Letter to the Editor

Comparison of Obesity Prevalence among Middle and High School Graduates before and after the COVID-19 Lockdown*

LU Yan Hui[1,&], DOU Zi Yan[2,&], ZHAO Kai Ping[3,&], YAN Dong[4,&], CHEN Shuo[2], CHENG Jun Xia[5], Glen M. BLAKE[6], Karen HIND[7], ZHANG Jing Bo[2], CHENG Xiao Guang[4,#], and WU Jing[5,#]

The world has been engulfed in a COVID-19 pandemic that has significantly affected the health and economics of the population. The Chinese authorities imposed lockdown measures to limit the spread of COVID-19 and stopped school programs for children and adolescents. Such measures have been associated with increased sedentary time and reduced physical activity[1-3]. An online questionnaire study of youth in China compared activity patterns before and after the COVID-19 lockdown. The results showed significant decreases in the frequency of engaging in active transport, moderate-to-vigorous housework, and physical activity, while significant increases were observed in the average sedentary and sleeping times during workdays and weekends[1]. A study of UK adults reported a disproportionately large and negative effect of the lockdown on weight-related behaviors[2]. A longitudinal study in Italy, including 41 children and adolescents with obesity, showed that potato chips, red meat, and sugary drink intake increased significantly during the lockdown, and time spent participating in sports activities decreased significantly, whereas sleep time and screen time increased significantly[3].

The present study aimed to investigate and compare population data on the prevalence of overweight and obesity in middle and high school student graduates before the lockdown (graduated in 2019) and post-lockdown (graduated in 2020).

The database came from the 2017–2020 Beijing High School data and the score on the college entrance physical examination, which is mandatory for all students graduating from middle school and entering high school or graduating from high school and entering college. The Beijing Physical Examination Center is the designated location for organizing and overseeing this mandatory physical examination, which includes body height, weight, and blood pressure. The physical examinations were carried out from March to April 2019, while the following year's examinations were carried out from June to July 2020 due to the COVID-19 lockdown. In 2019, there were 32,024 female and 34,632 male graduates from middle school (average age of 15.0 years) and 28,944 female and 29,180 male graduates from high school (average age of 17.5 years). The corresponding numbers for 2020 were 38,262 female and 42,433 male middle school graduates and 28,169 female and 27,378 male high school graduates.

All measurements were made by trained technicians using identical apparatus. Body height was measured to the nearest 0.1 cm, and body weight was measured to the nearest 0.1 kg with standardized equipment and procedures. Body mass index (BMI) was calculated according to the formula: BMI = weight (kg)/height^2 (m^2).

Subjects were defined as being overweight or obese according to the BMI reference norms for screening overweight and obesity in Chinese children and adolescents proposed by the China Obesity Task Force Group[4].

Statistical analysis was performed using SPSS version 24.0 for Windows software (SPSS Inc., Chicago, IL, USA). Continuous data are described as mean ± standard deviation (SD), and percentages or

doi: 10.3967/bes2022.145

*This work was supported by the National Key R&D Program of China [code: 2020YFC2008900] and the Beijing Hospital Authority Clinical Medicine Development of Special Funding Support [code: ZYLX202107].

1. Department of Endocrinology, the Second Medical Center, Chinese PLA General Hospital, National Clinical Research Center for Geriatric Disease, Beijing 100000, China; 2. Beijing Physical Examination Center, Beijing 100000, China; 3. Department of Medical Record Management and Statistics, Beijing Jishuitan Hospital, Beijing 100000, China; 4. Department of Radiology, Beijing Jishuitan Hospital, Beijing 100000, China; 5. National Center for Chronic and Noncommunicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing 100000, China; 6. School of Biomedical Engineering & Imaging Sciences, King's College London, St Thomas' Hospital, London SE1 7EH, United Kingdom; 7. Department of Sport and Exercise Sciences, Durham University, Durham 27704, United Kingdom

rates were calculated for categorical variables. Differences between the 2019 and 2020 results were analyzed using the student's *t*-test and the chi-square test. A *P*-value < 0.05 was considered significant.

The anthropometric characteristics of all students graduating from middle school and entering high school or graduating from high school and entering college in 2019 and 2020 are shown in Table 1, respectively. After the 2020 lockdown, height, weight, and blood pressure increased significantly among middle school and high school graduates ($P < 0.01$). BMI increased significantly in males but not in females.

