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Association of sociodemographic and lifestyle factors and dietary intake with overweight and obesity among U.S. children: findings from NHANES

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Abstract

Childhood overweight/obesity is a serious problem that has not been adequately addressed. As a key factor affecting weight gain, the association between dietary intake with childhood overweight and obesity is still unclear. The objective of this study was to analyze the association between sociodemographic, lifestyle factors and dietary intake with overweight or obesity. We used data from a large cross-sectional National Health and Nutrition Examination Survey (NHANES). The U.S. children aged 6–15 years with both weight data and dietary data were included. For univariate analysis of sociodemographic data, t tests was performed for continuous variables and chi-square tests was performed for discrete variables. Dietary intakes were described by median and quartile, and differences in dietary intake between children with normal weight and children with overweight or obesity were compared by rank sum tests. A modern statistical shrinkage technique, LASSO regression was used to examine the association between dietary intake and childhood obesity. Our study confirms that Hispanic ethnicity, increasing age, passive exposure to smoking, higher protein intake, and higher caffeine intake were positively associated with child overweight or obesity. Additionally, non-Hispanic White race, higher physical activity levels, higher household income, and higher vitamin A intake were negatively associated with child overweight or obesity.

Keywords Child, Overweight, Obesity, Dietary intake

Introduction

Overweight/obesity is considered to be one of the most serious global health issues [1].In recent years, this problem has become increasingly prominent among children. Over the past 40 years, the prevalence of childhood obesity has doubled, and in some developing countries it has nearly tripled [2].In 2015, 107.7 million children were considered obese [3].Although the overall prevalence of childhood obesity is only 5%, it can be as high as 20% in some developed countries [4]. Moreover, childhood obesity rates have reached 10% in some developing countries and are still rising [4].

Children with overweight or obesity are thought to be more likely to develop multiple diseases in adulthood [5].A 40-year follow-up study reported a strong association between overweight and obesity in childhood and the risk of cardiovascular disease and death in adulthood [6].Some studies have also reported that childhood overweight and obesity can increase the risk of type 2

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diabetes, asthma, sleep disease, liver disease and cancer in adulthood [7, 8].

Childhood overweight or obesity is influenced by genetics and other factors (such as diet, environment, society, and behavior) that influence energy intake and expenditure [9, 10]. The influence of genetically related sociodemographic factors such as race and gender on childhood overweight or obesity is well known [11]. Since it is difficult to prevent childhood overweight and obesity from a genetic point of view, the balance between energy intake and expenditure is the determinant factor affecting the incidence of overweight and obesity. Specifically, proper exercise and diet may be effective in preventing overweight, obesity and obesity-related diseases. Poor lifestyle choices such as smoking may increase the risk of overweight and obesity. As for the relationship between dietary intake and overweight/obesity, previous studies have mainly recommended low-calorie, high-fiber fruits and vegetables to prevent obesity [12]. Some studies have reported that calcium, dietary fiber and nutritionally balanced dietary patterns may be negatively associated with overweight/obesity in children, while B vitamins, snacks and beverages may play a positive role in the development of overweight/obesity in children [12–14]. However, the current data is still limited. Due to the complexity and diversity of dietary variables, most studies on the influencing factors of overweight/obesity have focused only on dietary patterns or single nutrients. Furthermore, the possible multicollinearity between dietary macro and micronutrients and the model's limitations on the type and number of variables also pose challenges to statistical analysis. Therefore, it is necessary to further analyze the effects of dietary intake on obesity.

This study used NHANES data combined with LASSO regression methods to analyze the association between sociodemographic, lifestyle factors and dietary intake with overweight or obesity among U.S. children. NHANES is a large, open-source database, which includes the information of the dietary, lifestyle, laboratory, physical examination and other health information of patient. LASSO regression is a special modern statistical technique that allows a large number of covariables in the model, and can actively select from a set of potentially multicollinearity variables, resulting in a more relevant and explainable set of predictors [15]. Based on high quality data combined with modern statistical methods, we have the opportunity to elucidate the association between diet and childhood obesity that has not been observed by traditional statistical methods and small sample size data sets.

Materials and methods

Study design

NHANES is a study conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention (CDC) to assess the health and nutritional status of the U.S. population. The NHANES uses a complex multi-stage probabilistic sampling design and includes information on sociodemographic, socioeconomic, and health-related factors, as well as a 24-hour dietary recall assessment. Since 1999, NHANES has collected data on nearly 5,000 participants from the United States each year. There were 29,902 participants in the NHANES during the period from 2011 to 2016, including 6,134 children aged 6–15. Children with diet and weight data were included in our study. A total of 4764 participants were included in our study(Fig. 1). Since NHANES is a publicly available dataset, the current study is exempt from approval by an Institutional Review Board. All participants provided informed consent.

