

The Impact of COVID-19 Pandemic Restrictions on Sedentary Behavior Among Chinese

University Students: A Retrospectively-Matched Cohort Study

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Abstract:

Purpose: This study was to estimate the impact of COVID-19 pandemic restrictions on sedentary behavior (SB) for Chinese university students during the pandemic period, as well as explore how sedentary behavior changed as a function of sex.

Methods: We conducted an online questionnaire (the Sedentary Behavior Questionnaire) on students from one university in China during the pandemic period (March 29- April 15, 2020) and students retrospectively recalled pre-pandemic physical activity levels (before January 26, 2020). Sedentary behavior was measured using the short version of the Sedentary Behavior Questionnaire (SBQ). SB in a typical week during the COVID-19 pandemic period and before the COVID-19 pandemic restrictions were measured based on SBQ. The data was analyzed using a paired-samples t-test. Chi-square tests were to compare categorical variables.

Results: A total of 1487 (947 males & 513 females; Age 19.72 ± 1.32 yr., BMI = 21.12 ± 4.50) participated in this study. Before the COVID-19-associated lockdown restriction, on weekdays, survey participants averaged engaged in 11.41 (SD =3.93) hours of SB, 10.97 (SD = 3.85) hours of SB in males, 12.25 (SD =3.94) hours of SB in females; on weekends, survey participants averaged engaged in 13.18 (SD =4.06) hours of SB, 12.74 (SD = 3.96) hours of SB in males, 14.04 (SD =4.11) hours of SB in females. During the COVID-19-associated lockdown restriction, on weekdays, survey participants averaged engaged in 13.34 (SD =3.78) hours of SB, 12.90 (SD = 3.67) hours of SB in males, 14.19 (SD =3.83) hours of SB in females; on weekends, survey participants averaged engaged in 14.48 (SD =3.93) hours of SB, 14.10 (SD = 3.81) hours of SB in males, 15.22 (SD =4.04) hours of SB in females. Overall, on weekdays, The COVID-19-associated lockdown restriction on average appeared to increase SB by 1.93 (16.91% ↑, 95% CI = 1.74, 2.12) hours, an increase in daily total SB by 1.92 (17.50% ↑, 95% CI = 1.92, 2.15) hours for males, and an increase 1.94 (15.84% ↑, 95% CI = 1.62, 2.27) hours in females. On weekends, The COVID-19-associated lockdown restriction on average appeared to increase SB by 1.30 (9.86% ↑, 95% CI = 1.12, 1.48) hours, an increase in daily total SB by 1.36 (10.68% ↑, 95% CI = 1.13, 1.58) hours for males, and an increase 1.18 (8.40% ↑, 95% CI = 0.87, 1.50) hours in females.

Conclusions: The COVID-19 restriction may lead to an increase in SB of Chinese university students. The total sedentary time of female students per week was higher than that of male students. Public policy action might be urgently needed to decrease the sedentary behavior of Chinese university students.

Keywords: sedentary behavior; COVID-19; university students

At the beginning of 2020, the coronavirus disease 2019 (COVID-19) spread rapidly in many countries. World Health Organization (WHO) announced that the pandemic of pneumonia caused by New Coronavirus has become a public health emergency of international concern and declared the pandemic of New Coronavirus pneumonia a "pandemic" (Li et al., 2021). The spread of New Coronavirus pneumonia is infectious, and population movements will accelerate the spread of the pandemic, which is a serious threat to human life and health. Therefore, in order to effectively stop the spread of the pandemic throughout the country, the Chinese government has timely taken isolation and prevention and control measures. Home quarantine refers to a health action aimed at protecting public health and restricting individual action (Drazen et al., 2014). Home quarantine is considered an effective means to block the spread of New Coronavirus pneumonia (Anderson et al., 2020).

After the outbreak of the COVID-19, as of January 26, 2020, 30 provinces in China have activated the first-level response to public health emergencies. In order to stop the spread of the virus, the Chinese government has taken a series of social isolation measures, such as locking down cities where major pandemics have occurred, canceling all mass gatherings, and closing restaurants, cinemas, gymnasiums, shopping malls and other public places (Kraemer et al., 2020; Wang & Wang, 2020). Schools are places where New Coronavirus pneumonia is easy to break out. Therefore, many colleges and universities in China have suspended the opening of school and adopted the teaching method of online teaching (Xiang et al., 2020). The change of learning style will also change university students' living habits and behavior. Previous studies have reported that during the blockade of the pandemic, adults from South Africa, the United States, Brazil and China experienced significant changes in their physical and mental health compared with pre-pandemic conditions, such as a significant reduction in physical activity, an increase in weight gain and so on (Lewis et al., 2021; Meyer et al., 2020; Pereira da Silva et al., 2021; Wang et al., 2020). The online teaching method

