Research Square

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A moderated mediation model explains the association between sedentary time and depressive symptoms among Chinese university students

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Abstract

Background

Sedentary behavior is a critical public health concern for university students and linked to increased depressive symptoms, yet its mechanisms are unclear. This study aimed to examine the relationship between sedentary time and depressive symptoms among Chinese university students, with a focus on sleep quality as a mediator and sports participation as a moderator.

Methods

A cross-sectional survey was conducted among 2,661 college students from one university in Jiangsu, China. Data were collected using a validated self-report questionnaire including sedentary time, depressive symptoms, sleep quality, and sports participation. Model 4 and Model 59 in Hayes' PROCESS macro for SPSS were employed to test both the mediation effect and the moderated mediation model.

Results

Sleep quality partially mediated the relationship between sedentary time and depressive symptoms, accounting for 68.6% of the total effect (*effect* = 0.074, 95% CI [0.049, 0.113]). Sports participation moderated the indirect effect: the link between sedentary time and sleep quality (β= -0.044, $p < 0.01$), and between sleep quality and depressive symptoms (β=-0.093, $p < 0.001$) weakened with higher sports participation. However, sports participation did not moderate the direct effect of sedentary time on depressive symptoms.

Conclusions

Sedentary time contributes to depressive symptoms indirectly through poor sleep quality. Sports participation buffers these effects by improving sleep quality and reducing the psychological impact of sedentary behavior. Interventions targeting sleep hygiene and promoting sports participation may mitigate depression risk in university students.

1. Introduction

Sedentary behavior has emerged as one of the most critical public health issues worldwide and represents a modifiable behavioral risk factor. Sedentary behavior is defined as any waking behavior characterized by an energy expenditure of 1.5 METs or lower while sitting or reclining. Sitting time is a common measure of sedentary behaviour(Healy et al., 2011)systematic review and meta-analysis of 32 studies reveals that, when relying on self-report, university students accumulate a mean of 7.29 h of total sedentary behaviour daily(Castro et al., 2020). Data from a large-scale prospective cohort study involving

half a million Chinese adults showed average sedentary leisure time was 179.4 minutes/day(Collings et al., 2025). College students demonstrate even more concerning patterns with an average sitting time exceeding 12 hours daily(Carpenter et al., 2021). Chinese college students similarly exhibit high sedentary levels, with daily sitting time ranging from 7.51 to 14.93 hours(Ge et al., 2019).

Empirical studies demonstrate that prolonged sedentary behavior is associated with multiple chronic health issues, including increased risk of depressive symptoms(Goyal & Rakhra, 2024). Additionally, sedentary lifestyles often coincide with unhealthy behaviors such as reduced physical activity and irregular eating habits, which further impact mental health(Johnstad, 2023). Prospective studies have consistently demonstrated that prolonged sitting predicts adverse mental health outcomes (Ellegast et al., 2012). Given that both sedentary behavior and depressive symptoms are modifiable, research has established a positive association between most sedentary behaviors and depressive symptoms(Huang et al., 2020). This highlights the need to examine modifiable behavioral and lifestyle mechanisms linking sedentary behavior to depressive symptoms.

Strong evidence suggests that sleep quality is a crucial factor in maintaining good physical and mental health(Alvarez & Ayas, 2004). Good sleep quality can promote bodily recovery and regulation, helping to improve mood and alleviate depressive symptoms. Meanwhile, current research has established an association between prolonged sitting and increased risk of sleep-related problems. These findings suggest that sleep quality may serve as a potential mediating factor explaining the relationship between sedentary time and adverse mental health outcomes. Additionally, sports participation represents another modifiable behavioral factor linked to sleep quality and mental health. Sports participation typically refers to organized sports activities(O'Donnell et al., 2020). Unlike general physical activity, it involves rules, formal training, or competition(Chen et al., 2020; OWEN et al., 2022), and plays a significant role in shaping physiological, psychological and social health through social interaction and team involvement. Research has found that increased physical activity levels are positively associated with emotional and behavioral health(Donaldson & Ronan, 2006). There is also evidence suggesting that sports participation can prevent mental disorders(Eime et al., 2013). A meta-analysis clearly indicated that sports participation significantly reduces depressive symptoms, anxiety, psychological stress and mood disorders in both clinical and non-clinical children and adolescent samples(Ahn & Fedewa, 2011). As a positive lifestyle factor, sports participation may moderate the relationship between sedentary behavior and mental health.

