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Role of breakfast skipping, depression, and other risk factors for obesity: The Youth Risk Behavior Surveillance System

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Abstract

***Background and objectives*:** Obesity among adolescents is a significant public health concern in the United States. The prevalence of obesity has increased from 13.0% in 2011 to 15.5% in 2019. The association between breakfast skipping and obesity is still controversial, and a mediator role of depression in this association is limited. The purpose of this study was to investigate the independent association between breakfast skipping and obesity and to investigate the mediator role of depressive symptomology between breakfast skipping and obesity prevalence.

***Materials and methods*:** In this cross-sectional study, data were extracted from the CDC's Youth Risk Behavior Surveillance System (YRBSS) for 9th to 12th graders from 2011 through 2020. SAS version 9.4 was used to analyze the data using proc survey frequency and proc survey logistic regression models. The adjusted odds ratios (aORs) with 95% confidence intervals (CI) were estimated. The Sobel test also was performed to test the mediator role of self-reported depression.

***Results*:** Of the 56,320 adolescents, 13.7% did not eat breakfast, 14.1% were obese, and 15.1% had depressive symptomology. Breakfast non-eaters was associated with a 24% increased odds of obesity (aOR: 1.24; 95% CI: 1.14 to 1.36) after adjusting for race/ethnicity, gender, grade level, and behavioral risk factors. A mediator role of self-reported depression was noted using the regression model and Sobel test (z = 3.90, S.E. = 0.02, p< 0.0001) between breakfast skipping and obesity.

***Conclusions*:** Breakfast skipping was independently associated with obesity. Self-reported depression was identified as a mediator factor. Therefore, the mental health condition also needs to be addressed in the prevention of obesity among adolescents.

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Introduction

Obesity is a major risk factor for several illnesses including diabetes, cardiovascular disease, asthma, sleep disorders, and osteoarthritis. Many children grow up as obese adults, and are victims of several morbidities and mortalities in the adulthood [1]. An estimated 191,986 U.S. youths aged <20 years had diabetes, with 20,262 having type-2 diabetes in 2009 and was projected to increase it to 84,131 in 2050 [2,3]. The economic burden of the annual medical spending attributable to an obese individual was $1901 ($1239 to $2582) in 2014, accounting for $149.4 billion at the national level [4]. Studies showed that soda consumption, and physical inactivity, watching television and playing video games played significant role in obesity in youth [5.6]. Data are scarce on the role of breakfast skipping in obesity.

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Breakfast is an important first meal of the day that impacts behavior, academic performance, and physical and mental well-being [7-11]. Adolescence is a critical transition period from childhood to adulthood as it represents the vulnerable phase of human development to physical, mental, and social maturity [12]. Although breakfast impacts both short- and long-term health and wellbeing of adolescents, the barrier to eating breakfast prevail among adolescents, especially in minority population having several risk factors such as lower family income, lower education, physical inactivity, watching television, and alcohol consumption [6,12-15]. However, controversy remains in the relationship between breakfast skipping and obesity prevalence among adolescents in the U.S., mainly because of inadequate adjustment of confounding variables. For example, conflicting results within four U.S. studies are notable – breakfast skipping was associated with obesity among adolescents in study of Kentucky adolescents and in a national study [15,16]. On the other hand, the National Heart, Lung, and Blood Institute Growth and Health Study found no association of breakfast skipping with obesity measures used after controlling for race, age, parental education, energy intake [13,14]. According to the Centers for Disease Control and Prevention (CDC), the rate of breakfast non-eaters increased from 13.1% to 16.7% and obesity rates increased from 13.0% to 15.5% among adolescents during the 2011-2012 survey period to the 2019-2020 survey period [17].

In addition to the possible role of breakfast skipping on obesity, breakfast skipping is linked to depressive symptomology in adolescents. Depression is a mood disorder associated with a consistent feeling of sadness, worthlessness, guilt, and the lack of interest or pleasure in activities [18]. In U.S., over 2.5 million youth are reported to have severe depression and 10.6% have severe major depression [19]. Depressed adolescents had a 70% increased risk of developing obesity than non-depressed adolescents [20].

The importance of breakfast consumption and obesity in youth needs to be further investigated because of inconclusive findings in the literature [15,16]. Therefore, our research goal was to objectively measure the role of breakfast skipping and depression in obesity status, after controlling for major confounding variables using a large representative sample of the U.S. population.

