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# COVID-19–Related Childhood BMI Increases in China: A Health Surveillance–Based Ambispective Cohort Analysis



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**Introduction:** The COVID-19 pandemic–related BMI gain and obesity prevalence changes in children have not been clearly elucidated, especially in China. This study aims to assess the impact of pandemic-related BMI and obesity prevalence change in Chinese children aged 8–12 years.

**Methods:** On the basis of the Health Promotion Program for Children and Adolescents in Suzhou of China, a total of 72,175 children aged 8–12 years with complete data during 2017–2020 were included. Yearly BMI z-score changes and age- and sex-adjusted BMI changes before (2017–2019) and during (2019–2020) the pandemic were calculated. Multivariate mixed linear models were used to examine the possible difference in annual BMI change rate before and during the pandemic among subgroups.

**Results:** The obesity prevalence slightly increased from 12.29% (2017) to 13.28% (2019) but substantially increased to 15.29% in 2020. The mean yearly change in BMI z-score before and during the pandemic were 0.039 (95% CI=0.037, 0.042) and 0.131 (95% CI=0.125, 0.138), respectively, yielding a difference of 0.092 (95% CI=0.087, 0.096). Similarly, changes and age- and sex-adjusted BMI increased by 0.191 (95% CI=0.179, 0.202) during the pandemic compared with those of previous years. Meanwhile, the increase in BMI changes in 2019–2020 compared with that before the pandemic was more obvious in boys than in girls and in underweight or normal-weight children than in their overweight and obese counterparts.

**Conclusions:** BMI gain increased among Chinese children aged 8–12 years during the pandemic. There is an urgent need to formulate effective public health policies to reduce the risk of pandemic-related childhood obesity.

*Am J Prev Med* 2022;63(4):647–655. © 2022 American Journal of Preventive Medicine. Published by Elsevier Inc. All rights reserved.

## INTRODUCTION

The childhood obesity epidemic has become a significant public health challenge in China.<sup>1</sup> Approximately a fifth of children aged 6–17 years were either overweight or obese.<sup>2,3</sup> If there is no effective intervention, the prevalence of overweight and obesity among Chinese school-aged children and adolescents will reach 31.80% by 2030, with 58.92 million pediatrics affected.<sup>4</sup> Obesity not only affects children's physical development and physiologic function but also impairs their motor and learning abilities.<sup>5,6</sup> In addition, excessive weight gain in childhood contributes to an

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0749-3797/\$36.00

<https://doi.org/10.1016/j.amepre.2022.04.015>

elevated risk of obesity morbidity and premature mortality in adulthood.<sup>7-9</sup> Therefore, the rising incidence of obesity among children would likely place a considerable burden on China's future healthcare system.

The coronavirus disease 2019 (COVID-19) has spread to nearly every country. To curb the spread of the virus, the Chinese government implemented comprehensive and strict health system strategies, such as home confinement, avoiding mass gathering events, and postponing the 2020 spring semester.<sup>10</sup> School closures had been implemented in nearly 200 countries,<sup>11</sup> and >180 million school-aged children and adolescents in China had to stay at home to access online education.<sup>12</sup> For instance, schools in Suzhou of China were closed until the middle of April 2020 for grades 4 and 5 and the middle of May 2020 for lower grades. Taking the subsequent summer vacation into consideration, children in Suzhou spent >6 months staying at home in 2020. Apparently, when children were confined in homes and studied online, eating habits and lifestyles changed dramatically compared with lifestyles during their school days.<sup>13,14</sup> Although China's epidemic is effectively controlled in the short term, regular pandemic mitigation strategies such as wearing masking, traffic restrictions, and social distancing are now adopted to protect public health. In summary, the COVID-19 pandemic has disrupted all aspects of life for children, which may create an unprecedented obesogenic environment for children.<sup>15</sup>

