

## ORIGINAL ARTICLE

## Pediatric Obesity

# Unfavorable progression of obesity in children and adolescents due to COVID-19 pandemic: A school-based survey in China

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## Abstract

**Objective:** The Chinese government decisively imposed nationwide confinement in response to the COVID-19 outbreak. This study aimed to evaluate the impact of the COVID-19 pandemic on the progression of obesity in children and adolescents in Changshu, China.

**Methods:** Based on the Health Promotion Program for Children and Adolescents (HPPCA), which is a prospective cross-sectional and school-based study, BMI assessed in seven consecutive years (2014 to 2020) among children and adolescents aged 6 to 17 years in Changshu city was extracted. The standardized BMI z scores (zBMI) and prevalence of obesity between 2020 (after COVID-19 home confinement) and the previous 6 years were compared among age-specific subgroups and between sexes.

**Results:** The mean number of participants per year was 29,648. The overall mean zBMI drastically increased from 0.29 in 2019 to 0.45 in 2020, resulting in a rise of 0.16 (95% CI: 0.14-0.18); the prevalence of obesity substantially elevated to 12.77% in 2020 (versus 10.38% in 2017), with an acceleration of 2.39% (95% CI: 1.88%-2.90%). Of note, these increases were more likely to be observed in boys and those 6 to 11 years old.

**Conclusions:** The COVID-19 pandemic seemed to exacerbate the obesity epidemic among pediatric populations in Changshu, China.

## INTRODUCTION

Obesity presents an alarming risk to both physical and psychological health. The obesity epidemic in the pediatric population has become a major public health concern in China and around the world (1). Excessive weight gain in early life is likely to lead

to lifelong overweight and obesity and is associated with greater risk and earlier onset of chronic disorders, such as cardiovascular and metabolic diseases (2,3). In recent years, insufficient outdoor physical activity has been recognized as a major risk factor for pediatric overweight or obesity development (4). A large and growing evidence base also suggested that unhealthy weight gain

of children mainly occurred during summer months, when they were out of school (5,6).

In December 2019, a novel coronavirus (SARS-CoV-2) rapidly spread in China. At the spring semester of 2020, in response to the COVID-19 outbreak, the Chinese government ordered a nationwide school closure as an emergency measure to slow down the spread of COVID-19 (7). Public activities were discouraged, and online courses were offered and delivered through TV broadcast and the internet. The Ministry of Education of China estimated that more than 180 million school-aged children and adolescents were confined to their homes (8). Notably, once the epidemic in China had been effectively controlled, schools in various regions then sequentially reopened from the end of March to June 2020. In Changshu, China, for example, school reopened on April 7, 2020, for students of grades eight and eleven; on April 13, 2020, for grades six, seven, and ten; and on April 15, 2020, for grades four and five. In addition, students of grades three and two returned to school on May 7 and 11, respectively. However, several mitigation strategies for COVID-19 were still recommended for regular epidemic prevention and control, for instance, constraint of movement, social distancing, and online classes via digital devices. Overall, the lifestyles of Chinese children and adolescents were unintentionally disrupted by this rare event.

Rundle et al. (9) hypothesized that the COVID-19 pandemic would “exacerbate all of the risk factors for weight gain associated with summer recess.” In support of this hypothesis, one systematic review concluded that decreases in physical activity coupled with increases in sedentary behaviors occurred among children during the COVID-19 lockdown (10). Meanwhile, An et al. (11) speculated that, compared with the prepandemic period in the United States, both BMI z scores (zBMI) and childhood obesity prevalence under COVID-19 would be expected to rise, and the magnitude of the increase would be proportional to the length and severity of the pandemic. However, evidence to support this presumption is currently lacking, especially in populous China. In addition, obesity is identified as an independent risk factor for COVID-19 severity (12); patients with obesity may experience a more severe course of COVID-19 (13). Therefore, an investigation into the progression of obesity development among children and adolescents is urgently warranted in China.

Based on the data of the Health Promotion Program for Children and Adolescents (HPPCA), we aimed to comprehensively understand and analyze the impact of confinement due to the COVID-19 outbreak on obesity development in children and adolescents in Changshu, China.