of home quarantine also has a negative impact on the health behavior of university students in Canada, Saudi Arabia, Italy, the United Kingdom and China (Bertrand et al., 2021; Jalal et al., 2021; Luciano et al., 2021; Savage et al., 2020; Zhou et al., 2021). For instance, a study of 407 Pakistani university students showed that about 48.2% of the participants were physically inactive and 2.5 times more likely to report sedentary behaviors than their more active counterparts during the lockdown (Ullah et al., 2021). A cross-sectional survey showed that the sedentary time of American university students increased from 4 h per day before the COVID-19 pandemic restrictions to 7 h per day (Sidebottom et al., 2021). Another study from Italy shows that during COVID-19 pandemic restrictions, university students spend more time using electronic devices, and their sedentary time increases significantly, while their physical activity decreases significantly (Gallè et al., 2020). The COVID-19 pandemic restrictions have caused unprecedented damage, restrictions and concerns about physical and mental health. Previous studies from Britain, Spain, Italy, Canada and other countries showed that university students' SB increased significantly during COVID-19 pandemic restrictions (Bertrand et al., 2021; Luciano et al., 2021; Rodríguez-Larrad et al., 2021; Savage et al., 2021). A recent report based on Chinese youths shows that during the lockdown, participants' sedentary time on working days and weekends increased significantly, and the prevalence of obesity increased, while the physical activity time decreased significantly (Jia et al., 2021).

Sedentary behavior (SB) is a conscious activity characterized by low energy expenditure and performed in a sitting or reclining position, such as watching TV, reading, or driving (Tremblay et al., 2017). There is evidence of an association between sedentary behavior and cancer mortality, and that high levels of sedentary increase the risk of premature death as well as chronic disease (Castro et al., 2020; Ekelund et al., 2016). Previous research has also shown that sedentary behavior reduces health-related quality of life and increases the risk of depression (Boberska et al., 2018; Teychenne et al., 2010). A

study of Korean college students showed that with increasing sitting time, university students' stress, anxiety and depression increased significantly (Lee & Kim, 2019). And research by Wu et al. shows that high screen time increases the risk of mental health problems and poor sleep quality among university students (2015). Since the outbreak of New Coronavirus pneumonia, students have been forced to make a big change in their life and work arrangements to adapt to the practice of online learning. University students spend less time on transportation and physical education. These changes increase the risk of university students' SB. The increase of SB may have serious consequences for students' long-term health (Deliens et al., 2015). University is a critical period for developing healthy habits, and it is also a special period for a person's physical, psychological and social adaptation. Furthermore, China is one of the countries most affected by the pandemic, the SB of Chinese university students may be greatly affected, however, less attention has been paid to the SB of Chinese university students during the pandemic. Therefore, there is an urgent need to investigate how the outbreak of the pandemic affects the lifestyle of university students in order to help public health guidance and future suggestions.

Despite the aforementioned work, three major gaps in the previous studies remain. Firstly, a cross-sectional study design was used to analyze the SB of university students during the COVID-19 pandemic restrictions (Rahman et al., 2021). However, few studies have used retrospective matched cohort studies to study the impact of the COVID-19 pandemic restrictions on SB of university students. Second, although the previous literature reports researched for the public health impact of SB for the COVID-19 pandemic restrictions (from January 26, 2020, to April 15, 2020), to our best knowledge, no research has been conducted to investigate the impact of the COVID-19 pandemic restrictions on Chinese university Students' SB under the strict control strategy of China. Third, previous studies mainly used the international physical activity questionnaire (IPAQ) to evaluate the impact of the pandemic

restrictions on university students' SB. However, the IPAQ only assesses sitting in general and driving/riding in motor vehicles and provides no information on other types of sedentary behavior.

Therefore, the purpose of this study was to comprehensively estimate the impact of the COVID-19 pandemic restrictions on sedentary behavior for Chinese university students during the pandemic period using an individual-level retrospectively matched cohort study. Understanding SB of Chinese university students during the COVID-19 confinement will help public health authorities implement future policies on recommendations when new pandemics arrive, and confinement policies are implemented. We hypothesized that the SB of Chinese university students increased significantly during the COVID-19 lockdown. In addition, male students prefer sports to female students (Lores & Murcia, 2008), we assume that female students spend more sedentary time than male students.

Materials and Methods

Participants

A total of 1500 online surveys were collected from March 29, 2020, to April 15, 2020. Participants were university students at Tsinghua University (Tsinghua University is large university in China, and the campus of Tsinghua University is situated in northwest Beijing). Among them, 99.1% were valid, which included 974 males and 513 females. Participants who didn't complete the survey (n = 13) were excluded from the analyses.

Procedures

Participants were recruited in Tsinghua University online course by faculty. Survey participation was voluntary. All participants gave their consent to the survey. Participants completed a survey using online software (the WeChat Subscription WeChat and online questionnaire—Sojump Wenjuanxing platform: <https://www.wjx.cn/>) from March 29, 2020, to April 15, 2020, during the strictest

social isolation in China. The survey includes questions regarding participants' sociodemographic, physical and mental health conditions, and sedentary behavior and other health behaviors. Participants reported sedentary behavior during the pandemic period (current sedentary behavior), and they retrospectively recalled pre-pandemic sedentary behavior (report time per day spent on a typical weekday and weekend day in sedentary behaviors in past one semester from September 29, 2019, to December 29, 2019).

