

Research Article

An investigative study of anxiety, depression and sleep quality in college students after the COVID-19 pandemic - the moderating effect of physical activity

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(Received: January 10, 2024; Revised: February 26, 2024; Accepted: February 28, 2024; Published: March 13, 2024)

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ABSTRACT

To explore the current situation of anxiety, depression and sleep quality among college students after the COVID-19 pandemic, as well as the moderating effect of physical activity on negative emotions, and to provide a theoretical basis for colleges and universities to formulate corresponding interventions. An online cross-sectional questionnaire survey was carried out by convenience sampling method on 801 college students from China through the General Information Questionnaire (GIQ), Anxiety Self-Rating Scale (ASRS), Depression Self-Rating Scale (DSRS), Pittsburgh Sleep Quality Index Scale (PQIS), and Physical Activity Rating Scale (PARS). Data were analysed using SPSS 25.0 software and Pearson correlation was used to explore the correlations between variables. The scores of anxiety, depression, sleep quality, and physical activity level of the 801 college students included in the study after the Covid-19 pandemic were 37.15, 40.93, 2.9, and 14.44, respectively; and the detection rates of anxiety symptoms, depressive symptoms, and sleep disorders were 41.09%, 42.89%, and 30.82%, respectively. The detection rate of negative emotions was significantly higher in females than in males, and the senior group was significantly higher than the junior group in terms of depression and anxiety symptoms. The amount of physical activity of college students was significantly negatively correlated with anxiety ($r=-0.691$, $P<0.001$), depression ($r=-0.767$, $P<0.001$), and sleep quality ($r=-0.814$, $P<0.001$); anxiety was positively correlated with depression ($r=0.622$, $P<0.001$) and sleep quality ($r=0.598$, $P<0.05$); and positive correlation between depression and sleep quality ($r=0.512$, $P<0.05$). After the Covid-19 pandemic, college students showed different degrees of anxiety, depression and sleep disorders, the appropriate frequency of exercise can effectively improve the negative emotions of college students, and colleges and universities should pay attention to guiding the students and give them enough care and support to improve their mental health status.

Key words: COVID-19, Depression, Anxiety, Sleep quality, Physical activity

INTRODUCTION

During the COVID-19 pandemic in 2020, some scholars pointed out that university students generally faced psychological problems and were associated with factors such as whether they were in an infected area and fear of infection (Leung, 2023). Although the direct risk of death in China has been significantly reduced after the COVID-19 pandemic, many universities still adopt a series of preventive and control measures to ensure the safety of university students, such as the implementation of health punch cards, nucleic acid testing, and registration for returning to school in on-campus and off-campus provinces. These measures may lead to boredom among college students, especially those who lack practical experience in society and are under pressure from various aspects, and are prone to various psychological problems. If these problems are not intervened in time, they may lead to neuroendocrine disorders, which may affect the quality of sleep.

It is particularly important to understand the impact of the COVID-19 pandemic on the mental health of college students.

Therefore, physical exercise, as an adjunctive psychotherapy, has a significant effect on improving mental health (Yazdani *et al.*, 2024). Through physical activity, individuals can be helped to maintain emotional stability and effectively alleviate anxiety and depression (Wenig *et al.*, 2023). Participation in forms of exercise such as team sports, school clubs, and extracurricular and community sport and non-sport activities can help to substantially reduce anxiety in exercisers (Andersson *et al.*, 2023), thereby positively affecting mental health. However, there may be differences in the duration, frequency, and intensity of physical activity among different populations, and it remains to be further explored whether their psychological well-being is affected to varying degrees, and what level of exercise best improves psychological well-being. Therefore, by investigating anxiety, depression, sleep quality, and physical activity among college students after the COVID-19 pandemic, the present study aims to delve deeper into the relationships between exercise frequency, intensity, and duration of exercise and these mental health indicators. Through these investigations, we hope to provide clues to

reveal the causes of anxiety, depression, and sleep disorders among college students after the COVID-19 pandemic, and to help them make timely psychological adjustments, so as to promote the overall development of students' mental and physical health.