## METHODS

### Study area and population

This study was based on the data of seven consecutive years (from 2014 to 2020) from the HPPCA. Detailed descriptions of the HPPCA were reported previously (14). In brief, in order to

### Study Importance

#### What is already known?

- ▶ The COVID-19 pandemic may deteriorate children's health behaviors and thereby increase weight gain.

#### What does this study add?

- ▶ Compared with the highest value in previous years (2014 to 2019), the overall mean zBMI drastically increased to 0.45 in 2020 (from 0.29 in 2019), and the prevalence of obesity substantially elevated to 12.77% in 2020 (versus 10.38% in 2017) among pediatric populations in Changshu, China.
- ▶ The COVID-19 pandemic seemed to accelerate obesity progression among pediatric populations in China.

#### How might these results change the direction of research or the focus of clinical practice?

- ▶ Strategies are needed to counteract the impact of the COVID-19 pandemic on unhealthy weight gain among school-aged children.

investigate the health status of school-aged children, the HPPCA was designed to annually assess the health status (including BMI) of all potential students aged 6 to 17 years from elementary, middle, and high school (grades one to twelve) in the Suzhou region of China. Chronically ill or disabled children were not included. In particular, students in the third year of middle and high school (ninth and twelfth graders) who would take other special physical examinations for school entrance were not included in this study, as their data are currently not available. In general, students' physical examination was taken in general hospitals, centers for disease prevention and control, or community health care centers.

In the current study, we focused on Changshu city, which is a county-level city in Suzhou. In accordance with the Chinese National Survey on Students' Constitution and Health, which was a national surveillance every 5 years (15), stratified cluster random sampling was selected to keep equality of selected numbers in every grade in the current study. As the second-largest city for immigrants, the population of Suzhou increases rapidly. In order to keep representativeness and consistency of students in these years, selected schools should meet the following criteria: from 2014 to 2020, school did not change address, merge other schools, or be merged by other schools. Finally, 12 primary schools, 8 junior high schools, and 4 senior high schools were selected. Schools were divided by urban or rural area according to their addresses.

**TABLE 1** zBMI of school-aged children and adolescents in each year

	zBMI, mean (SE)							<i>p</i> <sup>a</sup>
	2014	2015	2016	2017	2018	2019	2020	
Overall	0.21 (0.01)	0.18 (0.01)	0.21 (0.01)	0.28 (0.01)	0.27 (0.01)	0.29 (0.01) <sup>b</sup>	0.45 (0.01)	<0.0001
Sex								
Boy	0.43 (0.01)	0.42 (0.01)	0.43 (0.01)	0.49 (0.01)	0.48 (0.01)	0.50 (0.01) <sup>b</sup>	0.68 (0.01)	<0.0001
Girl	-0.03 (0.01)	-0.08 (0.01)	-0.03 (0.01)	0.04 (0.01)	0.04 (0.01)	0.06 (0.01) <sup>b</sup>	0.20 (0.01)	<0.0001
Age (y)								
6 to 11	0.28 (0.01)	0.25 (0.01)	0.26 (0.01)	0.33 (0.01)	0.33 (0.01)	0.36 (0.01) <sup>b</sup>	0.55 (0.01)	<0.0001
12 to 17	0.10 (0.01)	0.09 (0.01)	0.15 (0.01)	0.21 (0.01)	0.20 (0.01)	0.21 (0.01) <sup>b</sup>	0.33 (0.01)	<0.0001
Region								
Urban	0.22 (0.01)	0.18 (0.01)	0.24 (0.01)	0.35 (0.01) <sup>b</sup>	0.32 (0.01)	0.28 (0.01)	0.45 (0.01)	<0.0001
Rural	0.19 (0.01)	0.18 (0.01)	0.17 (0.01)	0.13 (0.01)	0.18 (0.01)	0.32 (0.01) <sup>b</sup>	0.45 (0.01)	<0.0001

zBMI, BMI z scores.