Significant increases in the prevalence of overweight and obesity were seen in males from middle school and high school after the 2020 lockdown compared to that in 2019 (overweight: 19.8% *vs.* 17.8%, 23.3% *vs.* 22.5%; obesity: 23.2% *vs*. 16.6%, 22.0% *vs.* 20.3%, respectively, $P < 0.001$). A significant increase in the obesity rate was detected in females from middle school ($P < 0.001$), whereas no significant difference ($P = 0.265$) was observed in females from high school (Figure 1).

We evaluated the prevalence rates of age-specific overweight and obesity in 2019 and 2020. The prevalence of overweight and obesity in middle school graduates increased significantly in males from all age groups (14–17 years old), and the obesity rate also increased in girls of all age groups ($P < 0.01$) (Figure 2A and 2B). A significant increase in the prevalence of obesity was detected among male high school graduates of all age groups (16–20 years old), whereas no significant changes were observed in the prevalence of overweight or obesity in the 2020 female graduates compared with those in 2019 (Figure 2C and 2D).

The trends in the prevalence rates of overweight and obesity among Chinese middle school and high school graduates from 2017 to 2020 were analyzed. A significant increase in the prevalence of obesity was observed among middle school graduates from 2017 to 2020. The obesity rate from 2019 to 2020 increased from 9.7% to 11.2% for females and from 16.6% to 23.2% for males, respectively, compared with from 9.0% to 9.6% for females and from 17.3% to 17.5% for males from 2017 to 2018. The COVID-19 lockdown may have accelerated the increase in the obesity rate.

The prevalence rates of overweight and obesity increased significantly in male graduates from middle school and high school after the 2020 lockdown. The obesity rate also significantly increased in females from middle school, but no

Table 1. Anthropometric characteristics of the middle school and the high school graduates in 2019 and 2020 (mean ± SD)

Characteristics	2019		2020		2019 *vs.* 2020	
	Female	Male	Female	Male	*P*1	*P*2
Mddle school	**(*n* = 320,24)**	**(*n* = 34,632)**	**(*n* = 38,262)**	**(*n* = 42,433)**		
Age (year)	15.0 ± 0.4	15.0 ± 0.4	15.0 ± 0.3	15.1 ± 0.4	*P* < 0.001	*P* < 0.001
Height (cm)	163.0 ± 5.6	173.6 ± 6.3	163.6 ± 5.7	174.8 ± 6.3	*P* < 0.001	*P* < 0.001
Weight (kg)	56.7 ± 11.7	67.1 ± 16.2	57.1 ± 12.8	70.8 ± 18.3	*P* < 0.001	*P* < 0.001
BMI (kg/cm^2)	21.3 ± 4.0	22.2 ± 4.8	21.3 ± 4.4	23.1 ± 5.5	*P* = 0.968	*P* < 0.001
SBP (mmHg)	113.6 ± 10.0	120.0 ± 10.2	114.0 ± 10.3	120.8 ± 10.1	*P* < 0.001	*P* < 0.001
DBP(mmHg)	69.4 ± 6.6	71.5 ± 7.1	69.2 ± 6.9	70.7 ± 7.1	*P* < 0.001	*P* < 0.001
High school	**(*n* = 28,944)**	**(*n* = 29,180)**	**(*n* = 28,169)**	**(*n* = 27,378)**		
Age (year)	17.8 ± 1.8	17.9 ± 1.9	17.5 ± 0.9	17.6 ± 1.1	*P* < 0.001	*P* < 0.001
Height (cm)	163.8 ± 5.7	176.8 ± 6.1	164.6 ± 5.8	177.2 ± 6.2	*P* < 0.001	*P* < 0.001
Weight (kg)	59.1 ± 12.4	75.2 ± 16.9	59.4 ± 12.8	76.2 ± 17.4	*P* = 0.019	*P* < 0.001
BMI (kg/cm^2)	22.0 ± 4.3	24.0 ± 5.0	21.9 ± 4.5	24.2 ± 5.2	*P* = 0.001	*P* < 0.001
SBP (mmHg)	112.2 ± 11.6	121.1 ± 11.5	114.1 ± 11.5	122.5 ± 11.0	*P* < 0.001	*P* < 0.001
DBP (mmHg)	70.8 ± 7.7	73.2 ± 7.5	71.3 ± 7.5	73.3 ± 7.8	*P* < 0.001	*P* = 0.024

