

ORIGINAL RESEARCH ARTICLE

Obesity and activity patterns before and during COVID-19 lockdown among youths in China

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Summary

This study aim to assess changes in obesity and activity patterns among youths in China during the COVID-19 lockdown. We used the COVID-19 Impact on lifestyle change survey (COINLICS), a national retrospective survey distributed via social media platforms in early May 2020 where more than 10 000 youth participants in China have voluntarily reported their basic sociodemographic information, weight status, and routine lifestyles in the months before and during COVID-19 lockdown. The extended IOTF and WHO standards were used to define overweight and obesity of the participants. We used paired t-tests or χ^2 tests and non-parametric methods to evaluate the significance of differences in weight-related outcomes and lifestyles across education levels, between sexes, and before and during COVID-19 lockdown. The mean body mass index of all participating youths has significantly increased (21.8-22.6) and in all education subgroups during COVID-19 lockdown. Increases also occurred in the prevalence of overweight/obesity (21.3%-25.1%, $P < .001$) and obesity (10.5% to 12.9%, $P < .001$) in overall youths, especially in high school and undergraduate students. Their activity patterns had also significantly changed, including the decreased frequency of engaging in active transport, moderate-/vigorous-intensity housework, leisure-time moderate-/vigorous-intensity physical activity, and leisure-time walking, and the increased sedentary, sleeping, and screen time. Our findings would inform policy-makers and clinical practitioners of these changes in time, for better policy making and clinical practice. School administrators should also be informed of these changes, so in-class and/or extracurricular physical activity programs could be designed to counteract them.

KEYWORDS

COVID-19, lockdown, overweight, physical activity, youth

1 | INTRODUCTION

Obesity is a health condition that occurs when a person carries excess weight or body fat, which has been associated with the increased risk

of many chronic diseases, such as type 2 diabetes, heart disease and stroke.¹ The global prevalence of overweight and obesity has been more than 1.9 billion in adults, 38 million in children under the age of five, and over 340 million in children and adolescents aged 5-19.² To curb the obesity epidemic globally, access to healthy environments has been promoted by multiple stakeholders in the past, in order to encourage the healthy lifestyles.^{3,4}

Shujuan Yang and Bing Guo contributed equally to this study.

However, the coronavirus disease 2019 (COVID-19) pandemic has brought significant impact on human's lives. "Stay-at-home" has been ordered by many governments around the world, aiming at containing the spread of COVID-19, which, on the other side, may have changed activity patterns and consequently weight status among people at all ages. Furthermore, such contagious epidemics may cancel out the existing efforts to curb obesity epidemic. Among all affected, the youth is a particular vulnerable population to such changes, due to their newly obtained freedom to manage their lifestyles with, however, relatively insufficient capacity of coping with such unexpected changes. School or campus closures may have further aggregated the impact of lockdown measures on them by creating physical activity (PA) challenges.^{5,6} Millions of students are thus affected by school closures globally.

Limited studies have shown how the youth's obesity and activity patterns have been changed by COVID-19. A recent study in Italy has explored the changes in lifestyles associated with COVID-19 lockdown among 41 children and adolescents with obesity.⁷ It revealed that sports activities decreased, sleep time increased, and screen time increased significantly. However, lifestyle changes in Italy may only represent the situation in western countries; the neighbourhood environment, lifestyles among the youth, and the degree to which lockdown measures have been implemented are different in eastern countries, especially in China, which has also been severely affected by the COVID-19 at early stages. Also, further understanding on the basis of larger samples is urgently needed.

Therefore, to obtain a timely, fuller picture of the impact of the COVID-19 pandemic on obesity and activity patterns among the youth worldwide, we need evidence from Eastern countries on obesity and lifestyle changes, so future global strategies of obesity prevention could be designed from evidence obtained across countries. This study aimed to fill this critical, urgent gap by assessing changes in nine key activity patterns of clinical and policy relevance, overweight, and obesity among youths in China.

