

# Association between physical activity levels and anxiety or depression among college students in China during the COVID-19 pandemic

## A meta-analysis

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### Abstract

**Background:** This meta-analysis aimed to investigate the links between the level of physical activity and the risk of anxiety or depression among college students in China during the Coronavirus Disease 2019 pandemic.

**Methods:** Eligible studies were searched from the PubMed, Embase, and Web of Science databases. The associations between them were assessed with odd ratio (OR) and 95% confidence interval (CI). The heterogeneity of the included studies was evaluated and subgroup analysis was performed. Sensitivity analysis was executed using leave-one-out method. Publication bias of included studies was evaluated. Ten studies with moderate quality were included.

**Results:** Physical activity levels of college students were associated with reduced risk of depression (OR [95%CI] = 0.69 [0.58, 0.82],  $P < .001$ ) and anxiety (OR [95%CI] = 0.71 [0.62, 0.80],  $P < .001$ ). The measurement scale of depression or anxiety and whether multi-factor correction was performed or not did not influence the pooled results. The pooled results of depression and anxiety were stable and were not significantly influenced by a single study. No publication bias was observed in the included studies reporting depression and anxiety.

**Conclusion:** The physical activity level of college students is negatively correlated with anxiety and depression in China during the pandemic. During the Coronavirus Disease 2019 pandemic, it is necessary to strengthen the construction of university physical education courses. As an organized form of physical activity, physical education classes are a necessary and effective way to increase physical activity among college students.

**Abbreviations:** AHRQ = Agency for Healthcare Research and Quality, CI = confidence interval, COVID-19 = Coronavirus Disease 2019, OR = odd ratio.

**Keywords:** anxiety, college students, COVID-19, depression, meta-analysis, physical activity

## 1. Introduction

The Coronavirus Disease 2019 (COVID-19) was first reported in December 2019 and spreads rapidly worldwide.<sup>[1]</sup> Due to strong infectivity and diverse transmission routes of COVID-19, suppression strategies such as closing of public transport and shutdown of public places are made to curb the transmission of the COVID-19 epidemic at the beginning of 2020, which widely affect the lifestyle of global individuals.<sup>[2,3]</sup> The pandemic not only brings the risk of death from viral infections, but also creates psychological problems to residents due to negative news

such as an increase in the number of patients and deaths and a lack of medical resources.<sup>[4,5]</sup>

College students are in the transition period from adolescence to adulthood, which makes them susceptible to emotional and behavioral problems that can be triggered by negative emotions.<sup>[6]</sup> To control the pandemic, the Chinese government has taken strong management measures such as home quarantine and delaying the start of school, which can affect the study plans of college students. Factors like fear of the epidemic and long-term home isolation have increased the psychological burden on college students, leading to mental health problems,

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especially anxiety, and depression.<sup>[7–9]</sup> The prevalence of anxiety and depression among Chinese college students is reported to be approximately 24.9% and 9.0%, respectively, during the COVID-19 outbreak.<sup>[10,11]</sup> Moreover, anxiety and depressive disorders are associated with negative outcomes, such as the reduced quality of life, underachievement, as well as an increased risk of suicide.<sup>[12]</sup> As a high-risk group with poor mental health during the epidemic, it is necessary to pay attention to the mental health status of college students, which can help to early detection of mental health problems and implementation of psychological intervention.

Physical activity is found to play a potential protective role on mental health, like anxiety and depression.<sup>[13]</sup> Physical activity may be an effective approach to help individuals maintain the mental health of individuals during quarantine. The World Health Organization has released guidance for people in self-isolation, giving the practical advice and importance of staying physically active at home.<sup>[14]</sup> Accumulating studies have explored the association between physical activity levels and negative emotions like anxiety and depression among Chinese college students in the context of the pandemic, however, results are inconsistent among these studies. For instance, some studies have demonstrated that physical activity was negatively related to anxiety and depression symptoms,<sup>[15,16]</sup> while Yang et al revealed that weekly exercise was only associated with anxiety symptoms of graduating university students, not depression symptoms.<sup>[17]</sup> Given the above research controversy, it is crucial to conduct more studies to explore the impact of physical activity on the mental health problems of Chinese college students amidst the pandemic.

This study conducted meta-analysis of multiple observational studies to investigate the links between the level of physical activity and the risk of anxiety or depression among college students in China during the pandemic.