Sedentary behavior measurements

The Sedentary Behavior Questionnaire (SBQ) was used to measure the sedentary behavior of the participants. Previous studies have confirmed the reliability and validity of The Sedentary Behavior Questionnaire (Rosenberg et al., 2010). It gave information about the time spent watching television, using computer, sitting and reading, sitting and talking on the phone, doing arts and crafts, sitting and driving/riding in a car, and other sedentary activities. The 7 items were completed separately for weekdays and weekend days.

During the pandemic period

Total hours of sedentary behavior in a typical week/weekend day (from March 29, 2020, to April 15, 2020) were constructed based on the answers to the seven questions adapted from The Sedentary Behavior Questionnaire (SBQ) (Rosenberg et al., 2010; Sallis et al., 2020) —“On a typical WEEK DAY, how much time do you spend (from when you wake up until you go to bed) doing the following?”, and “On a typical WEEKEND DAY, how much time do you spend (from when you wake up until you go to bed) doing the following?” a) Watching TV; b) Playing computer or video games; c) Reading; d) Sit talk on telephone; e) Driving or riding in a car; f) Arts and crafts; g) Other sedentary activities (doing paperwork or sitting listening to music or playing a musical instrument). Total hours of sedentary behavior in a typical week/weekend day were calculated by summing the

hours per day separately for weekday and weekend items.

Pre-pandemic sedentary behavior

Retrospectively recalled pre-pandemic sedentary behavior about the time participants spend doing different types of sedentary behavior in a typical week (in past one semester from September 29, 2019, to December 29, 2019). The content of sedentary behavior questionnaire is the same as that of the above questionnaire. We only modified “during a typical week/weekend day” as “a typical week/weekend day during pre-pandemic period.” Other questions are the same as during the pandemic period about the time spent watching television, using computer, sitting and reading, sitting and talking on the phone, doing arts and crafts, sitting and driving/riding in a car, and other sedentary activities.

Statistical analyses

Descriptive statistics (sex, age, BMI, smoking and drinking behavior), including means, standard deviations and percentages, were used to analyze and compare characteristics of the participant by sex. Chi-square tests were to compare categorical variables. Paired sample T-test were conducted to measure the difference of sedentary behavior in the typical week during the COVID-19 pandemic restrictions period and before the COVID-19 pandemic outbreak. All statistical procedures were performed in SPSS-26.0 (SPSS Inc., Chicago, IL, USA) and significance was set at $p < 0.05$.

Results

Table 1 presents baseline characteristics of the survey participants. Males accounted for almost two-thirds ($n = 974$; 65.50%) of the total sample ($n = 1,487$). The mean age of participants was 19.72 (SD = 1.32), and the mean BMI was 22.12 kg/m² (SD = 4.50). There are just 1.3% of participants were current smokers and 4% were current drinkers.

Table 1. Baseline characteristics of survey participants

Characteristics	total	male	female	p
N	1487	974	513	
Age (yr), mean (SD)	19.72 (1.32)	19.53 (1.28)	20.09 (1.31)	<0.001
Body mass index, mean (SD)				
BMI (kg/m ²)	22.12(4.50)	22.74(4.50)	20.94(4.26)	<0.001
Smoking, n (%)				
Current smoker	20 (1.30)	10 (1.00)	10 (1.90)	0.142
Current nonsmoker	1467 (98.70)	964 (99.00)	503 (98.10)	
Drinking n (%)				
Current drinker	59 (4.00)	33 (3.40)	26 (5.10)	0.115
Current nondrinker	1428 (96.00)	941 (96.60)	487 (94.90)	

Table 2 shows the average sedentary behavior of the participants before and during the pandemic on weekdays. Before the COVID-19 pandemic restrictions, on weekdays, survey participants averaged engaged in 0.63 (SD =1.17) hours of watching TV, 5.65 (SD = 3.30) hours of using computer, 1.91 (SD = 1.95) hours of reading, 0.74 (SD = 0.65) hours of sitting talking on telephone, 0.18 (SD = 0.45) hours of driving or riding in a car, 1.02 (SD = 1.03) hours of doing arts and crafts, 1.28 (SD = 0.75) hours of other sedentary activities. Participants on averaged engaged in 11.41 (SD =3.93) hours of sedentary behavior in weekday. During the COVID-19 pandemic restrictions, survey participants averaged

engaged in 1.07 (SD =1.53) hours of watching TV, 7.23 (SD = 2.89) hours of using computer or video games, 1.42 (SD = 1.54) hours of reading, 1.06 (SD = 0.77) hours of sitting talking on telephone, 0.08 (SD = 0.29) hours of driving or riding in a car, 1.21 (SD = 1.14) hours of doing arts and crafts, 1.28 (SD = 0.79) hours of other sedentary activities. Participants on averaged engaged in 13.34 (SD =3.78) hours of total sedentary behavior in weekday. Before and during the pandemic period, besides arts and crafts, female students spend more time on other types of SB than male students. In our analysis, there was no significant difference in the time spent in arts and crafts between male and female students.