Therefore, this study aims to investigate the relationship between sedentary time and depressive symptoms among university students and examine the potential mediating role of sleep quality in this relationship. It will also explore the moderating effect of sports participation on the associations between sedentary time, sleep quality and depressive symptoms. This research will deepen understanding of how sedentary behavior affects mental health from the perspective of modifiable behavioral and lifestyle factors.

2. Research hypothesis

2.1 The relationship between sedentary time and depressive symptoms

Studies have proposed that sedentary time has a significant impact on depressive symptoms(Choi et al., 2021). On one hand, sedentary behavior can lead to insufficient physical activity, affecting the adolescents' physical health and further impacting their mental health; on the other hand, increased sedentary time, such as watching TV and using electronic devices, can increase the risk of mental health issues by promoting social isolation and limiting the development of social networks(Ancoli-Israel, 2009). Currently, the potential mechanisms linking sedentary time and mental health proposed by research are explained as including effects mediated by endorphins and neurotransmitters, increased blood flow to brain regions involved in mood regulation, and disruption of the hypothalamic-pituitary-adrenal axis, which regulates endocrine responses to stress, body temperature changes, and improved sleep(H. et al., 2007). These findings provide physiological explanations for how sedentary time can contribute to psychological distress, including symptoms of anxiety and depressive symptoms, in populations. Therefore, we have reason to hypothesize that there may be a significant association between sedentary time and depressive symptoms in university students.

2.2 The mediating effect of sleep quality

The World Health Organization (WHO) recently identified poor sleep quality as a public health problem and believes that it increases the risk of early onset of disease and death(Stranges et al., 2012). Evidences suggest that poor sleep quality negatively impacts mental health, leading to increased rates of depressive symptoms(Beiter et al., 2015). A large-scale population study in Norway found that Norwegian adolescents aged 16–18 who slept less than 6 hours per night had an 8-fold higher risk of developing depressive symptoms(Sivertsen et al., 2014). Similarly, a cross-sectional survey in China indicated that adolescents with sleep disorders are more likely to have depressive symptoms(Zhu, 2024).

Currently, more research is focusing on the relationship between prolonged sitting and sleep quality(Seol et al., 2020; Wu et al., 2015). Studies have shown that the sitting duration is independently correlated with lower overall sleep quality, with longer sitting times leading to worse sleep quality(Borges Cosic et al., 2019). Prolonged sitting can contribute to the development of metabolic syndrome, which can also lead to sleep problems(Sisson et al., 2009). Conversely, studies suggest that compared to individuals with sedentary behavior, those without sedentary behavior can increase energy expenditure or metabolic rate and reduce fatigue, which may lower the risk of sleep problems(Uchida et al., 2012).

Sleep quality is a core mediating variable of sedentary behavior's effect on depressive symptoms. Prolonged sitting impairs sleep quality by interfering with melatonin secretion, metabolic disorders and behavioral patterns (such as screen exposure)(Goran et al., 2017); decreased sleep quality further increases the risk of depressive symptoms through emotional regulation disorders, impaired cognitive control and increased neuroendocrine dysfunction(Guo et al., 2022). Therefore, based on the above

research, we have reason to hypothesize that sedentary time in college students may affect the depressive symptoms of college students by affecting sleep quality.

2.3 The moderating effect of sports participation

The positive impact of sports participation on physical and mental health and personal development has been supported by numerous studies. Sports participation offers opportunities to enhance personal skills and develop, maintain, and promote interpersonal relationships with peers(O'Donnell et al., 2020). Research indicates that, unlike physical activities, sports participation has unique advantages in that it not only improves physical health through physical activity but also has social functions which help students build supportive social networks, thus buffering mental health issues by promoting social interaction(Holbrook et al., 2020). Sports participation has been demonstrated to have positive effects on mental health benefits, particularly improvements in anxiety and depressive symptoms(Morgan, 1985).

Sports provide individuals with protective social networks and connections with caring adults and prosocial peers, which are crucial for promoting the psychological well-being of adolescents(Montgomery et al., 2021). Moreover, although research on sports participation as a moderating variable is limited, one study has found that sports participation significantly moderates the relationship between bullying and depressive symptoms in adolescents(Holbrook et al., 2020). Additionally, sports participation positively impacts sleep quality, as it reflects an individual's level of physical activity, a recognized intervention for improving sleep, endorsed by the American Sleep Disorders Association(Miller et al., 2013). Based on the above studies, it is reasonable to assume that physical participation can not only regulate the direct effect of sedentary time on mental health, but also regulate the indirect effect of sedentary time on mental health through sleep quality.

To summarize, this study proposed the following hypotheses and established a moderated mediation model, as illustrated in Fig. 1.