Indeed, increased obesity prevalence and BMI gain among children during the COVID-19 pandemic have been observed in America.<sup>16,17</sup> However, most existing studies relied on self-report data of weight status<sup>18,19</sup> and just adopted a single or 2 measurements of BMI,<sup>18,19</sup> which ignores the inherent changing pattern of a specific child. Longitudinal evidence based on objective measurement of heights and weights among a broad pediatric population is still lacking. Given that relevant studies have been conducted in Chinese preschool children<sup>20</sup> (aged 3–5 years) and youths<sup>18</sup> (aged 16–28 years), there was little evidence for primary and junior high-school students whose BMI changes were more profoundly impacted by the pandemic.<sup>21</sup>

Considering that BMI z-score (zBMI) changes depend on initial BMI, a child with obesity has to acquire a higher BMI than that of normal or underweight children to obtain the same zBMI difference. Therefore, assessing BMI change in children with obesity longitudinally is inefficient.<sup>22-24</sup> Fortunately, the *age- and sex-adjusted BMI ( $\Delta\text{BMI}_{\text{adj}}$ ) change*,<sup>17,25</sup> defined as the change in distance from the median BMI for age and sex between any consecutive times, was recommended to complementarily assess weight changes for children with different weight statuses. Therefore, on the basis of 4 consecutive years of

longitudinal cohort data from the Health Promotion Program for Children and Adolescents (HPPCA), this study aims to compare children's yearly zBMI changes and  $\Delta\text{BMI}_{\text{adj}}$  before (2017–2019) and during (2019–2020) the COVID-19 pandemic and assess the impact of the pandemic on BMI gain and obesity prevalence among Chinese children aged 8–12 years.

## METHODS

### Study Sample

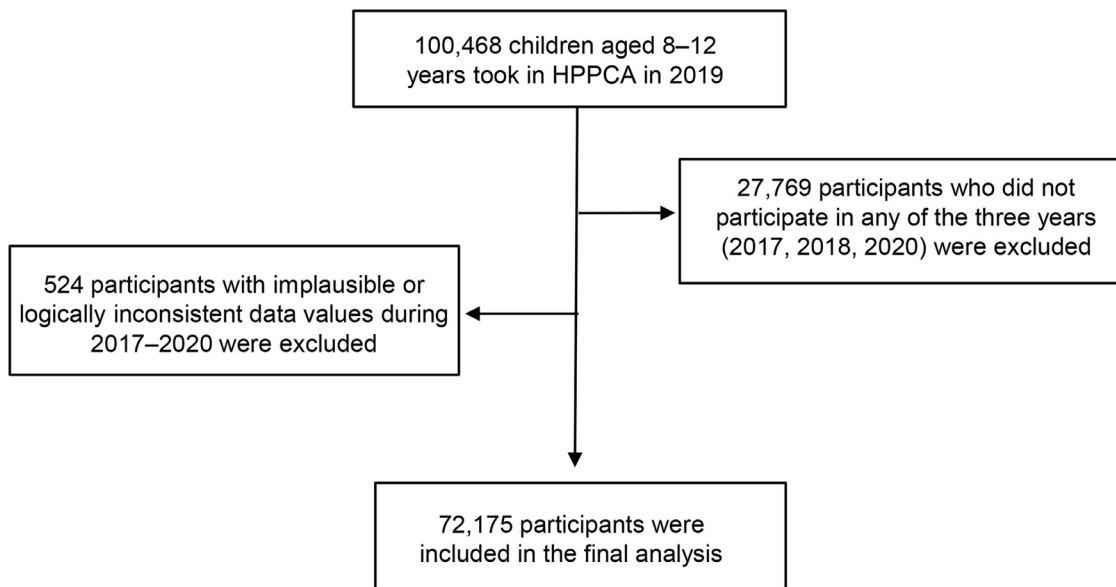
This study was an ambispective cohort study based on HPPCA data from 2017 to 2020. HPPCA is an ongoing monitoring program in Suzhou of China; the detailed description had been reported in a previous study.<sup>26,27</sup> In short, HPPCA provided free annual health check-ups for all regular primary, junior, and senior high-school students aged 6–17 years in Suzhou to assess the growth and development of children and adolescents. Students' physical examinations were often conducted at general hospitals, disease prevention and control centers, or community healthcare facilities. Notably, students in the third year of the junior (age 14 years) and third year of senior (age 17 years) high school who would take other special physical examinations for school entrance were not included.

