



Impact of COVID-19 lockdown on activity patterns and weight status among youths in China: the COVID-19 Impact on Lifestyle Change Survey (COINLICS)

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Abstract

Lockdown measures including school closures due to COVID-19 may affect youths' activity patterns and obesity status. This will be for the first time examined in China in this study on the basis of a large national sample from the COVID-19 Impact on Lifestyle Change Survey (COINLICS). Through an online questionnaire, 10,082 participants from high schools, colleges, and graduate schools, aged 19.8 ± 2.3 years, voluntarily reported their lifestyles and weight status before (January 2020) and after lockdown (April–May 2020). The significance of these changes was assessed between sexes and across education levels. We found that the youths' average body mass index significantly increased from 21.8 to 22.1 kg/m², with the prevalences of overweight/obesity and obesity increasing from 21.4% to 24.6% and from 10.5% to 12.6%, respectively. Also, significant decreases were seen in the frequency of engaging in active transport, moderate-/vigorous-intensity housework, leisure-time moderate-/vigorous-intensity physical activity, and leisure-time walking, while significant increases were observed in the average sedentary time during workdays and weekends, the average sleeping time during workdays and weekends, and screen time. Our findings would serve as important evidence for shaping global strategies to counteract or reverse the lockdown effects on youths' obesity.

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Introduction

Obesity is defined as abnormal or excessive fat accumulation which presents risks to human health. Although a growing awareness of health threats of obesity, the global prevalence of obesity has steadily risen [1], which is related to the sedentary nature of modern post-industrial life, with increased levels of options in our environments to be physically inactive [2–7]. This may have been aggravated by lockdown measures due to coronavirus disease 2019 (COVID-19) [8]. Furthermore, as school is an important locale with many factors (e.g., physical education classes, extracurricular physical activity requirement) that could alleviate youths' obesity risk [9], school closures may disproportionately affect activity patterns and weight status of youths during the lockdown period [10]. For example, an Italian study found that children with obesity had decreased exercise time and increased screen and sleeping time after COVID-19 during lockdown [11]. These effects might remain after lockdown was lifted. To the best knowledge of the authors, studies assessing the lockdown effects on youths' activity patterns and weight status in the post-lockdown period are still lacking. This study aims to fill this

gap by presenting the changes in a set of activities of great clinical and policy relevance among the Chinese youths before and after lockdown. Our findings would serve as important evidence for shaping global strategies to counteract or reverse the effects of COVID-19 lockdown on weight status in youths.

Methods

Study design, sample setting

This study was based on the COVID-19 Impact on Lifestyle Change Survey (COINLICS) in China, a national retrospective survey distributed via two major Chinese social media platforms (WeChat and Tencent QQ) in early May 2020. A snowball sampling method was used to recruit participants. An internet-based questionnaire was initially distributed among several social media groups of educators at all three education levels (high school, college, and graduate school), which contained at least one of the investigators of the survey team and were formed during the national conferences in the field; at least two educators in each of the 32 provinces, autonomous regions, and municipalities of China were ensured to share the questionnaire with their surrounding students through chat groups and/or moments. Those who had completed the questionnaire were also encouraged to forward it to others. Three common-sensical questions (e.g., where the capital of China is) were placed among the questions to test the validity of the questionnaire. If any of them were answered incorrectly, that questionnaire was considered invalid. The questionnaire was required to be completed online anonymously. More than 10,000 youth participants at three education levels have voluntarily reported their basic sociodemographic information and routine lifestyles in the months before (23 December 2019 to 23 January 2020) and after COVID-19 lockdown (8 April to 8 May 2020).

It has been stated on the cover page that the participants cannot proceed with the online survey without consent; for the youth under 18, consent must be obtained from their parents or guardians. The study was approved by the Sichuan University Medical Ethical Review Board (KS2020414).

