Article

Longitudinal Shifts in Movement Behaviors during the COVID-19 Pandemic: Relations to Posttraumatic Stress Disorder among University Students

Jie Feng 1, Patrick Wing Chung Lau 1, Lei Shi 2 and Wendy Yajun Huang 1,*

1 Department of Sport, Physical Education and Health, Hong Kong Baptist University, Kowloon Tong, Hong Kong, China
2 Laboratory of Exercise Science and Health, BNU-HKBU United International College, Zhuhai 519088, China
* Correspondence: wendyhuang@hkbu.edu.hk; Tel.: +852-34116401

Abstract: This study examined the longitudinal changes of movement behaviors and their relationships with posttraumatic stress disorder (PTSD) among university students during the coronavirus disease 2019 in China. A total of 569 university students completed online surveys twice (Time 1: between December 2020 and January 2021; Time 2: between November and December 2021). Physical activity, sedentary behavior, sleep duration and quality, as well as PTSD were self-reported. According to Canadian 24-h movement guidelines, the longitudinal shifts in each movement behavior from Time 1 to Time 2 were divided into four categories (consistently meeting the guidelines, from meeting to not meeting the guidelines, from not meeting to meeting the guidelines, and consistently not meeting the guidelines). Generalized linear mixed models were conducted using 410 valid responses (20.2 ± 1.0 years old at Time 2, 41.2% males). From Time 1 to Time 2, 22.2%, 2.0%, and 45.6% of the students consistently met the physical activity, sedentary behavior, and sleep guidelines, respectively. Compared to those who consistently met the sedentary behavior guideline, students who consistently failed to meet or changed from meeting to not meeting the guidelines had higher levels of PTSD. Students who had poor sleep quality at both time points or changed from good to bad sleep quality had higher levels of PTSD than those who maintained good sleep quality over time. Compared to those who consistently failed to meet the guideline, students who consistently met the PA guideline had higher levels of PTSD. These findings highlight the needs to improve and maintain healthy behaviors for mental health.

Keywords: physical activity; sedentary behavior; sleep; posttraumatic stress disorder; undergraduate; COVID-19

1. Introduction

The university years occur when late adolescents are transferring to adulthood; students at this age may establish new habits of movement behaviors. Movement behaviors, including physical activity (PA) [1], sedentary behavior (SB) [2], and sleep [3] in isolation, have been found to be closely associated with a variety of health outcomes. A healthy combination of movement behaviors (high PA, low SB, sufficient sleep) was associated with greater health benefits among adults [4,5]. However, previous studies have documented unhealthy movement behaviors among university students, such as insufficient PA [6], overmuch SB [6], insufficient sleep duration [7], and poor sleep quality [7]. After the outbreak of the coronavirus disease 2019 (COVID-19), many measures were taken to decrease the spread of the virus, such as stay-at-home requirements, travel restrictions, and facial covering [8]. Additionally, more than 150 countries adopted school closures [8]. Not surprisingly, in response to the disturbed routines, unfavorable changes of movement behaviors, such as decreased PA of all intensities [9], higher level of SB [10], delayed bedtime
and wake up time [11], and worse sleep quality [12], have been widely reported among university students.

The rapid transmission and mortality risk of the virus, the subsequent social distancing, increased financial burden, resources shortage, decreased basic services, and decreased social support could negatively impact mental health [13,14]. A systematic review reported a high prevalence of mental health problems (e.g., stress, anxiety, depression, posttraumatic stress disorder [PTSD]) among the general population after the pandemic outbreak [15]. Among university students, a systematic review covering 706,415 participants found more than ten mental health problems, with depression, anxiety, stress, and PTSD being the most prevalent [16]. Among them, PTSD, in particular, persists for a long period even after the epidemic has vanished [17]. PTSD often developed after people experienced a traumatic event, and is characterized by avoidance to the event, negative changes in mood and cognition, reexperiencing the event, hyperarousal, etc. [18]. Individuals with PTSD are at a higher risk of experiencing cardiovascular disease [19], all-cause dementia [20], and even suicides [21]. A cross-country study observed PTSD symptoms in response to pandemic-related direct (e.g., exposure to the virus) and indirect (e.g., unemployment, social distancing, increased caring burden, changes in daily routine) events [22]. With regard to university students, a systematic review pooling 90,879 university students from 15 countries reported that 30% of them had PTSD during the COVID-19 pandemic (from December 2019 to July 2020) [23]. This further shows the importance of the early prevention and treatment of PTSD.

It is noteworthy that movement behaviors (e.g., PA, SB, sleep) were closely associated with PTSD [24,25]. More specifically, healthy adults with higher PA had lower levels of PTSD [26], whereas longer sedentary time predicted more symptoms of PTSD [24]. Regarding sleep, limited sleep time, low sleep quality, and PTSD were very likely to co-concur [27]. Such cross-sectional associations have been echoed by research findings observed during the COVID-19 pandemic. For example, regular and sufficient PA after the pandemic outbreak was associated with lower levels of mental health problems (e.g., depression, anxiety, stress) among university students in China [28]. Different findings were observed in our previous study among Chinese university students, that is, higher levels of PA during the pandemic peak (January to March, 2020) was associated with a higher risk of PTSD [29]. Another study among more than ten thousand university students observed positive associations between screen time and depressive symptoms [30]. Moreover, our previous study conducted among Chinese university students found that longer sleep duration and better sleep quality were associated with lower levels of PTSD one year after the outbreak of the pandemic [29].

Though a wide range of studies have compared movement behaviors before and during the early phase of the COVID-19 pandemic outbreak, there is scarce evidence on how movement behavior shifts across time predict PTSD. Therefore, this longitudinal study aimed to investigate the relationships between the changes of movement behaviors at two time points (one year and two years after the epidemic outbreak) and PTSD. Specifically, at Time 1 (between December 2020 and January 2021, one year after the pandemic outbreak) and Time 2 (between November and December 2021, two years after the pandemic outbreak), universities have reopened and daily routine has become normal in China. To classify the longitudinal changes of movement behaviors, the Canadian 24-h movement guidelines for adults were applied [31], which integrate all three movement behaviors across a 24-h day. Based on the PA, SB, and sleep recommendations of the Canadian 24-h movement guidelines for adults [31], the longitudinal shifts of movement behaviors were categorized into four groups: consistently meet the guideline, from meet to not meet the guideline, from not meet to meet the guideline, and consistently not meet the guideline. We hypothesized that compared with those who kept healthy (consistently meet the guidelines), university students who maintained unhealthy (consistently not meet the guidelines) and changed from being healthy to unhealthy (changed from meet to not meet guidelines) had higher levels of PTSD.
2. Materials and Methods