OBJECTS AND METHODS

Target Population

This survey used convenience sampling, from 25 September 2023 to 12 November 2023, an online questionnaire survey of college students studying in colleges and universities in China. A total of 832 questionnaires were collected, among which 801 questionnaires were valid (validity rate 96.27%). The study was approved by the Biomedical Ethics Committee of Shandong University before starting the survey. The purpose of the study, the content of the survey and the ethical review were informed to the subjects in advance, and all subjects participated voluntarily under the premise of informed consent. Inclusion criteria: full-time undergraduate students. Exclusion criteria: those who have been diagnosed with anxiety disorder or depression.

Research Instrument

Data collection for this study was conducted through the Questionnaire Star online questionnaire. The questionnaire includes a general information questionnaire, anxiety self-assessment scale, depression self-assessment scale, Pittsburgh sleep quality index scale, and physical activity level scale. The questionnaire was finalised after pre-survey and reliability tests, and the Cronbach coefficient of the questionnaire in this study was 0.814, and the validated factor analysis fit indices were: $\chi^2/df = 7.264$, CFI = 0.948, TLI = 0.929, RMSEA = 0.067, and SRMR = 0.061.

Self-Rating Anxiety Scale (SAS)

The scale (Bulten *et al.*, 2022) contains 20 items reflecting subjective feelings of anxiety, and each item is divided into four levels of scoring according to the frequency of symptoms, with a standard score of ≥ 50 as having anxiety symptoms, 50-59 as mild, 60-69 as moderate, and 70 and above as severe.

Self-Rating Depression Scale (SDS)

The scale (Ahuvia *et al.*, 2024) consists of 20 items, and the severity is rated according to a four-point scale, which consists of 20 entries, from 1 (never) to 4 (always) accordingly rated on a scale of 1-4. Among them, 2, 5, 6, 11, 12, 14, 16, 17, 18, and 20 are reverse scoring, and the scores of each item are summed up to get the crude score, which is rounded up to get the standard score after multiplying by 1.25, and the scores of all the items are summed up to be the total score of the scale. In our country, the SDS standard score ≥ 50 is regarded as having depressive symptoms, 50-59 is regarded as mild, 60-69 is regarded as moderate, and 70 and above is regarded as severe.

Pittsburgh Sleep Quality Index (PSQI)

The Pittsburgh Sleep Quality Index (PSQI) (Ehlers *et al.*, 2018) is widely used to assess the sleep status of subjects in the last month, and has good reliability and validity, with a re-test reliability of 0.81 among Chinese college students. The scale consists of 24 entries that make up 7 factors, namely sleep quality, sleep latency, sleep persistence, sleep efficiency, sleep disorders, hypnotic drugs, and daytime dysfunction. Each factor is scored on a 0-3 scale, with a total score between 0-21, with higher scores reflecting poorer sleep quality.

Physical Activity Level Scale

The Physical Activity Rating Scale (PARS-3) (Zhao & Kou, 2024) compiled by Liang Deqing was used, combined with the purpose of the study, the amount of physical activity was used as an indicator to reflect the situation of physical activity level of college students, which consisted of three rating indicators, namely, weekly frequency of physical activity, time of each physical activity and intensity of physical activity, and the indicators of exercise intensity and exercise time were divided into five grades, with grades 1-5 corresponding to scores of 1-5, respectively. Exercise frequency is divided into four grades, with 1~4 grades corresponding to 1~4 points, and the results are calculated according to the formula "Physical Activity = Exercise Time \times Exercise Intensity \times Exercise Frequency" as a measure of the amount of physical activity of college students.

Quality Control

We excluded the samples whose filling time of the questionnaire is less than 2s and the total filling time is less than 200s, and excluded the respondents whose age range is not between 16 and 30 years old. The data for this study was obtained from students' self-reports, so a common method bias test was required. The study controlled for common method bias procedurally by measuring anonymously and using reverse questions for some of the questions. Using SPSS 25.0, the variables involved in this study were included in the exploratory factor analysis, and the data collected were tested for common method bias using Harman's one-way test, and the maximum factor variance explained in the unrotated exploratory factor analysis was 30.04% (<40%), from which it was inferred that the data from this study did not suffer from serious common method bias.