Hypothesis 1

University students' sedentary time is positively correlated with depressive symptoms;

Hypothesis 2

Sleep quality mediates the relationship between sedentary time and depressive symptoms;

Hypothesis 3

Sports participation plays a moderating role in moderating the relationship between sedentary time, sleep quality, and depressive symptoms, respectively. Specifically:

Hypothesis

3a: Sports participation can moderate the association between sedentary time and sleep quality;

Hypothesis

3b: Sports participation can regulate the relationship between sleep quality and depressive symptoms;

Hypothesis

3c: Sports participation moderates the direct relationship between sedentary time and depressive symptoms.

3. Method

3.1 Participants

This cross-sectional survey was conducted from Nov 2020 to Jan 2021 in Nantong University located in Jiangsu, China. Convenience sampling was adopted to recruit college student participants. We firstly recruited 20 student investigators from all schools of the main campus of the university. Then the student investigators were responsible for sending the online questionnaire by WeChat or QQ group to students of his/her school to invite them to participate on a voluntary basis. Prior to the survey, all potential participants received detailed explanations regarding the objectives, the confidential nature, and the voluntary basis of the study. In total, 2947 university students took part in the survey. However, 286 questionnaires were excluded due to missing key information or logical inconsistencies, resulting in 2661 valid questionnaires. Among them, 1,153 (43.3%) were male and 1,508 (56.7%) were female, with the mean age of 19.97 ± 1.253 years. The numbers of participants with medical and non-medical majors were 995 (37.4%) and 1,666 (62.6%), respectively.

This study was approved by the [Name of Ethics Committee or Institutional Review Board (IRB)] in accordance with the relevant guidelines and regulations set forth by [Name of Relevant Institutional Guidelines or Declaration of Helsinki]. The protocol number for this approval is [Protocol Number, if applicable].

3.2 Measurements

3.2.1. Sedentary times

Sedentary times was collected using self-reported approach(Cao et al., 2022). We used two questions enquiring about sedentary time spent on weekday and weekend time according to Hamer (Hamer et al., 2014). Specifically, participants were asked as following: "How much time have you spend sitting during weekdays and weekends school days, respectively (e.g., computer use, lecture attendance, private study time, etc.(Castro et al., 2020))?" Responses were designed to be provided in hours and minutes, which were then converted into hours for analysis. Daily sitting time was calculated as a mean average sitting time per day (weekday time×5)+(weekend day time×2)/7)(Stamatakis et al., 2014).

3.2.2. Depressive symptoms

The Patient Health Questionaire-9 items (PHQ-9) was used to assess depressive symptoms(Kroenke et al., 2001). The PHQ-9 is composed of 9 items. Each item is scored on a 4-Likert scale from 0 to 3 (0 = never, 1 = sometimes, 2 = often, 3 = very often), with a higher total score indicating a higher level of depressive symptoms(Lin et al., 2021). PHQ-9 has been proved to have good reliability and validity(Du et al., 2017). The Cronbach's α of PHQ-9 in this study was 0. 935.

3.2.3. Sleep quality

The Pittsburgh Sleep Quality Index (PSQI) was used to measure sleep quality(Buysse et al., 1989). PSQI consists of 18 self-reported items that are divided into seven components including subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, sleep medication use, and daytime dysfunction. All components are scored on a 4-point Likert scale (from 0 to 3). The PSQI score is the sum of each component's score, with higher scores indicating poorer sleep quality. In this study, the Cronbach's α of PSQI was 0. 691, which was comparable with other studies(Hong, 2024).

3.2.4. Sports participation

Referring to the surveys of Holbrook et al. and Liu et al. (Holbrook et al., 2020; Liu et al., 2023), a single item is used to measure the frequency of sports participation: "How often have you participated in sports activities organized by schools, mass organizations, off-campus institutions, or clubs in the past year?" The item is scored on a 6-point Likert scale ranging from 1 to 6 (1 = never, 2 = once or twice, 3 = 1–3 times per month, 4 = 1–2 times per week, 5 = 3–5 times per week, 6 = almost every day), with higher scores indicating higher frequency of sports participation.