2.1. Participants

This longitudinal study was conducted among undergraduates in Guangdong province, China. The recruitment procedure has been described elsewhere [29] and is shown in Figure 1. Briefly, all undergraduates in one university were invited to this study if they were healthy physically and mentally. The questionnaire was generated by an online platform (Wenjuanxing; https://www.wjx.cn/, accessed on 10 December 2021). The students were directed to an online questionnaire by scanning the QR code or clicking the link distributed by staff and student helpers. The first survey was conducted one year after the outbreak of the COVID-19 pandemic, i.e., between 4 December 2020 and 4 January 2021 (Time 1). The second survey was conducted between 15 November and 3 December 2021 (Time 2). Only students who completed both surveys were included in this study. During the data collection period (Time 1, Time 2), the pandemic in China was stable, and fewer than 100 daily new cases were confirmed on most days [32,33]. School closures were relieved, and students’ daily routine returned to normal. Ethics approval was obtained from the Research Ethics Committee, Beijing Normal University & Hong Kong Baptist University United International College (Ref. No.: REC-2021-07).

![Flow diagram of sample selection](https://via.placeholder.com/150)

**Figure 1.** Flow diagram of sample selection. Note. Time 1: between December 2020 and January 2021; Time 2: between November and December 2021.

2.2. Exposures: Movement Behaviors

PA and sedentary time were measured using the Chinese version of the International Physical Activity Questionnaire-Short Form (IPAQ-SF), which was reliable (intraclass correlation coefficient > 0.70) and valid among Chinese university students [34]. Moderate-to-vigorous intensity PA (MVPA) was defined as the sum of moderate-intensity PA (MPA) and vigorous-intensity PA (VPA). Sedentary time was abstracted from IPAQ-SF and included all time spent sitting. Regarding screen time, participants reported their average total time spent on TV viewing and computer/tablets/mobile phone use. Sleep duration and sleep quality were assessed using the Chinese version of the Pittsburgh Sleep Quality Index (PSQI), which has shown good reliability (Cronbach’s alpha = 0.85) and validity [35]. Sleep duration was defined as the difference between the bedtime and the wakeup time on the subsequent day. Four options (“0, very good”, “1, fairly good”, “2, fairly bad”, and “3, very bad”) were provided for sleep quality, and the answers were integrated into two categories: good quality (“0” and “1”) and bad quality (“2” and “3”). More details about the data screening of PA, sedentary time, screen time, and sleep can be found in a previous study [29].
The longitudinal shifts of movement behaviors were evaluated based on the Canadian 24-h movement guidelines [31]. Meeting guidelines was defined as: (1) meeting the PA guideline: at least 150 min of MVPA per week; (2) meeting the SB guideline: no more than 8 h of sedentary time and no more than 3 h of screen time; (3) meeting the sleep guideline: 7 to 9 h of sleep per day [31]. Accordingly, the longitudinal shift of movement behaviors (PA, SB, sleep duration) was divided into four categories: consistently meet the guidelines, from meet to not meet the guidelines, from not meet to meet the guidelines, and consistently not meet the guidelines. Correspondingly, the longitudinal shift of sleep quality consisted of four categories: consistently good quality, from good to bad quality, from bad to good quality, and consistently bad quality.

2.3. Outcome: Posttraumatic Stress Disorder (PTSD)

The Chinese version of the Posttraumatic Stress Disorder Checklist-Civilian Version (PCL-C) was adopted to measure PTSD. The PCL-C has shown good reliability (Cronbach’s alpha = 0.89) and validity [36]. Based on Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV) [37], the PCL-C covers three dimensions (reexperiencing, avoidance, hyperarousal) and consists of 17 items in total. Five options were provided for each item, from “1, not at all” to “5, extremely”. The total score (ranging from 17 to 85) was obtained by summing up all items, with a higher score indicating a more severe symptom. In addition, students were considered having PTSD if they reported having symptoms (i.e., rated from 3 to 5) on at least one item of reexperiencing, three items of avoidance, and two items of hyperarousal.

2.4. Covariables: Demographic Information

Demographic information including age, sex, height, and weight were self-reported. Body mass index (BMI; kg/m²) was calculated as weight (kg) divided by height (m²).

2.5. Statistical Analyses

Continuous variables were presented as mean and standard deviation, categorical variables were presented as number of participants and percentages. Paired t-tests and Chi-squared tests were used to examine the difference of variables between Time 1 and Time 2. Similar to other studies examining the relationships between movement behaviors and mental health [29,38], demographic factors (age, sex, BMI) were included as covariates. Unadjusted generalized linear mixed models with Gamma distribution were conducted to examine the relationships between movement behavior shifts and PTSD at Time 2 (Model 1). After adjusting for demographic factors and baseline PTSD (Time 1), generalized linear mixed models with Gamma distribution were conducted to predict PTSD at Time 2, with one movement behavior shift (PA, SB, sleep duration, sleep quality) included as a predictor in each model (Model 2). In model 3, generalized linear mixed models with Gamma distribution were conducted, with all demographic factors, baseline PTSD (Time 1), and all movement behavior shifts included. SPSS 27.0 (IBM, Armonk, NY, USA) was used for data analysis, and p < 0.05 was considered significant.

3. Results

A total of 569 undergraduates completed the survey in both Time 1 and Time 2, and 410 of them (20.2 ± 1.0 years old [Time 2], 41.2% males) provided complete and valid data of demographics, movement behaviors, and PTSD and were included in the final data analysis. Compared with the excluded participants, the included students had a lower proportion of females (58.8% vs. 69.2%, p = 0.022), higher MVPA at Time 2 (171.5 ± 271.0 vs. 129.2 ± 206.5 min/week, p = 0.047), longer sleep duration at Time 1 (7.1 ± 1.0 vs. 6.7 ± 1.4 h/day, p = 0.010), and a higher proportion of good sleep quality at Time 2 (76.6% vs. 67.3%, p = 0.023). There was no significant difference in other variables (demographics, movement behaviors, and PTSD). The basic characteristics of participants and differences in variables between Time 1 and Time 2 are presented in Table 1. Characteristics in participants
with and without PTSD are presented in Table 1. Longer sleep duration and better sleep quality were observed among participants without PTSD.