## 2. Methods

### 2.1. Search strategy

Using the predetermined search strategy, we retrieved eligible studies from PubMed, Embase, and Web of Science databases. The search terms included “COVID-19,” “severe acute respiratory syndrome coronavirus 2,” “China,” “university,” “students,” “Depression,” and “anxiety.” The search terms of the same category were combined with “OR,” and those of different categories were combined with “AND.” The search used a combination of subjects and free words, and the search steps were adjusted according to the characteristics of each database (Tables S1–S3, Supplemental Digital Content, <http://links.lww.com/MD/K999>, <http://links.lww.com/MD/K1000>, <http://links.lww.com/MD/L2>). The search time was up to August 24, 2023, without any language restrictions. Additionally, relevant reviews and references from the included studies were screened to identify additional studies suitable for meta-analysis.

### 2.2. Study selection

The inclusion criteria were set as follows: (1) the subjects were college students in China; (2) the study type included cross-sectional studies, case-control studies, and cohort studies; (3) the study reported the association between the physical activity level of college students and the risk of anxiety and depression during the pandemic, without restrictions on the measurement methods and grouping criteria of physical activity; and (4) the association was expressed as odd ratio (OR) and 95% confidence interval (CI), or could be calculated based on other available data.

The exclusion criteria were: (1) intervention studies; (2) non-authoritative studies, such as comments, reviews, and

conference abstracts; and (3) repeated publications or multiple articles with the same data were excluded expect the study with the most complete research information.

### 2.3. Data extraction

Two investigators independently completed the study selection according to the above inclusion and exclusion criteria. After determining the included studies, they performed data extraction independently according to the predesigned table. The information to be extracted included first author, basic characteristics of study subjects (sample size, sex, and age), publication year, anxiety and depression evaluation scale and grouping criteria, definition and grouping criteria of physical activity, and study type. After completing data extraction work, they exchanged and reviewed the extracted data and resolved inconsistency via discussion.

### 2.4. Quality assessment

The methodological quality of case-control studies and cohort studies was assessed using Newcastle-Ottawa Scale.<sup>[18]</sup> The evaluation included 3 aspects: selection of study subjects, comparability, and exposure (a total of 8 scoring items, with a maximum score of 9). A score of 7 to 9 indicated high quality, 4 to 6 indicated moderate quality, and <4 indicated low quality.

The methodological quality of cross-sectional studies was evaluated using Agency for Healthcare Research and Quality (AHRQ), which included 11 evaluation items.<sup>[19]</sup> For each item, “yes” scored 1 and “no” or “unclear” scored 0. A score of 8 to 11 indicated high quality studies, 4 to 7 indicated moderate quality, and 0 to 3 indicated low quality.

### 2.5. Statistical analysis

To evaluate the link of the physical activity level of college students with the anxiety or depression risks, the comparison of physical activity levels was unified into high vs low physical activity, and OR with 95%CI was used as the effect size measure. Due to the large differences in the study design of the included studies, the random-effect model was utilized for meta-analysis. The heterogeneity among studies was assessed utilizing Cochran Q test and  $I^2$  test.<sup>[20]</sup> Significant heterogeneity was detected when  $P < .05$  and/or  $I^2 > 50\%$ . Subgroup analysis was carried out by the measurement scale of anxiety or depression and whether multi-factor correction was performed or not. Sensitivity analysis was executed using leave-one-out method to evaluate whether a single included study had a significant impact on the combined results.<sup>[21]</sup> Publication bias of included studies was evaluated using Egger test and funnel plot.<sup>[22]</sup> All statistical analyses were completed using Stata12.0 software (Stata Corp, College Station, TX).

### 2.6. Ethical review

Ethical approval and patient consent were not required because the meta-analysis and bioinformatic analyses were based on published research and public database.

## 3. Results

### 3.1. Study selection

In total, 289 studies (PubMed: 80, Embase: 82, and Web of Science: 127) were retrieved from electronic databases. After removing 115 duplicate articles, 154 studies that did not meet the selection criteria were excluded after browsing the title and abstract. Then, 10 literatures were eliminated after full reading. Finally, 10 studies<sup>[15–17,23–29]</sup> were included in the meta-analysis. The study selection process is displayed in Figure 1.