Weight status variables

Individuals' body weight one month before COVID-19 lockdown (around 23 December 2019) and weight and height one month after COVID-19 lockdown (the time of this survey) were self-reported. The body mass index (*BMI*, in kg/m^2) for each youth was calculated by dividing body weight by squared height. According to the World Health Organization (WHO) guidance, *obesity* and *overweight* for

those aged > 18 were defined as a *BMI* of ≥ 23 and $\geq 27 \text{ kg}/\text{m}^2$, respectively; [12] *obesity* and *overweight* for those aged < 18 were defined based on the International Obesity Task Force (IOTF) recommended age-sex-specific cut-offs corresponding to *BMI* ≥ 23 and $\geq 27 \text{ kg}/\text{m}^2$ at age 18, respectively [13, 14].

Measures of activity patterns

Activity patterns were measured using an International Physical Activity Questionnaire (IPAQ)-long form [15]. This study focused on changes in nine weight-related activity patterns related to COVID-19. The frequency of engaging in active transport (i.e., walking and cycling) for commuting/errands, moderate-/vigorous-intensity housework (MVH), leisure-time moderate-/vigorous-intensity physical activity (MVPA), and leisure-time walking was reported as days/week (only counting outings that had lasted at least 10 min). The average sedentary time during workdays and weekends, sleeping time during workdays and weekends separately, and screen time spent on TV and computers were reported as min/day.

Statistical analyses

Descriptive statistics of participating youths' basic characteristics before COVID-19 lockdown and activity patterns before and after COVID-19 lockdown were provided as mean and standard deviation for continuous variables and percentages for categorical variables. We used *t*-tests and ANOVA (or χ^2 tests for categorical variables) to evaluate the significance of differences in weight-related outcomes and lifestyles across education levels and between sexes at each education level. We also used paired *t*-tests to evaluate the significance of differences in weight-related outcomes and lifestyles before and after COVID-19 lockdown for each sex-education group. All statistical analyses were performed using R 3.6.2 and statistical significance was declared if $p < 0.05$.

Results

A total of 10,082 participants were included in the final analysis. The average age of the participants was 19.8 ± 2.3 years, most of whom were female (71.7%), Hans (95.3%), undergraduates (69.7%), and living in non-urban areas (63.2%) (Table 1). Most of the high-school (89%) and graduate students (49.1%) majored in medical science, and most undergraduates majored in social sciences (53.7%).

The average *BMI* of all youths before lockdown was $21.8 \text{ kg}/\text{m}^2$, with 21.4% with overweight/obesity and 10.5% with obesity only (Table 1). The *BMI* and prevalences of

Table 1 Baseline characteristics of participating youths and their weight status before and after COVID-19 lockdown.