Table 2. Sedentary behavior on weekdays before and during the pandemic period

Sedentary behavior Measure	Before the COVID-19 PANDEMIC RESTRICTIONS				During the COVID-19 PANDEMIC RESTRICTIONS			
	Male	Female	Total	p	Male	Female	Total	p
Watching TV (hours/day), mean (SD)	0.57 (1.09)	0.75 (1.28)	0.63 (1.17)	<0.001	0.91 (1.37)	1.37 (1.78)	1.07 (1.53)	<0.001
Using computer (hours/day), mean (SD)	5.27 (3.22)	6.37 (3.32)	5.65 (3.30)	<0.001	7.10 (2.98)	7.48 (2.95)	7.23 (2.98)	0.023
Reading (hours/day), mean (SD)	1.97 (2.03)	1.80 (1.78)	1.91 (1.95)	0.123	1.36 (1.50)	1.52 (1.61)	1.42 (1.54)	0.052
Sit talk on telephone (hours/day), mean (SD)	0.70 (0.64)	0.82 (0.65)	0.74 (0.65)	<0.001	1.00 (0.76)	1.18 (0.78)	1.06 (0.77)	<0.001
Driving or riding in a car (hours/day), mean (SD)	0.15 (0.41)	0.24 (0.52)	0.18 (0.45)	<0.001	0.06 (0.27)	0.10 (0.34)	0.08 (0.29)	0.054
Arts and crafts (hours/day), mean (SD)	1.07 (1.03)	0.91 (1.04)	1.02 (1.03)	0.003	1.23 (1.15)	1.17 (1.12)	1.21 (1.14)	0.362
Other sedentary activities (hours/day), mean (SD)	1.25 (0.71)	1.36 (0.83)	1.28 (0.75)	0.006	1.24 (0.73)	1.37 (0.89)	1.28 (0.79)	0.003
Total weekday (hours/day), mean (SD)	10.97 (3.85)	12.25 (3.94)	11.41 (3.93)	<0.001	12.90 (3.67)	14.19 (3.83)	13.34 (3.78)	<0.001

Table 3 shows the average sedentary behavior of the participants before and during the pandemic on weekend. Before the COVID-19 pandemic restrictions, on weekends, survey participants averaged engaged in 1.04 (SD =1.30) hours of watching TV, 6.05 (SD = 3.14) hours of using computer, 1.85 (SD = 1.84) hours of reading, 0.98 (SD = 0.77) hours of sitting talking on telephone, 0.38 (SD = 0.62) hours of driving or riding in a car, 1.54 (SD = 1.36) hours of doing arts and crafts, 1.34 (SD = 0.77) hours of other sedentary activities. Participants on averaged engaged in 13.18 (SD =4.06) hours of sedentary behavior in weekday. During the COVID-19

pandemic restrictions, survey participants averaged engaged in 1.55 (SD =1.63) hours of watching TV, 7.05 (SD = 3.00) hours of using computer, 1.41 (SD = 1.50) hours of reading, 1.31 (SD = 0.95) hours of sitting talking on telephone, 0.17 (SD = 0.50) hours of driving or riding in a car, 1.68 (SD = 1.43) hours of doing arts and crafts, 1.33 (SD = 0.78) hours of other sedentary activities. Participants on averaged engaged in 14.48 (SD =3.93) hours of total sedentary behavior on weekend. Before and during the pandemic period, besides arts and crafts, female students spend more time on other types of SB than male students.

Table 3. Sedentary behavior on weekends before and during the pandemic period

Sedentary behavior Measure	Before the COVID-19 PANDEMIC RESTRICTIONS				During the COVID-19 PANDEMIC RESTRICTIONS			
	Male	Female	Total	p	Male	Female	Total	p
Watching TV (hours/day), mean (SD)	0.92 (1.23)	1.29 (1.39)	1.04 (1.30)	<0.001	1.32 (1.54)	1.99 (1.84)	1.55 (1.63)	>0.001
Using computer (hours/day), mean (SD)	5.82 (3.10)	6.51 (3.18)	6.05 (3.14)	<0.001	7.08 (3.02)	7.01 (2.95)	7.05 (3.00)	0.701
Reading (hours/day), mean (SD)	1.89 (1.91)	1.75 (1.70)	1.85 (1.84)	0.249	1.35 (1.43)	1.54 (1.60)	1.41 (1.50)	0.019
Sit talk on telephone (hours/day), mean (SD)	0.91 (0.72)	1.13 (0.83)	0.98 (0.77)	<0.001	1.21 (0.93)	1.49 (0.96)	1.31 (0.95)	<0.001
Driving or riding in a car (hours/day), mean (SD)	0.31 (0.57)	0.52 (0.70)	0.38 (0.62)	<0.001	0.15 (0.50)	0.20 (0.49)	0.17 (0.50)	0.069
Arts and crafts (hours/day), mean (SD)	1.62 (1.38)	1.40 (1.32)	1.54 (1.36)	0.003	1.72 (1.43)	1.60 (1.43)	1.68 (1.43)	0.156
Other sedentary activities (hours/day), mean (SD)	1.28 (0.73)	1.45 (0.83)	1.34 (0.77)	<0.001	1.28 (0.77)	1.41 (0.79)	1.33 (0.78)	0.003
Total weekend (hours/day), mean (SD)	12.74 (3.96)	14.04 (4.11)	13.18 (4.06)	<0.001	14.10 (3.81)	15.22 (4.04)	14.48 (3.93)	<0.001