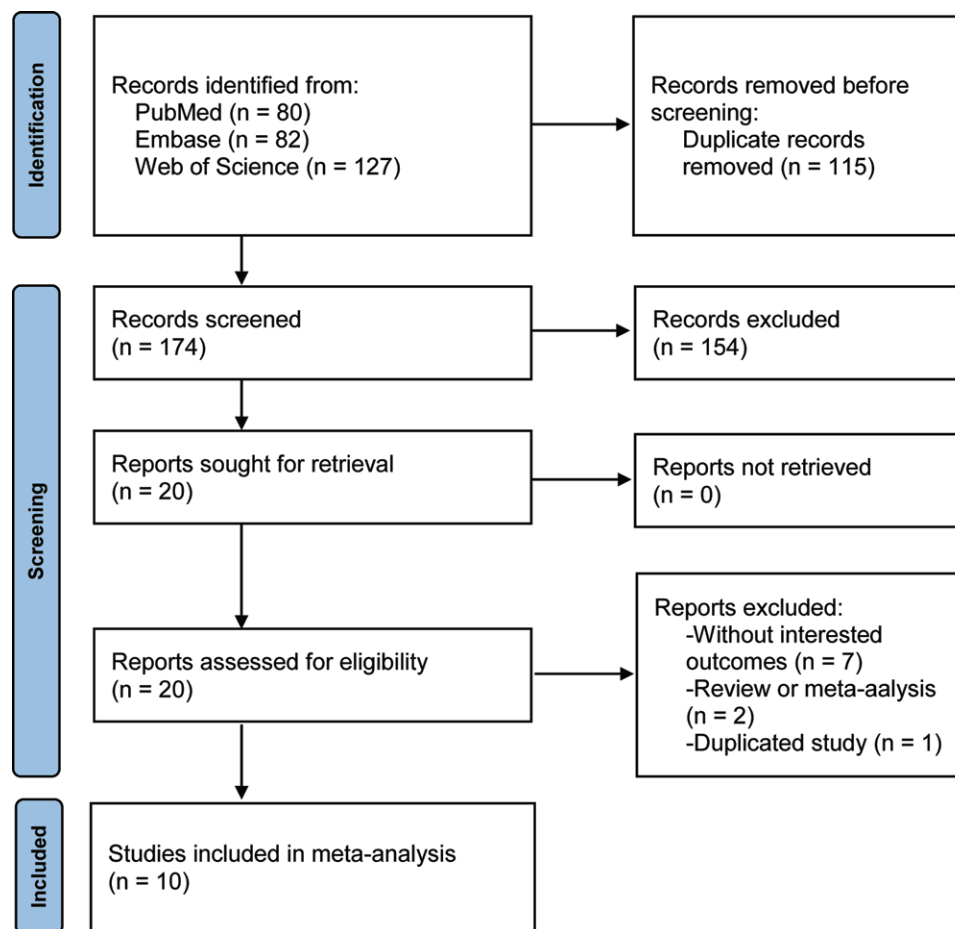


Figure 1. The flow chart of study selection.

### 3.2. Study characteristics

All the included studies were cross-sectional studies. These studies were published in 2021 to 2023. The sample size of the included studies was 584 to 11,787 cases, with a total of 39,017 cases (15,780 male and 23,237 female), all of whom were college students. According to the study outcomes (anxiety or depression), there were 9 relevant studies for each outcome. Other characteristics of the included studies, such as the sampling method, measurement scale, and grouping criteria, age, and physical activity measurement are shown in Tables 1 and 2.

### 3.3. Quality evaluation results

Because all the included studies were cross-sectional studies, AHRQ was used for quality evaluation. As results, the AHRQ scores of the included studies were 6 to 8 (Table S4, Supplemental Digital Content, <http://links.lww.com/MD/L3>), suggesting that their methodological quality was moderate.

### 3.4. Results of meta-analysis

The association between the physical activity level of college students and the risk of depression and anxiety were analyzed. Significant heterogeneity was observed among the included studies for both outcomes ( $I^2 > 50\%$ ,  $P < .05$ ). The pooled results revealed that physical activity levels of college students were significantly associated with reduced risk of depression (OR [95%CI] = 0.69 [0.58, 0.82],  $P < .001$ , Fig. 2A) and anxiety (OR [95%CI] = 0.71 [0.62, 0.80],  $P < .001$ , Fig. 2B).

### 3.5. Results of subgroup analysis

To investigate the influence of the measurement scale of depression or anxiety and whether multi-factor correction was performed or not on pooled results, subgroup analyses were carried out.

For depression, after grouping according to the measurement scale, the pooled results of PHQ-9 and DASS-C21 subgroups were statistically significant (OR [95%CI] = 0.70 [0.59, 0.84],  $P < .001$ ; OR [95%CI] = 0.72 [0.61, 0.84],  $P < .001$ ), however, the combined results of SDS subgroup were not significant (OR [95%CI] = 0.66 [0.22, 2.02],  $P = .466$ ) (Fig. S1A, Supplemental Digital Content, <http://links.lww.com/MD/K998>). After grouping according to whether multi-factor correction was performed or not, the pooled results of 2 subgroups (yes and no) yielded statistically significant results (OR [95%CI] = 0.76 [0.65, 0.90],  $P = .001$ ; OR [95%CI] = 0.50 [0.30, 0.84],  $P = .009$ ) (Fig. S1B, Supplemental Digital Content, <http://links.lww.com/MD/K998>).