Variable	Percentage or mean \pm standard deviation									
	High school students			Undergraduate students			Graduate students			All
	Male (n = 678)	Female (n = 2146)	Total (n = 2824)	Male (n = 2106)	Female (n = 4918)	Total (n = 7024)	Male (n = 68)	Female (n = 166)	Total (n = 234)	Grand total (n = 10,082)
Age (years)	17.5 \pm 1.2	17.5 \pm 1.2	17.5 \pm 1.2	20.6 \pm 2.0	20.6 \pm 1.6	20.6 \pm 1.8	24.3 \pm 4.1	24.7 \pm 3.2	24.6 \pm 3.5	19.8 \pm 2.3
Ethnic										
Han	96.9	96.7	96.7	94.2	95.1	94.8	92.6	92.2	92.3	95.3
Minority	3.1	3.3	3.3	5.8	4.9	5.2	7.4	7.8	7.7	4.7
Urbanicity										
Urban	31.9	22.1	24.4	40.2	41.3	41.0	57.4	63.3	61.5	36.8
Non-urban	68.1	77.9	75.6	59.8	58.7	59.0	42.6	36.7	38.5	63.2
Household income (yuan/year)										
<12k	20.8	25.7	24.5	21.7	18.5	19.4	13.2	4.3	6.9	20.6
\geq 12k–20k	28	37.9	35.5	23.2	28.2	26.7	4.5	11.4	9.4	28.9
\geq 20k–60k	28.3	25	25.8	26.3	28.1	27.6	14.7	24.7	21.8	27.0
\geq 60k–100k	15.2	7.8	9.6	14.8	13.4	13.8	22.1	22.9	22.6	12.8
\geq 100k–200k	5.5	2.6	3.3	9.4	8.6	8.9	27.9	24.7	25.6	7.7
\geq 200k	2.2	1.0	1.3	4.6	3.2	3.6	17.6	12.0	13.7	3.2
Major										
Medical Science	59.0	98.4	89.0	12.4	16.0	14.9	41.2	52.4	49.1	36.4
Science/Engineering	39.4	1.0	10.2	51.9	22.6	31.4	44.1	20.5	27.4	25.4
Social Science	1.6	0.6	0.8	35.7	61.4	53.7	14.7	27.1	23.5	38.2
Weight (kg)										
Pre-lockdown	62.0 \pm 15.5	57.6 \pm 17.4	58.6 \pm 17.1	63.6 \pm 12.3	55.3 \pm 14.0	57.8 \pm 14.1	68.6 \pm 14.2	54.6 \pm 10.2	58.6 \pm 13.1	58 \pm 14.9
Post-lockdown	64.8 \pm 22.1^{***}	58.8 \pm 23^{***}	60.2 \pm 22.9^{***}	66.1 \pm 56.7*	55.6 \pm 17.3*	58.7 \pm 34.6^{**}	71.7 \pm 21.1*	55.8 \pm 13.4	60.4 \pm 17.5^{**}	59.9 \pm 31.5^{***}
BMI (kg/m ²)										
Pre-lockdown	21.7 \pm 6.0	23.0 \pm 6.9	22.7 \pm 6.7	21.4 \pm 4.5	21.5 \pm 5.5	21.4 \pm 5.2	23.0 \pm 3.5	20.8 \pm 3.8	21.4 \pm 3.8	21.8 \pm 5.7
Post-lockdown	22.8 \pm 7.9^{***}	23.8 \pm 8.8^{***}	23.6 \pm 8.6^{***}	22.3 \pm 20.1*	22.3 \pm 20.4^{***}	21.8 \pm 6.3^{***}	21.9 \pm 12.4*	23.9 \pm 4.7*	21.4 \pm 4.9^{***}	22.1 \pm 4.9^{***}
Overweight (BMI \geq 23)										
Pre-lockdown	23	27.9	26.7	22.4	17.8	19.1	46.3	14.5	23.6	21.4
Post-lockdown	30.2^{***}	30.5^{***}	30.4^{***}	27.4^{***}	19.8^{***}	22.1^{***}	56.7*	18.8	29.7*	24.6^{***}
Obesity (BMI \geq 27)										
Pre-lockdown	13.1	17	16.1	7.2	9	8.5	9	3.6	5.2	10.5
Post-lockdown	17.3^{***}	20^{***}	19.3^{***}	9.7^{***}	10.4^{***}	10.2^{***}	13.4	5.5	7.8*	12.6^{***}

*Values under a given variable were shown in **bold**, if the difference across education levels (High school students, Undergraduate students, Graduate students) within the overall population (Total) or within a given sex (Male, Female) was significant ($p < 0.05$); shown in *italic*, if the difference between sexes within a given education level was significant ($p < 0.05$); and marked by asterisks, if the difference before and after COVID-19 lockdown within a given education level and sex was significant ($\chi^2 p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$). p values were based on χ^2 tests for categorical variables or t -tests/AVONA for continuous variables.

