been different, perhaps resulting in more precision and less overlap around states' percentages and ranks; the influence of sample size on the width of the CI's and, as a result, conclusions about statistical differences is crucial. However, in the current analysis states had samples between 1,125 and 112,301 participants, affording a great deal of precision (even among states with relatively small samples). However, the sample sizes for the supplementary analyses of adolescent subgroups were necessarily smaller, resulting in some instability in the estimates; caution should be used in interpreting these findings, particularly for non-Hispanic blacks. Third, YRBSS is cross-sectional and relies on self-reported data; biases in survey data are well-recognized.²⁸ In particular, adolescents' self-reported weight may be underestimated while self-reported height may be overestimated.²⁹ Fourth, state-level estimates of percentages and ranks of adolescents engaging in these behaviors do not account for other individual- and area-level correlates of physical activity, F&V consumption, and healthy weight status; analyzing the influence of these correlates (and other excluded variables) was outside the scope of the current analysis.

Despite these limitations, this study has several strengths. Analyzing YRBSS data allowed us to examine behaviors among more than half a million adolescents. Samples of adolescents were representative of the populations in their respective states. We conducted rigorous statistical analysis of the error in states' ranks; ranks are often presented as error-free (i.e., without confidence intervals), which could bias their interpretation.^{18,19} Finally, we evaluated adolescents' behaviors in reference to nationally-established guidelines that promote public health.^{8,24-26}

Overall, only a quarter of adolescents met the guideline for physical activity²⁴, with higher levels among males than females (+15% points) and non-Hispanic whites than the other

Colorado) for implementation in states with low ranks to improve preventive health behaviors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

BMI	body mass index
CDC	Centers for Disease Control and Prevention
CI	confidence interval
DHHS	Department of Health and Human Services
F&V	fruit and vegetable
YRBSS	Youth Risk Behavior Surveillance System.

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Highlights

- Ranking states' performance on adolescent cancer prevention can motivate change.
- The prevalence of meeting some weight-related guidelines among adolescents was low.
- States' performance ranks varied across indicators and had considerable error.
- States' ranks for fruit/vegetable consumption and healthy weight were correlated.
- Precise ranks could inform research and states' policies for cancer prevention.

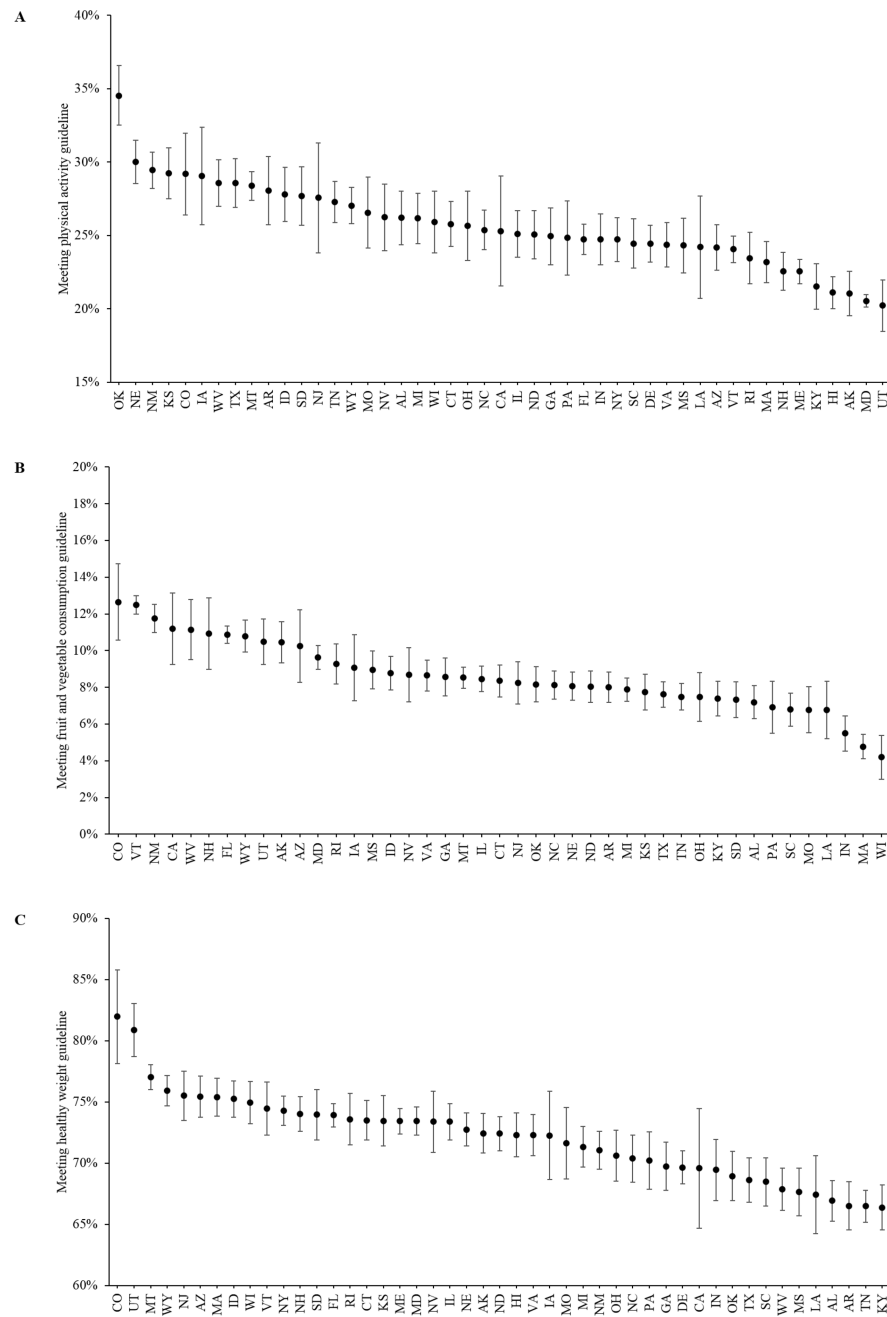


Figure 1. State percentages of adolescents meeting guidelines for (A) physical activity, (B) fruit and vegetable consumption, and (C) healthy weight status, 2011–2015 Youth Risk Behavior Surveillance System.