For anxiety, after grouping according to the measurement scale, the pooled results of DASS-C21, SAS, and GAD-7 subgroups were 0.63 (0.55, 0.77), 0.45 (0.32, 0.62), and 0.78 (0.69, 0.88), respectively, all of which were statistically significant ( $P < .001$ ) (Fig. S1C, Supplemental Digital Content, <http://links.lww.com/MD/K998>). After grouping according to whether multi-factor correction was performed or not, the pooled results of 2 subgroups (yes and no) exhibited statistically significant results (OR [95%CI] = 0.74 [0.63, 0.87],  $P < .001$ ; OR [95%CI] = 0.58 [0.39, 0.86],  $P = .006$ ) (Fig. S1D, Supplemental Digital Content, <http://links.lww.com/MD/K998>).

Collectively, these results showed that measurement scale and multi-factor correction were not the sources of heterogeneity among studies reporting depression or anxiety.

**Table 1**

**Characteristics of the included studies between physical activity and depression.**

Study	Sampling method	Scale	Cutoff	n, M/F	Age, years	Measurement of PA	Comparison	OR (95%CI)	Multivariate adjusted
Guo, Y 2022	Simple random sampling	PHQ-9	≥5	2048, 822/1226	20.35 ± 1.30	Exercise	≥2 vs. <2 day per week	0.718 (0.504, 1.024)	Yes
Han, SS 2022	Stratified random cluster sampling	DASS-C21	>9	3118, 1305/1813	NR	PEVS	High vs. Low or Medium	0.720 (0.615, 0.844)	Yes
Qin, B 2023	Convenience sampling	PHQ-9	≥5	1156, 269/887	NR	MET-min/week	High vs. Low or Medium	0.716 (0.477, 1.075)	Yes
Xiao, P 2021	Multistage cluster random sampling	PHQ-9	≥5	3951, 1674/2277	19.58 ± 1.67	Regular PA	Yes vs. No	0.85 (0.72, 0.99)	Yes
Xu, Y 2021	Convenience sampling	PHQ-9	≥5	11,254, 4054/7200	≥15	Regular PA	Yes vs. No	0.86 (0.77, 0.97)	Yes
Yang, N 2022	Total sample	SDS	≥53	681, 352/329	22.38 ± 1.16	Weekly exercise time	≥1 vs. <1 hours	1.174 (0.823, 1.676)	Yes
Zhang, X 2021	Snowball sampling	SDS	≥53	2270, 877/1393	NR	Daily exercise	Yes vs. No	0.375 (0.285, 0.492)	No
Zhang, Y 2022	Stratified random cluster sampling	PHQ-9	≥5	11,787, 5056/6731	20.51 ± 1.88	Exercise > 1 hour/day last week	≥3 vs. <3 days	0.639 (0.580, 0.703)	No
Zhou, H 2021	NR	PHQ-9	≥5	584, 349/235	NR	Regular vigorous PA	Yes vs. No	0.420 (0.297, 0.593)	Yes

DASS = depression anxiety stress scales; F = female; M = male; NR = not reported; PA = physical activity; PHQ-9 = The Chinese version of the Patient Health Questionnaire 9; PVES = physical-exercise volume score; SDS = the self-rating depression scale.

**Table 2**

**Characteristics of the included studies between physical activity and anxiety.**

Study	Sampling method	Scale	Cutoff	n, M/F	Age, years	Measurement of PA	Comparison	OR (95%CI)	Multivariate adjusted
Ding, T 2022	Convenience sampling	SAS	≥50	2168, 1022/1146	22.16 ± 2.59	Daily exercise	Yes vs no	0.514 (0.205, 0.814)	Yes
Guo, Y 2022	Simple random sampling	GAD-7	≥5	2048, 822/1226	20.35 ± 1.30	Exercise	≥2 vs <2 day per week	1.124 (0.734, 1.718)	Yes
Han, SS 2022	Stratified random cluster sampling	DASS-C21	>7	3118, 1305/1813	NR	PEVS	High vs low or medium	0.627 (0.546, 0.718)	Yes
Qin, B 2023	Convenience sampling	GAD-7	≥5	1156, 269/887	NR	MET-min/week	High vs low or medium	0.716 (0.532, 0.963)	Yes
Xiao, P 2021	Multistage cluster random sampling	GAD-7	≥5	3951, 1674/2277	19.58 ± 1.67	Regular PA	Yes vs no	0.82 (0.70, 0.96)	Yes
Xu, Y 2021	Convenience sampling	GAD-7	≥5	11,254, 4054/7200	≥15	Regular PA	Yes vs no	0.82 (0.75, 0.91)	Yes
Yang, N 2022	Total sample	SAS	≥50	681, 352/329	22.38 ± 1.16	Weekly exercise time	≥1 vs <1 hours	0.381 (0.184, 0.792)	Yes
Zhang, X 2021	Snowball sampling	SAS	≥50	2270, 877/1393	NR	Daily exercise	Yes vs no	0.445 (0.288, 0.686)	No
Zhang, Y 2022	Stratified random cluster sampling	GAD-7	≥5	11,787, 5056/6731	20.51 ± 1.88	Exercise > 1 hour/day last week	≥3 vs <3 days	0.674 (0.604, 0.753)	No