Materials and Methods

Study population

A total of 56,320 adolescent students from the survey of Youth Risk Factor Surveillance System (YRBSS) 2011-2012 through 2019-2020 were included in this cross-sectional study. The samples included in the study were: White (n=25,570), African American (n=8,703), Hispanic/Latino (n = 15,791), and all other races (n=6,256); both genders (female, n=28,495), age group of 12 to 18 years, and grade level of 9th to 12th grade. Data were extracted from the YRBSS conducted by the CDC. The survey was approved by State and local Institutional Review Boards for their respective YRBSS surveys. The parental permission was obtained before the survey was administered at the schools. The YRBSS was conducted biennially among a nationally representative sample of the U.S. public and private high school students to measure the health risk behaviors and experiences of adolescents. A full description of YRBSS methods was published elsewhere [21].

Procedures and measurements

Outcome variable: Body mass index (BMI) was calculated based on self-reported weight and height data. BMI status was compared based on sex- and age-specific reference data from the 2000 CDC growth charts. Obesity was defined as sex- and age-specific BMI ≥ 95th percentile and overweight was defined as sex- and age-specific BMI ≥85th and < 95th percentile. Covariates and mediator variables are described below.

Inclusion criteria: Variables with no missing information on race, gender, age, breakfast consumption, and obesity were included in the analysis.

Main independent variables: Students were asked to respond to the following question regarding breakfast eating, "During the past seven days, on

how many days did you eat breakfast? They were given eight options from 0 days to 7 days. We collapsed the breakfast variable into a dichotomized variable – breakfast skipping was defined as the zero days of eating breakfast for the last seven days. Depressive symptomology was examined with the following question, "During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities "? If the answer was yes, then adolescents were assigned as depressed individuals. Currently drinking alcohol was defined as yes to drinking any day within the past 30 days. Similarly, smoking cigarettes was defined as yes to smoking any day within the last 30 days. Sugar-sweetened soda drinking was defined as drinking a can, bottle, or glass of soda or pop, such as Coke, Pepsi, or Sprite, during the past seven days. Physically active was defined as active physically for at least 60 minutes a day for five days or more. Watching television was defined as watching three or more hours per day on an average school day. Similarly, playing video or computer games was defined as playing three or more hours on an average school day.

Sampling: A three-stage cluster sample was used in the YRBSS survey. The first-stage sampling frame comprised 1,257 primary sampling units (PSUs) which were categorized into 16 strata based on their metropolitan statistical area status (e.g., urban or rural) and the percentages of non-Hispanic black and Hispanic students in each PSU. Of that, 54 were sampled with probability proportional to the overall school enrollment size. In the second stage of sampling, schools were selected from the PSUs. The total numbers of cluster was 238. The 3rd stage of selection comprised of a random sample of one or two classrooms in grade levels 9–12. The students took one class period (around 45 minutes) to complete the instrument anonymously. Schools, classes, and students who refused to participate were not replaced in the sample design. Survey data were not imputed for missing data as a very small percent of information on variables was missing [21,22].

Weighting: Each sample was weighted based on student gender, race/ethnicity, and grade level. A weighted factor on the data set was applied by the CDC so that the findings represent the U.S. youth school-based participants for nonresponse and over sampling minorities [21]. A weight factor is an inflation factor applied to each sample in relation to probability of selection in a sample. Each record was adjusted so that the proportions of students matched the national population proportions. Therefore, weighted estimates are reported so that they reflect the representative sample of all students in grade levels 9-12 attending the U.S. public and private schools.

Statistical analysis

SAS (version 9.4; SAS Institute Inc., Cary, NC, United States) was used to analyze complex survey data. Given the complex survey design, descriptive analyses were performed using the Proc survey frequency for categorical variables. Rao-Scott Chi-Square or simple survey logistic regression was used to test the relationship between two categorical variables. Series of proc survey multivariate logistic regression was applied to adjust the confounding mediating variables in the model for predicting obesity indicator. In the multivariate analysis, 3,759 were deleted due to missing values for the response variables for predicting the obesity. Online Sobel test was also performed to test the mediator role of depressive symptomology to investigate the association between breakfast skipping and obesity [23]. Two-sided tests with a p-value ≤ 0.05 were considered significant.