Table 1

Frequencies and percentages of adolescents meeting guidelines for physical activity, fruit and vegetable consumption, and healthy weight status, 2011–2015 Youth Risk Behavior Surveillance System.

	<i>n</i>	<i>N</i>	%	(95% CI)	<i>p</i>
	Physical activity				
Total	118,167	491,093	25.8%	(25.2%–26.4%)	
Sex					
Female	42,533	249,715	17.7%	(17.1%–18.3%)	
Male	75,036	237,957	33.8%	(33.1%–34.6%)	<.0001
Race/ethnicity					
Non-Hispanic white	66,265	256,967	27.7%	(27.0%–28.4%)	
Non-Hispanic black	12,887	60,859	23.6%	(22.7%–24.5%)	
Hispanic/Latino	16,978	77,819	23.7%	(22.6%–24.7%)	
Other	19,216	82,448	24.1%	(22.2%–26.0%)	<.0001
	Fruit and vegetable consumption				
Total	37,809	488,149	8.0%	(7.6%–8.3%)	
Sex					
Female	17,623	248,831	7.1%	(6.8%–7.5%)	
Male	19,822	236,173	8.7%	(8.2%–9.1%)	<.0001
Race/ethnicity					
Non-Hispanic white	18,210	250,077	7.1%	(6.8%–7.4%)	
Non-Hispanic black	4,650	64,463	8.2%	(7.7%–8.8%)	
Hispanic/Latino	6,254	78,444	9.0%	(8.4%–9.7%)	
Other	7,537	82,367	9.8%	(8.3%–11.4%)	<.0001
	Healthy weight status				
Total	355,603	490,919	71.5%	(70.7%–72.3%)	
Sex					
Female	188,033	248,691	74.8%	(74.1%–75.6%)	
Male	167,570	242,228	68.3%	(67.2%–69.3%)	<.0001
Race/ethnicity					

	<i>n</i>	<i>N</i>	%	(95% CI)	<i>p</i>
Non-Hispanic white	194,365	257,731	75.0%	(74.4%–75.6%)	
Non-Hispanic black	42,983	64,712	65.8%	(64.9%–66.7%)	
Hispanic/Latino	52,572	77,613	65.1%	(63.6%–66.6%)	
Other	58,179	80,264	76.1%	(73.3%–78.8%)	<.0001

Note. Frequencies are unweighted, and percentages are weighted. *P*-values indicate results of chi-square tests of independence of health behaviors for sex or race/ethnicity subgroups. CI=confidence interval.

Table 2

Percentages of adolescents meeting guidelines for physical activity, fruit and vegetable consumption, and healthy weight status by state, 2011–2015 Youth Risk Behavior Surveillance System.

State	Physical activity	Fruit and vegetable consumption	Healthy weight status
Alabama	26.2%	7.2%	66.9%
Alaska	21.1%	10.5%	72.4%
Arizona	24.2%	10.2%	75.4%
Arkansas	28.1%	8.0%	66.5%
California	25.3%	11.2%	69.6%
Colorado	29.2%	12.6%	82.0%
Connecticut	25.8%	8.4%	73.5%
Delaware	24.4%	--	69.6%
Florida	24.7%	10.9%	73.9%
Georgia	24.9%	8.6%	69.7%
Hawaii	21.1%	--	72.3%
Idaho	27.8%	8.8%	75.2%
Illinois	25.1%	8.5%	73.4%
Indiana	24.7%	5.5%	69.4%
Iowa	29.1%	9.1%	72.3%
Kansas	29.2%	7.8%	73.5%
Kentucky	21.5%	7.4%	66.4%
Louisiana	24.2%	6.8%	67.4%
Maine	22.5%	--	73.4%
Maryland	20.5%	9.6%	73.4%
Massachusetts	23.2%	4.8%	75.4%
Michigan	26.2%	7.9%	71.3%
Mississippi	24.3%	8.9%	67.7%
Missouri	26.6%	6.8%	71.6%
Montana	28.4%	8.5%	77.0%
Nebraska	30.0%	8.1%	72.8%
Nevada	26.2%	8.7%	73.4%
New Hampshire	22.6%	10.9%	74.0%
New Jersey	27.6%	8.2%	75.5%
New Mexico	29.4%	11.8%	71.1%
New York	24.7%	--	74.3%
North Carolina	25.4%	8.1%	70.4%
North Dakota	25.1%	8.0%	72.4%
Ohio	25.6%	7.5%	70.6%
Oklahoma	34.6%	8.2%	68.9%

State	Physical activity	Fruit and vegetable consumption	Healthy weight status
Pennsylvania	24.8%	6.9%	70.2%
Rhode Island	23.5%	9.3%	73.6%
South Carolina	24.5%	6.8%	68.5%
South Dakota	27.7%	7.3%	74.0%
Tennessee	27.3%	7.5%	66.5%
Texas	28.6%	7.6%	68.6%
Utah	20.2%	10.5%	80.9%
Vermont	24.1%	12.5%	74.5%
Virginia	24.4%	8.6%	72.3%
West Virginia	28.6%	11.1%	67.9%
Wisconsin	25.9%	4.2%	75.0%
Wyoming	27.0%	10.8%	75.9%

Note. Percentages are weighted.

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