2 | METHODS

2.1 | Study design, sample and setting

This study was based on the COVID-19 Impact on Lifestyle Change Survey (COINLICS), a national retrospective survey distributed via social media platforms in early May 2020 using a snowball sampling method. An online questionnaire was initially distributed among several WeChat and Tencent QQ groups of educators at three education levels (high school, college, and graduate school). At least two educators in each province of China had shared the questionnaire with their surrounding students through WeChat and Tencent QQ groups and/or moments. Those who had completed the questionnaire were also encouraged to forward it to others. As a result, more than 10 000 youth participants at three education levels in China have voluntarily reported their basic sociodemographic information and routine

What is already known about this subject?

There are hypotheses that social distancing and stay-at-home orders issued in many cities globally might reduce physical activity opportunities and expand sedentary activities and screen time. An Italian study on the basis of 41 children with obesity showed the reduced screen, sleeping, and sports time after COVID-19 lockdown.

What are the new findings in your manuscript?

Findings from this national, large-sample retrospective survey, conducted in China, support the hypothesis of the decreased physical activity opportunities and increased sedentary activities and screen time. This study further demonstrated the unique changes in activity patterns among youths in China during COVID-19 lockdown.

How might your results change the direction of clinical practice?

Our results would inform policy-makers and clinical practitioners of the changed activity patterns among youths during COVID-19 lockdown for better policy making and clinical practice. School administrators should also be informed of these changes, so in-class and/or extracurricular physical activity programs could be designed to counteract them.

lifestyles in the months before (December 23, 2019 to January 23, 2020) and during COVID-19 lockdown (24 January to February 23, 2020). The study was approved by the Sichuan University Medical Ethical Review Board (KS2020414).

2.2 | Weight status variables

Individuals' height at the time of survey and body weight 1 month before (around December 23, 2019) and 1 month after implementing COVID-19 lockdown (around February 23, 2020) were self-reported. The body mass index (BMI, in kg/m²) 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 ≥ 27 kg/m², respectively; and for those aged <18 were defined based on the extended International Obesity Task Force recommended age-sex-specific cut-offs corresponding to BMI ≥ 23 and ≥ 27 kg/m² at age 18, respectively.⁸⁻¹⁰

2.3 | Measures of activity patterns

Activity patterns were measured using the International Physical Activity Questionnaire (IPAQ)-long form.¹¹ This study focused on changes in nine weight-related activity patterns due to COVID-19. The average time of engaging in active transport (ie, walking and cycling) for commuting/errands, moderate-/vigorous-intensity housework (MVH), leisure-time moderate-/vigorous-intensity physical activity (MVPA), and leisure-time walking, sedentary time during workdays and weekends, sleeping time during workdays and weekends separately, and screen time spent on TV and computers were reported as minutes/day.

2.4 | Statistical analyses

The participating youths' basic characteristics and weight-related outcomes are described as mean and SD (SD) for continuous variables and percentages for categorical variables, with their activity patterns presented as median (25% and 75%). We used paired t-tests (or χ^2 tests for categorical variables) to evaluate the significance of differences in basic characteristics and weight-related outcomes across education levels, between sexes at each education level, and before and during COVID-19 lockdown for each sex-education group. We also used non-parametric methods to test the significance of differences in activity patterns among groups (Mann-Whitney *U* test and Kruskal-Wallis *H* test for two and three groups, respectively). All statistical analyses were performed using R 3.6.2 and statistical significance was declared if $P < .05$.

3 | RESULTS

A total of 10 082 youths responded to the survey, with 71.7% being females, 4.7% being minority students, 63.2% living in non-urban areas. There were no significant differences in the age and ethnic constitution between males and females (Table 1). The majority of high school and graduate participants majored in medical science; most of undergraduate participants majored in social science.