Results

Association of obesity with demographic characteristics

Table-1 shows that the obesity rate was highest among Black youth, followed by Hispanic youth, all other races, and whites (17.9%, 16.9%, 12.8%, and 12.5%, respectively, p <0.0001). Boys were significantly more obese than girls (17.2% vs. 11.1%, p<0.001). Youths of grade 10 and grade 11 had significantly higher rates of obesity compared

Table 1: *Association of obesity with demographic characteristics*

Variables	Sample size	Obese (%)	Non-obese (%)	p-value
Race/ethnicity				
Whites	25,570	12.5	87.5	
African American	8,688	17.9	82.1	<0.0001
Hispanic/Latino	15,766	16.9	83.1	
All other races	6,238	12.8	87.2	
Gender				
Girls	28,495	11.1	88.9	<0.0001
Boys	27,825	17.2	82.8	
Age category				
12-14	5,933	13.1	86.9	
15	13,363	13.7	86.3	0.11
16	14,411	14.6	85.3	
17	14,284	14.6	85.4	
18	8,329	13.9	86.1	
Grade level				
9	14,132	13.5	86.5	
10	14,042	14.5	85.5	0.04
11	14,192	14.8	85.2	
12	13,821	13.7	86.3	
Missing value	133			

with others (p = 0.04). Although the obesity rates were higher among adolescents of age 16 and 17 years compared to others, the differences were not statistically significant.

Association of obesity with breakfast skipping, personal habits, and depression

As shown in Table-2, youths who did not eat breakfast had a significantly higher rate of obesity than youths who ate breakfast (17.9% vs. 13.5%, p <0.0001). Soda beverage consumption was more likely to contribute to obesity than no soda consumption (p < 0.0001).

Obesity was significantly higher amongst the smokers compared to non-smokers (17.2% vs. 13.6%, p<0.0001). The obesity rate was significantly higher among the adolescents who played video games or watched television for ≥3 hours on school days vs. than those who did not play video games or watched television (16.3% vs. 12.7%, p <0.0001; 17.6% vs. 12.9%, p< 0.0001 respectively). Obesity was less among adolescents carrying out physical activity than those with no physical activity (11.9% vs. 16.2%, p<0.0001). Youths with depressive symptomology had a higher rate of obesity than youth without depressive symptomology (15.1% vs. 13.7%, p = 0.0004).

Demographic and behavioral risk factors

Table-3 displays the unadjusted obesity status by demographic and behavioral risk factors. Among ethnicity/races, compared to Whites, the odds ratio (OR) of obesity was 1.53 (95% CI = 1.37-1.71) among Blacks and 1.42 (95% CI = 1.29-1.56) among Hispanics/Latino. Boys were significantly more obese than girls (OR = 1.67, 95% CI = 1.54-1.78). There were no differences in obesity by age group. Eleventh-grade adolescents were more obese than ninth-graders (OR = 1.12, 95% CI =1.02-1.22). Adolescents with no physical activity were 43% more obese than adolescents with physical activity (OR = 1.43, 95% CI =1.33-1.52). Among obese kids, soda beverage consumption was 20% more than no soda consumption (OR = 1.20, 95% CI = 1.12-1.30). Kids watching television and playing video games

Table-2: *Association of obesity with breakfast skipping, personal habits, and presence of depressive symptoms*

Variables	Sample size	Obese (%)	Non-obese (%)	p-value
Breakfast consumption				
Yes	48,310	13.5	86.5	<0.0001
No	8,010	17.9	82.1	
Beverage drinks				
Did not drink Soda	13,914	12.5	87.5	<0.0001
Drank Soda	41,994	14.7	85.3	
Missing vale (%)	412 (0.7)			
Smoked at least one day within the last 30 days				
Yes	6,201	17.2	82.8	<0.0001
No	48,464	13.6	86.4	
Missing value (%)	1,655 (2.9)			
At least one drink within the last 30 days				
Yes	17,309	13.7	86.3	0.06
No	34,050	13.9	86.0	
Missing value (%)	4,961 (8.8)			
Physical activity ≥ 5 days				
Yes	26,289	11.9	88.1	<0.0001
No	29,790	16.2	83.8	
Missing value (%)	241 (0.42)			
TV watching for ≥ 3 hrs on a school day				
Yes	15,464	17.6	82.4	<0.0001
No	39,713	12.9	87.1	
Missing value (%)	1143 (2.0)			
Playing video game for ≥ 3 hrs on a school day				<0.0001
Yes	23,107	16.3	83.7	
No	32,444	12.7	87.3	
Missing	769 (1.4)			
Depressive symptomology				
Yes	17,782	15.1	84.9	0.0004
No	38,716	13.7	86.3	
Missing value (%)	362 (0.6)			