The end of 2019 was a turning point, coinciding with the distinction around the COVID-19 pandemic outbreak in China. In China, the age of children in first and seventh grades are usually 6 and 12 years, respectively. Therefore, to have sufficient physical examination data of HPPCA before and during the pandemic, this study focused on children aged 8–12 years without chronic disease or disability ( $n=100,468$ ) in a county and a district of Suzhou in 2019. A total of 27,769 participants who did not participate in any of the 3 years (2017, 2018, 2020) were excluded. Next, participants with implausible or logically inconsistent data values ( $n=524$ ) during 2017–2020 were excluded, for example, extreme values of height and/or weight ( $>+3$  SDs or  $<-3$  SDs from the mean) and if the height of participants was at least 1-cm shorter than that of the previous year. In final, a total of 72,175 children were included in this study. Figure 1 shows the details of the study population selection.

All HPPCA work was carried out with the consent of participants and their parents. This study was approved by the Ethics Committee of Suzhou Center for Disease Prevention and Control (number SZJK2020-XW001).

### Measures

All HPPCA health examinations were scheduled for September–December of each year, either before or during the COVID-19 pandemic. In light clothes and without shoes, the participants' heights (nearest 0.1 cm) and weights (nearest 0.01 kg) were measured with stadiometers and calibrated digital scales. BMI was calculated as weight (kg) divided by the square of the height (m) and then transformed into a zBMI corresponding to the age- and sex-specific reference outlined by WHO.<sup>28</sup> Next,  $\Delta\text{BMI}_{\text{adj}}$  was calculated using the following equations:  $\Delta\text{BMI}_{\text{adj}} = (\text{BMI}_{\text{B}} - \text{BMI}_{\text{A}}) - (\text{BMI}_{\text{B, median}} - \text{BMI}_{\text{A, median}})$ , where  $\text{BMI}_{\text{B, median}}$  and  $\text{BMI}_{\text{A, median}}$  represent the median BMI of the child's age and sex at dates B and A in the WHO standards,<sup>17,28</sup> respectively. Differences in



**Figure 1.** Details of the study population selection. HPPCA, Health Promotion Program for Children and Adolescents.

yearly zBMI changes and  $\Delta\text{BMI}_{\text{adj}}$  before and during the pandemic were calculated. According to the WHO standards,  $\text{zBMI} > 1$  and  $\text{zBMI} > 2$  were defined as overweight and obesity, respectively.<sup>28</sup>

In the 2020 examination, all participants were obliged to monitor temperature (below 37.3°C), show a health code, and wear medical masks. 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

The continuous and categorical variables were represented as mean (SD) and  $n$  (%) and were correspondingly compared using ANOVA and chi-square tests, respectively. Multivariate mixed linear models were used to examine whether the rate of BMI change before versus during the pandemic was different among subgroups. The optimal unstructured covariance matrix is obtained with the lowest Akaike's Information Criterion. Averaged yearly zBMI changes and  $\Delta\text{BMI}_{\text{adj}}$  before and after the pandemic were dependent variables. The time before and after the pandemic was included as fixed effects, and the individual was included as random effects. Analyses were adjusted for sex, district, age, and weight status in baseline and interactions of age and weight status in baseline with time. A Bonferroni–Holm adjustment was performed considering the association between BMI changes and weight status in 2019. All analyses were conducted using SAS statistical (version 9.4) and Stata (version 16.1) software. A value of  $p < 0.05$  was considered statistically significant.

