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Association between body weight status and suicidal ideation among Chinese adolescents: the moderating role of the child's sex

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Abstract

Purpose Suicidality (ranging from suicidal ideation to suicidal attempts and completed suicide) is a major and preventable public health concern, and body weight is considered a modifiable factor which might be helpful to the early risk assessment of suicidal ideation. This study aimed to comprehensively evaluate the association of body weight status with suicidal ideation across sex among Chinese adolescents.

Methods Data were drawn from the 2015 National School-based Chinese Adolescents Health Survey, and 54,640 students' questionnaires were completed and qualified for the survey. Body mass index z scores were calculated and categorized into four levels: underweight (less than the 5th percentile for sex and age), normal weight (between the 5th and 85th percentile), overweight (between the 85th and 95th percentile), and obese (above the 95th percentile).

Results Of the total sample, 47.3% (25,852) were boys. The weighted prevalence of suicidal ideation among Chinese adolescents is 15.7% (14.6% in boys and 17.3% in girls). After adjusting for demographics, smoking, drinking, and depressive symptoms, our final multivariate logistic regression models demonstrated that only boys identified as underweight (Adjusted odds ratio [AOR] = 1.23, 95% CI = 1.06–1.44) or obese (AOR = 1.19, 95% CI = 1.02–1.38) were at a higher risk of suicidal ideation. Additionally, the association between weight status and suicidal ideation among boys might be moderated by academic pressure, smoking, and depressive symptoms.

Conclusions There was a significant J-shaped association between relative body weight and suicidal ideation in boys. The child's sex should be taken into consideration when developing interventions against unhealthy weight and suicidal ideation.

Keywords Body weight status · Suicidal ideation · Chinese adolescents · Sex difference

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Background

Suicidality (ranging from suicidal ideation to suicidal attempts and completed suicide) is a major and preventable public health concern causing more than 800,000 deaths worldwide ever year, and suicide ideation can occur throughout the lifespan and is the leading cause of death among adolescents and young adults (between 15 and 29 years old) [1]. Suicidal ideation is more common than suicidal attempts and completed suicide, and is considered a risk factor of suicidal attempts and completed suicide in adolescence [2]. Despite the fact that the overall suicide rate in China has been decreased from the ratio in the 1990s [3], suicidal ideation among Chinese adolescents is still a major public health problem recently [4]. Cui et al. [4] reported that approximately 16.9% of Chinese adolescents reported having had suicidal ideation during the last year, and our previous study also demonstrated that the prevalence of suicidal ideation in adolescents was 16.7% [5]. Suicidal ideation among adolescents can lead to a substantial economic, social and psychological burden for the individuals, families, and communities [1]. Moreover, girls were reported to have higher rates of suicidal ideation than boys [6]. Suicidal ideation is multifactorial; age, sex, and unanticipated adverse life events are conventional risk factors of suicidal ideation; however, most of these factors are not modifiable.

Body mass index (BMI) has been a conventional measure of relative body weight status and can be a marker of underweight or overweight/obesity [7]. Recently, evidence exists that despite the rapid rising of worldwide prevalence of overweight and obesity among adolescents [8], underweight remains an important problem for adolescents in developing countries [9]. Previous studies showed that compared to their normal-weight peers, adolescents who were underweight or overweight/obese were more likely to experience lower levels of social support and higher levels of perceived self-stigma [10], and these experiences were found to be positively associated with suicidal ideation [11]. However, the association between body weight status and suicidal ideation is still controversial. Some previous studies have demonstrated that adolescents identified as overweight or obese were at an increased risk of suicidal ideation [12], and women who were severely obese and underweight were at a higher risk of suicidal ideation [13]; whereas, other studies illustrated an inverse relationship between BMI and suicidal ideation [14] or a non-significant association [15]. Although the impact of body weight on suicidal ideation is still unclear [16], body weight is considered a vital modifiable factor which might be helpful to the early risk assessment of suicidal ideation, and can contribute to providing suggestions for interventions [17].

Adolescence is often characterized as a stage of increased imitation and exploration along with a range of risky health behaviors (e.g., suicidal ideation) [18], but few studies have examined the association between weight status and suicidal ideation among adolescents. Additionally, there is also a paucity of studies considering the potential effects of the sex of the child on the association.