Prior to COVID-19, the mean BMI of all youths was 21.8 kg/m², with the prevalence of overweight/obesity and obesity being 21.3% and 10.5%, respectively. BMI was similar between genders in undergraduates, with a mean BMI of 21.4 kg/m²; and was higher in female than male high school students (23.0% vs 21.7%, $P < .05$) and higher in male than female graduate students (23.0% vs 20.8%, $P < .05$). The group with the highest prevalence of overweight/obesity was the male graduate student (45.6%), although the sample size was relatively small. Within the month during COVID-19 lockdown, BMI has significantly increased in overall youths (21.8-22.6, $P < .001$) and in all subgroups: high school (22.7-23.8, $P < .001$), undergraduate (21.4 to 22.2, $P < .001$), and graduate students (21.4-22.3, $P < .001$). Moreover, the prevalence of overweight/obesity has significantly increased generally (21.3%-25.1%, $P < .001$) and in high school (26.6%-30.3%,

$P < .01$) and undergraduate students (19.1%-22.8%, $P < .001$); obesity prevalence has also significantly increased generally (10.5%-12.9%, $P < .001$) and in high school (16.0%-18.8%, $P < .01$) and undergraduate students (8.5%-10.7%, $P < .001$) (Table 1).

The youths' activity patterns had significantly changed during COVID-19 lockdown, with heterogeneities existing to different extent between sexes and across education levels (Table 2). The significant decreases were observed in the frequency of engaging in active transport for commuting/errands ($P < .001$), MVH ($P < .05$), leisure-time MVPA ($P < .05$), and leisure-time walking ($P < .001$) during the lockdown period. The average sedentary time increased during both workdays ($P < .001$) and weekends ($P < .001$), so did the average sleeping time during workdays ($P < .001$) and weekends ($P < .001$), as well as the screen time ($P < .001$). These changes were also observed in all subgroups.

In addition, in the analyses for individual-level changes in activity patterns, most youths had maintained their activity levels, varying from 50.2% for MVH to 78.5% for MVPA; most of the remaining youths had experienced a decrease in PA, from 18.0% for MVPA to 37.0% for MVH (Table 3). Comparatively, less youths had maintained their sleeping (about 50%) and screen time (57%), with about 30% increasing their sleeping time and 36% increasing their screen time. Furthermore, more youths (about 42%) had increased their sedentary time during both workdays and weekends, compared to their counterparts who had maintained the level before COVID-19 (about 37%).

4 | DISCUSSION

This study revealed results from COINLICS that the prevalence of overweight/obesity and obesity has significantly increased in overall youths, specifically in high school and undergraduate students. Also, significant changes during COVID-19 lockdown have been observed in patterns of all PA, sedentary, sleeping, and screen use variables, with more youths increasing their sedentary, sleeping, and screen time relative to their counterparts who had decreased their PA frequency.

Findings from this large-sample survey demonstrated the unique changing patterns of activities in China, which supports the previous hypotheses that social distancing and stay-at-home orders issued in many cities might reduce PA opportunities and expand sedentary activities and screen time.⁶ Also, our findings corroborate a small-sample Italian study showing reduced screen, sleeping, and sports time.⁷ Some other patterns we found include that, although weight status and sedentary time had increased in all youth groups, more than half of participating youths had maintained their activity frequency at the same level as before COVID-19; also, a larger proportion of medical higher school and graduate students, compared to their counterparts in other major disciplines, may have reflected their increased awareness of the importance of this type of surveys.

The findings of this study should be treated with caution. First, COINLICS generated a convenience sample that may not be fully representative of the Chinese youth. Also, recalling what have happened about 2 to 4 months ago, including self-reported body weight, may be

TABLE 1 Baseline characteristics of participating youths and their weight status before and during COVID-19 lockdown