## RESULTS

The included sample consisted of 72,175 participants in 2019. The values of BMI and zBMI in the included and

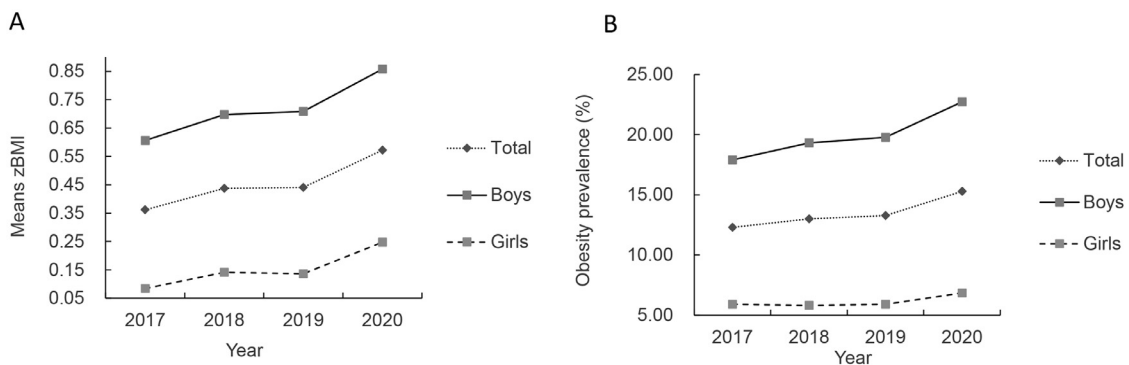
excluded samples were very close (Appendix Table 1, available online). Table 1 shows the basic characteristics of the included population. In 2019, the participants were averagely aged 10.45 years (SD=1.38), including 38,393 boys (53.19%) and 33,782 girls (46.81%). During 2017–2020, there were statistically significant differences between boys and girls in height, weight, and BMI ( $p < 0.001$ ). zBMI showed a steady and slow increase before the pandemic but showed a dramatic elevation in 2020, both in the total population and specific sex subgroups (Figure 2). zBMI values were consistently and significantly higher for boys than for girls ( $p < 0.001$ ). A similar trend was revealed for the obesity prevalence (Figure 2). Generally, the prevalence of obesity increased from 12.29% (2017) to 13.28% (2019) but substantially increased to 15.29% in 2020. The shift in weight status (i.e., underweight, normal, overweight, and obesity) before and during the pandemic are shown in Appendix Table 2 (available online). A total of 22.22% of children with overweight in 2017 became normal-weighted in 2019, whereas only 14.41% of overweight children in 2019 shifted to normal weight in 2020. At the same time, 77.95% of children who were obese in 2017 remained obese in 2019, whereas this percentage was up to 85.84% during the pandemic.

Table 2 indicates the mean annual changes in zBMI and  $\Delta\text{BMI}_{\text{adj}}$  before and during the pandemic. The changing patterns in zBMI and  $\Delta\text{BMI}_{\text{adj}}$  were consistent in the overall population and subsets. Children's mean yearly zBMI change before and during the pandemic were 0.039 (95% CI=0.037, 0.042) and 0.131 (95%