Table 4 reports the paired t-test outcomes for sedentary behavior on weekdays before and during the pandemic restrictions period by sex. During the COVID-19 pandemic restrictions, in the sedentary behavior on weekdays, male students reported increased in daily hours of watching TV by 0.35 (61.40% ↑, 95% CI = 0.27, 0.43), increased in daily hours of using computer by 1.83 (34.72% ↑, 95% CI = 1.64, 2.02), decreased in daily hours of reading by 0.61 (30.96% ↓, 95% CI = -0.73, -0.50), increased in daily hours of sitting talking on telephone by 0.29 (41.43% ↑, 95% CI = 0.24, 0.34), decreased in daily hours of driving or riding in a car by 0.08 (53.33% ↓, 95% CI = -0.01, -0.06), increased in daily hours of doing arts and crafts by 0.16 (14.95% ↑, 95% CI = 0.09, 0.22), respectively. Male students reported had no statistically significant differences in time spent on other sedentary activities when we compared before and during the pandemic restrictions period.

The total sedentary time of male students increased by 1.92 (17.50% ↑, 95% CI = 1.92, 2.15) hours during weekdays. During the pandemic restrictions period, female students reported increased

in daily hours of watching TV by 0.63 (84.00% ↑, 95% CI = 0.47, 0.78), increased in daily hours of using computer by 1.11 (17.43% ↑, 95% CI = 0.86, 1.36), decreased in daily hours of reading by 0.28 (15.56% ↓, 95% CI = -0.42, -0.14), increased in daily hours of sitting and talking on telephone by 0.36 (43.90% ↑, 95% CI = 0.29, 0.43), increased in daily hours of doing arts and crafts by 0.26 (28.57% ↑, 95% CI = 0.19, 0.34), respectively. Female students reported had no statistically significant differences in time spent on driving or riding in a car and other sedentary activities when we compared before and during the pandemic restrictions period.

The total sedentary time of female students increased by 1.94 (15.84% ↑, 95% CI = 1.62, 2.27) hours. The total sedentary time of male students increased by 1.92 (17.50% ↑, 95% CI = 1.92, 2.15) hours during weekdays. As shown in Table 4, excepting other sedentary activities, paired t-tests revealed a statistically significant difference in SB hours for each dimension and total SB hours per day before versus after the COVID-19 pandemic restrictions among male and female students.

Table 4. Paired t test outcomes for Sedentary behavior on weekdays before and during the pandemic period by sex