Variable	Percentage or mean \pm SD											
	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)	Male (n = 68)	Female (n = 166)	Total (n = 234)
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	24.3 \pm 4.1	24.7 \pm 3.2	24.6 \pm 3.5
Ethnic												
Han	96.9	96.7	96.7	94.2	95.1	94.8	92.6	92.2	92.3	92.6	92.2	92.3
Minority	3.1	3.3	3.3	5.8	4.9	5.2	7.4	7.8	7.7	7.4	7.8	7.7
Urbanicity												
Urban	31.9	22.1	24.4	40.2	41.3	41.0	57.4	63.3	61.5	57.4	63.3	61.5
Non-urban	68.1	77.9	75.6	59.8	58.7	59.0	42.6	36.7	38.5	42.6	36.7	38.5
Household income (yuan/year)												
<12 K	20.8	25.7	24.5	21.7	18.5	19.4	13.2	4.2	6.8	13.2	4.2	6.8
\geq 12 K-20 K	28	37.9	35.6	23.2	28.2	26.7	4.4	11.4	9.4	4.4	11.4	9.4
\geq 20 K-60 K	28.3	25	25.8	26.4	28.1	27.6	14.7	24.7	21.8	14.7	24.7	21.8
\geq 60 K-100 K	15.2	7.8	9.6	14.8	13.4	13.8	22.1	22.9	22.6	22.1	22.9	22.6
\geq 100 K-200 K	5.5	2.6	3.3	9.4	8.6	8.9	27.9	24.7	25.6	27.9	24.7	25.6
\geq 200 K	2.2	1.0	1.3	4.6	3.2	3.6	17.6	12.0	13.7	17.6	12.0	13.7
Major												
Medical Science	59.0	98.4	89.0	12.4	16.0	14.9	41.2	52.4	49.1	41.2	52.4	49.1
Science/Engineering	39.4	1.0	10.2	51.9	22.6	31.4	44.1	20.5	27.4	44.1	20.5	27.4
Social Science	1.6	0.6	0.8	35.7	61.4	53.7	14.7	27.1	23.5	14.7	27.1	23.5
Weight (kg)												
Pre-COVID-19	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	68.6 \pm 14.2	54.6 \pm 10.2	58.6 \pm 13.1
Lockdown	64.9 \pm 20.9 ^c	59.9 \pm 22.9 ^c	61.1 \pm 22.5 ^c	66.2 \pm 56.6 ^b	56.5 \pm 17.8 ^c	59.4 \pm 34.7 ^c	73.1 \pm 25.1 ^a	56.3 \pm 11.6 ^c	61.1 \pm 18.2 ^c	73.1 \pm 25.1 ^a	56.3 \pm 11.6 ^c	61.1 \pm 18.2 ^c
BMI (kg/m ²)												
Pre-COVID-19	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	23.0 \pm 3.5	20.8 \pm 3.8	21.4 \pm 3.8
Lockdown	22.8 \pm 7.5 ^c	24.1 \pm 9.1 ^c	23.8 \pm 8.7 ^c	22.3 \pm 20.1 ^a	22.1 \pm 6.7 ^c	22.2 \pm 12.4 ^c	24.4 \pm 6.4 ^a	21.4 \pm 4.3 ^c	22.3 \pm 5.2 ^c	24.4 \pm 6.4 ^a	21.4 \pm 4.3 ^c	22.3 \pm 5.2 ^c
Overweight (BMI \geq 23 kg/m ²)												
Pre-COVID-19	22.7	27.8	26.6	22.3	17.7	19.1	45.6	14.5	23.5	45.6	14.5	23.5
Lockdown	30.1 ^b	30.4 ^b	30.3 ^b	27.0 ^c	21.0 ^b	22.8 ^c	54.4	20.5	30.3	54.4	20.5	30.3
Obesity (BMI \geq 27 kg/m ²)												
Pre-COVID-19	13.0	17.0	16.0	7.2	9.0	8.5	8.8	3.6	5.1	8.8	3.6	5.1
Lockdown	16.8 ^a	19.5 ^a	18.8 ^a	10.0 ^b	11.0 ^a	10.7 ^c	13.2	4.8	7.3	13.2	4.8	7.3

Note: 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 ($P < .05$); shown in *italic*, if the difference between sexes within a given education level was significant ($P < .05$); and marked by asterisks. P -values were based on χ^2 tests for categorical variables or t -tests for continuous variables.

^aIf the difference before and during COVID-19 lockdown within a given education level and sex was significant $P < 0.05$.

^bIf the difference before and during COVID-19 lockdown within a given education level and sex was significant $P < 0.01$.

^cIf the difference before and during COVID-19 lockdown within a given education level and sex was significant $P < .001$.