Statistical Analysis

SPSS 25.0 was used for data analysis. Measurement data were satisfied with normal distribution, expressed as mean \pm standard deviation, and comparisons between different groups were satisfied with normality and chi-square, using T-test and one-way ANOVA. Count data were expressed as the number of cases and percentage (%), and comparisons between groups were made using the χ^2 test. Differences were considered statistically significant at $P < 0.05$.

RESULTS

General Characteristics of the Study Subjects

A total of 801 college students were included, including 335 male students (41.82%) and 466 female students (58.18%); 317 freshmen (39.58%), 204 sophomores (25.47%), 154 juniors (19.23%) and 126 seniors (15.73%). The age of the respondents was 17-26 years with a mean (20.6±1.9) (Table 1).

Current Status of Anxiety, Depression, Sleep Quality and Physical Activity among College Students After Covid-19 Pandemic

After the Covid-19 pandemic, the total detection rates of anxiety symptoms, depression symptoms and sleep disorders among college students were 41.09%, 42.89%, and 30.82%, respectively, with the vast majority of them being mild. Comparison of the above symptoms by gender, grade, and aspect showed significant differences ($P<0.05$). The detection rate of anxiety in females (56.73%) was significantly higher than that of males (49.82%), and the higher grade group had significantly higher symptoms of depression and anxiety than the lower grade group. 32.46% (260/801) of the students had sleep disorders (with a score of ≥ 3), 30.71% (246/801) had difficulty in falling asleep, and 22.85% (183/801) had waking up easily at night or waking up early waking. Sleep problems were more serious in the senior group ($P<0.05$), and females were more likely to have sleep problems compared to males ($P<0.05$). Male students were more physically active than female students, and senior

students were significantly less physically active than junior students.

The results of bivariate correlation showed that the amount of physical activity of college students after the Covid-19 pandemic was significantly and negatively correlated with anxiety ($r=-0.691$, $P<0.001$), depression ($r=-0.767$, $P<0.001$), and sleep quality ($r=-0.814$, $P<0.001$); anxiety was positively correlated with depression ($r=0.622$, $P<0.001$) and sleep quality ($r=0.598$, $P<0.05$) were positively correlated; and there was a positive correlation between depression and sleep quality ($r=0.512$, $P<0.05$) (Table 2), in which the frequency of physical activity had the greatest effect on anxiety, depression and sleep quality.

DISCUSSION

This study used a cross-sectional survey to observe the mental health status and physical activity of the college student population after the COVID-19 pandemic. The results showed that after the COVID-19 pandemic, the total detection rates of anxiety symptoms, depressive symptoms and sleep disorders among college students were 41.09%, 42.89%, and 30.82%, respectively, most of which were mild, with significant differences in gender and grade level. The detection rate of anxiety in females (56.73%) was significantly higher than that of males (49.82%), and males were better than females in terms of sleep quality. The senior group was significantly higher than the junior group in terms of anxiety, depression, and sleep disorders, and lower than the junior group in terms of the amount of physical activity. A foreign

Table 1: Status of anxiety, depression, sleep quality and physical activity levels

variant	n(%)	Anxiety	χ^2	Depression	χ^2	Sleep quality	χ^2	Physical activity	χ^2
Gender			0.42		0.46		0.21*		0.33*
Man	335 (41.82)	37.32±6.15		40.58±5.91		2.82±0.78		14.63±10.88	0.33*
Female	466 (58.18)	36.91±7.22		41.39±6.12		2.98±0.71		14.21±9.67	
Grade			7.33***		10.15***		2.98**		9.86**
First year	317 (39.58)	32.39±5.90		39.12±4.98		2.31±0.65		15.93±8.69	
Second year	204 (25.47)	35.91±6.01		40.56±5.11		2.36±0.69		15.21±9.85	
Third year	154 (19.23)	38.22±6.86		41.46±5.83		2.99±0.91		14.33±10.56	
Fourth year	126 (15.73)	39.85±7.93		42.09±6.33		3.35±0.89		13.15±9.21	
All	801(100)	37.15±6.86		40.93±6.09		2.91±0.73		14.44±10.21	