overweight/obesity and obesity significantly varied across education levels, with high-school students having the highest BMI (22.7 ± 6.7 kg/m²) and the highest prevalences of overweight/obesity (26.7%) and obesity (16.1%). Male graduate students had the highest prevalence of overweight/obesity (46.3%) in stratified analyses by sex and education level. Gender differences in the prevalence of overweight/obesity were also observed among different education levels, for example, higher in male than female graduate students (46.3% vs. 14.5%, $p < 0.05$) and undergraduate students (22.4% vs. 17.8%, $p < 0.05$), and higher in female than male high-school students (27.9% vs. 23.0%, $p < 0.05$). After the lockdown was lifted, the youths showed a significant increase in BMI on average (21.8 to 22.1 kg/m², $p < 0.001$), which was also observed in all education subgroups. Similarly, increases in the prevalence of overweight/

obesity (21.4% to 24.6%, $p < 0.001$) and obesity (10.5% to 12.6%, $p < 0.001$) were also observed in all education subgroups.

After lifting lockdown measures, the activity patterns of the youths changed differently between sexes and among educational levels (Table 2). Significant decreases were seen in the frequency of engaging in active transport for commuting/errands (1.3–0.9 days/week, $p < 0.001$), MVH (2.3–1.9 days/week, $p < 0.05$), leisure-time MVPA (0.7–0.65 days/week, $p < 0.001$), and leisure-time walking (1.0–0.7 days/week, $p < 0.001$). In contrast, significant increases were observed in the average sedentary time during workdays (4.2–5.3 h/week, $p < 0.001$) and weekends (4.3–5.1 h/week, $p < 0.001$), the average sleeping time during workdays (7.4–7.6 h/week, $p < 0.001$) and weekends (7.9–8.0 h/week, $p < 0.001$), and screen time (4.9–5.6 h/week, $p < 0.001$).

Table 2 Physical activity patterns of participating youths before and after COVID-19 lockdown.