Overweight and obesity data

In the "Body Measures" portion of the NHANES examination, the growth of infants, children and adolescents was collected, including information on overweight and obesity. Body measures data were collected by trained health technicians in the Mobile Examination Center (MEC). During the body measures examination, the health technician was assisted by a recorder. The age of the participants at the time of the screening interview determined the body measures examination protocol. Standing height was measured using a stadiometer with a fixed vertical backboard and an adjustable head piece. Participants were weighed using a digital weight scale. When measuring standing height, participants should wear the standard MEC test clothing, including a disposable shirt, pants, and slippers. Body Mass Index (BMI) was calculated as weight in kilograms divided by height in meters squared, and then rounded to one decimal place. The criteria of obesity are based on the Centers for Disease Control and Prevention's sex-specific 2000 BMI-for-age growth charts for the United States. Obesity is defined as BMI ≥ 95th percentile. overweight is defined as BMI 85th to < 95th percentiles.

Dietary intake

Dietary intakes were obtained from the "Total Nutrient Intake" portion of the NHANES dietary interview. Dietary intakes were assessed using a 24-h dietary recall method to estimate the types and amounts of foods and beverages (including all types of water) consumed in the 24 h before the interview (midnight to midnight). Interview data were encoded using the USDA Food and Nutrient Database for Dietary Studies, 5.0 (FNDDS 5.0)

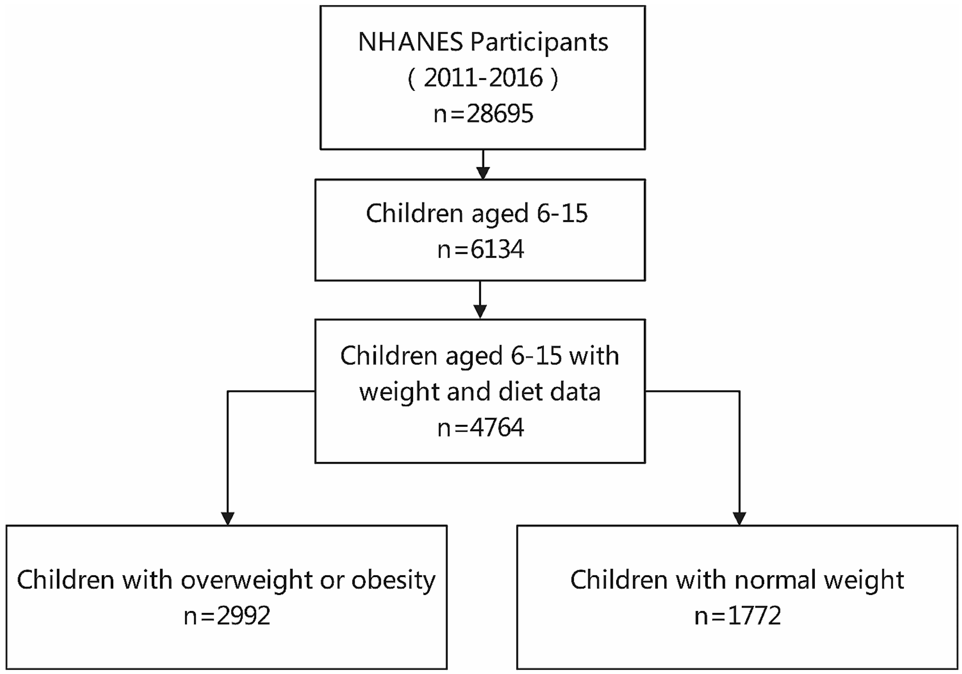

Fig. 1 Flowchart of study participants

to estimate intakes of energy, nutrients, and other food components from these foods and beverages.

Other measures

Age, gender, ethnicity and annual household income were obtained from the demographic variables and sample weights data set. The information of passive smoking was obtained from household smoker data set and ascertained via the following NHANES question, "Not counting decks, porches, or detached garages, how many people who live here smoke cigarettes, cigars, little cigars, pipes, water pipes, hookah, or any other tobacco product inside this home?". Passive smoking was defined as at least one person who lives here smoking in the home. The data of physical activity was obtained from physical Activity data set and ascertained via the following NHANES question, "During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?"