To our knowledge, most prior studies evaluating the association between body weight status and suicidal ideation were performed in western or developed countries. China is one of the largest developing countries in the world with nearly a fifth of the global population [19], and Chinese diets is shifting from a rice-based diet to a diet with high fat and energy density with the development of economy [20]. However, very few studies on Chinese adolescents have addressed this topic. Therefore, we conducted this national study to estimate the prevalence of suicidal ideation and body weight status (underweight, normal weight, overweight, and obese) among Chinese adolescents, and to comprehensively evaluate the association of body weight status with suicidal ideation across sex.

Methods

Study design and participants

Data were drawn from the 2015 National School-based Chinese Adolescents Health Survey (SCAHS). The 2015 SCAHS sampling is structured to obtain representative populations of Chinese adolescents. In stage 1, five large provinces were selected according to geographic locations: (1) Eastern China including Shandong; (2) Western China including Guizhou; (3) Southern China including Guangdong; (4) Northern China including Liaoning; (5) Central China including Hunan. According to gross domestic product (GDP) per capita, each province was categorized into three stratifications (high economic level, middle economic level, and low economic level), and there were two representative cities randomly selected from each stratification. In stage 2, in each representative city, there were two types of high schools (general high schools focusing on educating students for entering university and vocational high schools offering specific vocational training). Four general and four vocational high schools were randomly chosen. In stage 3, we randomly chose two classes from each grade within the chosen schools. All available students in the selected classes were invited to voluntarily participate in our study. A total of 57,589 students were invited to participate in this study, and 54,640 students completed the questionnaires successfully (response rate: 94.9%). To protect the students' privacy, a rigorously anonymous method was utilized to collect information from the self-report questionnaires. Additionally, to

minimize the potential information bias, students fulfilled the questionnaires during the normal class period (45 min) in the classroom without the presence of teachers.

Ethical statement

This study obtained the ethical approval from the Sun Yat-Sen University School of Public Health Institutional Review Board. After the study procedure had been fully explained, written informed consents were obtained from each participating student who was at least 18 years of age. If the student was under 18 years of age, a written informed consent was obtained from the student's parents (or legal guardians).

Measures

Suicidal ideation

Suicidal ideation was defined as responding "one or more times" to the question, "During the past 12 months, how many times did you seriously consider attempting suicide [21]?"

BMI

BMI was an individual's weight in kilograms divided by the square of height in meters. According to the standardized growth charts from the Working Group on Obesity for Children (WGOC) in China, BMI z scores (standard deviation: SD) for each student were calculated to represent the deviation compared with an average child of the same sex and age [22]. Students with a BMI z score less than the 5th percentile for sex and age were considered "underweight", students with a BMI z score between the 5th and 85th percentile were deemed "normal or healthy weight", students with a BMI z score between the 85th and 95th percentile were considered overweight, and those with a BMI z score above the 95th percentile were thought obese [23].

Measures of control variables

Control variables included the factors that have previously been reported to be related to BMI or suicidal ideation [13, 17, 24]. First, the Center for Epidemiologic Studies scale (CES-D) in Chinese was used to measure depressive symptoms, and the scale in Chinese has been validated [25] and extensively utilized. The respondents were asked to rate the frequency of 20 items about depressive symptoms over the past week, with four response options of each item that range from "rarely or none of the time = 1" to "most or all of the time = 4". The total score of the 20 items ranges from 0 to 60 with higher scores indicating more severe depressive symptomatology.

Second, demographic information including sex (1 = boys, 2 = girls), age, living arrangement, household socioeconomic status (HSS), classmate relations, and relationships with teachers was also collected. Students' living arrangements (including "living with both parents" = 1, "living with a single parent" = 2, and "living with others" = 3) were measured by asking students who were living in their primary home. HSS (categorized into "excellent or very good" = 1, "good" = 2, and "fair or poor" = 3) was assessed by asking students about their perception of their family's economic status. Classmate relations and relationships with teachers were measured by asking the student's perception of their relationships with classmates and teachers (responses range from "good" = 1 to "poor" = 3). Academic pressure was assessed by the student's self-rating of his or her academic pressure (responses were coded as "above average" = 1, "average" = 2, "below average" = 3). Current smokers represented the students who reported smoking cigarettes on 1 or more days during the last month [26]. Students who reported drinking alcohol on at least 1 day during the last month were considered as current drinkers [27].