TABLE 2 Physical activity patterns of participating youths before and during COVID-19 lockdown (unit: hours/day)

Variable	Median (25%, 75%)											
	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)	Male (n = 68)	Female (n = 166)	Total (n = 234)
Physical activity												
Active transport for commuting/errands												
Pre-COVID-19	1.5 (1.0, 2.2)	1.5 (1.0, 2.1)	1.5 (1.0, 2.2)	1.3 (1.0, 2.2)	1.2 (1.0, 2.0)	1.3 (1.0, 2.0)	1.0 (0.8, 2.0)	1.0 (0.7, 1.6)	1.0 (0.7, 1.8)	1.0 (0.8, 2.0)	1.0 (0.7, 1.6)	1.0 (0.7, 1.8)
Lockdown	1.0 (0.5, 1.4)	1.0 (0.5, 2.0) ^b	1.0 (0.5, 1.8) ^b	1.0 (0.5, 1.7) ^b	1.0 (0.5, 1.5) ^c	1.0 (0.5, 1.5) ^c	0.5 (0.5, 1.0)	0.5 (0.4, 1.0)	0.5 (0.5, 1.1) ^c	0.5 (0.5, 1.0)	0.5 (0.4, 1.0)	0.5 (0.5, 1.1) ^c
Housework activity												
Pre-COVID-19	2.0 (1.1, 3.0)	2.0 (1.3, 3.5)	2.0 (1.3, 3.3)	1.5 (1.0, 3.0)	1.5 (1.0, 2.7)	1.5 (1.0, 2.7)	1.0 (0.3, 1.6)	1.0 (0.5, 1.8)	1.0 (0.5, 1.8)	1.0 (0.3, 1.6)	1.0 (0.5, 1.8)	1.0 (0.5, 1.8)
Lockdown	2.0 (1.2, 3.0) ^b	2.5 (1.5, 4.0) ^c	2.3 (1.5, 4.0) ^c	2.0 (1.0, 3.3)	2.0 (1.0, 3.5)	2.0 (1.0, 3.5) ^c	1.0 (0.5, 2.3)	1.2 (1.0, 2.0)	1.1 (0.8, 2.0) ^b	1.0 (0.5, 2.3)	1.2 (1.0, 2.0)	1.1 (0.8, 2.0) ^b
Moderate to vigorous physical activity												
Pre-COVID-19	2.0 (1.0, 3.0)	1.5 (1.0, 2.3)	1.5 (1.0, 2.5)	1.5 (1.0, 2.5)	1.1 (0.7, 2.0)	1.2 (0.8, 2.0)	0.8 (0.5, 1.0)	1.0 (0.7, 1.5)	1.0 (0.7, 1.5)	0.8 (0.5, 1.0)	1.0 (0.7, 1.5)	1.0 (0.7, 1.5)
Lockdown	2.0 (1.4, 3.0) ^b	1.5 (1.0, 2.5) ^b	1.5 (1.0, 2.8) ^b	1.3 (1.0, 2.5) ^c	1.0 (0.7, 2.0) ^c	1.0 (0.7, 2.2) ^b	1.0 (1.0, 1.0) ^c	1.0 (0.6, 1.4)	1.0 (0.6, 1.4)	1.0 (1.0, 1.0) ^c	1.0 (0.6, 1.4)	1.0 (0.6, 1.4)
Walking for leisure												
Pre-COVID-19	1.0 (0.7, 1.5)	1.0 (0.7, 1.5)	1.0 (0.7, 1.5)	1.0 (0.5, 1.5)	1.0 (0.5, 1.5)	1.0 (0.5, 1.5)	1.0 (0.5, 1.0)	1.0 (0.5, 1.0)	1.0 (0.5, 1.0)	1.0 (0.5, 1.0)	1.0 (0.5, 1.0)	1.0 (0.5, 1.0)
Lockdown	1.0 (0.5, 1.5) ^b	1.0 (0.5, 1.5) ^b	1.0 (0.5, 1.5) ^b	1.0 (0.5, 1.3)	0.8 (0.5, 1.0) ^c	1.0 (0.5, 1.2) ^c	1.0 (0.5, 1.0)	1.0 (0.5, 1.0)	1.0 (0.5, 1.0)	1.0 (0.5, 1.0)	1.0 (0.5, 1.0)	1.0 (0.5, 1.0)
Sedentary time												
During workdays												