**Rao-Scott Chi-square test.*

for ≥3 hours on weekdays were 44% and 34% more obese respectively than those who did not watch television and played video games (OR = 1.44, 95% CI=1.34-1.56; OR = 1.34, 95% = CI 1.26-1.44). There were no differences in obesity among drinkers vs. non-drinker adolescents. Adolescents with smoking habit were 31% more obese compared to nonsmokers (OR = 1.31, 95% CI: 1.19-1.45). Obesity was significantly higher among kids with depressive symptomology compared to those without non-depressive symptomology (p <0.0001, OR = 1.23, 95% CI = 1.05-1.20). Obesity was 40% higher among breakfast non-eaters than breakfast eaters (OR = 1.40, 95% = 1.28-1.52).

Multivariate analyses of independent risk factors

Table-4 displays the odds ratio for obesity by breakfast consumer status. A multivariate logistic regression model with four-block was constructed for adjusting demographic and behavioral factors sequentially in the presence of breakfast-consumer

Table-3: *Demographic and behavioral risk factors for obesity*

Variables	Odds Ratio (95% Confidence Intervals)	p-value*
Race/ethnicity	Ref	
Whites	1.53 (1.37-1.71)	
African American	1.42 (1.29-1.56)	<0.0001
Hispanic/Latino	1.03 (0.88-1.20)	
All other races		
Gender	Ref	
Girls	1.67 (1.54-1.78)	<0.0001
Boys		
Age category	Ref	
12-14	1.06 (0.94-1.19)	
15	1.14 (1.01-1.29)	
16	1.13 (1.02-1.27)	0.11
17	1.07 (0.94-1.22)	
18		
Grade level	Ref	
9^{th}	1.09 (0.99-1.20)	
10^{th}	1.12 (1.02-1.22)	0.04
11^{th}	1.02 (0.94-1.11)	
12^{th}		
Physical activity ≥ 5 days	Ref	
Yes	1.43 (1.33-1.52)	<0.0001
No		
Beverage drink	Ref	
Did not drink Soda	1.20 (1.12-1.30)	<0.0001
Drank Soda		
TV watching ≥3 hrs on a school day	1.44 (1.34-1.56)	
Yes	Ref	<0.0001
No		
Playing video game ≥3 hrs on a school day	1.34 (1.26-1.44)	
Yes	Ref	
No		<0.0001
At least one drink for the last 30 days	0.99 (0.93-1.06)	
Yes	Ref	
No		0.81
Smoked at least one day during last 30 days	1.31 (1.19-1.45)	
Yes	Ref	
No		<0.0001
Depressive symptomology	1.23 (1.05-1.20)	
Yes	Ref	0.0004
No		
Breakfast consumption	1.40 (1.28-1.52)	
No	Ref	<0.0001
Yes		

Table-4: *Multivariate logistic regression analysis for independent risk factors for obesity*

	Estimate (β)	Standard error of estimate	p-value	Odds Ratio	95% CI of Odds Ratio
Model 1:					
Breakfast not consumed vs. consumed	0.33	0.04	<0.0001	1.40	1.29-1.52
Model 2:					
Breakfast non-consumer	0.32	0.04	<0.0001	1.38	1.27-1.50
Race (Ref: White)					
African American	0.41	0.06	<0.0001	1.51	1.35-1.69
Hispanic/Latino	0.34	0.05	<0.0001	1.41	1.28-1.56
All other races	0.02	0.08	0.84	1.03	0.88-1.20
Model 3:					
Breakfast non-consumer	0.23	0.05	<0.0001	1.26	1.15-1.38
Race (Ref: White)					
African American	0.35	0.06	<0.0001	1.42	1.27-1.59
Hispanic/Latino	0.32	0.05	<0.0001	1.37	1.24-1.52
All other races	0.003	0.08	0.98	1.00	0.86-1.17
Model 4:					
Breakfast not consumed vs. consumed	0.22	0.06	<0.0001	1.24	1.13-1.36
Race (Ref: White)					
African American	0.36	0.06	<0.0001	1.43	1.28-1.60
Hispanic/Latino	0.31	0.05	<0.0001	1.36	1.24-1.51
All other races	0.002	0.08	0.98	1.00	0.86-1.17
Depression	0.17	0.04	<0.0001	1.17	1.08-1.26