<sup>a</sup>*p* values were calculated by one-way ANOVA.<sup>b</sup>Highest zBMI within the subgroups during the 2014 to 2019 screening.**TABLE 2** Prevalence of obesity in school-aged children and adolescents in each year

	Prevalence, % ( <i>n</i> )							<i>p</i> <sup>a</sup>
	2014	2015	2016	2017	2018	2019	2020	
Overall	9.07 (2,578)	9.01 (2,678)	9.64 (2,779)	10.38 (3,030) <sup>b</sup>	10.37 (3,059)	10.02 (3,153)	12.77 (3,881)	<0.0001
Sex								
Boy	13.60 (2,004)	13.66 (2,119)	14.34 (2,164)	15.43 (2,348) <sup>b</sup>	15.29 (2,340)	14.88 (2,440)	18.61 (2,983)	<0.0001
Girl	4.19 (574)	3.94 (559)	4.47 (615)	4.88 (682)	5.07 (719) <sup>b</sup>	4.74 (713)	6.25 (898)	<0.0001
Age (y)								
6 to 11	10.89 (1,821)	10.76 (1,785)	11.28 (1,813)	11.75 (1,854) <sup>b</sup>	11.67 (1,867)	11.70 (1,885)	14.73 (2,480)	<0.0001
12 to 17	6.47 (757)	6.80 (893)	7.57 (966)	8.76 (1,176)	8.83 (1,192) <sup>b</sup>	8.26 (1,268)	10.33 (1,401)	<0.0001
Region								
Urban	8.54 (1,558)	8.55 (1,674)	9.48 (1,770)	10.47 (1,991) <sup>b</sup>	10.03 (1,941)	9.42 (2,011)	11.95 (2,445)	<0.0001
Rural	10.01 (1,020)	9.91 (1,004)	9.93 (1,009)	10.19 (1,039)	11.03 (1,118)	11.30 (1,142) <sup>b</sup>	14.44 (1,436)	<0.0001

<sup>a</sup>*p* value was calculated using two-proportion z test, comparing the prevalence in 2020 with the highest prevalence in 2014 to 2019.<sup>b</sup>Highest prevalence within the subgroups during the 2014 to 2019 screening.

## Ethics, consent, and permissions

For the recruited participants, informed consent forms in writing duly signed by their guardians were collected before their examination. This study was approved by the Ethics Committee of Suzhou Center for Disease Prevention and Control (No. SZJK2020-XW001).

## Measurements and obesity definition

All the health examinations of the HPPCA were taken during September and December, both in previous years and during the

COVID-19 pandemic in 2020. The heights (nearest 0.1 cm) and weights (nearest 0.01 kg) were measured with stadiometers and calibrated digital scales in light clothing and without shoes. BMI was calculated (BMI = kilograms/meter squared) and then transformed into a zBMI corresponding to the age- and sex-specific reference outlined by the WHO (16). Overweight and obesity were defined according to the WHO Child Growth Standards (16).

In 2020, owing to the COVID-19 pandemic, all the examiners and students were required to conduct temperature monitoring (below 37.3°C), present a health code, and wear medical masks during the screening. All examiners were trained to perform the professional

physical examination wearing gloves, and students were requested to stand at a safe distance from each other (at least 1 m) when queuing.

## Statistical analysis

Annual zBMI data are presented as mean (SE). zBMI and prevalence of obesity among the seven consecutive years were compared by using one-way ANOVA and  $\chi^2$  test, respectively; for comparing the prevalence of obesity in 2020 with the highest prevalence in 2014 to 2019, a two-proportion z test was performed. Additionally, subgroup differences of change in zBMI and obesity prevalence were compared by examining interaction effects through standard methods (17,18). All statistical analyses were performed using SAS software (version 9.4; SAS Institute, Inc., Cary, North Carolina). A two-sided  $p$  value  $< 0.05$  was considered statistically significant.

## RESULTS

A total of 207,536 children and adolescents were included in this study, with age ranging from 6 to 17 years old. The number of participants in each year is shown in Supporting Information Table S1, and the mean number of participants per year was 29,648. The age and sex distribution of the population is shown in Supporting Information Figure S1, and the numbers of included boys and girls in each of the screening years were quite close. zBMI and prevalence of obesity are illustrated in Table 1 and Table 2. In general, during the annual screenings conducted from 2014 to 2019, zBMI and prevalence of obesity steadily and slowly increased, and these values of boys were consistently higher than those of girls.

zBMI substantially increased in 2020 compared with previous years (2014 to 2019), regardless of sex (Figure 1). A similar trend was revealed for obesity prevalence (Figure 2). It was also found that zBMI in the 7 years was significantly different in each of the age groups (Supporting Information Table S2). Compared with the highest value during 2014 to 2019, obesity prevalence increased in 2020 in all the age groups, but only the ages of 6 to 11 and 15 to 16 showed statistical significance (Supporting Information Table S3).