Statistical analysis

Appropriate sampling weights and estimation procedures that accounted for the complex sampling design were utilized in the prevalence estimates and logistic regression analyses (National Health and Nutrition Examination Survey (NHANES) [28]). To assess any sex differences in the associations, sex-stratified analyses were conducted. First, descriptive analyses stratified by suicidal ideation were used to describe the sample characteristics, and the prevalence rates were weighted estimations for the study populations. Second, considering students were grouped into schools for the use of multistage cluster random sampling method in this study, multi-level logistic regression models in which schools were treated as clusters were fitted. To explore the potentially associated factors of suicidal ideation, univariate multi-level logistic regression analyses were performed first. Next, multivariate multi-level logistic regression analyses were conducted to assess the independent relationships between body weight status and suicidal ideation, and those variables that were widely reported in the literature (e.g., age) or significant at 0.10 level in the univariate analyses were simultaneously entered into the multivariate logistic regression models. For all relevant variables, the percentage of missing data was less than 2.2%. Regarding the logistic regression analyses, observations with missing data were eliminated. All statistical analyses were conducted using SAS 9.2 (SAS Institute, Inc., Cary, NC, USA). All statistical tests were two sided, and a P value of less than 0.05 was considered statistically significant.

Table 1 Sample characteristics stratified by suicidal ideation (N = 54,640)

Variables	Total, n (%)	Boys, n (%)			Girls, n (%)		
		Total	Suicidal ideation	P value[#]	Total	Suicidal ideation	P value[#]
Total	54,560 (100)	25,852 (47.3)	3605 (13.9)		28,788 (52.7)	4941 (17.2)	
Age[a]	15.3 (1.7)	15.2 (1.7)	15.3 (1.6)	0.097	15.3 (1.7)	15.2 (1.7)	<0.001
Living arrangement							
Living with parents	43,808 (80.4)	20,344 (78.9)	2672 (13.1)	<0.001	23,464 (81.7)	3735 (15.9)	<0.001
Living with a single parent	5028 (9.2)	2568 (10.0)	425 (16.5)		2460 (8.6)	574 (23.3)	
Living with others	5672 (10.4)	2870 (11.1)	493 (17.2)		2802 (9.8)	619 (22.1)	
Missing data	132	70			62		
HSS							
Excellent	13,226 (24.3)	6559 (25.5)	822 (12.5)	<0.001	6667 (23.2)	1148 (17.2)	<0.001
Good	33,833 (62.1)	15,326 (59.5)	2009 (13.1)		18,507 (64.5)	3029 (16.4)	
Fair	7411 (13.6)	3884 (15.1)	758 (19.5)		3527 (12.3)	752 (21.3)	
Missing data	170	83			87		
Academic pressure							
Above average	9612 (17.6)	5128 (19.9)	481 (9.4)	<0.001	4484 (15.6)	542 (12.1)	<0.001
Average	25,332 (46.4)	11,364 (44.0)	1165 (10.3)		13,968 (48.6)	1803 (12.9)	
Below average	19,643 (36.0)	9331 (36.1)	1958 (21.0)		10,312 (35.9)	2593 (25.1)	
Missing data	53	29			24		
Classmate relations							
Good	42,072 (77.2)	20,027 (77.7)	2435 (12.2)	<0.001	22,045 (76.8)	3362 (15.3)	<0.001
Average	11,579 (21.3)	5210 (20.2)	954 (18.3)		6369 (22.2)	1435 (22.5)	
Poor	838 (1.5)	529 (2.1)	204 (38.6)		309 (1.1)	137 (44.3)	
Missing data	151	86			65		
Teacher–classmate relationships							
Good	32,973 (60.5)	15,764 (61.2)	1694 (10.7)	<0.001	17,209 (59.9)	2401 (14.0)	<0.001
Average	20,011 (36.7)	8931 (34.7)	1515 (17.0)		11,080 (38.6)	2346 (21.2)	
Poor	1500 (2.7)	1062 (4.1)	385 (36.3)		438 (1.5)	184 (42.0)	
Missing data	156	95			61		
Smoking							
No	50,899 (95.3)	23,171 (91.7)	3061 (13.2)	<0.001	27,728 (96.3)	4644 (16.7)	<0.001
Yes	2513 (4.7)	2103 (8.3)	480 (22.8)		410 (1.4)	189 (46.1)	
Missing data	1228	578			650		
Alcohol drinking							
No	27,932 (52.2)	11,329 (44.7)	1061 (9.4)	<0.001	16,603 (58.9)	1903 (11.5)	<0.001
Yes	25,594 (47.8)	13,998 (55.3)	2490 (17.8)		11,596 (41.1)	2972 (25.6)	
Missing data	1114	525			589		
CES-D score[a]	20.8 (7.2)	20.7 (7.5)	21.6 (8.0)	<0.001	16,603 (58.9)	1903 (11.5)	<0.001
Depressive symptoms							
Yes (CES-D score ≥ 16)	15,285 (28.0)	7314 (18.3)	965 (13.2)	0.029	7971 (27.7)	1340 (16.8)	0.326
No	39,355 (72.0)	18,538 (71.7)	2640 (14.2)		20,817 (72.3)	3601 (17.3)	
BMI (kg/m^2)[a]	19.6 (3.1)	20.0 (3.4)	20.1 (3.6)	0.003	11,596 (41.1)	2972 (25.6)	<0.001
BMI z score[a]	0.06 (1.1)	0.1 (1.2)	0.2 (1.2)	0.012	589		<0.001