Note: *Model 2: Breakfast + race + sex + grade level; Model 3: Model 2+ soda consumption+ smoking + physical activity+ TV watching +playing video game; Model 4: Model 3 +depression*

status. Adolescents who did not eat breakfast were positively associated with obesity in model 1. The unadjusted OR was 1.40 (95 % CI =1.29-1.52). However, after adjusting for all covariates step by step, including race, gender, grade level, and all other behavior factors, breakfast skipping was significantly positively associated with obesity although attenuated from model 1 to model 4, with OR 1.40 (95 % CI = 1.29-1.52) to 1.24 (95% CI =1.13-1.36).

Mediator role of depression

The mediator role of depressive symptomology is displayed graphically in Figure-1. No breakfast consumption (breakfast skipping) was associated with obesity (β = 0.33, p < 0.0001) as shown in model 1 (unadjusted). In model 2, no breakfast consumption was significantly associated with depressive symptomology (β = 0.54, p< 0.0001). In model 3, depressive symptomology was significantly associated with obesity (β = 0.12, p< 0.001). In model 4, both breakfast consumption and depressive symptomology were included. The effect of breakfast non-eaters vs. breakfast eaters on obesity attenuated (β = 0.22, p<0.0001) after adjustment of covariates, which suggests that the effect of breakfast skipping on obesity was partially mediated by depressive symptomology. The Sobel test (z = 3.90, SE = 0.02, p < 0.0001) was also performed using model 2 and model 3. It indicated that breakfast skipping was associated with obesity, and the relationship was mediated by depressive status.

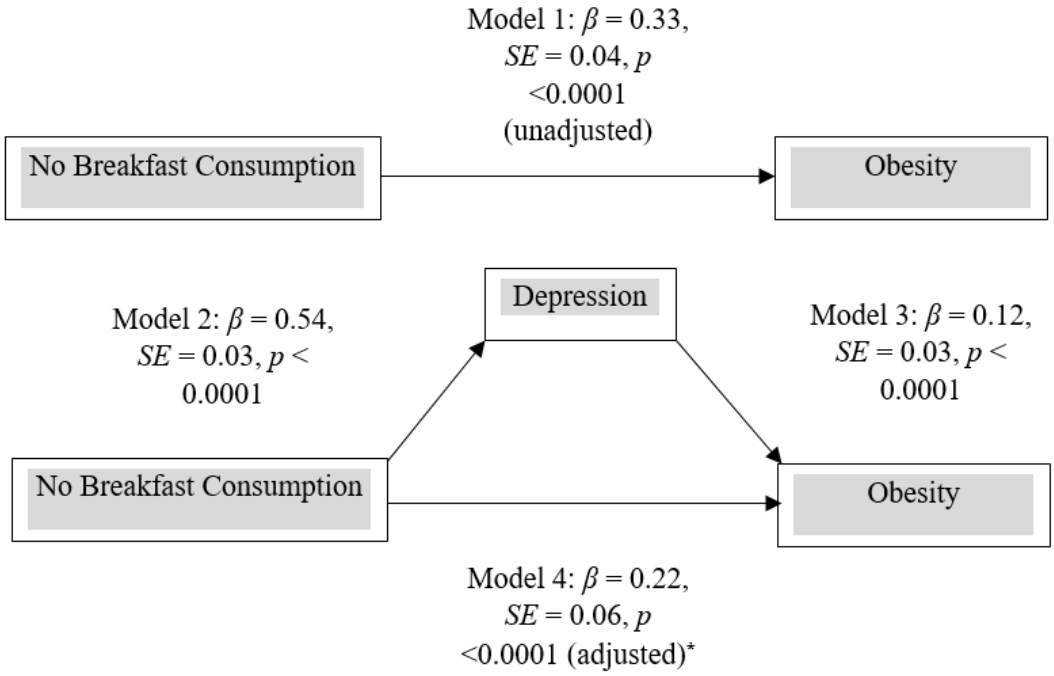

Figure-1: *The mediator role of depressive symptomology between breakfast consumption and obesity. β = Parameter estimate; SE=Standard error; *Adjusted for race, gender, grade level, soda consumption, smoking status, physical activity, TV watching, playing video game, and depression*

Discussion

The present study showed that 14.1% of adolescents were obese, 13.7% skipped breakfast, and 15.1% were depressed. The higher levels of youths with obesity were found in the U.S. among breakfast skippers compared to breakfast consumers. We also found that breakfast skipping was associated with obesity after controlling for gender, age, grade level, soda consumption, physical inactivity, watching television, and playing video games.