Statistical analysis

R Statistical Software (version 4.0.3) was used for all statistical analyses. The "survey" package was used to adjust the data according to the stratified, multi-stage probabilistic cluster sampling design in NHANES for univariate analyses. According to the survey design, appropriate stratification variable (SDMVSTRA) and primary sampling unit variable (SDMVPSU) were used. The sociodemographic and dietary variables were log-transformed appropriately, the raw/non-log transformed data were used for statistical descriptions, and the log-transformed data were used for statistical analyses (including univariate tests and Lasso regression).For univariate analysis of sociodemographic data, t tests was performed for continuous variables and chi-square tests was performed for discrete variables. Dietary variables were described by median and quartile, and differences in dietary intake between children with normal weight and children with overweight or obesity were compared by rank sum test. A p-value <0.05 (two-tailed) was considered to be statistically significant.

The "glmnet" package was used to fit the logistic LASSO regression. Lasso reduces the possibility of overfitting by penalizing the absolute value of the regression coefficient. The coefficients shrink as the penalty increases, and some unnecessary/non-influential covariables are automatically removed from the model when their coefficients reach zero. Overweight and obesity were included in the logistic LASSO regression as the dependent variable Y, coded as 0 represents children with normal weight, 1 represents children with overweight or obesity. We included 29 dietary variables as continuous variables into the model. In addition, 6 potential confounding variables (including gender, age, passive smoking, ethnicity, days of at least 60 min of physical activity and annual household income) were also included in the logistic LASSO model. Ten-fold cross-validation was used to select the penalty termlambda (λ). Binomial deviation was used to measure the prediction performance of the fitting model.The built-in function in R produces two automatic λ's, and we chose lambda.1se (the largest λ within one standard error range of the minimal binomial deviation) because it results in a stricter penalty and a smaller covariable number than lambda.min (λ with the minimal binomial deviation). In our study, the lambda.min is 0.0017, and the lambda.1se was 0.0133(Fig. 2).

Results

Sociodemographic description

The sociodemographic characteristic of the study population was shown in Table 1. A total of 4,764 children were included, of whom 1,772 (37.2%) were classified as overweight or obese. There was significant difference in age, ethnicity, passive smoking, time of activity and annual household income between children with normal weight and children with overweight or obesity ($p<0.05$). Compared with children with normal weight, children with overweight or obesity were more likely to be Mexican American, older, exposed to passive smoking, have less exercise time and have lower income.