**Table 1.** Characteristics of the Included Population

Variables	Total	Boys	Girls	p-value
n (%)	72,175 (100.00)	38,393 (53.19)	33,782 (46.81)	
Distract, n (%)				0.161
Urban	46,274 (64.11)	24,525 (63.88)	21,749 (64.38)	
Rural	25,901 (35.89)	13,868 (36.12)	12,033 (35.62)	
Grade				<b>0.027</b>
Primary school	62,219 (86.21)	33,184 (86.43)	29,035 (85.95)	
Middle school	9,956 (13.79)	5,209 (13.57)	4,747 (14.05)	
In 2017, mean±SD				
Age	8.39±1.38	8.39±1.37	8.39±1.39	0.692
Weight (kg)	30.15±8.44	31.20±8.83	28.97±7.80	< <b>0.001</b>
Height (cm)	132.37±9.85	132.80±9.55	131.90±10.15	< <b>0.001</b>
BMI (kg/m <sup>2</sup> )	16.92±2.86	17.38±3.02	16.40±2.57	< <b>0.001</b>
zBMI	0.36±1.30	0.61±1.38	0.08±1.15	< <b>0.001</b>
In 2018, mean±SD				
Age	9.43 ± 1.37	9.43 ± 1.37	9.43 ± 1.38	0.721
Weight (kg)	34.61 ± 10.00	35.74 ± 10.42	33.33 ± 9.35	< <b>0.001</b>
Height (cm)	138.47 ± 10.40	138.70 ± 10.01	138.20 ± 10.83	< <b>0.001</b>
BMI (kg/m <sup>2</sup> )	17.74 ± 3.18	18.25 ± 3.35	17.15 ± 2.86	< <b>0.001</b>
zBMI	0.44 ± 1.28	0.70 ± 1.34	0.14 ± 1.14	< <b>0.001</b>
In 2019, mean ± SD				
Age	10.45 ± 1.38	10.45 ± 1.37	10.45 ± 1.39	0.850
Weight (kg)	39.30 ± 11.56	40.59 ± 12.18	37.85 ± 10.63	< <b>0.001</b>
Height (cm)	144.79 ± 11.01	145.00 ± 11.08	144.50 ± 10.93	< <b>0.001</b>
BMI (kg/m <sup>2</sup> )	18.42 ± 3.45	18.95 ± 3.62	17.82 ± 3.15	< <b>0.001</b>
zBMI	0.44 ± 1.29	0.71 ± 1.34	0.14 ± 1.16	< <b>0.001</b>
In 2020, mean ± SD				
Age	11.44 ± 1.39	11.44 ± 1.38	11.44 ± 1.39	0.825
Weight (kg)	45.37 ± 12.90	47.19 ± 13.96	43.31 ± 11.23	< <b>0.001</b>
Height (cm)	151.41 ± 10.96	152.00 ± 11.83	150.70 ± 9.83	< <b>0.001</b>
BMI (kg/m <sup>2</sup> )	19.48 ± 3.74	20.07 ± 3.92	18.81 ± 3.40	< <b>0.001</b>
zBMI	0.57 ± 1.28	0.86 ± 1.32	0.25 ± 1.15	< <b>0.001</b>

Note: Boldface indicates statistical significance ( $p < 0.05$ ). zBMI, BMI z-score.



**Figure 2.** Mean zBMI and obesity prevalence changes in the total population and sex subgroups over 4 screening years. zBMI, BMI z-score.