F = female; M = male; NR = not reported; SAS = the self-rating anxiety scale; GAD-7 = the Chinese version of the general anxiety disorder-7; DASS = depression anxiety stress scales; PA = physical activity; PVES = physical-exercise volume score.

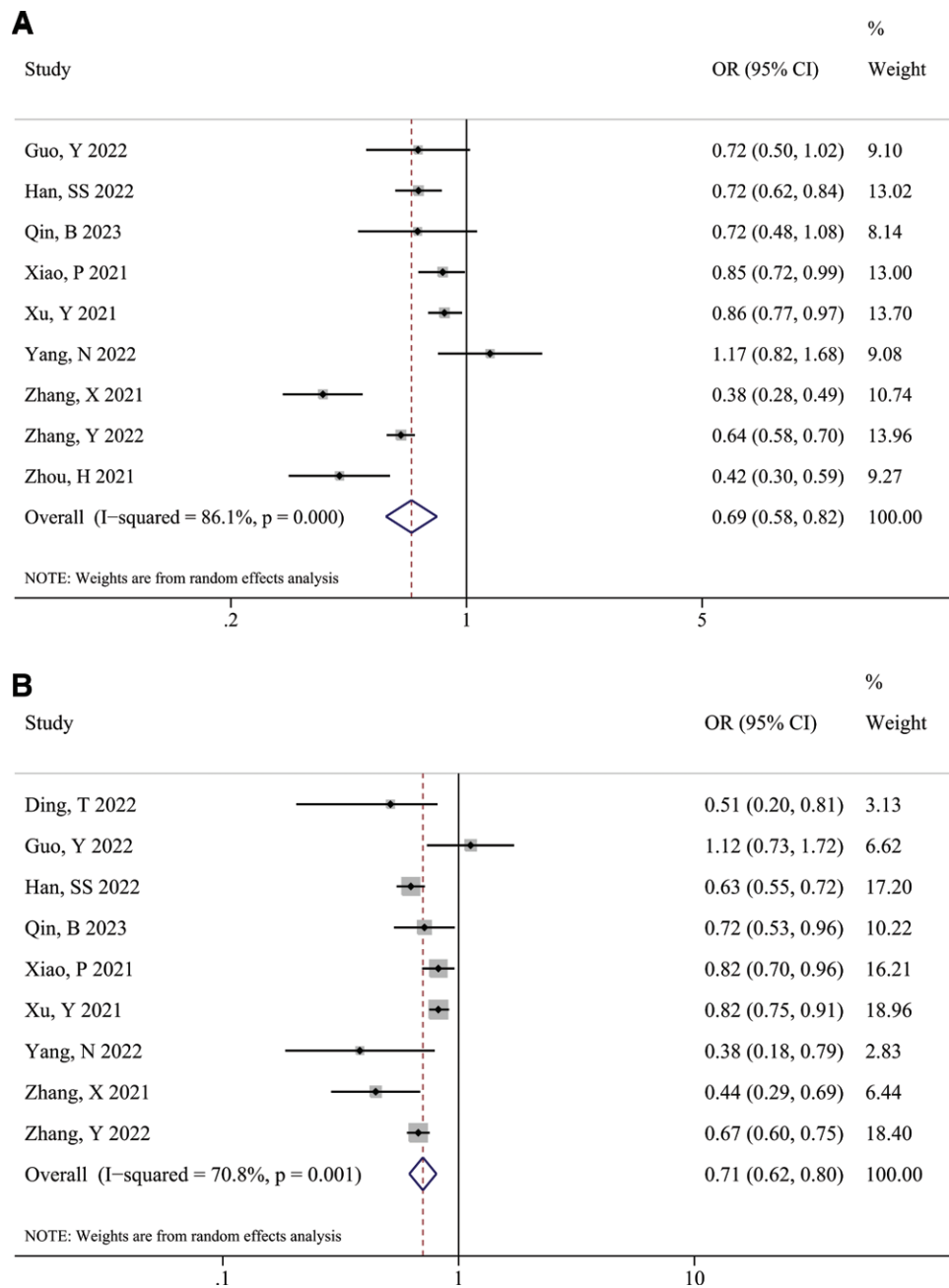


Figure 2. Forest plots showed the pooled results of depression (A) and anxiety (B).