Pre-COVID-19	3.0 (1.5, 5.5)	3.5 (2.0, 5.8)	3.5 (2.0, 5.5)	3.3 (2.0, 5.5)	4.0 (2.0, 6.0)	4.0 (2.0, 6.0)	5.0 (2.8, 8.0)	6.0 (4.0, 8.0)	6.0 (4.0, 8.0)	5.0 (2.8, 8.0)	6.0 (4.0, 8.0)	6.0 (4.0, 8.0)
Lockdown	3.0 (1.5, 6.0) ^c	4.2 (2.2, 6.9) ^c	4.0 (2.0, 6.5) ^c	4.0 (2.0, 7.0) ^c	5.0 (3.0, 8.0) ^c	5.0 (2.5, 8.0) ^c	6.0 (2.5, 8.0)	6.0 (4.0, 8.0)	6.0 (4.0, 8.0)	6.0 (2.5, 8.0)	6.0 (4.0, 8.0)	6.0 (4.0, 8.0)
During weekends												
Pre-COVID-19	3.0 (1.5, 5.0)	3.5 (2.0, 5.5)	3.3 (2.0, 5.5)	3.4 (2.0, 5.6)	4.0 (2.0, 6.0)	4.0 (2.0, 6.0)	6.0 (2.4, 8.0)	5.0 (3.1, 8.0)	5.0 (3.0, 8.0)	6.0 (2.4, 8.0)	5.0 (3.1, 8.0)	4.0 (2.0, 6.0)
Lockdown	3.0 (1.5, 6.0) ^c	4.0 (2.0, 6.5) ^c	4.0 (2.0, 6.2) ^c	4.0 (2.0, 7.0) ^c	5.0 (3.0, 8.0) ^c	5.0 (2.5, 8.0) ^c	6.0 (2.8, 9.0)	6.0 (4.0, 8.0) ^b	6.0 (4.0, 8.0) ^b	6.0 (2.8, 9.0)	6.0 (4.0, 8.0) ^b	4.5 (2.2, 8.0) ^c
Sleeping time												
During workdays												
Pre-COVID-19	8.0 (6.0, 9.0)	8.1 (6.5, 9.5)	8.0 (6.5, 9.4)	8.0 (5.5, 8.5)	8.0 (7.0, 9.0)	8.0 (7.0, 8.8)	7.5 (7.0, 8.0)	8.0 (7.0, 8.0)	8.0 (7.0, 8.0)	8.0 (7.0, 8.0)	8.0 (7.0, 8.0)	8.0 (7.0, 9.0)
Lockdown	8.0 (4.2, 9.1)	8.3 (7.0, 10.0) ^f	8.1 (6.5, 9.8) ^c	8.0 (5.1, 9.0) ^c	8.1 (7.5, 9.5) ^b	8.0 (7.0, 9.0) ^c	8.0 (7.0, 9.2) ^b	8.1 (8.0, 10.0) ^c	8.0 (7.5, 10.0) ^c	8.0 (7.0, 9.0) ^c	8.1 (8.0, 10.0) ^c	8.0 (7.0, 9.3) ^c
During weekends												
Pre-COVID-19	8.1 (6.0, 10)	9.0 (7.4, 10.0)	8.5 (7.0, 10.0)	8.0 (6.7, 9.0)	8.5 (8.0, 10)	8.2 (7.5, 9.5)	8.0 (6.5, 8.0)	8.0 (7.5, 9.0)	8.0 (7.0, 9.0)	8.0 (6.5, 8.0)	8.0 (7.5, 9.0)	8.4 (7.5, 10.0)
Lockdown	8.2 (6.0, 10)	9.0 (7.5, 10.0) ^f	9.0 (7.0, 10.0) ^c	8.0 (6.0, 9.0) ^b	9.0 (8.0, 10) ^c	8.5 (8.0, 10.0) ^c	8.0 (7.0, 9.0)	9.0 (8.0, 10) ^b	8.5 (8.0, 10.0) ^c	8.0 (7.0, 9.0)	9.0 (8.0, 10) ^b	8.5 (7.5, 10.0) ^c
Screen time												
Pre-COVID-19	4.0 (3.0, 6.0)	4.0 (4.0, 6.0)	4.0 (3.0, 6.0)	4.0 (4.0, 6.0)	4.0 (4.0, 6.0)	4.0 (4.0, 6.0)	5.0 (4.0, 7.0)	5.0 (4.0, 6.0)	5.0 (4.0, 6.0)	5.0 (4.0, 7.0)	5.0 (4.0, 6.0)	4.0 (4.0, 6.0)
Lockdown	4.0 (4.0, 6.0) ^c	5.0 (4.0, 6.0) ^c	5.0 (4.0, 6.0) ^c	5.0 (4.0, 6.0) ^c	6.0 (4.0, 7.0) ^c	5.0 (4.0, 7.0) ^c	6.0 (4.0, 7.0) ^c	5.0 (4.0, 6.0) ^c	5.0 (4.0, 6.0) ^c	6.0 (4.0, 7.0) ^c	5.0 (4.0, 6.0) ^c	5.0 (4.0, 6.0) ^c