Figure 3 illustrates the differences between zBMI in 2020 and the highest values during 2014 to 2019. The overall mean zBMI drastically increased from 0.29 in 2019 to 0.45 in 2020, resulting in a rise of 0.16 (95% CI: 0.14-0.18). The acceleration in zBMI change in the age category of 6 to 11 was 0.19, which was significantly larger than that of the age category of 12 to 17 (0.11,  $p < 0.001$ ); rise in zBMI change in urban areas (0.10) was comparable to that in rural areas (0.14,  $p = 0.066$ ); whereas the elevation in zBMI change in boys (0.18) was significantly higher than in girls (0.13,  $p = 0.014$ ). In addition, the prevalence of obesity substantially elevated to 12.77% in 2020 (versus 10.38% in 2017), with an acceleration of 2.39% (95% CI: 1.88%-2.90%). Besides, the difference (95% CI) in obesity prevalence between the previous highest value and 2020 was more remarkable in boys (3.18% [95% CI: 2.34%-4.01%]) than in girls (1.18% [95% CI: 0.65%-1.72%],  $p < 0.001$ ).

Also, the differences significantly differed between age categories and regions (Figure 4). When comparing values between 2020 and 2019, the changing patterns were generally not altered.

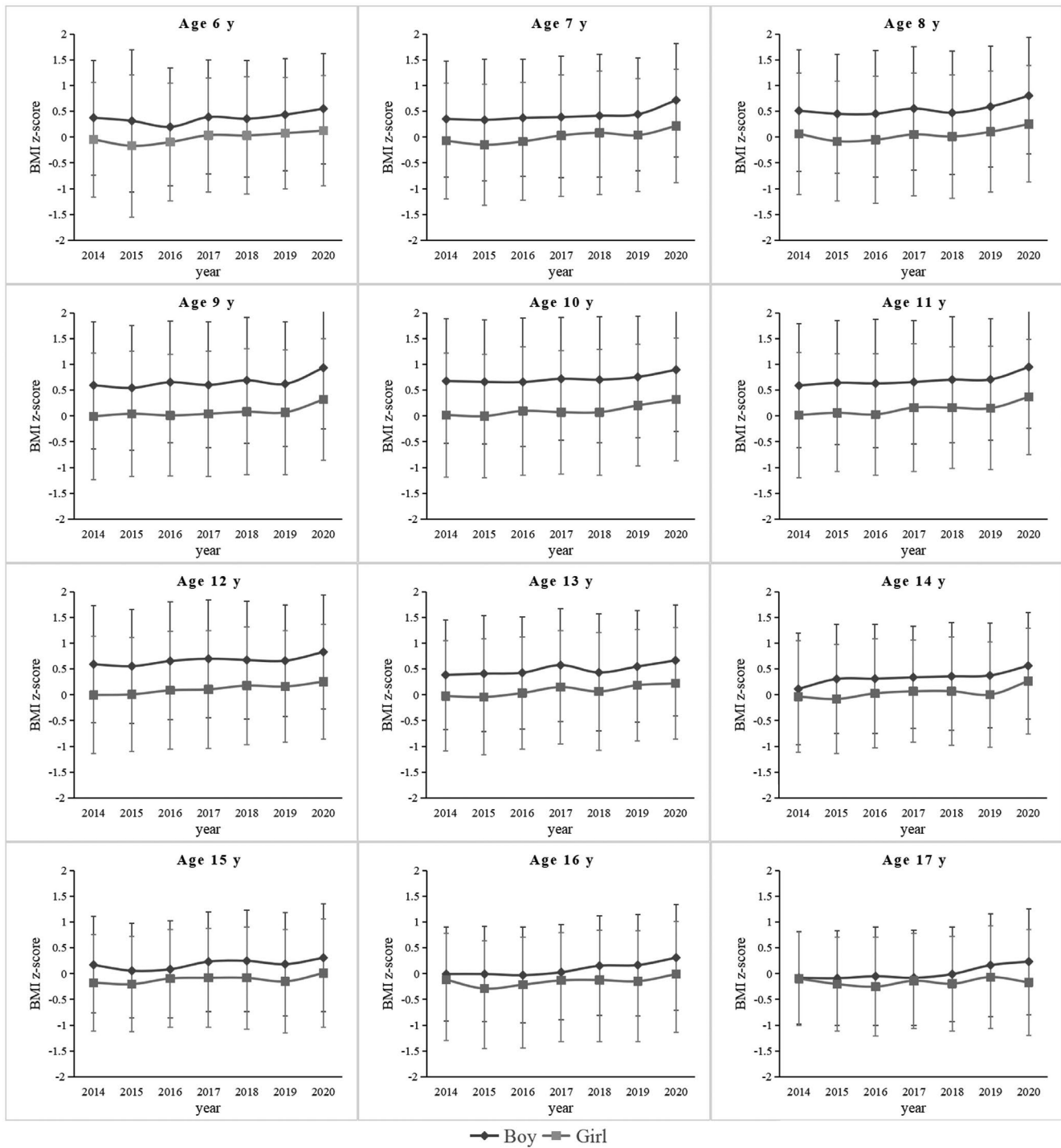
## DISCUSSION

Owing to the COVID-19 confinement, both overall mean zBMI and obesity prevalence significantly increased among children and adolescents aged 6 to 17 years in Changshu, China. In particular, it was found that boys and 6- to 11-year-old children were more sensitive to COVID-19 confinement regarding obesity aggravation. Our results strongly support the speculations that pandemic-related confinements were unfavorably related to weight status (9).