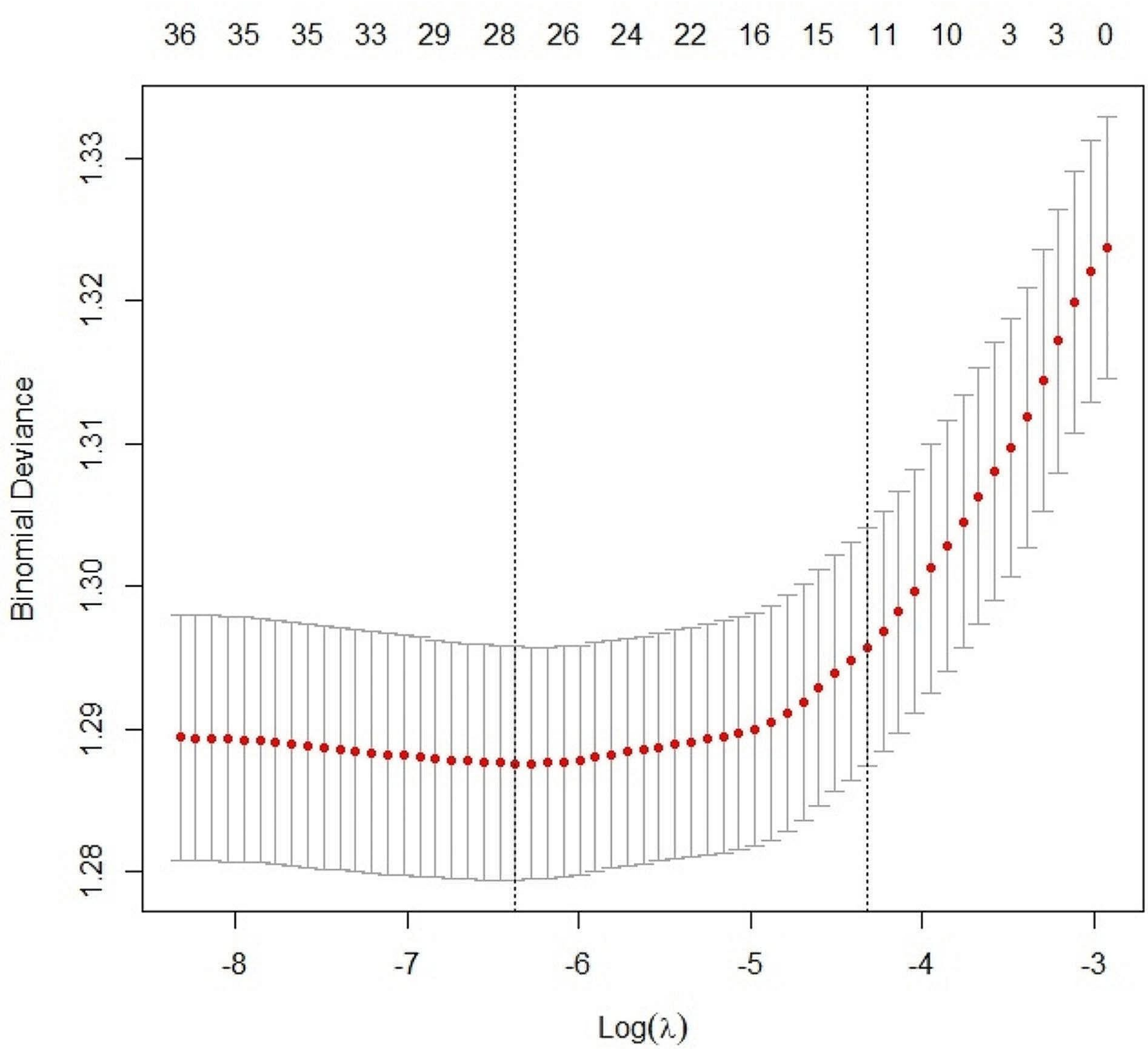

Fig. 2 Cross validation plot for the penalty term. Ten-fold cross-validation was used to select the penalty term lambda (λ). Binomial deviation was used to measure the prediction performance of the fitting model. The dotted line on the left indicated the value of the harmonicparameter log(λ) when λ = lambda. min (λ with the minimal binomial deviation). The dotted line on the right indicated the value of the harmonicparameter log(λ) when λ = lambda.1se(the largest λ within one standard error range of the minimal binomial deviation). The lambda. 1se was chosed because it results in a stricter penalty and a smaller covariable number than lambda.min. The lambda.1se was 0.0133 and 11 variables were selected

Table 1 The sociodemographic characteristics of the study population[1]

Characteristic	Children with normal weight (*n* = 2992)	Children with overweight or obesity (*n* = 1772)	t/χ²	*p*
Sex, n, (%)			0.272	0.602
Male	1541 (51.5%)	898 (50.68%)		
Female	1451 (48.5%)	874 (49.32%)		
Age, mean ± SD	9.59 ± 2.70	9.95 ± 2.70	-4.471	< 0.001
Passive smoking[2], n, (%)			6.346	0.012
No	2342(78.3%)	1330 (75.1%)		
Yes	650 (21.7%)	442 (24.9%)		
Race/Ethnicity, n, (%)			95.651	< 0.001
Mexican American	522 (17.5%)	464 (26.2%)		
Other Hispanic	309 (10.3%)	239 (13.5%)		
Non-Hispanic White	885 (29.6%)	401 (22.6%)		
Non-Hispanic Black	758 (25.3%)	464 (26.2%)		
Other Race[4]	518 (17.3%)	204 (11.5%)		
Days of at least 60 min of physical activity per week[3]	5.42 ± 2.14	5.07 ± 2.27	5.322	< 0.001
Annual household income			67.333	< 0.001
$0 to $14,999	403(13.5%)	257(14.5%)		
$15,000 to $24,999	446(14.9%)	313(17.7%)		
$25,000 to $34,999	364(12.2%)	274(15.5%)		
$35,000 to $44,999	305(10.2%)	227(12.8%)		
$45,000 to $54,999	234(7.8%)	151(8.5%)		
$55,000 to $64,999	150(5.0%)	101(5.7%)		
$65,000 to $74,999	147(4.9%)	71(4.0%)		
$75,000 and over	943(31.5%)	378(21.3%)		

[1] The study population comprised children aged 6–15 years who participated in the NHANES study from 2011 to 2016, n = 4764; [2] Passive smoking was defined as at least one person who lives here smoking in the home; [3] Days of at least 60 minutes of physical activity per week ascertained via the following NHANES question,"During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day? "; [4] Other races including non-Hispanic multiracial; The Sociodemographic variables were log-transformed appropriately, the raw/non-log transformed data were used for statistical descriptions, and the log-transformed data were used for statistical analyses; t test was performed for continuous variables and chi-square test was performed for discrete variables

Univariate analysis of dietary intake

The dietary intake of the study population was shown in Table 2. There was no significant difference in dietary intake of energy, protein, carbohydrate, fat, cholesterol, fiber, folate, vitamin B12, vitamin B6, thiamine, riboflavin, vitamin B3, choline, calcium, phosphorus, magnesium, iron, vitamin A, vitamin C, vitamin D, vitamin E, Vitamin K, zinc, sodium, potassium, selenium or caffeine between children with normal weight and children with overweight or obesity ($p > 0.05$).