**3.6. Results of sensitivity analysis**

The results of sensitivity analysis showed that the pooled results of depression and anxiety were stable and did not be significantly influenced by a single study. Through the leave-one-out approach, the effect sizes for the risk of depression ranged from OR (95%CI): 0.65 (0.55, 0.78) to 0.74 (0.64, 0.86). Even after excluding any single study, the combined results of the remaining studies were also significant ( $P < .05$ ) (Fig. 3A). Similarly, the effect sizes for the risk of anxiety ranged from OR (95%CI): 0.68 (0.59, 0.79) to 0.73 (0.64, 0.83), and the results were not affected by any single study ( $P < .05$ ) (Fig. 3B).

**3.7. Publication bias**

The results of Egger test did not show the publication bias in the included studies reporting depression ( $P = .680$ , Fig. 4A) and anxiety ( $P = .378$ , Fig. 4B). Likewise, the scatter distribution of

scatter points is symmetrical (Fig. 4C and D), confirming no significant publication bias among the included studies.

**4. Discussion**

This study was conducted with the goal of exploring the correlation between physical activity and the risk of premenstrual syndrome among university students. Our results suggest that the level of physical activity among Chinese university students has a negative association with symptoms of anxiety and depression. During COVID-19 pandemic, the mental health of college students faces increasing challenges and has attracted widespread attention.<sup>[30]</sup> Physical activity is revealed to impact positive impacts on mental health and well-being.<sup>[31]</sup> However, the results of current studies reporting the effects of physical activity on the risk of anxiety and depression are inconsistent.<sup>[15-17]</sup> In this meta-analysis, 10 studies were screened and



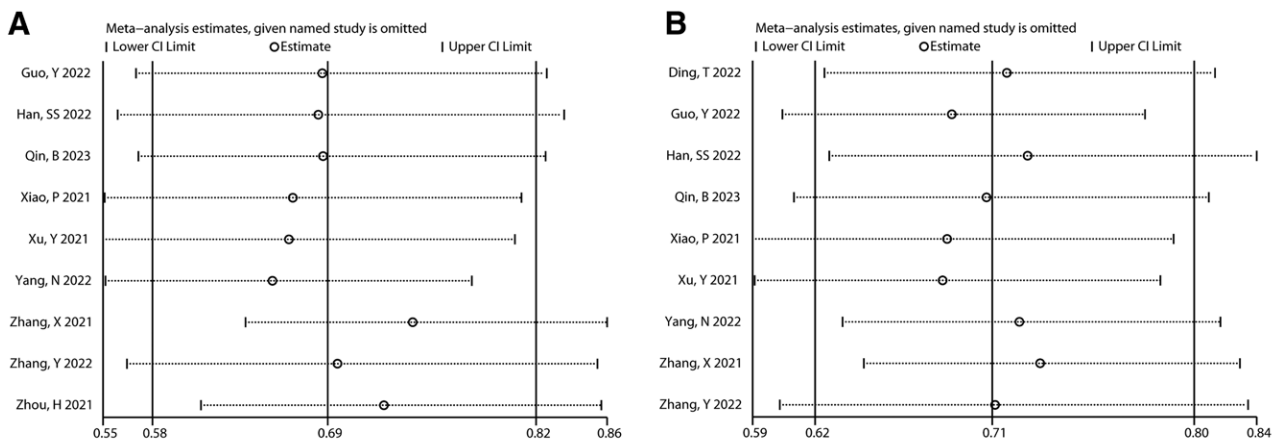


Figure 3. Sensitivity analysis showed the effect of a single study on the pooled results of depression (A) and anxiety (B).