SD standard deviation, HSS household socioeconomic status, CES-D Center for Epidemiologic Studies Scale, BMI body mass index

[#] Chi-squared tests were used for categorical variables, and t tests were used for continuous data

[a] Age data, CES-D score, BMI data, and BMI z score were presented as the mean (SD)

Results

Demographic characteristics of the study sample

Basic demographic information is shown in Table 1. Of the total sample, 47.3% (25,852) were boys, and 52.7% (28,788) were girls, yielding a male-to-female ratio of 1:1.11. The mean age of the students was 15.3 (SD: ± 1.7) years. The majority of students lived in families with two parents (80.4%); the proportion of students who reported poor classmate relations and relationships with teachers was 1.5% and 2.7%, respectively. Approximately 4.7% students admitted smoking, and 47.8% students reported drinking. The mean CES-D score of the students was 20.8 (SD: ± 7.2).

Prevalence of suicidal ideation and body weight status among adolescents

The weighted prevalence of suicidal ideation among Chinese adolescents was 15.7% [95% CI, 15.4–16.0] (14.0% [95% CI, 13.6–14.4] in boys and 17.3% [95% CI, 16.8–17.7] in girls). Regarding the body weight status, the weighted prevalence of underweight was 5.9% [95% CI, 5.7–6.1] (6.2% [95% CI, 6.0-6.5] in boys and 5.5% [95% CI, 5.3–5.8] in girls), the weighted prevalence of normal weight was 78.8% [95% CI, 78.5–79.2] (75.8% [95% CI, 75.1–76.3] in boys and 81.6% [95% CI, 81.1–82.0] in girls), the weighted prevalence of overweight was 10.1% [95% CI, 9.8–10.3] (11.2% [95% CI, 10.9–11.7] in boys and 8.0% [95% CI = 8.7–9.3] in girls), and the weighted prevalence of obesity was 5.3% [95% CI, 5.1–5.4] (6.8% [95% CI, 6.5–7.1] in boys and 3.9% [95% CI, 3.7–4.2] in girls).

Potential factors associated with suicidal ideation

First, without adjusting for other variables, living arrangement, academic pressure, HSS, classmate relations, relationships with teachers, smoking, drinking, depressive symptoms, and weight status were associated with suicidal ideation in boys ($P < 0.05$). Among girls, without adjusting for other variables, age, living arrangement, HSS, academic pressure, classmate relations, relationships with teachers, smoking, drinking, depressive symptoms, and weight status were also related to suicidal ideation ($P < 0.05$) (Table 2).

Associations of weight status with suicidal ideation among adolescents

First, the interaction item (between gender and weight status) was significantly associated with suicidal ideation in the multivariate multi-level logistic regression model ($P < 0.001$). Additionally, our final models demonstrated that after adjusting for age, living arrangement, HSS, academic pressure, classmate relations, relationships with teachers, smoking, drinking, and depressive symptom, only boys identified as underweight (Adjusted odds ratio [AOR] = 1.23, 95% CI = 1.06–1.44) and obese (AOR = 1.19, 95% CI = 1.02–1.38) were at a higher risk of suicidal ideation. (Table 3; Fig. 1).