The COVID-19 pandemic has had a negative impact on the obesity burden in the Chinese population. Similar to our findings, the COVID-19 Impact on Lifestyle Change Survey, which included 10,082 youths in China, 28.01% of whom were high school students, reported that both the BMI and the prevalence of overweight/obesity had increased after lockdown (19). Other Chinese studies, mainly for adults, also concluded that significant changes in body weight occurred during the lockdown period (20,21). In addition, the unfavorable influence of the COVID-19 pandemic on childhood obesity was observed in Korea (22), Italy (23), Greece (24), and the United States (25).

Exercise and diet are particularly related to obesity (4). During the home confinement, students' sleep was irregular, their indoor and sedentary activities increased, and their sport and outdoor activities decreased (19,26,27). It was also found that children often had an unhealthy diet at home during the COVID-19 pandemic lockdown, such as an increased intake of snacking, sugary drinks, and meals (26,28). Importantly, the months of January and February in 2020 were also the time of the Spring Festival in China, when people tend to consume more high-fat and high-calorie food than usual, which also created an unprecedented obesogenic environment. Besides, the COVID-19 confinement has increased isolation, psychological distress, anxiety, and depression, which may result in night and stress eating (29). Furthermore, extensively prolonged screen times (both for academic activity and leisure) during the lockdown (19) may also contribute to obesity due to lack of physical activity and increased energy intake (30). Moreover, potential adverse childhood events caused by significantly increased domestic violence during the COVID-19 pandemic might lead to eating disorders and thereby obesity in the pediatric population (31,32).