Sedentary behavior (hours/day)	Male				Female				Total			
	Paired difference mean (95% CI)	Performance (%)	Effect size (95% CI)	t	Paired difference mean (95% CI)	Performance (%)	Effect size (95% CI)	t	Paired difference mean (95% CI)	Performance (%)	Effect size (95% CI)	t
Watching TV	0.35 (0.27, 0.43)	61.40 ↑	0.28 (0.21, 0.34)	8.66***	0.63 (0.47, 0.78)	84.00 ↑	0.37 (0.27, 0.46)	8.18***	0.44 (0.37, 0.52)	69.84 ↑	0.31 (0.26, 0.36)	11.87***
Using computer	1.83 (1.64, 2.02)	34.72 ↑	0.60 (0.53, 0.67)	18.51***	1.11 (0.86, 1.36)	17.43 ↑	0.39 (0.30, 0.48)	8.69***	1.58 (1.43, 1.74)	27.96 ↑	0.52 (0.47, 0.58)	20.08***
Reading	-0.61 (-0.73, -0.50)	30.96 ↓	-0.34 (-0.41, -0.28)	-10.56***	-0.28 (-0.42, -0.14)	15.56 ↓	-0.17 (-0.26, -0.08)	-3.83***	-0.50 (-0.59, -0.41)	26.18 ↓	-0.28 (-0.34, -0.23)	-10.89***
Sit talk on telephone	0.29 (0.24, 0.34)	41.43 ↑	0.37 (0.31, 0.44)	11.53***	0.36 (0.29, 0.43)	43.90 ↑	0.47 (0.38, 0.56)	10.57***	0.32 (0.28, 0.36)	43.24 ↑	0.41 (0.35, 0.46)	15.50***
Driving or riding in a car	-0.08 (-0.11, -0.06)	53.33 ↓	-0.19 (-0.26, -0.13)	-5.98***	-0.14 (-0.19, 0.10)	58.33 ↓	-0.30 (-0.39, -0.21)	-6.62***	-0.10 (-0.13, -0.08)	55.56 ↓	-0.23 (-0.28, -0.18)	-8.80***
Arts and crafts	0.16 (0.09, 0.22)	14.95 ↑	0.15 (0.09, 0.21)	4.63***	0.26 (0.19, 0.34)	28.57 ↑	0.31 (0.22, 0.40)	7.04***	0.19 (0.14, 0.24)	18.63 ↑	0.20 (0.14, 0.25)	7.51***
Other sedentary activities	-0.01 (-0.06, 0.04)	0.80 ↓	-0.01 (-0.08, 0.05)	-0.35	0.01 (-0.05, 0.08)	0.74 ↑	0.02 (-0.07, 0.11)	0.40	0.00 (-0.04, 0.04)	0.00	-0.00 (-0.05, 0.05)	-0.08
Total weekday	1.92 (1.69, 2.15)	17.50 ↑	0.53 (0.46, 0.60)	16.45***	1.94 (1.62, 2.27)	15.84 ↑	0.53 (0.44, 0.62)	11.83***	1.93 (1.74, 2.12)	16.91 ↑	0.53 (0.48, 0.58)	20.26***

Notes: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

Table 5 reports the paired t-test outcomes for sedentary behavior on weekends before and during the pandemic period by gender. During the COVID-19 restrictions sedentary behavior on weekends, male students reported increased in daily hours of watching TV by 0.41 (44.57% ↑, 95% CI = 0.33, 0.49), increased in daily hours of using computer by 1.26 (21.65% ↑, 95% CI = 1.08, 1.44), decreased in daily hours of reading by 0.55 (29.10% ↓, 95% CI = -0.65, -0.44), increased in daily hours of sitting talking on telephone by 0.30 (32.97% ↑, 95% CI = 0.25, 0.36), decreased in daily hours of driving or riding in a car by 0.16 (9.88% ↓, 95% CI = -0.21, -0.12), no statistically significant differences in daily hours of doing arts and crafts and in daily hours of other sedentary activities, respectively. The total sedentary time of male students increased by 1.36 (10.68% ↑, 95% CI = 1.13, 1.58) hours. During the pandemic

period, female students reported increased in daily hours of watching TV by 0.70 (54.26% ↑, 95% CI = 0.55, 0.86), increased in daily hours of using computer by 0.49 (7.53% ↑, 95% CI = 0.25, 0.74), decreased in daily hours of reading by 0.21 (12.00% ↓, 95% CI = -0.35, -0.07), increased in daily hours of sitting talking on telephone by 0.36 (31.86% ↑, 95% CI = 0.28, 0.44), increased in daily hours of doing arts and crafts by 0.21 (15.00% ↑, 95% CI = 0.11, 0.30), no statistically significant differences in daily hours of driving or riding in a car and in daily hours of other sedentary activities, respectively. The total sedentary time of female students increased by 1.18 (8.40% ↑, 95% CI = 0.87, 1.50) hours. As shown in Table 5, excepting other sedentary activities, paired t-tests revealed a statistically significant difference in daily hours of SB before versus after the outbreak of COVID-19 for male and female students.

Table 5. Paired t test outcomes for Sedentary behavior on weekends before and during the pandemic period by sex