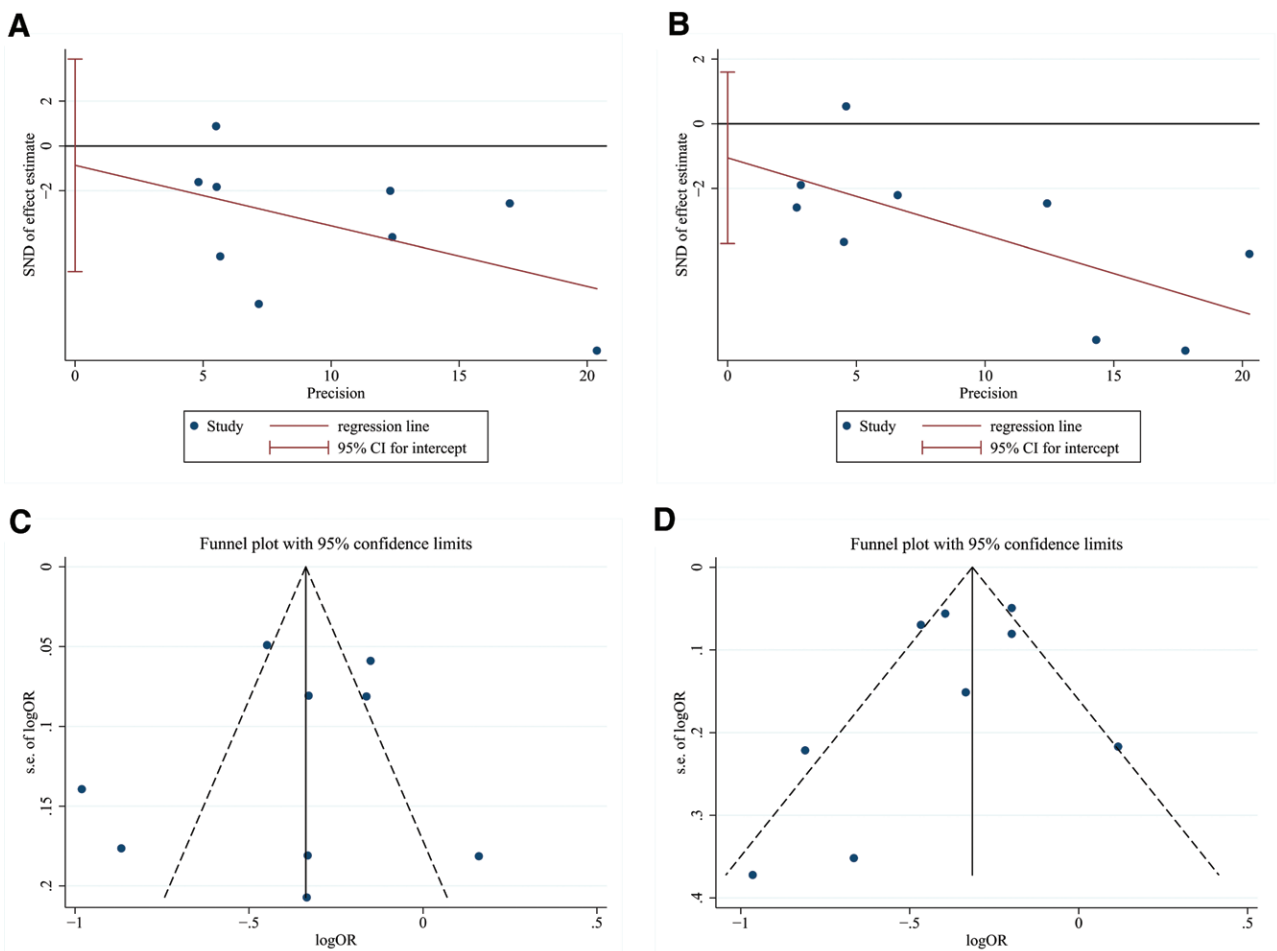


Figure 4. The publication bias results. (A) The results of Egger test for the included studies on depression. (B) The results of Egger test for the included studies on anxiety. (C) Funnel plot of the included studies on depression. (D) Funnel plot of the included studies on anxiety.

combined to explore the associations between physical activity and anxiety or depression risk. We found that there were negative associations between the level of physical activity and the risk of anxiety or depression, suggesting that physical activity could improve the anxiety and depression of Chinese college students during the pandemic.

Physical activity intervention is identified as a promising approach to mitigate the depression and anxiety caused by the

pandemic.<sup>[32]</sup> Physical exercise can have multiple positive effects, such as improving attention, and motor skills.<sup>[33]</sup> Numerous studies have revealed that individuals who could not keep their routine physical activity during the pandemic exhibit more depression and anxiety symptoms than those who engage in a lot of physical activity.<sup>[34–37]</sup> Consistent with these findings, our data also confirm the positive effect of physical activity on improving depression and anxiety symptoms in Chinese college