3.3 Data analyses

IBM SPSS Statistics 25.0 was used to conduct data analyses. First of all, participants' social-demographic characteristics and the study variables' fundamental state were represented using descriptive statistics. Second, pearson correlation coefficients were used to examine the correlations between the study variables. Third, after standardization of the data, Model-4 in the PROCESS macro for SPSS was used to test the mediation effect of sleep quality between sedentary time and depressive symptoms, and Model-59 was used to test the moderated effect of sports participation. The robustness of statistical analysis was tested by using the biased correction Bootstrap method with 5, 000 repeat samplings with a 95% confidence interval (CI), not containing 0 indicating a significant effect. (Preacher & Hayes, 2008; Schunk et al., 2022). Finally, simple slope analysis was used to further analyze the moderating effect of moderating variables and test whether the moderating effect changed at different levels of sports participants (M+1SD) and low (M-1SD)(Aiken, 1992).

In addition, since the survey is self-reported data, this deviation should be controlled as far as possible in the process of questionnaire survey to avoid possible common method bias, such as anonymous filling of the questionnaire. Before conducting the formal analysis, the Harman single-factor test was

performed to test for the common method bias, with the total variance extracted by the first factor below 40% representing the absence of common method bias variance inflation factor (VIF) was performed to test for the multicollinearity of the study variables, with VIF value of each variable below 5 representing the multiple collinearity problem has no effect on the result(Hair et al., 2010; Holbrook et al., 2020).

4. Results

4.1 Test of common method bias

Harman's single factor test obtained 8 components with eigenvalues above 1. The largest factor explained only 33.68% of the total variance, which was below the traditional threshold of 50%, indicating no significant multicollinearity bias in this study.

4.2 Test of multicollinearity

The collinearity diagnosis showed that the VIFs for sedentary time, sleep quality, sports participation were all below the recommended threshold of 5, suggesting that the data were less concerned about multi-collinearity.

4.3 Preliminary analysis

The results shown in Table 1 indicate that sedentary time was positively correlated with depressive symptoms ($r = 0.117$, $p < 0.001$), sleep quality ($r = 0.126$, $p < 0.001$), while it was not significantly negatively correlated with sports participation. Furthermore, sleep quality was positively correlated with depressive symptoms ($r = 0.649$, $p < 0.001$), and the negatively relationship with sports participation ($r = -0.125$, $p < 0.001$) was significant. Lastly, sports participation was significantly negatively correlated with depressive symptoms ($r = -0.062$, $p < 0.01$). These significant correlations confirm the relationship between the variables in our hypotheses.

Table 1
Descriptive statistics and Pearson correlations of the study variables

Variables	M	SD	1	2	3	4
1、Sedentary time	7.289	3.004	1			
2、Sleep quality	5.020	3.052	0.126***	1		
3、Sports participants	2.350	1.140	-0.004	-0.125***	1	
4、Depressive symptoms	4.030	4.794	0.117***	0.649***	-0.062**	1

Note: *M* = mean; *SD* = standard deviation; $^{**}p < 0.01$, $^{***}p < 0.001$

4.4 Testing for mediation effect

As shown in Table 2, after controlling for covariates, the bootstrapping test results indicated that sedentary time had a significant mediation effect on depressive symptoms through sleep quality (β = 0.074, 95% CI = [0.015, 0.044], $p < 0.001$). Which accounts for 67.27% of the total effect. In addition, the direct effect of sedentary time on depressive symptoms was also significant (β = 0.036, 95% CI = [0.006, 0.065], p = 0.017). Thus, Hypothesis 1 and Hypothesis 2 were supported.

Table 2
The mediation effect of sedentary time on depressive symptoms

Paths	***Effect***	**SE**	**LLCI**	**ULCI**
Sedentary time→Depressive symptoms(total)	0.110	0.019	0.079	0.155
Sedentary time→Depressive symptoms(direct)	0.036	0.019	-0.002	0.072
Sedentary time→Depressive symptoms(indirect)	0.074	0.016	0.0494	0.1134
Note: gender, grade, and academic major were controlled in the model. The study variables, excluding the control variables, were standardized in the model.				

4.5 Testing for moderated mediation effect

Model-59 of the PROCESS macro was employed to conduct a moderated mediation analysis. Specifically, we tested the hypothesis that a moderator influences both the direct link between the independent and dependent variables and the first- and second-stage paths of the mediation model. As demonstrated by Table 3, sports participation mediated the relationship between sedentary time and sleep quality (β=-0.044, $p < 0.01$), thus confirming Hypothesis 3a. Second, sports participation moderated both indirect pathways involving sleep quality (β =-0.093, $p < 0.001$), but it did’t moderate the direct effect of sedentary time on depressive symptoms. Therefore, Hypothesis 3b was confirmed, while Hypothesis 3c was not. Thus, the moderated mediation model was established.