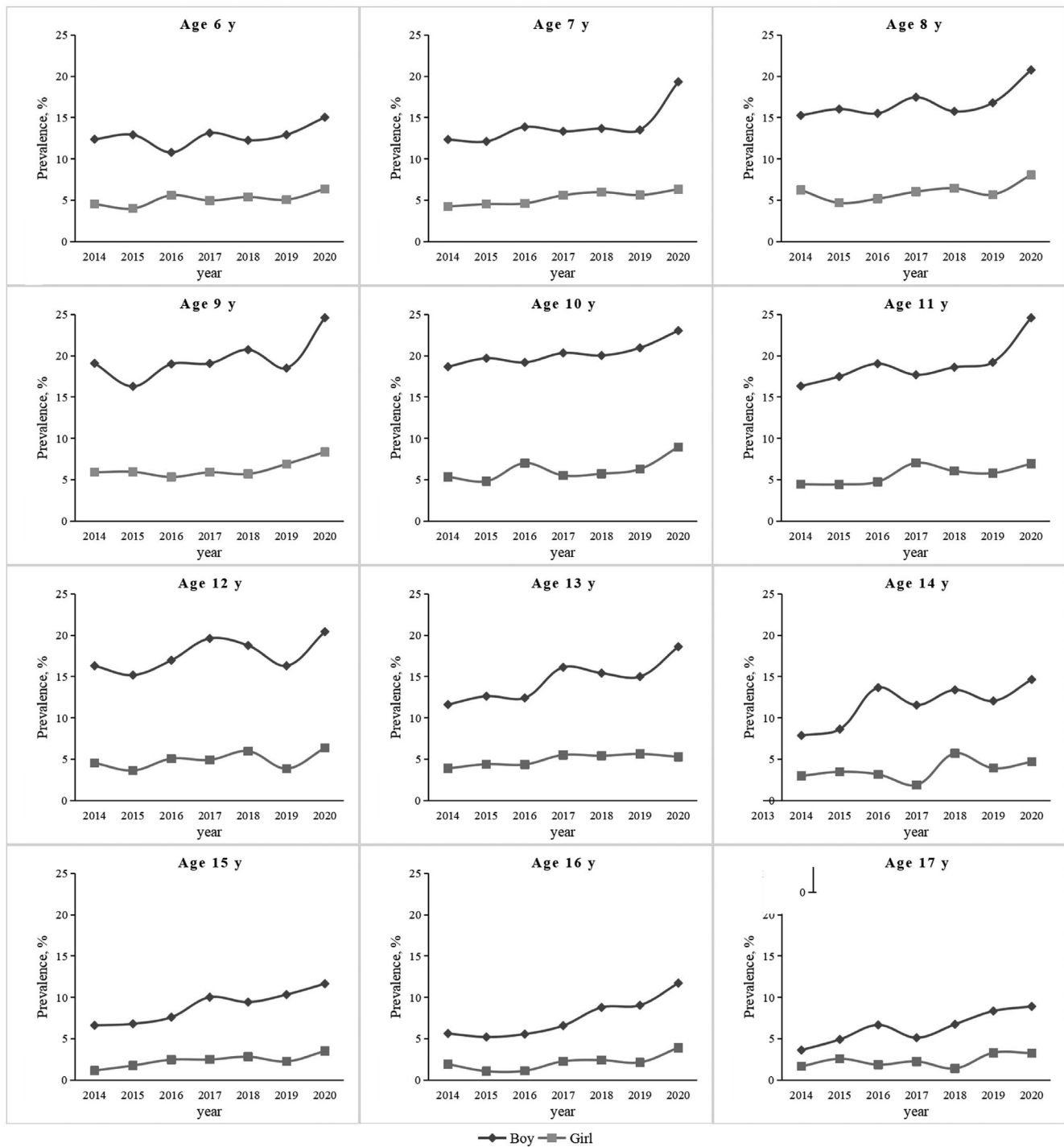
Specifically, the elevation of BMI and prevalence of obesity during the COVID-19 pandemic were more obvious in 6- to 11-year-old younger children. We speculate this age disparity could be explained by the following reasons. School is an important locale for physical education classes and extracurricular physical activity (33), and children lose access to almost all forms of supervised sources of physical activity as a result of school closures (34). The *Healthy China Initiative (2019-2030)* recommended 4 class hours of physical education for grades one and two, 3 class



**FIGURE 1** Mean BMI z scores by gender for children and adolescents aged 6 to 17 years during the 7 years of screenings

hours for grades three to nine, and 2 class hours for high school students per week. In addition, as we mentioned before, the days of school closure were longer in younger students in this research. Therefore, the younger the age, the more the physical activity may be reduced during the confinement. In case of dietary patterns, age differences may also exist. A recent study conducted in five countries found that adolescents under the age of 14 significantly increased the average consumption of fried and sweet foods,

whereas adolescents over the age of 14 significantly elevated vegetable and fruit intake during COVID-19 confinement versus before confinement (28). In short, lifestyle changes may be more pronounced in younger students during the confinement. For another, younger children might be more sensitive to environmental changes than older ones. For instance, analyses by age group showed that obesity prevention programs had a more positive effect on younger children (<12 years) (35).