Associations of weight status with suicidal ideation among boys: moderation by potential variables

First, after adjusting for other variables, the associations between the interaction items (between living arrangement, HSS, classmate relations, relationships with teachers, drinking and weight status, respectively) and suicidal ideation were not statistically significant among boys ($P = 0.371$, 0.537, 0.145, 0.483, 0.578, respectively). But the interaction items (between academic pressure, smoking, depressive symptoms and weight status, respectively) were significantly associated with suicidal ideation among boys ($P_{all} < 0.001$). Then, in Table 4, among boys, multivariate multi-level logistic regression analyses stratified by academic pressure, smoking, and depressive symptoms were performed. The results demonstrated that among boys reporting below average academic pressure, being underweight (AOR = 1.31, 95% CI = 1.05–1.65) or obese (AOR = 1.66, 95% CI = 1.16–2.37) was positively associated with suicidal ideation. Regarding the smoking status, among boys reporting not smoking, being underweight (AOR = 1.21, 95% CI = 1.03–1.43), was associated with an increased risk of suicidal ideation; regarding the depressive symptoms status, the association of being underweight (AOR = 1.24, 95% CI = 1.03–1.51), overweight (AOR = 1.23, 95% CI = 1.04–1.44), or obese (AOR = 1.34, 95% CI = 1.10–1.64) with suicidal ideation was only significant in boys without depressive symptoms. These findings suggested that the adjusted association between weight status and suicidal ideation among boys might be moderated by academic pressure, smoking, and depressive symptoms.

Discussion

The present study first found that the weighted prevalence of suicidal ideation among Chinese adolescents was 15.7%, and the results were consistent with our previous findings among adolescents (16.7%) [24] and a previous national survey among high school students in the United States (15.8%) [29]. It is well established that the rate of suicidal ideation was associated with sex, and our study also found that the prevalence of suicidal ideation in girls (17.3%) was higher than that in boys (14.0%). The use of BMI for age and sex to define underweight, overweight, and obese in adolescents is well established for both clinical and public

Table 2 Unadjusted odds ratios and 95% confidence interval of suicidal ideation among Chinese adolescents (N = 54,640)

Variables	Boys		Girls	
	OR (95% CI)	P value	OR (95% CI)	P value
Age (1-year increase)	1.02 (0.99–1.04)	0.083	0.95 (0.93–0.96)	<0.001
Living arrangement				
Living with parents	1.00 (reference)		1.00 (reference)	
Living with a single parent	1.31 (1.17–1.47)	<0.001	1.61 (1.46–1.78)	<0.001
Living with others	1.37 (1.23–1.52)	<0.001	1.50 (1.37–1.65)	<0.001
HSS				
Excellent	1.00 (reference)		1.00 (reference)	
Good	1.06 (0.97–1.15)	0.245	0.94 (0.87–1.01)	0.109
Fair	1.70 (1.52–1.89)	<0.001	1.31 (1.18–1.45)	<0.001
Academic pressure				
Above average	1.00 (reference)		1.00 (reference)	
Average	1.11 (0.99–1.24)	0.084	1.08 (0.97–1.20)	0.151
Below average	2.57 (2.31–2.86)	<0.001	2.45 (2.21–2.70)	<0.001
Classmate relations				
Good	1.00 (reference)		1.00 (reference)	
Average	1.62 (1.49–1.76)	<0.001	1.62 (1.51–1.73)	<0.001
Poor	4.52 (3.78–5.42)	<0.001	4.51 (3.59–5.66)	<0.001
Teacher–classmate relationships				
Good	1.00 (reference)		1.00 (reference)	
Average	1.70 (1.58–1.83)	<0.001	1.66 (1.56–1.76)	<0.001
Poor	4.74 (4.14–5.43)	<0.001	4.50 (3.70–5.47)	<0.001
Smoking				
No	1.00 (reference)		1.00 (reference)	
Yes	1.94 (1.74–2.16)	<0.001	4.27 (3.51–5.2)	<0.001
Alcohol drinking				
No	1.00 (reference)		1.00 (reference)	
Yes	2.09 (1.94–2.26)	<0.001	2.66 (2.49–2.83)	<0.001
CES-D score (1-score increase)	1.02 (1.01–1.03)	<0.001	1.03 (1.01–1.04)	<0.001
Weight status				
Normal weight	1.00 (reference)		1.00 (reference)	
Underweight	1.16 (1.01–1.34)	0.040	1.01 (0.88–1.16)	0.899
Overweight	1.12 (1.01–1.26)	0.029	1.19 (1.07–1.32)	0.001
Obese	1.16 (1.02–1.33)	0.029	1.26 (1.09–1.47)	0.002