Table 1. Characteristics of the longitudinal sample (n = 410).

| Characteristic                        | ALL (n = 410) | Mean ± SD or n (%) | t/χ² (Time 1 vs. Time 2) | With PTSD at Time 2 (n = 56) | Without PTSD at Time 2 (n = 354) | t/χ² |
|---------------------------------------|---------------|--------------------|--------------------------|-------------------------------|----------------------------------|------|
| Age (year)                            |               |                    |                          |                               |                                  |      |
| Time 1                                | 19.3 ± 1.0    | 20.4 ± 1.3         | 2.772 **                 |                               |                                  |      |
| Time 2                                | 20.2 ± 1.0    | 20.2 ± 1.0         | 1.604                    |                               |                                  |      |
| Sex (male)                            |               |                    |                          |                               |                                  |      |
| Time 1                                | 169 (41.2%)   | 22 (39.3%)         | 1.397                    |                               |                                  |      |
| Time 2                                | 22.5 ± 4.9    | 22.6 ± 4.8         | 0.402                    |                               |                                  |      |
| Body mass index (kg/m²)               |               |                    |                          |                               |                                  |      |
| Time 1                                | 22.2 ± 4.8    | 22.3 ± 5.2         | 0.782                    |                               |                                  |      |
| Time 2                                | 22.5 ± 4.9    | 22.6 ± 4.8         | 0.402                    |                               |                                  |      |
| MVPA (min/week)                       |               |                    |                          |                               |                                  |      |
| Time 1                                | 235.9 ± 291.8 | 233.0 ± 396.4      | 0.402                    |                               |                                  |      |
| Time 2                                | 217.5 ± 271.0 | 161.7 ± 244.8      | 1.307                    |                               |                                  |      |
| Sedentary time (h/day)                |               |                    |                          |                               |                                  |      |
| Time 1                                | 6.7 ± 2.8     | 5.6 ± 2.9          | 1.176                    |                               |                                  |      |
| Time 2                                | 6.1 ± 3.0     | 6.2 ± 3.0          | 0.976                    |                               |                                  |      |
| Screen time (h/day)                   |               |                    |                          |                               |                                  |      |
| Time 1                                | 6.0 ± 2.8     | 7.7 ± 2.6          | 0.434                    |                               |                                  |      |
| Time 2                                | 7.5 ± 2.7     | 7.5 ± 2.7          | 0.434                    |                               |                                  |      |
| Sleep duration (h/day)                |               |                    |                          |                               |                                  |      |
| Time 1                                | 7.1 ± 1.0     | 6.4 ± 1.8          | 2.107 *                  |                               |                                  |      |
| Time 2                                | 6.8 ± 1.5     | 6.9 ± 1.4          |                           |                               |                                  |      |
| Sleep quality (good)                  |               |                    |                          |                               |                                  |      |
| Time 1                                | 342 (83.4%)   | 32 (57.1%)         | 13.672 **                |                               |                                  |      |
| Time 2                                | 314 (76.6%)   | 282 (79.7%)        |                          |                               |                                  |      |
| Physical activity shift               |               |                    |                          |                               |                                  |      |
| Consistently meet the guidelines      | 91 (22.2%)    | 15 (26.8%)         | 3.630                    |                               |                                  |      |
| From not meet to meet the guidelines  | 42 (10.2%)    | 8 (14.3%)          | 3.630                    |                               |                                  |      |
| From meet to not meet the guidelines  | 100 (24.4%)   | 15 (26.8%)         | 3.630                    |                               |                                  |      |
| Consistently not meet the guidelines  | 177 (43.2%)   | 18 (32.1%)         | 3.630                    |                               |                                  |      |
| Sedentary behavior shift              |               |                    |                          |                               |                                  |      |
| Consistently meet the guidelines      | 8 (2.0%)      | 0 (0%)             | 1.956                    |                               |                                  |      |
| From not meet to meet the guidelines  | 13 (3.2%)     | 1 (1.8%)           | 1.956                    |                               |                                  |      |
| From meet to not meet the guidelines  | 65 (15.9%)    | 8 (14.3%)          | 1.956                    |                               |                                  |      |
| Consistently not meet the guidelines  | 324 (79.0%)   | 47 (83.9%)         | 1.956                    |                               |                                  |      |
| Sleep duration shift                  |               |                    |                          |                               |                                  |      |
| Consistently meet the guidelines      | 187 (45.6%)   | 19 (33.9%)         | 3.712                    |                               |                                  |      |
| From not meet to meet the guidelines  | 64 (15.6%)    | 10 (17.9%)         | 3.712                    |                               |                                  |      |
| From meet to not meet the guidelines  | 80 (19.5%)    | 13 (23.2%)         | 3.712                    |                               |                                  |      |
| Consistently not meet the guidelines  | 79 (19.3%)    | 14 (25.0%)         | 3.712                    |                               |                                  |      |
| Sleep quality shift                   |               |                    |                          |                               |                                  |      |
| Consistently good                     | 284 (69.3%)   | 25 (44.6%)         | 23.055 **                |                               |                                  |      |
| From bad to good                      | 30 (7.3%)     | 7 (12.5%)          |                           |                               |                                  |      |
| From good to bad                      | 58 (14.1%)    | 11 (19.6%)         |                           |                               |                                  |      |
| Consistently bad                      | 38 (9.3%)     | 13 (23.2%)         |                           |                               |                                  |      |
| PTSD score                             |               |                    |                          |                               |                                  |      |
| Time 1                                | 23.7 ± 9.1    | 25 (73.2%)         | 23.055 **                |                               |                                  |      |
| Time 2                                | 28.1 ± 12.5   | 23.100 **          |                           |                               |                                  |      |
| Having PTSD                           |               |                    |                          |                               |                                  |      |
| Time 1                                | 22 (5.4%)     | 16.378 **          |                           |                               |                                  |      |
| Time 2                                | 56 (13.7%)    | 23.100 **          |                           |                               |                                  |      |

Abbreviation: MVPA, moderate-to-vigorous intensity physical activity; PTSD, posttraumatic stress disorder. Note. Time 1: between December 2020 and January 2021; Time 2: between November and December 2021. ** p < 0.01, * p < 0.05.
The longitudinal shifts in movement behaviors are presented in Table 1. From Time 1 to Time 2, 22.2%, 2.0%, and 45.6% of students consistently met the PA, SB, and sleep guidelines, respectively; 43.2%, 79.0%, 19.3% of students consistently did not meet the PA, SB, and sleep guidelines, respectively. Regarding sleep quality, 69.3% of students consistently had good quality sleep, and 9.3% of them consistently had bad sleep quality. Figure 2 shows the time spent in PA, sedentary time, screen time, and sleep duration in Time 1 and Time 2, based on four categories of each behavior. The prevalence of PTSD among students was 5.4% and 13.7% at Time 1 and Time 2, respectively (see Table 1).

![Figure 2](https://example.com/figure2.png)

**Figure 2.** Movement behavior shifts among university students during the COVID-19 pandemic. Abbreviation: MVPA, moderate-to-vigorous intensity physical activity. Note. Time 1: between December 2020 and January 2021; Time 2: between November and December 2021.