Variable	Mean \pm standard deviation									
	High school students			Undergraduate students			Graduate students			All
	Male (n = 678)	Female (n = 2146)	Total (n = 2824)	Male (n = 2106)	Female (n = 4918)	Total (n = 7024)	Male (n = 68)	Female (n = 166)	Total (n = 234)	Grand total (n = 10,082)
Physical activity (days/week)										
<i>Active transport for commuting/errands</i>										
Pre-lockdown	0.6 \pm 1.8	0.7 \pm 1.7	0.6 \pm 1.7	<i>1.2 \pm 2.5</i>	<i>1.6 \pm 2.7</i>	<i>1.5 \pm 2.6</i>	3.1 \pm 4.1	2.9 \pm 3.1	2.9 \pm 3.4	1.3 \pm 2.5
Post-lockdown	0.4 \pm 1.5^{***}	0.6 \pm 1.5[*]	0.5 \pm 1.5^{**}	0.8 \pm 2^{***}	1.1 \pm 2.1^{***}	1 \pm 2.1^{***}	1.9 \pm 3.5[*]	1.8 \pm 2.7^{***}	1.8 \pm 3^{***}	0.9 \pm 0.2 ^{***}
<i>Housework activity</i>										
Pre-lockdown	<i>1.5 \pm 3.1</i>	<i>2.5 \pm 3.8</i>	2.3 \pm 3.6	<i>1.8 \pm 3.2</i>	<i>2.5 \pm 3.5</i>	2.3 \pm 3.4	1.3 \pm 2.6	1.5 \pm 2.5	1.5 \pm 2.6	2.3 \pm 3.5
Post-lockdown	<i>1 \pm 2.6^{***}</i>	<i>2.1 \pm 3.5^{***}</i>	1.8 \pm 3.3^{***}	<i>1.3 \pm 2.9^{***}</i>	<i>2.3 \pm 3.5^{**}</i>	2 \pm 3.4^{***}	<i>1.4 \pm 3</i>	<i>2.4 \pm 3.2^{***}</i>	2.1 \pm 3.2^{**}	1.9 \pm 3.4^{***}
<i>Moderate to vigorous physical activity</i>										
Pre-lockdown	<i>0.7 \pm 2.0</i>	<i>0.4 \pm 1.6</i>	0.5 \pm 1.7	<i>0.9 \pm 2.3</i>	<i>0.7 \pm 2.0</i>	0.8 \pm 2.1	0.5 \pm 1.2	0.7 \pm 1.6	0.6 \pm 1.5	0.7 \pm 2.0
Post-lockdown	<i>0.5 \pm 1.7[*]</i>	0.4 \pm 1.6	0.4 \pm 1.7[*]	<i>0.5 \pm 1.8^{***}</i>	0.8 \pm 2.2[*]	0.7 \pm 2.1	<i>0.2 \pm 0.7</i>	<i>1.0 \pm 2.7</i>	0.8 \pm 2.3	0.7 \pm 2.0 [*]
<i>Walking for leisure</i>										
Pre-lockdown	0.5 \pm 1.4	<i>0.7 \pm 1.7</i>	0.6 \pm 1.6	<i>1 \pm 2</i>	<i>1.3 \pm 2.2</i>	1.2 \pm 2.1	1.5 \pm 2.3	1.7 \pm 2.3	1.6 \pm 2.3	1.0 \pm 2.0
Post-lockdown	0.3 \pm 1.1^{***}	0.5 \pm 1.4^{***}	0.4 \pm 1.3^{***}	0.6 \pm 1.6^{***}	0.9 \pm 1.9^{***}	0.8 \pm 1.8^{***}	1.1 \pm 2.1	1.4 \pm 2.1	1.3 \pm 2.1	0.7 \pm 1.7 ^{***}
Sedentary time (h/day)										
<i>During workdays</i>										
Pre-lockdown	<i>3.7 \pm 2.9</i>	4.2 \pm 2.8	4.1 \pm 2.9	4.1 \pm 2.9	4.3 \pm 2.8	4.2 \pm 2.9	5.9 \pm 3.7	6.2 \pm 2.9	6.1 \pm 3.1	4.2 \pm 2.9
Post-lockdown	4.5 \pm 7.1^{***}	5.2 \pm 4.2^{***}	5.1 \pm 5.1^{***}	5.8 \pm 3.2	5.7 \pm 3.2	5.4 \pm 3.2	6.7 \pm 3.9	6.2 \pm 2.8	6.3 \pm 3.2	5.3 \pm 3.2^{***}
<i>During weekends</i>										
Pre-lockdown	<i>3.8 \pm 3.0</i>	<i>4.1 \pm 2.8</i>	4.0 \pm 2.9	4.1 \pm 3.0	4.4 \pm 2.9	4.3 \pm 2.9	5.7 \pm 3.8	5.6 \pm 2.9	5.6 \pm 3.2	4.3 \pm 2.9
Post-lockdown	<i>4.5 \pm 6.9</i>	<i>4.9 \pm 3.6^{***}</i>	4.8 \pm 4.6^{***}	4.8 \pm 3.2	5.4 \pm 3.1 ^{**}	5.2 \pm 3.2	6.6 \pm 3.9	5.9 \pm 2.7 [*]	6.1 \pm 3.1 ^{**}	5.1 \pm 3.2^{***}
Sleeping time (h/day)										
<i>During workdays</i>										
Pre-lockdown	7.2 \pm 3.2	7.6 \pm 3.2	7.5 \pm 3.2	6.8 \pm 3.0	7.6 \pm 2.6	7.4 \pm 2.8	6.7 \pm 2.8	7.4 \pm 2.0	7.3 \pm 2.2	7.4 \pm 2.9
Post-lockdown	7.3 \pm 6.7	7.8 \pm 3.8	7.7 \pm 4.7	7.3 \pm 15.1	7.7 \pm 3.2	7.5 \pm 8.7	7.1 \pm 3.7	7.5 \pm 2.3	7.4 \pm 2.8	7.6 \pm 7.7 ^{***}
<i>During weekends</i>										
Pre-lockdown	7.5 \pm 3.5	<i>8.1 \pm 3.4</i>	8.0 \pm 3.4	7.2 \pm 3.2	8.2 \pm 2.9	7.9 \pm 3.0	6.9 \pm 2.9	8.0 \pm 2.3	7.7 \pm 2.5	7.9 \pm 3.1
Post-lockdown	7.8 \pm 6.7	8.3 \pm 4.9	8.2 \pm 5.4	7.6 \pm 15.1	8.1 \pm 3.3 ^{**}	8 \pm 8.7	7.1 \pm 3.1	7.9 \pm 2.3	7.6 \pm 2.6	8.0 \pm 7.8^{***}
Screen time (h/day)										
Pre-lockdown	4.5 \pm 1.9	4.8 \pm 1.9	4.7 \pm 1.9	4.9 \pm 2	5 \pm 1.9	5 \pm 1.9	5.3 \pm 1.9	5.1 \pm 1.7	5.2 \pm 1.7	4.9 \pm 1.9
Post-lockdown	4.5 \pm 2	5.5 \pm 2.1^{***}	5.3 \pm 2.1^{***}	5.4 \pm 2.2^{***}	5.9 \pm 2.2^{***}	5.8 \pm 2.2^{***}	5.3 \pm 2.1	5.3 \pm 1.9[*]	5.3 \pm 1.9	5.6 \pm 2.2^{***}