OR odds ratio, *CI* confidence interval, *HSS* household socioeconomic status, *CES-D* Center for Epidemiologic Studies Scale

health applications; and our study using the standards for adolescents found that the weighted prevalence of underweight, normal weight, overweight, and obesity is 5.9% (6.2% in boys vs. 5.5% in girls), 78.8% (75.8% in boys and 81.6% in girls), 10.1% (11.2% in boys vs. 8.0% in girls), and 5.3% (6.8% in boys vs. 3.9% in girls), respectively. The prevalence of underweight was higher (the prevalence of overweight and obesity was lower) than that described in previous reports from the Centers for Disease Control and Prevention in the United States which showed that 3.2% of the adolescents aged 12–19 years were underweight, and the prevalence of overweight and obesity among children and adolescents was 16.2% and 17.2%, respectively [30].

These results might be related to the differences in the nature of the samples (e.g., body composition of different ethnic groups) and the disparities in dietary habit. Prior studies reported that Asians are different from Caucasians in body fat content and distribution, and in their BMI/body fat percent relationship, and Asians are more likely to have lower BMI but greater percent body fat than Caucasians [31, 32]. Additionally, although the Chinese diet is shifting to a diet with high fat and high energy density with the development of economy, the traditional Chinese diet is rice based, and includes plentiful vegetables [20].

Our univariate logistic regression models first demonstrated that underweight, overweight, and obesity were

Table 3 Adjusted odds ratios and 95% confidence intervals of suicidal ideation among Chinese adolescents ($N = 54,640$)

Variables	Boys[a]		Girls[a]	
	AOR (95% CI)	*P* value	AOR (95% CI)	*P* value
Weight status				
Normal weight	1.00 (reference)		1.00 (reference)	
Underweight	1.23 (1.06–1.44)	0.007	1.08 (0.93–1.25)	0.405
Overweight	1.10 (0.98–1.25)	0.087	1.11 (0.99–1.25)	0.065
Obese	1.19 (1.02–1.38)	0.018	1.13 (0.96–1.34)	0.115

AOR adjusted odds ratio, *CI* confidence interval

[a]Models for suicidal ideation in boys and girls were adjusted for age, living arrangement, HSS, academic pressure, classmate relations, relationships with teachers, smoking, drinking, and depressive symptoms, respectively

associated with suicidal ideation both in boys and girls. Additionally, previous studies reported that depressive symptoms are correlated with either under- or over-eating, and are associated with suicidal ideation [24, 33]. Importantly, after adjusting for depressive symptoms, as well as age, living arrangement, HSS, academic pressure, classmate relations, relationships with teachers, smoking, and drinking, our final multivariate multi-level logistic regression models illustrated that only boys who were underweight had a 1.23 times risk of suicidal ideation than those identified as normal weight, and boys who were obese were 1.19 times more likely to be involved in suicidal ideation than their corresponding group, suggesting that there was a J-shaped association between weight status and suicidal ideation in boys. Additionally, our adjusted models did not find a significant association between weight status and suicidal ideation in girls. These findings suggested that the sex of the child may play a moderating role in the association between body weight status and suicidal ideation. Similarly, Chang et al. [34] found a J-shaped association in which individuals who were underweight and obese were at a higher risk of suicide; Kelly et al. [35] suggested that only individuals who were obese were significantly more likely to experience suicidal ideation; Zeller et al. [36] also reported being obese or extremely obese was related to significantly greater risk for adolescent engagement in suicidal ideation. The interpersonal theory of suicidal behavior may prepare a possible explanation for these results, and that is individuals with low social support (even social stigma or isolation) were at an elevated risk of suicidal ideation. In today's society, fitness is popular among adolescents, negative attitudes towards individuals who were obese are obvious, and it is crucial to acknowledge that individuals identified as underweight may face stigma as well [37]. Students identified as obese are stigmatized as lacking in self-control [33], and boys who are underweight may be stigmatized for being "scrawny" [38]. Therefore, it is possible that adolescents identified as underweight or obese have higher levels of thwarted social support and perceived self-stigma, which may elevate their risks for suicidal ideation. Moreover, the association between underweight/obesity and suicidal ideation is biologically possible; low BMI is one of the insulin resistance markers which have shown to be associated with an elevated suicide risk [39] Obesity is a known risk factor of chronic disease, such as