Sedentary behavior (hours/day)	Male				Female				Total			
	Paired difference mean (95% CI)	Performance (%)	Effect size (95% CI)	t	Paired difference mean (95% CI)	Performance (%)	Effect size (95% CI)	t	Paired difference mean (95% CI)	Performance (%)	Effect size (95% CI)	t
Watching TV	0.41 (0.33, 0.49)	44.57 ↑	0.32 (0.25, 0.38)	9.85***	0.70 (0.55, 0.86)	54.26 ↑	0.41 (0.32, 0.50)	9.15***	0.51 (0.43, 0.58)	49.04 ↑	0.35 (0.30, 0.40)	13.38***
Using computer	1.26 (1.08, 1.44)	21.65 ↑	0.44 (0.37, 0.51)	13.57***	0.49 (0.25, 0.74)	7.53 ↑	0.18 (0.09, 0.27)	4.00***	1.00 (0.85, 1.15)	16.53 ↑	0.35 (0.30, 0.40)	13.34***
Reading	-0.55 (-0.65, -0.44)	29.10 ↓	-0.33 (-0.39, -0.26)	-10.12***	-0.21 (-0.35, -0.07)	12.00 ↓	-0.13 (-0.22, -0.05)	-2.98**	-0.43 (-0.52, -0.35)	23.24 ↓	-0.26 (-0.32, -0.21)	-10.00***
Sit talk on telephone	0.30 (0.25, 0.36)	32.97 ↑	0.33 (0.27, 0.40)	10.23***	0.36 (0.28, 0.44)	31.86 ↑	0.39 (0.30, 0.48)	8.70***	0.32 (0.28, 0.37)	32.65 ↑	0.35 (0.30, 0.41)	13.38***
Driving or riding in a car	-0.16 (-0.21, -0.12)	9.88 ↓	-0.25 (-0.31, -0.18)	-7.64***	-0.32 (-0.38, 0.25)	61.54 ↓	-0.43 (-0.52, -0.34)	-9.52***	-0.22 (-0.25, -0.18)	57.89 ↓	-0.31 (-0.36, -0.26)	-11.84***
Arts and crafts	0.00 (0.02, 0.18)	0.00	0.08 (0.01, 0.14)	2.48*	0.21 (0.11, 0.30)	15.00 ↑	0.20 (0.11, 0.29)	4.37***	0.14 (0.08, 0.20)	9.09 ↑	0.12 (0.06, 0.17)	4.37***
Other sedentary activities	-0.01 (-0.05, 0.05)	0.78 ↓	0.00 (-0.06, 0.06)	0.02	-0.03 (-0.10, 0.03)	2.07 ↓	-0.04 (-0.13, 0.05)	-0.97	-0.01 (-0.05, 0.03)	0.75 ↓	-0.01 (-0.07, 0.04)	-0.51
Total weekend	1.36 (1.13, 1.58)	10.68 ↑	0.38 (0.32, 0.45)	11.78***	1.18 (0.87, 1.50)	8.40 ↑	0.33 (0.24, 0.43)	7.36***	1.30 (1.12, 1.48)	9.86 ↑	0.37 (0.31, 0.42)	13.87***

Notes: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

Discussion

The purpose of this study was to estimate the impact of COVID-19 restrictions on sedentary behavior for Chinese university students during the pandemic period as well as explore how sedentary behavior changed by gender. Our study found that the sedentary time of Chinese university students increased significantly during the COVID-19 restrictions, and the sedentary time of female students per week was significantly higher than that of male students. To our knowledge, this is the first study that examined the impact of COVID-19 restrictions on sedentary behavior for Chinese university students using a retrospectively matched cohort study.

In our study, we have provided some evidence of the negative impact of a university closure, due to the COVID-19 pandemic restrictions, upon sedentary behavior in a sample of Chinese university students. An increase of SB in each of the participants was observed in our study. It is important to note that the proportional increase in total SB for the male students was large, then the increase in total SB for the female students was less. This is similar to past research, which showed that during the pandemic period, the university student population increased their SB (Gallè et al., 2020; Romero-Blanco et al., 2020). An online cross-sectional survey showed that due to the outbreak of New Coronavirus pneumonia, university students' walking and physical activity decreased significantly and SB increased significantly during home isolation (Rahman et al., 2021). Similarly, a study on first-year university students showed that their health habits are seriously affected during the COVID-19 lockdown, such as increasing sedentary time and reducing physical activities (LaCaille et al., 2021).

However, a systematic review of seven studies showed that most studies reported a significant increase in sedentary time among undergraduates, but not among postgraduates (Rivera et al., 2021). In addition, a study based on university students majoring in sports and medicine shows that during the

pandemic, the sedentary time of medical students is significantly more than that of university students majoring in sports (de Souza et al., 2021). Based on previous reports, we can find that COVID-19 restrictions may have different effects on the health behaviors of different student groups in universities. All of our research participants are undergraduates, and all of them are from the same university. Our findings also suggest that COVID-19 restrictions have a negative impact on the SB among the Chinese university students.

At present, many studies show that the level of physical activity of university students decreases significantly during the pandemic (Acs et al., 2020; Coakley et al., 2021; Coughenour et al., 2021; Osipov et al., 2021; Zhang et al., 2021). The increase of SB of university students may be related to the decrease of physical activity level. This may be because under the influence of the home isolation policy, university students can only stay at home, reducing the opportunities for outdoor exercise, but increasing the screen time for watching TV and online learning. Our results also show that during the COVID-19 restrictions, university students spend more time sitting watching TV and using computer. Moreover, this study presents those students have a significant increase in SB during the pandemic restrictions, which may also affect their weight change. There is increasing evidence that increased SB is associated with a higher risk of obesity (Hu, 2003; Must & Tybor, 2005). A Meta-analysis showed that the longer the total sitting time per day, the greater the risk of all-cause mortality, and medium and high intensity physical activity seemed to weaken this risk link (Chau et al., 2013). Inactivity and SB have many negative effects on human health at muscular, cardiovascular, metabolic and endocrine levels, as well as mental health (Mazza et al., 2020; Tremblay et al., 2017). Furthermore, in the early New Coronavirus pneumonia, previous studies reported that the mental health of university students was negatively affected (Copeland et al., 2021; Saraswathi et al., 2020). Previous longitudinal studies have also shown that the increase of SB of adults living in France and

Switzerland during the pandemic is associated with poor mental health and poor physical health (Cheval et al., 2021). In addition, there is evidence that unhealthy diet is associated with increased SB during COVID-19 pandemic (Ammar et al., 2020). If we do not put forward relevant intervention measures for decreasing sedentary behavior after the pandemic, it will further increase the risk of the mental health among university students.