The association of obesity with breakfast skipping agrees with the previous results with U.S. adolescents. The mechanism of how breakfast consumption might help to reduce BMI includes regular eating habits, exercise activity, healthy food habits, and cereal consumption [13,14]. A systematic review and meta-analysis of 36 cross-sectional studies and nine cohort studies were conducted in recent years [24]. This meta-analysis has confirmed that breakfast skipping increases the risk of overweight/obesity, including abdominal obesity [24]. In an earlier study, a dose-response relation was found between breakfast skipping and overweight in Dutch adolescents. However, the role of depressive symptomology was limited in those studies.

Race/ethnicity is considered a social construct [25]. In our regression model, African American race and the Hispanic ethnicity were independently associated with obesity. However, the effect was attenuated after adjusting for gender, grade level, and a wide range of behavioral factors. The previous study also did not confirm the race/ethnicity on BMI indicator among adolescents [15]. Findings of race/ethnicity independently predicting obese and overweight status need to be addressed in future studies.

Our study found that 15.1% of adolescents were depressed among adolescents with obesity. The rate of reported depressive illness in our study was comparable with the national figure [19], which

showed that 15.7% adolescents aged 12 to 17 in the U.S had at least one major episode of depression. That figure translates to 3.8 million adolescents in the U. S. who have a depressive illness [19]. The high percentage of adolescents with depression might be a driving force for breakfast skipping.

Association of breakfast skipping with depressive symptomology as found in our study are consistent with previous studies [10,12]. One cross-sectional study showed that there was a significant positive association between obesity and depression among non-Hispanic black adolescents [26]. We also found that depressive symptomology was related to obesity indicators, which was evident in recent studies [12, 20]. We also established the mediator role of depressive symptomology between breakfast skipping with obesity and overweight using the sober test. To date, there has been no study that investigated the mediator role of depressive symptomology between breakfast skipping and obesity.

The possible biological mechanism of association between breakfast skipping and obesity was energy homeostasis imbalance [27]. Leptin, a peptide hormone, regulates energy balance. It is secreted from white adipose tissue and positively correlated with fat mass [28]. Diurnal variation of leptin was documented with lower levels in the morning and higher levels at night [29]. The study found that leptin levels were more than 50% higher among people who skipped breakfast. Another study reported that cortisol, a stress hormone, is associated with depression and obesity. People who are depressed have higher levels of obesity because of increased cortisol levels. Although previous longitudinal study found bidirectional association [30,31], the Coronary Artery Risk Development in Young Adults (CARDIA) data with a longitudinal study of 5,115 men and women aged 18-30 years found depression led to obesity, and not the other way round [32]. A study also reported that white and Hispanic overweight youth were more likely to report depressive symptoms than their non-overweight counterparts. Black youth had similar depressive symptoms with obesity prevalence [33].

Limitations and strengths

This study had some limitations. First, we cannot infer the causal relationship between breakfast skipping and obesity from a cross-sectional study. Second, the results are applicable to adolescent of 9 to 12-grades and should not be generalized. Third, breakfast consumption and weight, height, and depressive illnesses were self-reported and prone to recall bias [34]. Fourth, social desirability bias might be present as adolescents tend to report lower weight and higher height [35]. Therefore, self-reported BMI could be underreported. Fifth, we could not control SES variables in our study, although parental education, income status, and obesity played a role in predicting overweight. However, we used race/ethnicity as a proxy measurement of social constructs.

Despite several limitations mentioned earlier, this study's findings were based on large data set of the U.S., using a nationally representative sample of 56,320. Multivariate survey statistics were applied to control various critical confounding variables, especially soda consumption, watching television, and playing video games. No previous studies could be found addressing the moderator role of depression between breakfast skipping and obesity.

Conclusions

The finding of the present study emphasizes the importance of consuming breakfast for reducing obesity among adolescents. In addition, breakfast consumption helps to improve academic performance, and reduce mental illnesses. Public health professionals, health educators, and healthcare professionals should give attention to identify depressive status in young children and adolescents during routine checkups and screening, and advice them to consume breakfast as part of their daily meals.

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Conflict of Interest: None.

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