Fig. 1 Association between weight status and suicidal ideation in boys and girls
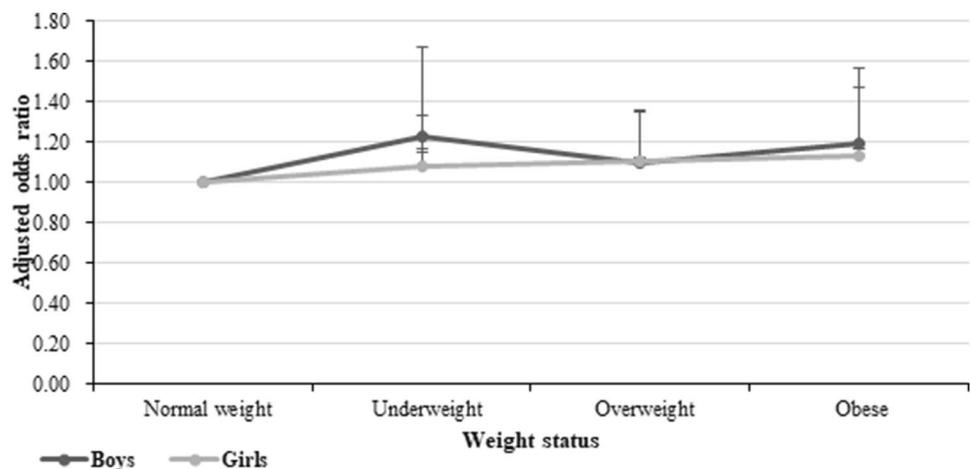
Table 4 Associations of weight status with suicidal ideation among boys: moderation by potential variables

Variables	Academic pressure, AOR (95% CI)[a]			Smoking, AOR (95% CI)[b]		Depressive symptoms, AOR (95% CI)[c]	
	Above average	Average	Below average	Yes	No	Yes (CES-D score ≥ 16)	No
Weight status							
Normal weight	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Underweight	0.95 (0.62–1.45)	1.26 (0.98–1.63)	1.31 (105–1.65)*	1.48 (0.95–2.30)	1.21 (1.03–1.43)*	1.06 (0.81–1.40)	1.24 (1.03–1.51)*
Overweight	1.23 (0.90–1.70)	1.25 (0.97–1.53)	1.00 (0.84–1.19)	0.93 (0.63–1.38)	1.14 (0.98–1.29)	1.08 (0.89–1.31)	1.23 (1.04–1.44)*
Obese	1.17 (0.94–1.44)	1.04 (0.80–1.36)	1.66 (1.16–2.37)*	1.51 (0.94–2.43)	1.17 (0.98–1.37)	1.22 (0.96–1.53)	1.34 (1.10–1.64)*

AOR Adjusted odds ratio, *CI* confidence interval, *CES-D* Center for Epidemiologic Studies Scale

*$P < 0.05$

[a]Model for the moderation effects of academic pressure were adjusted for age, living arrangement, HSS, classmate relations, relationships with teachers, smoking, drinking, and depressive symptoms

[b]Model for the moderation effects of smoking were adjusted for age, living arrangement, HSS, academic pressure, classmate relations, relationships with teachers, drinking, and depressive symptoms

[c]Model for the moderation effects of depressive symptoms were adjusted for age, living arrangement, HSS, academic pressure, classmate relations, relationships with teachers, smoking, and drinking

diabetes, and adolescents with diabetes have been shown to report higher levels of suicidal ideation. Although the reason why there was a difference in the association between relative body weight and suicidal ideation in boys and girls was unclear, in line with our study, Carpenter et al. [40] also reported that sex played a significant moderator role in the association between BMI and suicidal ideation, and Jee et al. [41] reported a significant inverse association between BMI and suicide among men, but no effect in women. A possible explanation for the difference by sex is that the number of boys who were underweight or obese was larger than that of girls, and the small number of girls identified as underweight or obese in the present study might have made it difficult to detect a significant association. Another plausible explanation might be related to social engagement. A positive social engagement could increase socio-emotional maturity, self-esteem, and body satisfaction [42], and some evidence suggested that girls generally reported more social engagement than boys [43]. Overall, these findings suggest some preventive and coping recommendations against unhealthy weight and suicidal ideation among adolescents: (1) providing early risk assessment and preventive strategies to adolescents who have experienced suicidal ideation; (2) improving awareness of the history of suicidal ideation in clinical assessments to help identify modifiable risk factors for adolescents with unhealthy weight; (3) offering effective intervention measures for students with unhealthy weight (e.g., encouraging physical activities, developing better dietary habits, providing proper nutritional supplements, and allowing suitable pharmacological treatments to adolescents who have a clinical diagnosis of unhealthy weight); (4) establishing a scientific long-term surveillance system to monitor BMI and suicidal behavior among Chinese adolescents. Additionally, the aforementioned interventions should take sex into consideration, and future studies are warranted to report the reasons of differences by sex in the association of relative body weight and suicidal ideation.