**FIGURE 2** Prevalence of obesity by gender for children and adolescents aged 6 to 17 years during the 7 years of screenings

In the current study, boys seemed to be more susceptible to adiposity than girls during the COVID-19 confinement. Studies conducted before the COVID-19 pandemic showed that boys spent more time on physical activity than girls, especially moderate and vigorous physical activity (36,37). However, during COVID-19 confinement, a larger drop of physical activity and a higher increase of sedentary behavior were observed in boys compared with girls (23,38). What's more, Chinese girls prefer a slender shape traditionally, especially

during puberty, so they are more likely to control their weight than boys (39,40). In a word, the gender disparity in physical self-concept and adherence to unhealthy lifestyles during COVID-19 pandemic may contribute to the observed results. Thus, it may be critical to develop and implement gender-specific preventive guidelines for obesity during the confinement.

On March 11, 2020, WHO announced that the novel COVID-19 virus had become a global pandemic. Although there

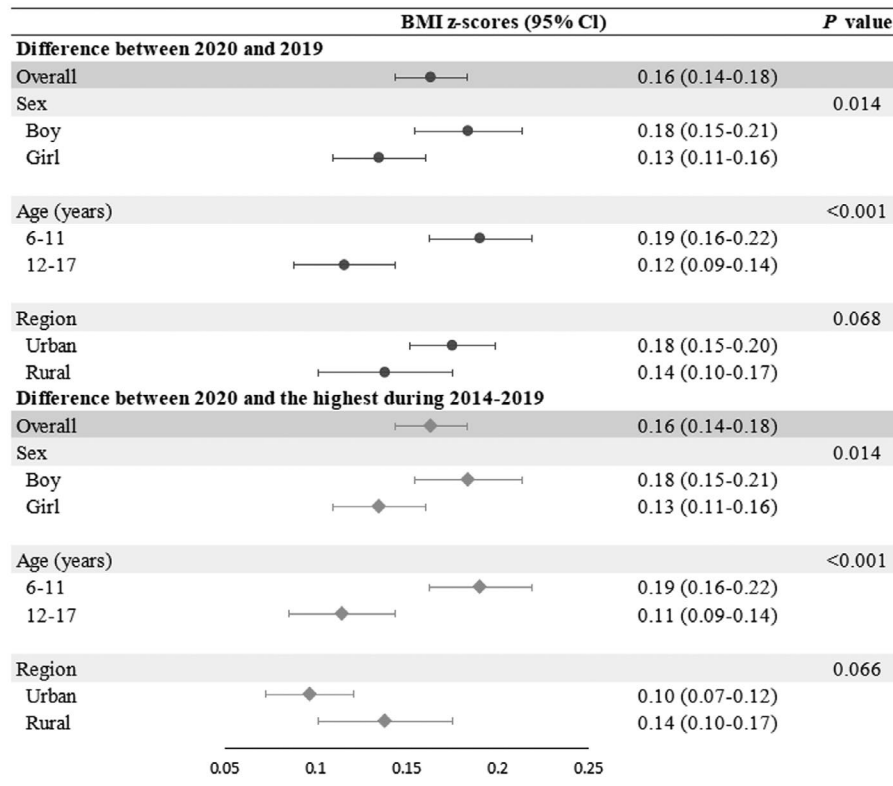


FIGURE 3 BMI z score changes from prepandemic period to 2020 between subgroups

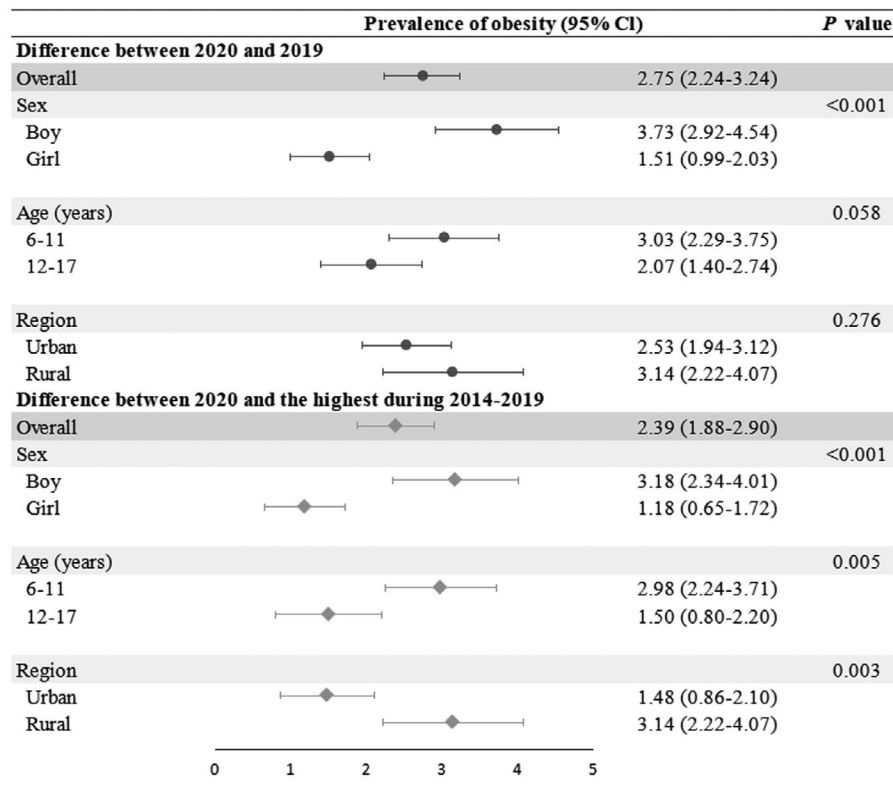


FIGURE 4 Difference of obesity prevalence from prepandemic period to 2020 between subgroups

has been a decline in the spread of the disease in China (41), the prevalence of COVID-19 around the world remains serious despite containment efforts undertaken by national authorities and the international community. Nobody can reliably predict how long the COVID-19 pandemic will last. The current survey, reporting that efforts to reduce COVID-19 transmission have likely contributed to worsening pediatric obesity, will have good reference value for countries that adopt “lockdown” measures. Therefore, involved stakeholders (including governments, schools, and families) should make prompt efforts to prevent childhood obesity during the pandemic, for example, connecting families to nutritious meals, advocating for safe and active physical activity, and providing telemedicine programs that encourage families and individuals to maintain healthy lifestyle choices. Apart from this, there is also a critical need to consider that obesity