Note: 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 ($P < .05$); shown in *italic*, if the difference between sexes within a given education level was significant ($P < .05$); and marked by asterisks. P-values were based on χ^2 tests for categorical variables or t-tests for continuous variables.

^aIf the difference before and during COVID-19 lockdown within a given education level and sex was significant $P < 0.05$.

^bIf the difference before and during COVID-19 lockdown within a given education level and sex was significant $P < 0.01$.

^cIf the difference before and during COVID-19 lockdown within a given education level and sex was significant $P < .001$.

TABLE 3 Changes in activity patterns among participating youths before and during COVID-19 lockdown

Variable	Percentage									
	High school students			Undergraduate students			Graduate students			All
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Grand total
	(n = 678)	(n = 2146)	(n = 2824)	(n = 2106)	(n = 4918)	(n = 7024)	(n = 68)	(n = 166)	(n = 234)	(n = 10 082)
Physical activity										
Active transport for commuting/errands										
Increased	2.2	2.3	2.3	2.0	1.9	1.9	1.5	1.8	1.7	2.0
Constant	81.0	76.4	77.4	70.3	61.5	64.2	50.0	41.6	44.0	67.4
Decreased	16.8	21.3	20.3	27.7	36.6	33.9	48.5	56.6	54.3	30.6
Housework activity										
Increased	6.9	12.0	10.8	8.5	15.5	13.4	16.2	22.3	20.5	12.8
Constant	62.1	46.3	50.1	61.4	45.3	50.1	64.7	46.4	51.7	50.2
Decreased	31.0	41.7	39.1	30.1	39.2	36.5	19.1	31.3	27.8	37.0
Moderate to vigorous physical activity										
Increased	2.4	3.8	3.5	2.0	4.1	3.5	1.5	7.8	6.0	3.5
Constant	79.5	80.7	80.4	77.7	77.9	77.8	79.4	74.1	75.6	78.5
Decreased	18.1	15.5	16.1	20.3	18.0	18.7	19.1	18.1	18.4	18.0
Walking for leisure										
Increased	1.4	2.1	1.9	1.6	2.1	1.9	2.9	4.2	3.8	2.0
Constant	83.9	78.6	79.9	76.0	67.4	70.0	64.7	59.0	60.7	72.5
Decreased	14.7	19.3	18.2	22.4	30.5	28.1	32.4	36.7	35.5	25.5
Sedentary time										
During workdays										
Increased	31.7	37.9	36.4	37.8	48.7	45.4	36.4	33.9	34.6	42.7
Constant	44.0	36.8	38.6	41.5	32.3	35.1	40.9	30.3	33.3	36.0
Decreased	24.3	25.3	25.0	20.7	19.0	19.5	19.7	35.8	32.1	21.3
During weekends										
Increased	29.5	39.8	37.4	37.6	47.8	44.7	39.4	44.5	43.1	42.6
Constant	47.4	38.4	40.5	42.1	33.9	36.3	40.9	26.2	30.4	37.4
Decreased	23.1	21.8	22.1	20.3	18.3	19.0	22.7	29.3	26.5	20.0
Sleeping time										
During workdays										
Increased	25.1	29.7	28.6	30.4	39.7	36.9	50.0	57.0	55.0	35.0
Constant	53.5	48.7	49.9	49.3	41.8	44.1	36.4	30.3	32.0	45.4
Decreased	21.4	21.6	21.5	20.3	18.5	19.0	13.6	12.7	13.0	19.6
During weekends										
Increased	25.0	27.1	26.6	25.9	31.1	29.6	39.4	40.6	40.3	29.0
Constant	54.3	52.1	52.6	52.7	48.6	49.8	43.9	44.9	44.6	50.5
Decreased	20.7	20.8	20.8	21.4	20.3	20.6	16.7	14.5	15.1	20.5
Screen time										
Increased	22.9	32.2	29.9	30.4	41.8	38.4	36.8	36.1	36.3	36.0
Constant	69.0	59.5	61.8	62.9	52.2	55.4	51.5	50.6	50.9	57.0
Decreased	8.1	8.3	8.3	6.7	6.0	6.2	11.7	13.3	12.8	7.0