Lasso regression analysis

Figure 3 showed the coefficient of variables in Lasso regression at $\lambda = 0.0133$. The results of Logistic Lasso regression analysis showed that age, Mexican American, other Hispanic, non-Hispanic White, other Race, passive smoking, days of at least 60 min of physical activity, annual household income, protein, vitamin A and caffeine contributed to childhood overweight and obesity. Specifically, increasing age($\beta = 0.010$),Mexican Americans($\beta = 0.322$), other Hispanic($\beta = 0.101$), passive exposure to smoking($\beta = 0.080$), higher protein intake($\beta = 0.013$) and higher caffeine intake($\beta = 0.0009$) were positively associated with overweight and obese, while non-Hispanic whites(β = -0.077), other races (β = -0.168), higher physical activity levels(β = -0.047), higher household income(β = -0.044) and higher vitamin A intake(β = -0.00003) were negatively associated with overweight and obese in children (Table 3).

Discussion

To our knowledge, this is the first study to analyze risk factors for childhood overweight and obesity utilizing the powerful LASSO shrinkage technique. A multitude of dietary variables were included in the model and unrelated variables were subsequently eliminated based on their correlation coefficients. Our initial univariate analysis showed significant differences in age, passive smoking, ethnicity, weekly active days and annual household income between children with normal weight and children with overweight or obesity, but no significant difference was observed in dietary nutrient intake. The ultimate Logistic Lasso regression analysis showed that increasing age, Hispanic ethnicity, passive exposure to smoking, higher protein intake, and higher caffeine intake were positively associated with overweight or obesity, while non-Hispanic White race, higher physical activity levels, higher household income, and higher vitamin A intake were negatively associated with child overweight or obesity.

In adults, especially older adults, age has been found to be associated with an increased risk of obesity [16]. Arner and colleagues followed the turnover of fat cell lipids in adults for 16 years and found that during the aging process, the lipid removal rate decreased, resulting in weight gain [14]. While evidence for this association in children is limited, our study provides insights by revealing that, in the absence of specific changes in diet and lifestyle, weight can accumulate with age, and this difference in weight is more pronounced in older children.

Race/ethnicity is a well established risk factor for childhood overweight and obesity. A study analyzed the influence of country of birth and country of residence on overweight and obesity found that children and adolescents born and raised in Mexico were less likely to be overweight or obese than Mexican-American children [17].Ogden and colleagues [18] analyzed the non-Hispanic population and found that the prevalence of obesity

Table 2 Dietary intake of the study population[1]