Note. *P*1: the difference between 2019 and 2020 in females; *P*2: the difference between 2019 and 2020 in males.

significant difference was detected in females from high school. The age-specific analysis showed that the prevalence of overweight and obesity increased significantly in male middle school graduates of all age groups (14–17 years old), and the obesity rate also increased in girls of all age groups ($P < 0.01$). The prevalence of obesity increased significantly among male high school graduates of all age groups (16–20 years old), but no significant changes were detected in the female graduates. The prevalence of obesity among middle school graduates increased significantly and continuously from 2017 to 2020 and increased sharply between 2019 and 2020. The increase in obesity rate was more obvious among male graduates than among female graduates. Female adolescents aged 16–20 years may pay more attention to their bodies than males and adhere to diet control, so the prevalence of obesity was maintained at a relatively stable level among female high school graduates. An Italian study showed an increase in the prevalence of obesity among obese adolescents during the lockdown, with males mainly affected, and the reason why females gained less weight than males was that females had fewer sedentary hours than males[5].

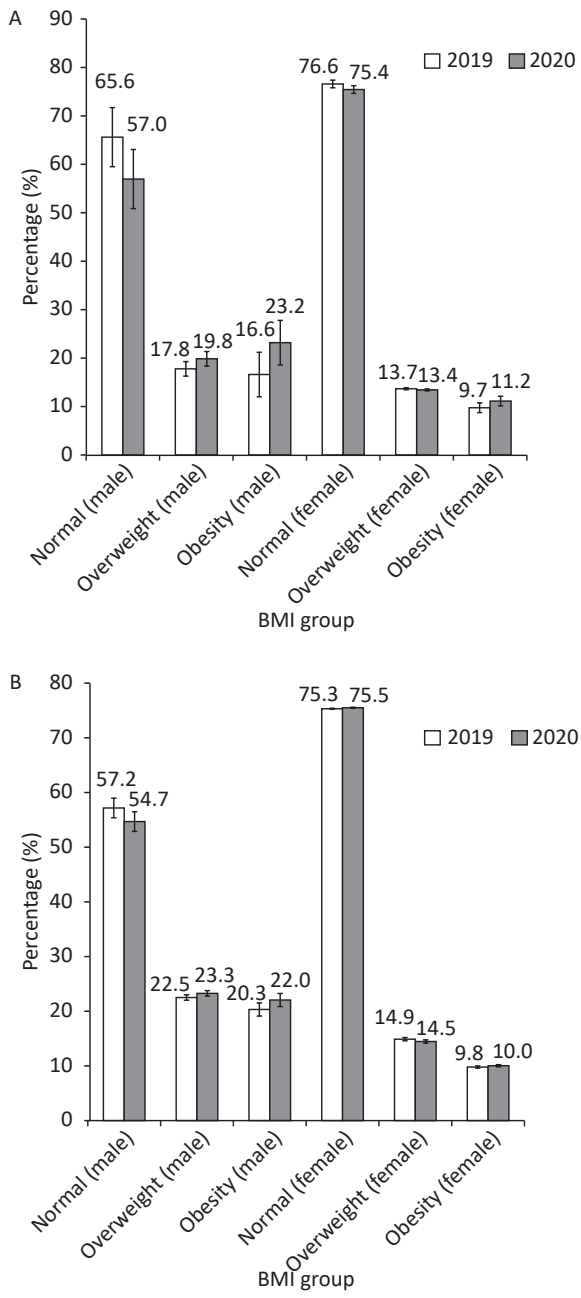

Figure 1. Sex-specific BMI group distribution among middle school graduates (A) and high school graduates (B) between 2019 and 2020.

COVID-19 has been a threat to physical and mental health since the outbreak began. Confinement due to the COVID-19 pandemic may not only affect dietary behavior and physical activity but also increase the risk of stress, particularly among adolescents. Graduates from middle school or high school are experiencing a transition, which is essential for forming healthy eating habits and activity levels. As these restrictive measures help reduce the infection rate, the appearance of sedentary behavior and inevitable changes in dietary choices has negative effects on health status. In addition, the lockdown was a source of stress. Numerous societal changes, change in the daily routine, and unpleasant information generates anxiety and fear in children and young people[6]. Emotional eating is defined as the tendency to overeat as a coping mechanism to regulate and reduce negative emotions, such as depression, anxiety, and stress[7]. Additionally, anxiety and stress among young adults may harm short- and long-term weight control[8,9]. As the lockdown had a greater impact on the emotional development of young children and adolescents compared to that of adults, there is a pressing need for designing longitudinal and developmental studies to provide psychosocial and mental health support to vulnerable children and adolescents during the pandemic as well as post-pandemic[10].