A previous report showed that 41.5% of adults around the world sit for 4 hours or more a day (Hallal et al., 2012). Due to the COVID-19 restrictions, this proportion may significantly increase. Moreover, undergraduate students are in the early stage of adulthood. The cultivation of healthy habits at this time is of great significance to the development of mental and physical health in the future (Services, 2000). A recent meta-analytic data highlights that university students are an at-risk subgroup due to high levels of accumulated SB (Castro et al., 2020). Therefore, it is necessary to take intervention measures to reduce SB and improve physical activity. A South Korean study found that the cognitive structure of health awareness and self-efficacy has a significant impact on university Students' physical exercise attitude, behavior intention and behavior. Health awareness has a great impact on physical activity attitude, while self-efficacy has a great impact on behavior intention and behavior (Hong & Chung, 2020). This suggests that enhancing university students' awareness of physical exercise may reduce their SB. Some researchers suggest that during the COVID-19 pandemic, simple measures, such as alternating between sitting and standing for 30 minutes, can break the state of sitting for a long time, so as to reduce the long-term sedentary (Narici et al., 2021).

Previous studies have reported that the environment will affect university students' SB (Molina-García et al., 2019). Therefore, in order to reduce their SB, we can provide exercise online course at home during the lockdown and offer sufficient fitness facilities and fitness equipment in the

community and build a good fitness environment for university students after the restrictions. Moreover, the research suggests that physical activity is very important to prevent and alleviate the complications of virus infection (Cheval et al., 2021). Maintaining regular physical activity during self-isolation is important for the prevention of future chronic health conditions due to a sedentary lifestyle (Jakobsson et al., 2020). University students should follow the recommendations of the WHO, that is, at least 150 minutes of moderate physical activity, 75 minutes of vigorous exercise, or both and reduce sedentary behaviors across different settings (World Health Organization, 2020) .

In this research, we found more sex-related differences from the confinement effects. Whether on weekdays or weekends, female students spend more time on SB than male students before the pandemic, but the increase proportion of male students' total SB is higher than that of female students due to the pandemic. The results showed that male students had more sedentary time than female students during the pandemic period. The results showed that male students had more sedentary time during the COVID-19 restrictions. In addition, the SB with the largest increase in the proportion of male and female students is the time spent sitting and watching TV behavior. Based on the findings of this study, the results suggest that we should actively formulate measures to reduce the SB of university students, especially to reduce the screen-based sedentary time of university students. Male students seem to need more intervention measures than female students to decrease the increase in the proportion of sedentary time.

The strength of this study is that this is a survey on the SB of Chinese university students during the COVID-19 pandemic using a retrospectively matched cohort study. Moreover, although many studies have reported the SB of university students, the SB of Chinese university students is less understood. We used SBQ to evaluate the SB of university students. This may provide effective information for relevant departments to formulate interventions to reduce the

SB of university students. However, there are several limitations in our study. First of all, the SB was self-reported by participants, which may be potentially subject to overreporting SB under social desirability or recall bias. The use of objective measuring tools such as pedometers, or accelerometers might have allowed more accurate quantification of time spent in SB. In addition, the purpose of this study was to investigate the SB of a sample of students from only one Chinese university who represent a specific population group. Therefore, the findings cannot be extended to the whole population of Chinese young adults. We didn't collect the information on participants' majors. Furthermore, there might as well be a seasonal effect in SB among the participants. Future studies need to consider the replication of the study findings in other universities.

Conclusion

This study examined the impact of the COVID-19 restrictions on sedentary behavior for Chinese university students during the pandemic period. The results showed that COVID-19 restrictions may encourage to an increase in sedentary behavior of Chinese university students. Our study addresses that it is necessary to take measures to intervene in decreasing sedentary behavior for Chinese university students after the COVID-19 pandemic. This finding should be highly considered by the public health system and higher education institutions, and effective intervention measures should be formulated to reduce sedentary behavior of university students after the pandemic restrictions.

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Conflict of Interest

We have no conflict of interest to disclose at this time.

Authors' contribution

HY designed and conceived the study. HY, LS, FX and YW wrote the manuscript. WX, CP, ZZ, WX, CF and were involved collected data. HY and YW analyzed data. All authors read and approved the final manuscript.

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Ethics approval and consent to participate

This study was approved by the Tsinghua University Institutional Review Board (IRB #2012534001). All the participants gave written informed consent during the survey.

Consent for publication

Not applicable

Competing interested

The author declare that they have no competing interests.

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