After adjusting for age (Time 2), sex (Time 2), BMI (Time 2), and baseline PTSD (Time 1), students who consistently did not meet the SB guideline ($B = 0.387; 95\%$ confidence interval [CI]: 0.123, 0.651), or changed from meeting to not meeting the SB guideline ($B = 0.392; 95\%$ CI: 0.118, 0.665) had higher levels of PTSD at Time 2, compared to those who consistently met the guideline (Table 2, Model 3). Similarly, those who consistently had bad sleep quality ($B = 0.187; 95\%$ CI: 0.054, 0.319), or changed from good to bad sleep quality ($B = 0.183; 95\%$ CI: 0.076, 0.290) had higher levels of PTSD, compared to those who consistently kept good sleep quality. Compared to those who consistently met the PA guideline, students consistently failing to meet the PA guideline had lower levels of PTSD ($B = -0.103; 95\%$ CI: $-0.201, -0.004$).
Table 2. Associations between changes in movement behaviors and post-traumatic stress disorder (95% confidence interval) (n = 410).

| Physical activity shift (reference: consistently meet the guidelines) | Posttraumatic Stress Disorder Score (Time 2) |
|-------------------------------------------------|------------------------------------------|
| From not meet to meet the guidelines            | Model 1 Model 2 Model 3                  |
| −0.026 (−0.175, 0.124)                          | −0.019 (−0.160, 0.121)                   |
| From meet to not meet the guidelines            | Model 2 Model 3                          |
| 0.003 (−0.114, 0.119)                           | −0.003 (−0.111, 0.106)                   |
| Consistently not meet the guidelines            | Model 2 Model 3                          |
| −0.044 (−0.148, 0.059)                          | −0.077 (−0.177, 0.024)                   |

Sedentary behavior shift (reference: consistently meet the guidelines)

| Sleep duration shift (reference: consistently meet the guidelines) | Posttraumatic Stress Disorder Score (Time 2) |
|-------------------------------------------------------------------|------------------------------------------|
| From not meet to meet the guidelines                              | Model 1 Model 2 Model 3                  |
| 0.305 (−0.051, 0.660)                                            | 0.218 (−0.118, 0.553)                    |
| From meet to not meet the guidelines                              | Model 2 Model 3                          |
| 0.420 (0.124, 0.716) **                                         | 0.383 (0.104, 0.662) **                  |
| Consistently not meet the guidelines                              | Model 2 Model 3                          |
| 0.484 (0.200, 0.767) **                                         | 0.401 (0.133, 0.670) **                  |

Sleep quality shift (reference: consistently good)

| From bad to good                                                  | Model 1 Model 2 Model 3                  |
| 0.153 (0.006, 0.300) *                                           | 0.095 (−0.047, 0.236)                    |
| From good to bad                                                 | Model 2 Model 3                          |
| 0.275 (0.165, 0.385) **                                         | 0.201 (0.094, 0.309) **                  |
| Consistently bad                                                 | Model 2 Model 3                          |
| 0.314 (0.182, 0.446) **                                         | 0.198 (0.066, 0.329) **                  |

Model 2: adjusted for age (Time 2), sex (Time 2), body mass index (Time 2), and posttraumatic stress disorder score (Time 1). Model 3: included physical activity shift, sedentary behavior shift, sleep duration shift, sleep quality shift, and adjusted for age (Time 2), sex (Time 2), body mass index (Time 2), and posttraumatic stress disorder score (Time 1). Note. Time 1: between December 2020 and January 2021; Time 2: between November and December 2021. ** p < 0.01, * p < 0.05.

4. Discussion

This longitudinal study examined the shifts in movement behaviors and their associations with PTSD among university students during the COVID-19 pandemic in China. The two timepoints were one year and two years after the pandemic outbreak when the pandemic was stable. Consistent compliance with the movement behavior guidelines was low especially for SB. The key findings were that, compared to students who did not meet guidelines at both time points or had unfavorable changes (i.e., from meet to not meet guidelines), those who consistently met the SB guideline and maintained good sleep quality had lower levels of PTSD.

A higher prevalence of PTSD among university students was reported two years into the pandemic period (Time 2, 13.7%), whereas the prevalence was 5.4% one year after the pandemic outbreak (Time 1). Another previous study among Chinese undergraduates during the early onset of the pandemic (February 2020) showed that the prevalence was 2.7% [39]. Though the above data were from different samples, PTSD seemed to emerge at the initial stage of the pandemic, and its prevalence became even higher two years after the outbreak of the pandemic. Such a phenomenon can be explained by the delayed onset of the PTSD, which has been frequently reported in different populations [40], including university students in China during the COVID-19 pandemic [41]. Furthermore, a systematic review summarizing 88 studies found that the prevalence of PTSD was 22.6% after pandemics (e.g., sudden acute respiratory syndrome [SARS], COVID-19) across all populations, including healthcare workers, infected cases, and the general public [42]. The above information affirms the long-standing existence and high incidence of PTSD, highlighting the urgency of deploying strategies to reduce mental health burden among university students.

The findings about the association between SB shift and PTSD are consistent with our hypothesis, that is, being less sedentary from Time 1 to Time 2 was associated with less symptoms of PTSD. It is worth noting that the SB guideline in the current study included recommendations for both sedentary time and screen time [31], which may partly explain the extremely low compliance rate (2.0%). Previous evidence consistently observed that higher sedentary time and longer screen time were associated with higher levels of...
mental health problems [43,44], as well as during the COVID-19 pandemic [45]. To be specific, a longitudinal study among adults found that those with increased screen time after the COVID-19 pandemic outbreak had a worse mental health status, i.e., higher levels of depression, stress, and loneliness [46]. Furthermore, Ellingson et al. found that decreased sedentary time across a one-year period was associated with better mental health (e.g., stress) in young adults [47]. The above evidence indicates that behaviors during a long period may predict mental health and shows the importance of maintaining a low level of sedentary behavior for a long period. However, it should be noted that specific domains of SB were not assessed in this study. A previous study conducted in adults found that depression symptoms were associated with leisure sedentary time, whereas largely non-significantly associated with occupational sedentary time [48].