Dietary Variables[2]	Children with normal weight (*n* = 2992)	Children with overweight or obesity (*n* = 1772)	Z	*p*
Energy (Kcal)	1834.50(1419.75–2317.00)	1820.00(1400.00-2306.00)	-1.017	0.495
Protein (g)	62.61(45.83-83.00)	64.24(48.32–85.78)	1.170	0.450
Protein, % energy	12.38(9.86–15.34)	13.03(10.42–15.83)	2.404	0.251
Carbohydrate (g)	242.46(181.58–311.10)	240.14(179.27-307.14)	-2.499	0.242
Carbohydrate, % energy	53.46(47.91–58.96)	52.80(46.92–58.54)	-2.195	0.272
Fat (g)	67.89(49.42–89.75)	67.93(47.79–93.26)	-0.478	0.716
Fat, % energy	33.73(28.94–38.33)	34.07(28.95–38.74)	0.408	0.754
Cholesterol (mg)	171(105–287)	179(112–291)	3.685	0.169
Fiber (g)	13.10(9.10–18.10)	13.10(9.00-18.10)	-0.454	0.729
Folate (µg)	329.00(221.00-471.25)	317.00(217.00-461.00)	-0.981	0.506
Vitamin B12 (µg)	0.00(0.00-1.85)	0.00(0.00-1.69)	-1.020	0.494
Vitamin B6 (mg)	1.50(1.03–2.13)	1.51(1.04–2.14)	-0.200	-0.874
Thiamin (Vitamin B1) (mg)	1.44(1.04–1.97)	1.41(1.02–1.96)	-0.402	0.757
Riboflavin (Vitamin B2) (mg)	1.76(1.24–2.43)	1.76(1.20–2.38)	-1.138	0.459
Vitamin B3 (mg)	19.38(14.12–26.36)	19.68(14.09–27.04)	0.313	0.807
Choline (µg)	219.15(155.00-314.80)	220.00(156.20-317.5)	0.515	0.697
Calcium (mg)	871.50(591.00-1257.25)	907.00(587.00-1330.00)	-0.389	0.767
Phosphorous (mg)	1162.5(857.00-1545.5)	1194.00(879.00-1570.00)	-0.118	0.925
Magnesium (mg)	216.00(160.00-280.00)	218.00(161.00-286.00)	-0.476	0.717
Iron (mg)	12.96(9.13–17.95)	12.49(8.72–17.58)	-2.047	0.289
Vitamin A (RE)	512.5(303.0-777.0)	484.0(283.0-744.0)	-2.039	0.290
Vitamin C (mg)	53.15(23.00-104.35)	51.60(20.50-104.60)	-0.036	0.977
Vitamin D (µg)	4.35(2.18–7.40)	4.40(2.00-7.20)	-0.669	0.625
Vitamin E (mg)	6.17(4.19–8.86)	6.06(4.06-9.00)	-0.955	0.515
Vitamin K (µg)	47.85(28.50–79.40)	45.80(28.30–75.40)	-1.963	0.300
Zinc (mg)	8.96(6.12–12.42)	9.00(6.13–12.50)	-0.787	0.576
Sodium (mg)	2859.50(2088.50–3749.00)	2870.00(2065.00-3850.00)	0.396	0.760
Potassium (mg)	1993.00(1466.00-2634.25)	2026.00(1500.00-2650.00)	0.230	0.856
Selenium (µg)	88.10(63.20-120.1)	90.60(65.10-123.80)	0.676	0.622
Caffeine (mg)	3.00(0–18.00)	4.00(0–23.00)	0.892	0.536

[1] The study population was drawn from US children aged 6–15 years who participated in the NHANES study from 2011 to 2016, *n*=4764; [2] Dietary intakes were reported via a 24-h dietary recall; The dietary variables were log-transformed appropriately, the raw/non-log transformed data were used for statistical descriptions, and the log-transformed data were used for statistical analyses; Dietary variables were described by median and quartile, and differences in dietary intake between children with normal weight and children with overweight or obesity were compared by rank sum test

and severe obesity was significantly lower among non-Hispanic white youth compared with non-Hispanic black and other Hispanic youth. Our study is consistent with previous findings that Hispanic children were more likely to be obese, and non-Hispanic white children were less likely to be obese. The influence of race/ethnicity on children's weight may be related to the differences in lifestyle among different ethnic groups. Lower household income has also been identified as risk factors for childhood overweight and obesity [19]. A prospective study that followed 534 children ages 2 to 4 for three years found that children from low-income families had both higher baseline BMI and Higher BMI increases [20]. It is easier for low-income families to buy fast food due to its lower cost. However, there is a strong correlation between fast food consumption and higher rates of obesity [21].Children from low-income families have fewer opportunities to engage in regular physical exercise, and they tend to watch more TV, which makes them more susceptible to weight gain [22].

Obesity is the consequence of cumulative energy surplus. Increasing physical activity can help expend energy and help control children's weight, which has been confirmed in many studies [23], and our findings are consistent with these findings. Our study also found that passive smoking may be associated with overweight or obesity in children. The findings of Moore and colleagues are consistent with our study [24]. Secondhand smoke contains many compounds such as nicotine and polycyclic aromatic hydrocarbons, which may be endocrine disruptors that negatively affect insulin utilization and promote metabolic imbalances [25]. In addition, secondhand smoke is independently associated with inflammation and systemic oxidative stress, which play a role in the development of overweight and obesity in children [20].