Our study had some limitations. We did not include a lifestyle questionnaire, self-reported data, or a psychological evaluation of the participants. Furthermore, we compared the graduates of different years before and after the COVID-19 lockdown, and participants were not their controls. A self-controlled study may exclude the effect of genetic factors.

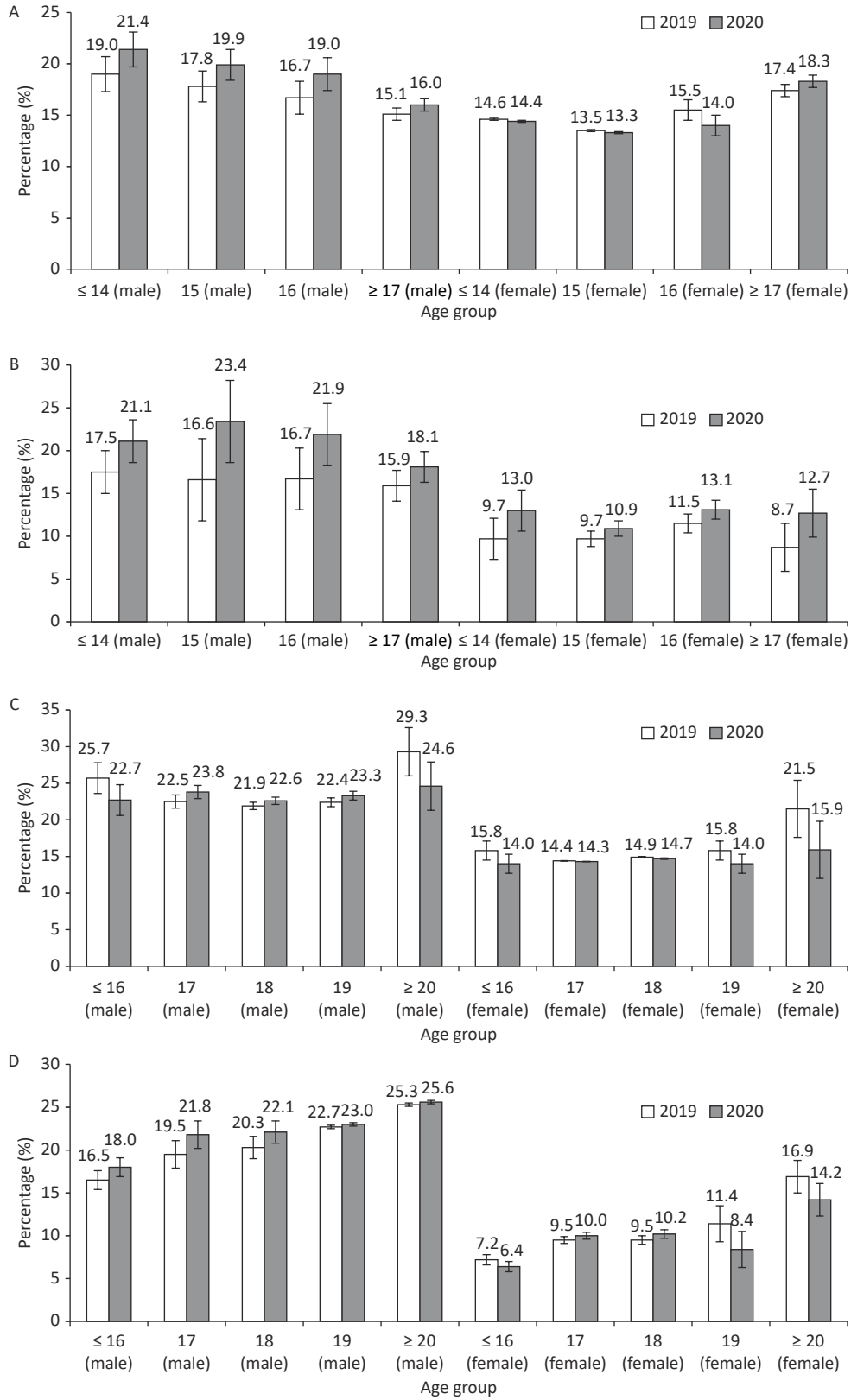

Figure 2. Age and sex-specific overweight and obesity prevalence rates among middle school graduates (A, B) and high school graduates (C, D) between 2019 and 2020.