**Table 2.** Mean Yearly zBMI Change and  $\Delta\text{BMI}_{\text{adj}}$  Before and During the Pandemic

Variables	zBMI				$\Delta\text{BMI}_{\text{adj}}$			
	Before pandemic (95% CI)	During pandemic (95% CI)	Difference (95% CI)	p-value	Before pandemic (95% CI)	During pandemic (95% CI)	Difference (95% CI)	p-value
Total populations	0.039 (0.037, 0.042)	0.131 (0.125, 0.138)	0.092 (0.087, 0.096)		0.283 (0.277, 0.289)	0.474 (0.463, 0.484)	0.191 (0.179, 0.202)	
Sex				<b>&lt;0.001</b>				<b>&lt;0.001</b>
Boys	0.051 (0.048, 0.055)	0.149 (0.140, 0.158)	0.098 (0.091, 0.104)		0.366 (0.358, 0.374)	0.592 (0.577, 0.607)	0.226 (0.209, 0.242)	
Girls	0.026 (0.023, 0.029)	0.112 (0.103, 0.120)	0.085 (0.079, 0.091)		0.189 (0.181, 0.197)	0.339 (0.325, 0.354)	0.151 (0.135, 0.167)	
District				<b>&lt;0.001</b>				<b>0.010</b>
Urban	0.017 (0.014, 0.020)	0.147 (0.139, 0.154)	0.129 (0.124, 0.135)		0.234 (0.227, 0.241)	0.498 (0.486, 0.511)	0.264 (0.250, 0.279)	
Rural	0.080 (0.075, 0.084)	0.104 (0.093, 0.115)	0.024 (0.016, 0.032)		0.371 (0.361, 0.381)	0.429 (0.411, 0.448)	0.059 (0.038, 0.079)	
Grade				<b>&lt;0.001</b>				<b>&lt;0.001</b>
Primary school	0.046 (0.043, 0.049)	0.158 (0.152, 0.165)	0.112 (0.107, 0.117)		0.297 (0.291, 0.304)	0.547 (0.536, 0.559)	0.250 (0.238, 0.263)	
Middle school	-0.002 (-0.008, 0.004)	-0.039 (-0.054, -0.024)	-0.037 (-0.048, -0.027)		0.194 (0.178, 0.210)	0.013 (-0.016, 0.041)	-0.181 (-0.214, -0.149)	
Weight status in 2019								
Underweight	-0.319 (-0.333, -0.304)	0.548 (0.509, 0.587)	0.867 (0.823, 0.910)	<b>&lt;0.001</b>	-0.535 (-0.561, -0.510)	0.532 (0.467, 0.597)	1.068 (0.998, 1.137)	<b>&lt;0.001</b>
Normal <sup>a</sup>	0.013 (0.010, 0.016)	0.184 (0.179, 0.189)	0.171 (0.166, 0.177)	Ref	0.029 (0.024, 0.034)	0.417 (0.406, 0.429)	0.388 (0.376, 0.401)	Ref
Overweight	0.141 (0.137, 0.145)	0.044 (0.035, 0.052)	-0.097 (-0.106, -0.088)	<b>&lt;0.001</b>	0.640 (0.629, 0.652)	0.565 (0.539, 0.591)	-0.076 (-0.104, -0.048)	<b>&lt;0.001</b>
Obesity	0.070 (0.065, 0.075)	-0.060 (-0.070, -0.050)	-0.130 (-0.140, -0.119)	<b>&lt;0.001</b>	1.083 (1.065, 1.102)	0.591 (0.552, 0.629)	-0.492 (-0.535, -0.450)	<b>&lt;0.001</b>

Note: Boldface indicates statistical significance ( $p < 0.05$ ).

<sup>a</sup>Bonferroni–Holm adjustment compared with normal weight was performed considering the association between BMI changes and weight status in 2019.

$\Delta\text{BMI}_{\text{adj}}$ , changes and age- and sex-adjusted BMI; zBMI, BMI z-score.

CI=0.125, 0.138), respectively, yielding a difference of 0.092 (95% CI=0.087, 0.096).  $\Delta\text{BMI}_{\text{adj}}$  increased by 0.191 (95% CI=0.179, 0.202) during versus before pandemic. Meanwhile, the differences in annual zBMI change between 2019 and 2020 and before the pandemic were 0.098 (95% CI=0.091, 0.104) and 0.085 (95% CI=0.079, 0.091) for boys and girls, respectively; the increase was more prominent among boys ( $p<0.001$ ). An enhanced increase of zBMI from 2017 to 2019 to 2019–2020 was also observed in subgroups of urban and primary schools. Interestingly, although  $\Delta\text{BMI}_{\text{adj}}$  of children with different weight statuses increased before and during the pandemic, the increases during the pandemic versus in previous years were more profound in children who were underweight (difference: 1.068 [95% CI=0.998, 1.137]) and normal weighted (difference: 0.388 [95% CI=0.376, 0.401]), in contrast to those who were overweight (difference:  $-0.076$  [95% CI=  $-0.104$ ,  $-0.048$ ]) and obese (difference:  $-0.492$  [95% CI=  $-0.535$ ,  $-0.450$ ]).