Moreover, we conducted the further stratification analyses among boys by academic pressure, smoking, and depressive symptoms. The results found that among boys reporting below average academic pressure, being underweight or obese was associated with an increased risk of suicidal ideation; among boys reporting not smoking, being underweight was positively related to suicidal ideation; among boys without depressive symptoms, being underweight, overweight, or obese was positively associated with suicidal ideation. These findings suggested that academic pressure, smoking, or depressive symptoms may moderate the associations between weight status and suicidal ideation among boys. These results might be related to that a number of studies have identified potential risk factors for comorbid overweight or obesity and depression, including academic pressure [44], and depressive symptoms are a well-known

risk factor for suicidal ideation among adolescents [45]. We hypothesized that in students with higher academic pressure or depressive symptoms, it might be depressive symptoms, rather than weight status, that predispose the associations between weight status and suicidal ideation. Additionally, academic stress has been a serious social problem. Most Chinese high schools start earlier than 07:00 a.m., keep students in classes for long hours, assign a mass of homework, and organize countless exams [46]. School schedule may also reflect certain cultural attributes, and it is well known that Chinese high school students are burdened with tremendous academic stress even to the extent of sacrificing sleep time [47]. Therefore, students with higher academic pressure may have higher likelihood of sleep problems, and sleep problems have been reported to be positively associated with suicidal ideation [5]. Among these students, it might be sleep problems rather than academic pressure predisposing the association between weight status and suicidal ideation. Moreover, prior studies show that smoking may be associated with lower BMI [48], and is a risk factor for suicidal ideation [49]. Thus, in this study, it is likely that students who are not smoking may be more vulnerable to the effects of weight status on suicidal ideation. These findings suggest that the mechanism of the associations between weight status and suicidal ideation among boys is complex and not entirely clear, and we cannot neglect the moderating effects of academic pressure, smoking, and depressive symptoms. Furthermore, the sample size may have influences on the stratification results. In this study, after stratified by academic pressure, smoking, and depressive symptoms, the number of students reporting above average pressure, smoking, or having depressive symptoms is less than their corresponding groups, and the small sample size may not have enough power to yield a statistically significant result. Thus, the stratification result needs to be verified by future studies.

In general, the primary strengths of the current study are that it includes a large-scale representative sample of Chinese adolescents, it illustrates the information about the less known association of relative body weight status and suicidal ideation among adolescents, it adopts the BMI z scores to categorize the adolescents' weight status, and it considers the effect of the child's sex on the association of relative body weight and suicidal ideation. Although there were some strengths, several limitations of this study should be noted when interpreting the results. First, only school students were sampled in this study, and adolescents dropping out of school or not presenting in school on the day the survey was administered were not covered. However, suicidal ideation might be more common among those who were absent. Second, due to the cross-sectional nature of the data, all reported associations should be interpreted with caution. Third, potential recall bias might exist due to the use of the retrospective self-report questionnaire. Fourth, the

association of relative weight status with suicidal ideation may be influenced not only by depressive symptoms, smoking, and drinking, but also other psychiatric comorbidities (e.g., bipolar disorder or anxiety) and psychoactive drug use.

Conclusions

In conclusion, our study identified that boys who were underweight or obese were at a higher risk of suicidal ideation than those identified as normal weight, suggesting that there was a J-shaped associations between weight status and suicidal ideation in boys. Based on the findings of our study, suicidal ideation and unhealthy weight among adolescents should be a matter of concern for public health authorities in China, the establishment of a national long-term surveillance system to monitor adolescents' suicidal behavior and weight status is recommended, and the child's sex should be taken into consideration when developing or implementing related interventions.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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