* $P<0.05$, ** $P<0.01$, *** $P<0.001$

Table 2: Bivariate correlations

	1	2	3	4
Anxiety	1.000			
Depression	0.622***	1.000		
Sleep quality	0.598*	0.512*	1.000	
Physical activity	-0.681***	-0.767***	-0.814***	1.000
Physical activity time	-0.146	-0.099	-0.156**	
Intensity of physical activity	-0.533**	-0.468**	-0.942***	
Frequency of physical activity	-0.798***	-0.885***	-0.891***	

* $P<0.05$, ** $P<0.01$, *** $P<0.001$

meta-analysis showed that the prevalence of COVID-19 has a greater impact on college students, specifically in terms of anxiety, depression, and stress, especially for women as well as final-year students (Baranauskas *et al.*, 2022). Domestic large-scale surveys in Guangdong and Hubei at the beginning of 2020 showed that the incidence of depression during the epidemic among college students was 21.2% and 37.92%, and the incidence of anxiety was 26.6% and 34.3%, respectively (Wang *et al.*, 2023), and there were grade differences, with the detection rate of anxiety, depression, and sleep disorders being much higher than that of lower-grade students in the case of higher-grade graduates who faced such important nodes as graduation defences, interviews, and job searches, and the number of sports. The detection rate of anxiety, depression and sleep disorders was much higher than that of lower grade students, and the amount of physical activity was lower than that of lower grade students. The higher detection rates of anxiety and depression in this study than previously reported in the literature may be related to the specific time and environment in which the students lived. Whether the student population was involved in the epidemic or quarantined was not reported in most surveys, and it has been shown that the prevalence of anxiety, depression, and insomnia increased under the conditions of colleagues or family members who had new crown infections, close contacts, or frontline work experience (James *et al.*, 2023). Petrie *et al.* (2023) showed that patients with sleep problems have a state of daily anxiety and depression, which can lead to prolonged sleep onset, reduced sleep duration and reduced sleep efficiency (McLeish *et al.*, 2023). In turn sleep deprivation can cause physical and mental anxiety arousal to intensify the situation (Lee *et al.*, 2022), and the vicious cycle repeats itself week after week, which is consistent with our finding that anxiety and depression can predict sleep quality. Therefore, schools can reduce the degree of anxiety and depression through psychological counselling for college students, thus improving sleep quality.

Appropriate physical exercise can help regulate mood. During the COVID-19 pandemic, college students lived indoors for a long time and exercised less, which made them more prone to anxiety and depression (Dinler *et al.*, 2020). It has been found that students who exercise regularly have lower levels of anxiety (Luo *et al.*, 2022) and depression (Simon *et al.*, 2023), which may be related to the increased secretion of dopamine (Merchán-Sanmartín *et al.*, 2022) and brain-derived neurofactors by exercise (Torres *et al.*, 2023). Appropriate sports exercise can promote students' mental health while enhancing physical fitness (Shen *et al.*, 2024), and in terms of the correlation of physical activity on psychological factors of college students, there is no correlation between exercise time and both anxiety and depression. There are two views in existing research on the relationship between exercise duration and anxiety and depression, one view is that exercise duration is the only significant predictor of anxiety reduction through exercise (Patin *et al.*, 2023), and that 20-40 minutes and 75 minutes of aerobic exercise improves anxiety and depression (Yan *et al.*, 2022), respectively,