Regarding sleep, the positive association between consistent good sleep quality and low level of PTSD is consistent with our hypothesis and affirmed the findings from our previous study [25]. It is commonly recognized that sleep quality plays an important role in mental health [24,39]. For example, during the COVID-19 pandemic, negative changes in sleep quality was associated with worse mental health (e.g., depression, anxiety, stress) [49]. Furthermore, it is worth noting that the relationship between sleep quality and mental health can be bidirectional, which has been examined in previous studies. Specifically, a longitudinal cohort study among adolescents reported bidirectional associations between sleep problems (e.g., insomnia) and mental health (e.g., PTSD, depression) [50]. Among the clinical population, sleep disturbance was considered as a chief predictor of mental health disorders; in turn, neurophysiological changes in sleep were often seen in patients with mental illness [51]. It can also be supported by the comparison of sleep quality shift between participants with and without PTSD (Table 1), that is, a larger proportion of participants without PTSD had consistent good sleep quality over time, compared with those having PTSD. However, due to the cross-sectional study design, no cause-and-effect relationship can be revealed in the present study. Furthermore, in future studies, device-based measurement can be adopted to provide more objective information about sleep.

Students who consistently met the PA guideline had higher levels of PTSD compared to those who remained physically inactive. This finding is not consistent with our hypothesis but coincides with the results of our previous study [29]. That is, higher total PA during the outbreak peak (January to March, 2020) was associated with a higher risk of having PTSD after the pandemic outbreak peak (Time 1 in this study) among university students in China [29]. A potential explanation may be the non-linear relationship between PA and mental health, that is, higher or lower PA was associated with poorer mental health, compared with an optimal range of PA (2.5 to 7.5 h per week) [52]. The same pattern was reported by another study measuring PA objectively among adults; that is when daily MVPA participation was higher than 50 min, higher PA was associated with poorer mental health [53]. In addition, interestingly, COVID-19 increased population-level interest in active lifestyle. A previous study based on big data analysis showed that following the COVID-19 pandemic outbreak, the interest on the topic of exercise surged immediately and increased sharply [54]. The potential explanations for the above phenomenon include increased availability of discretionary time, messages recommending PA from media, compensation for reduced PA, and increased health awareness [54]. Furthermore, a previous study examined stress-lead changes of PA among young females aged 18 to 23 years old and observed that more than one-in-five increased PA, and 16.5% became more inactive during emotional stress [55]. Furthermore, people who either increased or decreased PA had higher levels of emotional problems, compared with those whose PA remained unchanged [55]. Similarly, a study conducted during the pandemic observed increased MVPA and total PA among university students after the pandemic outbreak compared with before the pandemic [56]. From a practical standpoint, engaging in PA has been found to be a coping strategy in response to stress in previous studies [57]. For example, a national survey of 36,984 Canadians aged 15 years and above reported that 40% of them used exercise to cope with stress [58]. Therefore, the findings in this study were not surprising. However, it
is worth noting that PA was measured using a self-reported questionnaire (i.e., IPAQ) in this study. Though IPAQ has shown its high reliability and validity in many countries [59], the recall bias is inevitable. In addition, the exclusion of participants in the final analysis (27.9%) due to incomplete and unreliable data may also have had an impact on findings.

To the best of our knowledge, this is the first study examining the association between longitudinal changes of movement behaviors and PTSD among university students during the pandemic in China. However, some limitations should be noted. Firstly, self-reported questionnaires were used to measure movement behaviors, which may lead to reporting bias. Secondly, a self-reported questionnaire rather than clinical diagnosis was used to measure PTSD symptoms; also, the questionnaire was developed using DSM-IV criteria rather than the most updated DSM-5. However, the questionnaire has been widely used to evaluate PTSD among different population groups [60,61]. Thirdly, similar to other studies conducted among university students during the pandemic [62,63], a greater proportion of females than males was found in this study. However, no gender difference was found in the regression models. Finally, the generalization of our findings should be cautious, given that the development of the pandemic and the strict measures differed across countries. A nationwide survey in China observed high levels of psychological distress among people at the initial stage of the pandemic, due to the rapid spread of the virus and the unprecedented rigorous public health measures taken [64]. Globally, a systematic review of studies from 33 countries, including China, found that the risk of having severe depression was lower in countries that implemented strict measures earlier, and China is the first country that reacted to the pandemic [65].

5. Conclusions

The prevalence of PTSD was high among university students two years after the COVID-19 pandemic outbreak. Maintaining a healthy lifestyle (less sedentary behavior and good-quality sleep) is important to mitigate PTSD and should be considered in future interventions to improve mental health among university students. Besides, awareness and caution should be given to university students with elevated PA levels, as it might be related to a higher PTSD. Coping strategies should be developed by universities and public health systems to support students in having a balanced lifestyle and healthy mental health during the pandemic.

Author Contributions: Conceptualization, W.Y.H.; methodology, J.F. and W.Y.H.; data curation, J.F., P.W.C.L., L.S. and W.Y.H.; writing—original draft preparation, J.F.; writing—review and editing, P.W.C.L., L.S. and W.Y.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with Beijing Normal University & Hong Kong Baptist University United International College and approved by the Research Ethics Committee of Beijing Normal University & Hong Kong Baptist University United International College (Ref. No.: REC-2021-07).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available upon reasonable request from the corresponding author.

Acknowledgments: We would like to acknowledge and thank all participants and research collaborators from Beijing Normal University-Hong Kong Baptist University United International College for their contribution in the study.

Conflicts of Interest: The authors declare no conflict of interest.
References

1. Jakicic, J.M.; Kraus, W.E.; Powell, K.E.; Campbell, W.W.; Janz, K.F.; Troiano, R.P.; Sprow, K.; Torres, A.; Piercy, K.L.; The 2018 Physical Activity Guidelines Advisory Committee. Association between Bout Duration of Physical Activity and Health: Systematic Review. Med. Sci. Sport. Exerc. 2019, 51, 1213–1219. [CrossRef] [PubMed]

2. Saunders, T.J.; McIIsaac, T.; Douillette, K.; Gaulton, N.; Hunter, S.; Rhodes, R.E.; Prince, S.A.; Carson, V.; Chapatu, J.-P.; Chastin, S.; et al. Sedentary Behaviour and Health in Adults: An Overview of Systematic Reviews. Appl. Physiol. Nutr. Metab. 2020, 45, S197–S217. [CrossRef] [PubMed]

3. Chaput, J.-P.; Dutil, C.; Featherstone, R.; Ross, R.; Giangregorio, L.; Saunders, T.J.; Janssen, I.; Poitras, V.J.; Kho, M.E.; Ross-White, A.; et al. Sleep Duration and Health in Adults: An Overview of Systematic Reviews. Appl. Physiol. Nutr. Metab. 2020, 45, S218–S231. [CrossRef]

4. Kastelic, K.; Pedišić, Ž.; Lipovac, D.; Kastelic, N.; Chen, S.-T.; Sarabon, N. Associations of Meeting 24-h Movement Guidelines with Stress and Self-Rated Health among Adults: Is Meeting More Guidelines Associated with Greater Benefits? BMC Public Health 2021, 21, 929. [CrossRef] [PubMed]