Despite these limitations, this study investigated a large representative population from a Beijing High School database and college entrance physical examination data and is of particular importance for concluding the impact of the COVID-19 lockdown on the obesity of graduates from middle and high school in China.

In conclusion, the COVID-19 lockdown had a negative effect on the obesity status of middle and high school graduates in China. The results from this large-scale survey will be useful for policymakers to change the overweight/obesity status of adolescents during the lockdown and consider effective measures to help graduates keep physically and mentally fit and minimize adverse consequences.

Author Contributions Conceptualization, CHENG Xiao Guang and WU Jing; Data curation, DOU Zi Yan, YAN Dong, CHEN Shuo, and ZHANG Jing Bo; Formal analysis, ZHAO Kai Ping; Investigation, LU Yan Hui; Project administration, CHENG Xiao Guang and WU Jing; Validation, DOU Zi Yan, CHEN Shuo, and ZHANG Jing Bo; Visualization, ZHAO Kai Ping; Writing – original draft, LU Yan Hui and YAN Dong; Writing – review & editing, CHENG Jun Xia, Glen M. BLAKE, Karen HIND, CHENG Xiao Guang, and WU Jing.

Conflict of Interest The authors declare that there are no conflicts of interest.

[&]These authors contributed equally to this work.

[#]Correspondence should be addressed to CHENG Xiao Guang, E-mail: xiao65@263.net, Tel: 86-10-58516688; WU Jing, E-mail: wujing@ncncd.chinacdc.cn, Tel: 86-10-8315 4663.

Biographical notes of the first authors: LU Yan Hui, female, born in 1978, Dr., Associate Professor, majoring in comprehensive prevention and treatment of metabolic diseases such as diabetes; DOU Zi Yan, male, born in 1978, Technician in Charge, majoring in physical examination quality control; ZHAO Kai Ping, female, born in 1986, Senior Statistician, majoring in osteoporosis epidemiology, health statistics and health management; YAN Dong, male, born in 1980, Dr., Associate Chief Physician, majoring in imaging diagnosis of skeletal and muscle diseases.

Received: April 6, 2022;

Accepted: November 8, 2022

REFERENCES

1. Jia P, Zhang L, Yu WQ, et al. Impact of COVID-19 lockdown on activity patterns and weight status among youths in China: the COVID-19 Impact on Lifestyle Change Survey (COINLICS). Int J Obes (Lond), 2021; 45, 695−9.
2. Robinson E, Boyland E, Chisholm A, et al. Obesity, eating behavior and physical activity during COVID-19 lockdown: a study of UK adults. Appetite, 2021; 156, 104853.
3. Pietrobelli A, Pecoraro L, Ferruzzi A, et al. Effects of COVID-19 lockdown on lifestyle behaviors in children with obesity living in Verona, Italy: a longitudinal study. Obesity (Silver Spring), 2020; 28, 1382−5.
4. Group of China Obesity Task Force. Body mass index reference norm for screening overweight and obesity in Chinese children and adolescents. Chin J Epidemiol, 2004; 25, 97−102. (In Chinese)
5. Maltoni G, Zioutas M, Deiana G, et al. Gender differences in weight gain during lockdown due to COVID-19 pandemic in adolescents with obesity. Nutr Metab Cardiovasc Dis, 2021; 31, 2181−5.
6. Lambrese JV. Helping children cope with the COVID-19 pandemic. Cleve Clin J Med, 2020. 10.3949/ccjm.87a.ccc010.
7. Ganley RM. Emotion and eating in obesity: a review of the literature. Int J Eat Disord, 1989; 8, 343−61.
8. Devonport TJ, Nicholls W, Fullerton C. A systematic review of the association between emotions and eating behaviour in normal and overweight adult populations. J Health Psychol, 2019; 24, 3−24.
9. Luo MY, Wang QJ, Yang SJ, et al. Changes in patterns of take-away food ordering among youths before and after COVID-19 lockdown in China: the COVID-19 Impact on Lifestyle Change Survey (COINLICS). Eur J Nutr, 2022; 61, 1121−31.
10. Singh S, Roy D, Sinha K, et al. Impact of COVID-19 and lockdown on mental health of children and adolescents: a narrative review with recommendations. Psychiatry Res, 2020; 293, 113429.