however, the other view is opposite (Nugraha *et al.*, 2023), and those who participated in 10 minutes of exercise had higher levels of anxiety compared to the results of the present agree with the latter view that the duration of exercise does not correlate with anxiety and depression in university students, and is largely based on the effect of exercise frequency. Some studies have shown that anxiety and depression improve with regular exercise, but few people currently engage in regular physical activity for a long period (de Sá *et al.*, 2023), and college students after the COVID-19 pandemic, who felt mentally drained by the various campus epidemic prevention and control measures, were more emotionally sensitive and anxious than usual (Gu *et al.*, 2023), and few students were able to engage in a certain amount of physical activity for a long period, and thus, in one-time physical activity, which has a very short-lived, if any, favourable effect (Massey *et al.*, 2023). Another possibility is the effect of stress on physical activity and exercise, *i.e.*, the experience of stress affects physical activity effort, and college students in the wake of the COVID-19 pandemic face stress in many ways, and thus the favourable effects of exercise may be attenuated or lost.

The correlations between exercise intensity and anxiety, depression, and sleep quality were -0.533, -0.468, and -0.942, respectively, with $p < 0.01$, suggesting that exercise intensity has a low negative correlation with anxiety and depression, *i.e.*, moderate- to high-intensity exercise may be associated with a lower incidence of anxiety and depression. This study is in line with Chirico *et al.* (2020).

The correlations between exercise frequency and college students' anxiety, depression, and sleep quality were -0.798, -0.885, and -0.891, respectively, with $p < 0.001$, indicating that the frequency of exercise showed a significant negative correlation with anxiety, depression, and sleep quality, which is consistent with many studies (Yang *et al.*, 2023). From the viewpoint of psychological factors, the reason why exercise frequency can affect anxiety, depression and sleep quality of college students, there exist the mediating variables of external exercise motivation (Takagaki & Yokoyama, 2023) and subjective exercise experience (Zdravkovic & Goldstein, 2023), and external exercise motivation is significantly and positively correlated with exercise frequency, and higher exercise frequency can build up the external motivation (Lee *et al.*, 2023), which can reduce the depressed mood (Luo *et al.*, 2023). Regular participation in sports activities can sharpen college students' emotions and will, so that bad moods can also be alleviated (Zhao *et al.*, 2023). On the other hand, regular exercise can accelerate the accumulation of neurotransmitters in the brain, which lays the foundation for relieving anxiety and promotes good sleep. In continuous exercise, college students can master motor skills and generate self-confidence to face work and life. Contemporary college students have received a good education, physical and mental maturity and development, and know how to release emotions more positively, exercise can improve college students' self-control ability, to reduce the generation of negative emotions.

CONCLUSION

After the COVID-19 pandemic, college students' physical fitness has declined, and they are still facing the risks brought by the epidemic, coupled with the pressure of study, life and work, the incidence of anxiety, depression, and sleep disorders among college students is still high, but the amount of physical activity is low. Exercise frequency and intensity were negatively correlated with anxiety, depression, and sleep disorders, and those who exercised regularly had lower anxiety and depression. Thus, increasing the amount of exercise within the appropriate range may produce better results in improving adverse mood. The main problems faced by college students may be different in different cycles of their growth, so the mental health education for college students should be targeted. The present study was a cross-sectional survey, which could not fully explore the differences in individual psychological status at different stages of the epidemic, and future studies should expand the sample size and carry out multi-stage comparative surveys to further demonstrate the impact of negative events on the psychological status of college students.

ACKNOWLEDGEMENTS

We would like to thank the participants in the study and the reviewers for their valuable comments.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and analysed during the current study available from the corresponding author on reasonable request.

AUTHORS' CONTRIBUTIONS

RZ, CMC and LQZ participated in the design of the study, conducted the statistical analysis and interpretation of data, drafted the manuscript, and critically reviewed the manuscript. All authors read and approved the final manuscript.

FUNDING

China Ministry of Education Humanities and Social Sciences Research Youth Fund Project (19YJC890045).

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was performed in accordance with the Declaration of Helsinki, the studies involving human participants were reviewed and approved by the Institution Review Board of the Zhejiang University of Finance and Economics of China. All subjects provided their written informed consent to participate in the study.

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