5. Rollo, S.; Lang, J.J.; Roberts, K.C.; Bang, F.; Carson, V.; Chapatu, J.-P.; Colley, R.C.; Janssen, I.; Tremblay, M.S. Health Associations with Meeting the Canadian 24-hour Movement Guidelines for Adults: Results from the Canadian Health Measures Survey. Health Rep. 2022, 33, 16–26. [CrossRef] [PubMed]

6. Deforche, B.; Van Dyck, D.; Deliens, T.; De Bourdeaudhuij, I. Changes in Weight, Physical Activity, Sedentary Behaviour and Dietary Intake during the Transition to Higher Education: A Prospective Study. Int. J. Behav. Nutr. Phys. Act. 2015, 12, 16. [CrossRef]

7. Becker, S.P.; Jarrett, M.A.; Luebbe, A.M.; Garner, A.A.; Burns, G.L.; Kohler, M.J. Sleep in a Large, Multi-University Sample of College Students: Sleep Problem Prevalence, Sex Differences, and Mental Health Correlates. Sleep Health 2018, 4, 174–181. [CrossRef]

8. Hale, T.; Angrist, N.; Goldszmidt, R.; Kira, B.; Petherick, A.; Phillips, T.; Webster, S.; Cameron-Blake, E.; Hallas, L.; Majumdar, S.; et al. A Global Panel Database of Pandemic Policies (Oxford COVID-19 Government Response Tracker). Nat. Hum. Behav. 2021, 5, 529–538. [CrossRef]

9. López-Valenciano, A.; Suárez-Iglesias, D.; Sanchez-Lastra, M.A.; Ayán, C. Impact of COVID-19 Pandemic on University Students’ Physical Activity Levels: An Early Systematic Review. Front. Psychol. 2021, 11, 624567. [CrossRef]

10. Savage, M.J.; Hennis, P.J.; Magistro, D.; Donaldson, J.; Healy, L.C.; James, R.M. Nine Months into the COVID-19 Pandemic: A Longitudinal Study Showing Mental Health and Movement Behaviours Are Impaired in UK Students. Int. J. Environ. Res. Public Health 2021, 18, 2930. [CrossRef]

11. Marelli, S.; Castelnuovo, A.; Somma, A.; Castronovo, V.; Mombelli, S.; Bottoni, D.; Leitner, C.; Fossati, A.; Ferini-Strambi, L. Impact of COVID-19 Lockdown on Sleep Quality in University Students and Administration Staff. J. Neurol. 2021, 268, 8–15. [CrossRef] [PubMed]

12. Benham, G. Stress and Sleep in College Students Prior to and during the COVID-19 Pandemic. Stress Health 2021, 37, 504–515. [CrossRef] [PubMed]

13. Moreno, C.; Wykes, T.; Galdersi, S.; Nordentoft, M.; Crossley, N.; Jones, N.; Cannon, M.; Correll, C.U.; Byrne, L.; Carr, S.; et al. How Mental Health Care Should Change as a Consequence of the COVID-19 Pandemic. Lancet Psychiatry 2020, 7, 813–824. [CrossRef]

14. Pfefferbaum, B.; North, C.S. Mental Health and the COVID-19 Pandemic. N. Engl. J. Med. 2020, 383, 510–512. [CrossRef]

15. Xiong, J.; Lipsitz, O.; Nasri, F.; Lui, K.L.W.; Gill, H.; Phan, L.; Chen-Li, D.; Iacobucci, M.; Ho, R.; Majeed, A.; et al. Impact of COVID-19 Pandemic on Mental Health in the General Population: A Systematic Review. J. Affect. Disord. 2020, 277, 55–64. [CrossRef]

16. Li, Y.; Wang, A.; Wu, Y.; Han, N.; Huang, H. Impact of the COVID-19 Pandemic on the Mental Health of College Students: A Systematic Review and Meta-Analysis. Front. Psychol. 2021, 12, 669119. [CrossRef]

17. Wu, P.; Fang, Y.; Guan, Z.; Fan, B.; Kong, J.; Yao, Z.; Liu, X.; Fuller, C.; Susser, E.; Lu, J.; et al. The Psychological Impact of the SARS Epidemic on Hospital Employees in China: Exposure, Risk Perception, and Altruistic Acceptance of Risk. Can. J. Psychiatry 2009, 54, 302–311. [CrossRef]

18. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, 5th ed.; American Psychiatric Association: Arlington, VA, USA, 2013.

19. Edmondson, D.; von Känel, R. Post-Traumatic Stress Disorder and Cardiovascular Disease. Lancet Psychiatry 2017, 4, 320–329. [CrossRef]

20. Günnak, M.M.; Billings, J.; Carratu, E.; Marchant, N.L.; Favaro, G.; Orgeta, V. Post-Traumatic Stress Disorder as a Risk Factor for Dementia: Systematic Review and Meta-Analysis. Br. J. Psychiatry 2020, 217, 600–608. [CrossRef]

21. Fox, V.; Dalman, C.; Dal, H.; Hollander, A.-C.; Kirkbride, J.B.; Pitman, A. Suicide Risk in People with Post-Traumatic Stress Disorder: A Cohort Study of 3.1 Million People in Sweden. J. Affect. Disord. 2021, 279, 609–616. [CrossRef]

22. Bridgland, V.M.E.; Moeck, E.K.; Green, D.M.; Swain, T.L.; Nayda, D.M.; Matson, L.A.; Hutchison, N.P.; Takarangi, M.K.T. Why the COVID-19 Pandemic Is a Traumatic Stressor. PLoS ONE 2021, 16, e0240146. [CrossRef] [PubMed]