## DISCUSSION

Until now, the COVID-19 pandemic has been raging worldwide for 3 years, which will likely trigger a global pandemic of childhood obesity.<sup>15</sup> However, no one can accurately predict how long it will last. This study found a significant increase in body weight and obesity prevalence among children aged 8–12 years in Suzhou during the COVID-19 pandemic. Interestingly, compared with the findings in 2017–2019, boys and children who were underweight and normal weighted had an exacerbated BMI elevation during the pandemic, whereas children who were overweight and obese did not.

The escalating COVID-19 pandemic may worsen the childhood obesity epidemic.<sup>15</sup> Obesogenic behaviors, such as physical inactivity and sedentary lifestyle, were favorably regulated when children followed a scheduled school day.<sup>10,29</sup> However, children in Suzhou experienced a different daily routine than usual in 2020. First, this might result in increased screen time and sedentary behavior because of both online courses offerings and increased leisure screen exposure.<sup>30</sup> Second, without schools' physical education classes and organized sports activities as well as closures of sports fields, most children were less physically active, which was a significant risk of unhealthy weight gain.<sup>31</sup> Third, many children were exposed to less favorable dietary quality.<sup>32</sup> The intakes of snacks and sugary beverages between meals increased significantly during the lockdown.<sup>33</sup> Fourth, affected by the pandemic, children may experience frustration and boredom, further promoting stress-related eating and excessive energy intake.<sup>34,35</sup> Although China's

epidemic was currently controlled, the global epidemic still continued.<sup>36</sup> Regular epidemic prevention and control strategies were still advocated to protect public health in China; children and their parents may also reduce unnecessary outings. Therefore, the impact of COVID-19 on children's lifestyles may be mitigated but may not vanish during regular epidemic prevention and control. In summary, the COVID-19 pandemic has disrupted all aspects of life for children and may create an unfavorable obesogenic environment for children.

Boys had a higher prevalence of overweight and obesity than girls in China.<sup>2</sup> Consistently, the obesity prevalence for boys was about twice higher than that for girls in this study. Because sex influences the exposure and vulnerability to obesity risk factors, COVID-19-related measures undoubtedly had a differential impact on boys' and girls' weight gain.<sup>11</sup> The authors also found that boys experienced greater accelerations in BMI gain than girls during the pandemic. Similar results had been found in other studies.<sup>21,37</sup> For example, a cohort study of 445 Chinese children aged 7–12 years showed that BMI was more likely to increase in boys during the 5-month COVID-19-related quarantine.<sup>21</sup> A simulation of COVID-19's impact on childhood obesity and zBMI in America also showed a greater effect on boys than on girls.<sup>37</sup> Boys and girls were differently affected for various reasons. Before the pandemic, boys tended to spend more time on physical activity than girls, especially moderate and intense physical activity.<sup>33,38</sup> However, a larger drop in physical activity levels and a higher increase in sedentary behavior in boys had been observed during COVID-19 home confinement and school closures.<sup>39,40</sup> Sex differences in food intake changes were also reported, with girls increasing their vegetable and fruit intake, whereas boys increased processed meat consumption during the pandemic.<sup>41</sup>

Consistent with the results of an interrupted time-series study in the southeastern U.S.,<sup>16</sup> this study found that underweight or normal-weight children rather than the overweight and obesity group underwent more accelerated weight gain during the pandemic. There is no doubt that human weight cannot increase indefinitely. Another possible explanation was that children who were overweight or obese had developed risky obesity behaviors before the pandemic; thus, behavioral changes were not as profound as in children of normal weight.<sup>16</sup> This finding provides new insights for public health policy development. Governments, schools, and families should not only actively guide children with obesity to lose weight but should also not ignore the unhealthy weight changes among COVID-19 epidemic-related underweight or normal-weight children.