students. The psychosocial and behavioral mechanism hypotheses have provided possible explanations that physical activity not only contributes to the improvement of students' self-efficacy and social interaction, but also enhances their self-regulation ability and coping skills, which can help students effectively maintain positive mentality.<sup>[38,39]</sup> Moreover, the social relationships formed through regular physical activity could have a positive impact on mental health.<sup>[40]</sup> Exercises can also distract stressors to enjoy the physical activity moment, thus effectively reducing anxiety.<sup>[41]</sup> On the contrary, mental problems such as anxiety and depression can negatively impact physical activity patterns due to symptoms like apathy, low energy levels, or social isolation.<sup>[42,43]</sup> Individuals with these mental problems are found to have a low serum level of brain-derived neurotrophic factors and endorphins,<sup>[44]</sup> and these factors can be improved by physical exercise.<sup>[45]</sup> Besides, there may be common risk factors between physical inactivity and depression and anxiety such as parental rearing style.<sup>[46,47]</sup> Taken together, we believe that physical activity could improve the anxiety and depression. However, Yang et al did not observe the link between physical activity and depression risk,<sup>[17]</sup> inconsistent with our results, which might be caused by different intensity and type of physical activities, whether the college students were graduates, and outcome evaluation criteria.

Given the positive effects of physical activities on mental health, active physical exercises are called to improve relieve stress and promote mental health during the pandemic.<sup>[48,49]</sup> The pandemic leads to the population including students being confined to their homes, therefore, home-based exercise provides a safe alternative to promote psychological well-being, which include balance and flexibility training like yoga<sup>[50]</sup> and muscle strength exercise, such as weightlifting.<sup>[51]</sup> In addition, online PA training on e-learning platforms is proposed: the aerobic and anaerobic exercises with different intensity trainings are developed by professional sports coaches and then chosen by students based on their own athletic ability and interest.<sup>[52]</sup> For exercise intensity, the recommended intervention measures for college students include 108 minutes of light-intensity physical activity, 80 minutes of moderate-intensity physical activity, or 45 minutes of vigorous-intensity physical activity per day, which is enough to prevent or control mental health problems and maintain well-being during the pandemic.<sup>[34]</sup>

The present meta-analysis had several advantages. Firstly, the sample size was large in the included studies, resulting in high statistical power for analyzing the results. Secondly, the results of sensitivity analysis indicated that the meta-analysis results were stable and not significantly influenced by an individual study. Thirdly, no publication bias was observed among the included studies, suggesting the high level of credibility in the combined results.

Despite these virtues, the limitations of this analysis also should be addressed. Firstly, the included studies exhibited a significant heterogeneity, and subgroup analysis did not identify significant influencing factors. Factors, such as the intensity and type of physical activities as well as whether the college students were graduates, may have an impact on the heterogeneity. However, due to substantial differences in the above information in the included studies, it was impossible to determine their effects on heterogeneity through quantitative analysis. Secondly, all the included studies were cross-sectional and had a large number of confounding factors, which may potentially compromise the objectivity of the results and overestimate the strength of the association between physical activity and anxiety or depression. Thirdly, due to the limitations of cross-sectional studies, the causal relationships between physical activity and anxiety or depression cannot be established, but we recommend engaging in appropriate physical activity on a daily basis. Lastly, this study focused only on whether physical activity was dramatically related to the mental health of Chinese college students. Further analysis is required to determine whether there

is a significant association among college students globally and to explore whether the association is consistent across different regions. Collectively, more studies with high-quality and large sample are still required to verify our results.

## 5. Conclusion

In conclusion, our findings indicate that the physical activity level of Chinese college students is negatively correlated with anxiety and depression. Increasing physical activity could potentially be a method to reduce depression and anxiety among college students during a pandemic. This can be promoted through increased awareness campaigns and demonstrative guidance to encourage physical activity among students, thereby preventing the occurrence of depression and anxiety and improving the condition of those already suffering from these ailments. Due to high heterogeneity among the included studies, it is recommended for future research to establish standardized outcome evaluation criteria and quantitative measurement standards for physical activity levels, so as to enable a more accurate assessment of the relationships between physical activity and mental health outcomes of individuals, as well as to explore whether exercise interventions can alleviate anxiety, depression, and other psychological disorders.

## Author contributions

**Conceptualization:** Hongchang Yang, Wenchao Li.

**Formal analysis:** Hongchang Yang, Chengjie Fu.

**Funding acquisition:** Hongchang Yang.

**Methodology:** Chengjie Fu, Hongchang Yang.

**Resources:** Hongchang Yang, Xiaoxia Zhang.

**Writing – original draft:** Hongchang Yang, Chengjie Fu, Xiaoxia Zhang, Wenchao Li.

**Writing – review & editing:** Hongchang Yang, Chengjie Fu, Xiaoxia Zhang, Wenchao Li.

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