*Values under a given variable were shown in **bold**, if the difference across education levels (High school students, Undergraduate students, Graduate students) within the overall population (Total) or within a given sex (Male, Female) was significant ($p < 0.05$); shown in *italic*, if the difference between sexes within a given education level was significant ($p < 0.05$); and marked by asterisks, if the difference before and after COVID-19 lockdown within a given education level and sex was significant ($p < 0.05$, $**p < 0.01$, $***p < 0.001$). p values were based on χ^2 tests for categorical variables or t -tests/AVONA for continuous variables.

Discussion

Using the national COINLICS dataset, we found that, after the COVID-19 lockdown, the youths' weight status has increased at all three education levels; the frequencies of their physical activities have reduced, and their sedentary, sleeping, and screen time have all increased. At least two factors may underlie the low level of physical activity in China after lockdown: although most cities in China were designated as low-risk areas in May, people remained wary of going outside; also, most high schools and universities started online teaching between March and April, which may account for the increases in sedentary and screen time in our survey.

However, findings of this study should be treated with caution for the following reasons. First, COINLICS

generated a convenience sample that may not be perfectly representative of the Chinese youths. Also, recalling what have happened about four months ago, including self-reported body weight, may be subject to recall bias; moreover, height was only self-reported once at the time of survey, which may affect the precise calculation of the time-varying BMI. However, our participants were aged about 20 on average (with the youngest aged > 16), which had been at least 5–7 years after the major growth spurt happened, so the effect was reasonably considered minimal. Second, without assistance of the trained staff, variation in understanding the same questions among different individuals, especially across different education levels, might affect the comparability of results among different education groups. Third, the IPAQ form was not originally designed for the purpose of this study, so its applicability to this context and

the possibility of using alternative survey instruments need to be further discussed.

Despite those limitations, this online survey presented unique strengths by accumulating a large sample size in the targeted population promptly for drawing strong conclusions, which is of particular importance in the context of public health emergencies [16]. The design of the online questionnaire used is also a strength, where questions on each lifestyle before and after COVID-19 lockdown were placed next to each other for participants to better recall and compare. Therefore, their answers could be treated as good indicators for their lifestyle changes or the perceived lifestyle changes; the latter is usually highly correlated with their actual lifestyle changes. In sum, the information from this timely, large-scale national survey would be useful for multiple stakeholders including policy makers to learn the status quo of activity patterns and changes among the Chinese youths and consider potential further effects when making future decisions regarding when and how to loosen restrictions. School administrators should also be informed of these changes, so in-class and/or extra-curricular physical activity programs could be designed to counteract the negative impact.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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