could shift severe COVID-19 to younger ages (11). Moreover, accumulating evidence suggests that the COVID-19 pandemic has unfavorably impacted the mental health of individuals (42). It was revealed that children with overweight may be more vulnerable than their counterparts to the psychosocial effects of the pandemics (43). As a result, government officials and policy makers may pay attention to relief of the COVID-19-related fear, stress, and depression in pediatric populations.

The current study benefits from its large sample size and representativeness of the general pediatric population. Meanwhile, in contrast to the self-reported data used in previous studies (19,24), BMI in the current study was objectively measured by trained examiners. However, several limitations should be admitted. First, preschool-aged children and students in the third year of junior and senior high school were not included in the current study. Besides, the participants were only recruited from Changshu, a developed city in Eastern China. Hence, caution must be exercised when interpreting evidence from other populations. Second, as well-documented by other studies (19,26-28), COVID-19 restrictions imposed changes in the lifestyle behaviors of children and adolescents. However, the lack of such measures in the current study prevented us from examining the possible determinants of these dramatic changes in zBMI and prevalence of obesity.

## CONCLUSION

In conclusion, COVID-19 confinement may aggravate the childhood obesity epidemic. In particular, boys and younger children may be more sensitive to environmental changes than their counterparts. Strategies to manage unhealthy weight gain are urgently needed in the context of COVID-19. Future researchers are encouraged to examine the effect of specific measures taken to counteract the pandemic on obesity progression. Additionally, government officials and policy makers may want to consider the deleterious lifestyle effects of possible lockdowns, school closures, or mobility restrictions on children and adolescents in the future. **O**

## CONFLICT OF INTEREST

The authors declared no conflict of interest.

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## SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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