In China, the prevalence of childhood overweight and obesity was higher in the urban area.<sup>2</sup> In this study, urban children seemed more vulnerable to COVID-19–related measures. Compared with their rural peers who could continue the outdoor physical activity, urban children might have little access to safe outdoor spaces where they could maintain social distance.<sup>42</sup> This study also found that BMI elevation was more evident in primary school students than in middle-school students. Health habits may be well established when a child reaches adolescence; younger students were in the critical time node of healthy habits development, thus they were more susceptible to external influences.<sup>17</sup> Besides, primary school students spent more time on physical activity at school, and the days of school closures were longer for younger students in Suzhou. Therefore, the younger the age, the more significant BMI gain was observed.

Recent studies have shown that children with obesity were at increased risk of developing COVID-19.<sup>43</sup> Therefore, preventing and controlling the childhood obesity epidemic became an urgent task for policymakers, schools, and healthcare workers. Increased public open space and active transport infrastructure were encouraged to promote urban children's physical activity.<sup>44</sup> In addition, the WHO suggested that children should take online exercise classes and use video- or application-guided aerobic training at home as well as monitor dietary intake through the Internet during the pandemic.<sup>45</sup> The longer the home confinement and isolation, the more likely children would experience stress, anxiety, panic, and other psychological problems.<sup>10,46</sup> The government should also take measures to prevent further deterioration of children's psychological problems.

There were some strengths in this study. This is one of the first longitudinal studies to assess the impact of the COVID-19 pandemic on BMI gain and obesity prevalence changes in general Chinese children aged 8–12 years. The relatively large sample size recruited from the general population and objectively measured data strengthen the representativeness, in contrast to Internet self-reported surveys<sup>18,19</sup> or hospital-based studies.<sup>21</sup> Besides, multiple repeated measurements could help to eliminate the influence of the inherent weight change pattern before the pandemic.

### Limitations

However, several limitations should be admitted. First, only children aged 8–12 years in Suzhou, a developed area in eastern China, were recruited for this study, which would not fully represent children from other regions and age groups in China. Second, the HPPCA

failed to collect evidence about changes in children's lifestyle and dietary habits before and during the COVID-19 pandemic, so the authors could not explore the possible risk factors of BMI and obesity prevalence gain. Third, the excluded individuals in this study were younger because they had inadequate information before the pandemic or were more likely to live in rural areas because of high-school mobility and poor compliance to the physical examination. Therefore, the included sample was slightly different from the excluded sample to some extent, but important variables such as BMI and zBMI values were very close between these 2 groups, and the included sample may still be sufficient to reflect the main characteristics of the whole population. Finally, this study only explored changes in children's BMI and obesity prevalence before and during the pandemic. Therefore, future follow-up studies on the current topic are warranted.

## CONCLUSIONS

The COVID-19 pandemic coincides with a significant increase in BMI and obesity prevalence among Chinese children. Currently, there is an urgent need to formulate effective public health policies to reduce the risk of childhood obesity during the pandemic. In China, as vaccination coverage continues to improve, future prevention and control policies and children's lifestyles would change; continuous monitoring of this cohort should be undertaken in the next phase to examine the current progression of obesity and its adverse outcomes over time.

## ACKNOWLEDGMENTS

This study was supported by the National Natural Science Foundation of China (grant: 81602911); Priority Academic Program Development of Jiangsu Higher Education Institutions; and Gusu Health Talents Program Training Project in Suzhou, China (GSWS2020100). WG and JH contributed equally to this work.

No financial disclosures were reported by the authors of this paper.

## CREDIT AUTHOR STATEMENT

Wenxin Ge: Formal analysis, Methodology, Visualization, Writing - Original Draft, Writing - Review and Editing. Jia Hu: Conceptualization, Funding acquisition, Investigation, Resources, Writing - Review and Editing. Yue Xiao: Writing - review and editing. Fei Liang: Writing - review and editing. Liping Yi: Methodology, Formal analysis, Writing - original draft. Rushun Zhu: Writing - review and editing. Jieyun Yin: Conceptualization, Formal analysis, Writing - Review and Editing, Funding acquisition.



## SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at <https://doi.org/10.1016/j.amepre.2022.04.015>.

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