High protein diet used to be thought to reduce the risk of overweight and obesity by increasing satiety [26–28],

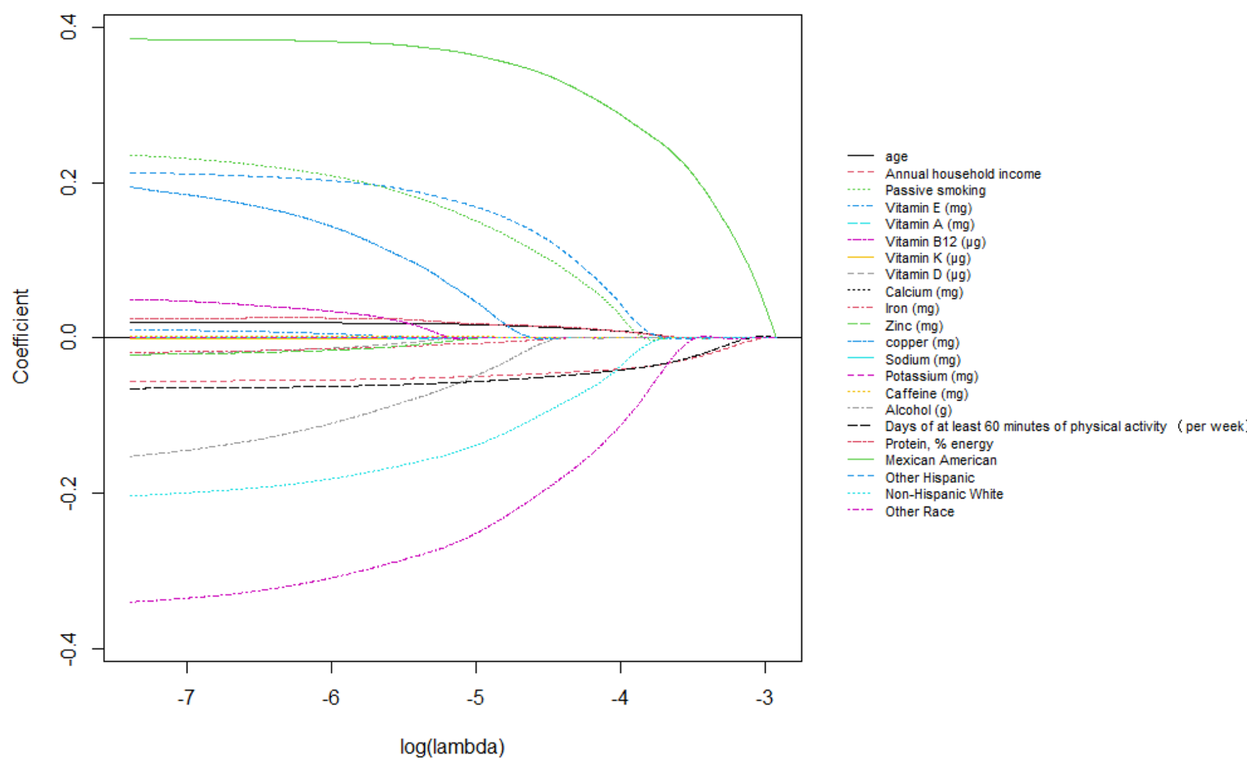

Fig. 3 Plots for LASSO regression coefficients over different values of the penalty parameter. I

which is inconsistent with our findings. Our study found that high protein intake may be positively associated with childhood overweight and obesity. In fact, several studies have found that high protein intake in infants and early childhood increases the risk of obesity [29]. Experts believe that once protein intake is enough to promote net lean body mass, the extra energy mainly produces more body fat [30]. The effect of protein on obesity remains controversial. The Chinese Adolescent Cohort (CAC) study found that higher protein intake in girls may increase the risk of childhood obesity, but no such relationship was found in boys [31]. A systematic review reported that the effects of a high-protein diets on body weight was inconclusive [32].In addition, animal and plant proteins may not have the same impact on childhood overweight and obesity. Epidemiological studies have shown that protein from dairy and vegetarian diets is associated with obesity prevention, while protein from meat (especially red meat) predicts higher weight gain [33, 34]. Therefore, further study is still needed.

The effects of caffeine on human health are not fully understood. Most previous studies have used coffee consumption to analyze the health effects of caffeine and have linked coffee consumption to a lower risk of type 2 diabetes, high blood pressure, obesity and depression [35]. But caffeine has also been suggested to increase the risk of anxiety, insomnia, tremors, heart palpitations, and bone loss [36]. The recent studies have found that caffeine may affect adults and children differently. Caffeine consumption in children may increase caloric intake and decrease intake of key nutrients, which can contribute to weight gain [37]. McCormick et al. found that caffeine consumption in childhood increases the risk of overweight and obesity [31]. Yu and colleagues found that the positive association between caffeine exposure and waist circumference, obesity, and overweight risk was more pronounced in children aged 6–11 years than in children aged 12–19 years, and this significant association remained when stratified by sex [38]. Multiple studies have shown that caffeine consumption in pregnant women has been associated with overweight and obesity in children [35]. In addition, studies have reported that caffeine consumption causes insufficient sleep in adolescents, which may also increase the risk of depression and obesity [39]. Our study also found an association between higher caffeine intake and higher rates of overweight or obesity in children. In order to determine the health effects of caffeine, more randomized controlled studies are needed.