23. Batra, K.; Sharma, M.; Batra, R.; Singh, T.P.; Schvaneveldt, N. Assessing the Psychological Impact of COVID-19 among College Students: An Evidence of 15 Countries. Healthcare 2021, 9, 222. [CrossRef] [PubMed]
24. Mason, J.E.; LeBouthillier, D.M.; Asmundson, G.J.G. Relationships between Health Behaviors, Posttraumatic Stress Disorder, and Comorbid General Anxiety and Depression. Cogn. Behav. Ther. 2019, 48, 184–199. [CrossRef] [PubMed]  
25. van den Berk-Clark, C.; Secrest, S.; Wallis, J.; Hallberg, E.; Lustman, P.J.; Schneider, F.D.; Scherrner, J.F. Association between Posttraumatic Stress Disorder and Lack of Exercise, Poor Diet, Obesity, and Co-Occurring Smoking: A Systematic Review and Meta-Analysis. Health Psychol. 2018, 37, 407–416. [CrossRef]  
26. LeardMann, C.A.; Kelton, M.L.; Smith, B.; Littman, A.J.; Boyko, E.J.; Wells, T.S.; Smith, T.C. Prospectively Assessed Posttraumatic Stress Disorder and Associated Physical Activity. Public Health Rep. 2011, 126, 371–383. [CrossRef] [PubMed]  
27. Zhang, Y.; Ren, R.; Sanford, L.D.; Yang, L.; Zhou, J.; Zhang, J.; Wing, Y.-K.; Shi, J.; Lu, L.; Tang, X. Sleep in Posttraumatic Stress Disorder: A Systematic Review and Meta-Analysis of Polysomnographic Findings. Sleep Med. Rev. 2019, 48, 101210. [CrossRef]  
28. Deng, C.-H.; Wang, J.-Q.; Zhu, L.-M.; Liu, H.-W.; Guo, Y.; Peng, X.-H.; Shao, J.-B.; Xia, W. Association of Web-Based Physical Education with Mental Health of College Students in Wuhan during the COVID-19 Outbreak: Cross-Sectional Survey Study. J. Med. Internet Res. 2020, 22, e21301. [CrossRef]  
29. Feng, J.; Lai, P.W.C.; Shi, L.; Huang, W.Y. Movement Behaviors and Posttraumatic Stress Disorder during the COVID-19 Pandemic: A Retrospective Study of Chinese University Students. J. Exerc. Sci. Fit. 2022, 20, 263–268. [CrossRef]  
30. Zhang, Y.; Wu, X.; Tao, S.; Li, S.; Ma, L.; Yu, Y.; Sun, G.; Li, T.; Tao, F. Associations between Screen Time, Physical Activity, and Depressive Symptoms during the 2019 Coronavirus Disease (COVID-19) Outbreak among Chinese College Students. Environ. Health Prev. Med. 2021, 26, 107. [CrossRef]  
31. Ross, R.; Chaput, J.-P.; Giangregorio, L.M.; Janssen, I.; Saunders, T.J.; Kho, M.E.; Poitras, V.J.; Tomasono, J.R.; El-Kotob, R.; McLaughlin, E.C.; et al. Canadian 24-Hour Movement Guidelines for Adults Aged 18–64 Years and Adults Aged 65 Years or Older: An Integration of Physical Activity, Sedentary Behaviour, and Sleep. Appl. Physiol. Nutr. Metab. 2020, 45, S57–S102. [CrossRef]  
32. Chinese Center for Disease Control and Prevention Tracking the Epidemic (2020). Available online: https://weekly.chinacdc.cn/news/TrackingtheEpidemic2020.htm (accessed on 11 August 2022).  
33. Chinese Center for Disease Control and Prevention Tracking the Epidemic (2020). Available online: https://weekly.chinacdc.cn/news/TrackingtheEpidemic2020.htm (accessed on 11 August 2022).  
34. Qu, N.; Li, K. Study on the Reliability and Validity of International Physical Activity Questionnaire (Chinese Version, IPAQ). Chinese J. Epidemiol. 2004, 25, 265–268.  
35. Liu, X.; Tang, M.; Hu, L.; Wang, A.; Wu, H.; Zhao, G.; Gao, C.; Li, W. Reliability and Validity of the Pittsburgh Sleep Quality Index. Chinese J. Psychiatry 1996, 29, 103–107.  
36. Wang, M.-C. Posttraumatic Stress Disorder Checklist—Civilian Version. In Handbook of Commonly Used Psychological Assessment Scale; Dai, X.-Y., Ed.; People’s Military Medical Press: Beijing, China, 2010; pp. 117–121.  
37. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders: DSM-IV; American Psychiatric Association: Arlington, VA, USA, 1994.  
38. Chekroud, S.R.; Gueorguieva, R.; Zheutlin, A.B.; Paulus, M.; Krumholz, H.M.; Krystal, J.H.; Chekroud, A.M. Association between Physical Exercise and Mental Health in 1.2 Million Individuals in the USA between 2011 and 2015: A Cross-Sectional Study. Lancet Psychiatry 2018, 5, 739–746. [CrossRef]  
39. Tang, W.; Hu, T.; Hu, B.; Jin, C.; Wang, G.; Xie, C.; Chen, S.; Xu, J. Prevalence and Correlates of PTSD and Depressive Symptoms One Month after the Outbreak of the COVID-19 Epidemic in a Sample of Home-Quarantined Chinese University Students. J. Affect. Disord. 2020, 274, 1–7. [CrossRef]  
40. Andrews, B.; Brewin, C.R.; Philpott, R.; Stewart, L. Delayed-Onset Posttraumatic Stress Disorder: A Systematic Review of the Evidence. Am. J. Psychiatry 2007, 164, 1319–1326. [CrossRef]  
41. Liao, Z.; Zhang, X.; Wang, Y.; Wang, T.; Li, X.; Zhao, M.; Zhuang, Q. Delayed-Onset PTSD and Coping Strategies of Chinese College Students during the COVID-19 Pandemic. Front. Sociol. 2021, 6, 734738. [CrossRef]  
42. Yuan, K.; Gong, Y.-M.; Liu, L.; Sun, Y.-K.; Tian, S.-S.; Wang, Y.-J.; Zhong, Y.; Zhang, A.-Y.; Su, S.-Z.; Liu, X.-X.; et al. Prevalence of Posttraumatic Stress Disorder after Infectious Disease Pandemics in the Twenty-First Century, Including COVID-19: A Meta-Analysis and Systematic Review. Mol. Psychiatry 2021, 26, 4982–4998. [CrossRef]  
43. Huang, Y.; Li, L.; Gan, Y.; Wang, C.; Jiang, H.; Cao, S.; Lu, Z. Sedentary Behaviors and Risk of Depression: A Meta-Analysis of Prospective Studies. Transl. Psychiatry 2020, 10, 26. [CrossRef]  
44. Allen, M.S.; Walter, E.E.; Swann, C. Sedentary Behaviour and Risk of Anxiety: A Systematic Review and Meta-Analysis. J. Affect. Disord. 2019, 242, 5–13. [CrossRef]  
45. Cheval, B.; Sivaramakrishnan, H.; Maltagliati, S.; Fessler, L.; Forestier, C.; Sarrazin, P.; Orsholits, D.; Chalabaev, A.; Sander, D.; Ntoumanis, N.; et al. Relationships between Changes in Self-Reported Physical Activity, Sedentary Behaviour and Health during the Coronavirus (COVID-19) Pandemic in France and Switzerland. J. Sports Sci. 2021, 39, 699–704. [CrossRef]  
46. Meyer, J.; McDowell, C.; Lansing, J.; Brower, C.; Smith, L.; Tully, M.; Herring, M. Changes in Physical Activity and Sedentary Behavior in Response to COVID-19 and Their Associations with Mental Health in 3052 US Adults. Int. J. Environ. Res. Public Health 2020, 17, 4649. [CrossRef] [PubMed]  
47. Ellingson, L.D.; Meyer, J.D.; Shook, R.P.; Dixon, P.M.; Hand, G.A.; Wirth, M.D.; Paluch, A.E.; Burgess, S.; Hebert, J.R.; Blair, S.N. Changes in Sedentary Time Are Associated with Changes in Mental Wellbeing over 1 Year in Young Adults. Prev. Med. Rep. 2018, 11, 274–281. [CrossRef] [PubMed]
48. Hallgren, M.; Nguyen, T.-T.-D.; Owen, N.; Vancampfort, D.; Dunstan, D.W.; Wallin, P.; Andersson, G.; Ekblom-Bak, E. Associations of Sedentary Behavior in Leisure and Occupational Contexts with Symptoms of Depression and Anxiety. *Prev. Med.* 2020, 133, 106021. [CrossRef] [PubMed]