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 to 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, it is worth noting that the IPAQ form was not originally designed for the purpose it has been used for in this study, so its applicability to this context and the possibility of using alternative survey instruments need to be further discussed. Last, considering that the length of the questionnaire may affect the quality and even the completeness of responses, we did not ask more questions which might have better assisted in explaining the current findings reported.

Despite these limitations, this online survey presents unique strengths by accumulating a prompt and large sample size in a targeted population, which is of particular importance in the context of public health emergencies.¹² The design of the online questionnaire used is also a strength, where questions on each lifestyle before and during COVID-19 lockdown were placed next to each other for participants to better recall and compare. Therefore, their answers can be considered as robust indicators of their lifestyle changes (at least, perceived lifestyle changes) which are usually highly correlated with actual lifestyle changes. In conclusion, the information from this timely, large-scale national survey should be useful for multiple stakeholders including policy makers 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 extracurricular PA programs could be designed to counteract them.

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CONFLICT OF INTEREST

No conflict of interest was declared.

AUTHORS' CONTRIBUTIONS

SY, JZ, and PJ designed the survey. PJ and SY designed the study. BG led data analysis. All authors were involved in analysing data, writing the paper and had final approval of the submitted and published versions.

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REFERENCES

- Jia P, Cheng X, Xue H, Wang Y. Applications of geographic information systems (GIS) data and methods in obesity-related research. *Obes Rev*. 2017;18:400-411.
- World Health Organization. Obesity and overweight. 2020.
- Xu F, Jin L, Qin Z, et al. Access to public transport and childhood obesity: a systematic review. *Obesity Reviews*; 2020. <https://onlinelibrary.wiley.com/doi/full/10.1111/obr.12987>.
- Jia P, Zou Y, Wu Z, et al. Street connectivity, physical activity, and childhood obesity: a systematic review and meta-analysis. *Obes Rev*. 2019. <https://onlinelibrary.wiley.com/doi/10.1111/obr.12943>.
- Joob B, Wiwanitkit V. COVID-19, school closings and weight gain. *Obesity (Silver Spring)*. 2020;28:1006.
- Rundle AG, Park Y, Herbstman JB, Kinsey EW, Wang YC. COVID-19 related school closings and risk of weight gain among children. *Obesity (Silver Spring)*. 2020;28:1008-1009.
- 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;28:1382-1385.
- Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes*. 2012;7:284-294.
- Jia P, Xue H, Zhang J, Wang Y. Time trend and demographic and geographic disparities in childhood obesity prevalence in China-evidence from twenty years of longitudinal data. *Int J Environ Res Public Health*. 2017;14:369.
- Consultation WHOE. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*. 2004;363:157-163.
- Craig CL, Marshall AL, Sjöström M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003;35:1381-1395.
- Cohen AB, Lee D, Long MD, et al. Dietary patterns and self-reported associations of diet with symptoms of inflammatory bowel disease. *Dig Dis Sci*. 2013;58:1322-1328.

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