We also found that vitamin A may reduce the risk of overweight and obesity. A cross-sectional study from the China National Nutrition and Health Surveillance of Children and Lactating Mothers is consistent with our conclusion, showing that the risk of obesity in

Table 3 The estimated coefficients for logistic LASSO regression between dietary data, and sociodemographic factors and overweight or obese

Variables[1]	Coefficients[2]
Sociodemographic variable	
Gender	0
Age (years)	0.010
Mexican American	0.322
Other Hispanic	0.101
Non-Hispanic White	-0.077
Non-Hispanic Black	0
Other Race	-0.168
Passive smoking	0.080
Days of at least 60 min of physical activity (per week)	-0.047
Annual household income(per$10,000)	-0.044
Dietary Variables	
Energy (Kcal)	0
Carbohydrate, % energy	0
Protein, % energy	0.013
Fat, % energy	0
Cholesterol (mg)	0
Fiber (g)	0
Folate (μg)	0
Vitamin B12 (μg)	0
Vitamin B6 (mg)	0
Thiamin (Vitamin B1) (mg)	0
Riboflavin (Vitamin B2) (mg)	0
Vitamin B3(mg)	0
Choline (μg)	0
Calcium (mg)	0
Phosphorous (mg)	0
Magnesium (mg)	0
Iron (mg)	0
copper(mg)	0
Vitamin A (RE)	-0.00003
Vitamin C (mg)	0
Vitamin D (μg)	0
Vitamin E (mg)	0
Vitamin K (μg)	0
Zinc (mg)	0
Sodium (mg)	0
Potassium (mg)	0
Selenium (μg)	0
Caffeine (mg)	0.0009

[1] The log-transformed sociodemographic and dietary variables were used for Lasso regression; [2] The estimated coefficients for logistic LASSO regression

adolescents and children increases with vitamin A levels [40]. Studies of children and adolescents in the United States have also found that vitamin A may cause overweight and obesity [41, 42]. This may be related to the important role vitamin A plays in immune function [43]. In addition, obesity is A chronic inflammatory state, and vitamin A has been found to have anti-inflammatory effects [44]. Vitamin A deficiency may increase the risk of fat deposits, as well as the risk of chronic inflammation associated with overweight and obesity. However, this conclusion needs to be further tested. Some studies have produced different results, finding that low serum retinol concentrations are associated with higher BMI [45, 46]. These studies included people with higher BMIs. Vitamin A, as a fat-soluble vitamin, is involved in lipid metabolism in its active form and is associated with elevated lipid concentrations [47]. Therefore, the effects of retinol on fat biology may vary in different BMI individuals.

Our study obtained a large national sample through the NHANSE, including diverse racial subgroups, with strong representativeness, and provided sufficient power to detect clinically relevant differences. Simultaneously, a modern statistical technique LASSO regression was used to ensure more reasonable results. There are some limitations in our study: (1)Cross-sectional design limits the inference of causality. (2)The dietary intake we reported come from food only, and supplements may have an impact on the results of the study.(3) Obese children may change their eating habits, affecting the relationship between dietary intake and obesity. In future studies, we will conduct prospective research to delve deeper into the association between dietary intake and overweight and obesity in children. Furthermore, we aim to provide a more detailed classification of nutrients, considering factors such as plant vs. animal sources of protein, and simple versus complex carbohydrates.

Conclusion

Our study confirms that ethnicity, annual household income, physical activity and passive smoking are contributing factors to overweight and childhood obesity. We also found that a high-protein diet, increasing age and caffeine intake were positively associated with childhood overweight and obesity, while higher intake of Vitamin A was negatively associated with childhood overweight and obesity.

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None.

Author contributions
Wu Hui and Yangming Qu conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript. Wei Xu and Shijie Guo collected data, carried out the initial analyses, and reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Data availability
We used data from NHANES database, which is a publicly available dataset.

Declarations

Ethics approval
We used data from NHANES database. Since NHANES is a publicly available dataset, the current study is exempt from approval byanInstitutional Review Board.

Consent for publication
All co-authors agree to publish this manuscript.

Competing interests
The authors declare no competing interests.

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