49. Stanton, R.; To, Q.G.; Khalesi, S.; Williams, S.L.; Alley, S.J.; Fenning, A.S.; Vandelanotte, C. Depression, Anxiety and Stress during COVID-19: Associations with Changes in Physical Activity, Sleep, Tobacco and Alcohol Use in Australian Adults. *Int. J. Environ. Res. Public Health* 2020, 17, 4065. [CrossRef]

50. Geng, F.; Liang, Y.; Li, Y.; Fang, Y.; Pham, T.S.; Liu, X.; Fan, F. Bidirectional Associations between Insomnia, Posttraumatic Stress Disorder, and Depressive Symptoms among Adolescent Earthquake Survivors: A Longitudinal Multiwave Cohort Study. *Sleep* 2019, 42, zsz162. [CrossRef]

51. Fang, H.; Tu, S.; Sheng, J.; Shao, A. Depression in Sleep Disturbance: A Review on a Bidirectional Relationship, Mechanisms and Treatment. *J. Cell. Mol. Med.* 2019, 23, 2324–2332. [CrossRef]

52. Kim, Y.S.; Park, Y.S.; Allegrante, J.P.; Marks, R.; Ok, H.; Ok Cho, K.; Garber, C.E. Relationship between Physical Activity and General Mental Health. *Prev. Med.* 2012, 55, 458–463. [CrossRef]

53. Bernard, P.; Doré, I.; Romain, A.-J.; Hains-Monfette, G.; Sabiston, C. Dose Response Association of Objective Physical Activity with Mental Health in a Representative National Sample of Adults: A Cross-Sectional Study. *PLoS ONE* 2018, 13, e0204682. [CrossRef]

54. Ding, D.; del Pozo Cruz, B.; Green, M.A.; Bauman, A.E. Is the COVID-19 Lockdown Nudging People to Be More Active: A Big Data Analysis. *Br. J. Sports Med.* 2020, 54, 1183–1184. [CrossRef]

55. Seigel, K.; Broman, J.-E.; Hetta, J. Behavioral Activation or Inhibition during Emotional Stress–Implications for Exercise Habits and Emotional Problems among Young Females. *Nord. J. Psychiatry* 2002, 56, 441–446. [CrossRef]

56. Romero-Blanco, C.; Rodríguez-Almagro, J.; Onieva-Zafra, M.D.; Parra-Fernández, M.L.; Prado-Laguna, M.D.; Hernández-Martínez, A. Physical Activity and Sedentary Lifestyle in University Students: Changes during Confinement Due to the COVID-19 Pandemic. *Int. J. Environ. Res. Public Health* 2020, 17, 6567. [CrossRef] [PubMed]

57. Stults-Kolehmainen, M.A.; Sinha, R. The Effects of Stress on Physical Activity and Exercise. *Sport. Med.* 2014, 44, 81–121. [CrossRef] [PubMed]

58. Cairney, J.; Kwan, M.Y.W.; Veldhuizen, S.; Faulkner, G.E.J. Who Uses Exercise as a Coping Strategy for Stress? Results from a National Survey of Canadians. *J. Phys. Act. Health* 2014, 11, 908–916. [CrossRef] [PubMed]

59. Craig, C.L.; Marshall, A.L.; Sjöström, M.; Bauman, A.E.; Booth, M.L.; Ainsworth, B.E.; Pratt, M.; Ekelund, U.; Yngve, A.; Sallis, J.F.; et al. International Physical Activity Questionnaire: 12-Country Reliability and Validity. *Med. Sci. Sports Exerc.* 2003, 35, 1381–1395. [CrossRef]

60. Conybeare, D.; Behar, E.; Solomon, A.; Newman, M.G.; Borkovec, T.D. The PTSD Checklist—Civilian Version: Reliability, Validity, and Factor Structure in a Nonclinical Sample. *J. Clin. Psychol.* 2012, 68, 699–713. [CrossRef]

61. Brewin, C.R. Systematic Review of Screening Instruments for Adults at Risk of PTSD. *J. Trauma. Stress* 2005, 18, 53–62. [CrossRef]

62. Li, Y.; Zhao, J.; Ma, Z.; McReynolds, L.S.; Lin, D.; Chen, Z.; Wang, T.; Wang, D.; Zhang, Y.; Zhang, J.; et al. Mental Health among College Students during the COVID-19 Pandemic in China: A 2-Wave Longitudinal Survey. *J. Affect. Disord.* 2021, 281, 597–604. [CrossRef]

63. Yu, Y.; She, R.; Luo, S.; Xin, M.; Li, L.; Wang, S.; Ma, L.; Tao, F.; Zhang, J.; Zhao, J.; et al. Factors Influencing Depression and Mental Distress Related to COVID-19 among University Students in China: Online Cross-Sectional Mediation Study. *JMIR Ment Health* 2021, 8, e22705. [CrossRef]

64. Qiu, J.; Shen, B.; Zhao, M.; Wang, Z.; Xie, B.; Xu, Y. A Nationwide Survey of Psychological Distress among Chinese People in the COVID-19 Epidemic: Implications and Policy Recommendations. *Gen. Psychiatry* 2020, 33, e100213. [CrossRef]

65. Lee, Y.; Lui, L.M.W.; Chen-Li, D.; Liao, Y.; Mansur, R.B.; Brietzke, E.; Rosenblat, J.D.; Ho, R.; Rodrigues, N.B.; Lipsitz, O.; et al. Government Response Moderates the Mental Health Impact of COVID-19: A Systematic Review and Meta-Analysis of Depression Outcomes across Countries. *J. Affect. Disord.* 2021, 290, 364–377. [CrossRef]