Table 3
The moderated mediation effect of sedentary time on depressive symptoms

Predictor	Sleep Quality (Model 1)			Depressive Symptoms (Model 2)		
	β	t	95%CI	*β*	t	95%CI
Sedentary time	0.122	6.317***	0.084, 0.160	0.025	1.651	−0.005, 0.055
Sleep quality	—	—	—	0.636	42.530***	0.606, 0.665
Sports participation	−0.114	−5.717***	−0.152, −0.075	0.023	1.496	−0.007, 0.053
Sedentary time × Sports participation	−0.044	−2.950**	−0.073, −0.015	0.001	0.128	−0.021, 0.024
Sleep quality × Sports participation	—	—	—	−0.093	−6.798***	−0.119, −0.066

Note: gender, grade, and academic major were controlled in the model. The study variables, excluding the control variables, were standardized in the model. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

The bias-corrected bootstrap test was further used to test for the conditional direct and indirect effects of sedentary time to university students' mental health on depressive symptoms at values of sports participation. As shown in Table 4, the direct effect of sedentary time on depressive symptoms was both not significant when sports participation for individuals was low (β = 0.023, 95% CI = [-0.016,0.063]), medium (β = 0.025, 95% CI = [-0.005, 0.055]), and high (β = 0.026, 95% CI= [-0.009, 0.062]). Moreover, the indirect effect of sedentary time on depressive symptoms through sports participation was more significant at three levels of social supports; however, the effect was strongest at low levels of sports participation (β = 0.139, 95% CI = [0.111, 0.170]), weaker at medium levels of sports participation (β = 0.078, 95% CI = [0.049, 0.107]) and weakest at high levels of sports participation (β = 0.043, 95% CI = [0.016,0.068]). These findings suggested that sports participation not only moderated the direct effect of sedentary time on depressive symptoms but also moderated the indirect effect of sleep quality, and a moderated mediation model was established.

Table 4
Conditional direct and indirect effects of sedentary time on depressive symptoms at different levels of sports participation

	Sports Participation	Effect	SE	LLCI	ULCI
Direct effects	Low(M−1SD)	0.023	0.020	-0.016	0.063
	Medium(M)	0.025	0.015	-0.005	0.055
	High(M+1SD)	0.026	0.018	-0.009	0.062
Indirect effects	Low(M−1SD)	0.121	0.024	0.073	0.168
	Medium(M)	0.078	0.015	0.049	0.107
	High(M+1SD)	0.043	0.013	0.016	0.068

Simple slope analysis was shown in Fig. 2. As can be seen in Fig. 2A, for individuals with high sports participation (M+1SD), sedentary time had a significant positive effect on sleep quality (*simple* = 0.079, $p < 0.001$); whereas for individuals with low sports participation (M-1SD), the positive effect of sedentary time on sleep quality was albeit weak (*simple* = 0.157, $p < 0.001$). As can be seen in Fig. 2B, for individuals with low sports participation (M-1SD), sleep quality had a significant positive effect on depressive symptoms (*simple* = 0.724, $p < 0.001$); meanwhile, for individuals with high sports participation (M+1SD), the positive effect of sleep quality on depressive symptoms was also significant (*simple* = 0.537, $p < 0.001$).

5. Discussion

In this study, we formulated and examined a moderated mediation model to not only clarify how sedentary time influences depressive symptoms through enhancing sleep quality but also analyzed how the effects of sedentary time and sleep quality on depressive symptoms change across different levels of sports participation. The findings of this study enhanced our comprehensive understanding of the complex interplay between depressive symptoms and mental health and offer a potential avenue for intervention.

5.1 The association between sedentary time and depressive symptoms

In this study, we found a positive relationship exists between sedentary time and depressive symptoms, supporting our Hypothesis 1. Consistent with our research, data from the middle-aged cohort of the Australian Women's Health Longitudinal Study (ALSWH) showed that women who sat for more than 7 hours and did not exercise had a three times higher risk of depression than those who sat for less than 4 hours and exercised regularly(van Uffelen et al., 2013).

The underlying mechanisms between sedentary time and mental health include the physiological, psychological and behavioral mechanisms. In terms of psychological mechanisms, prolonged sitting dulls people's perception of happiness and leads to the accumulation of negative emotions. Besides, prolonged sitting leads to reduced self-efficacy, leads to social withdrawal and weakens social support. Physiologically, neural plasticity is inhibited, and metabolic and endocrine disorders are caused by damage to the nerve cells that perform control and regulate emotions.

Sedentary has emerged as a critical health risk among university students. Extended sedentary time in classrooms, libraries, laboratories and dormitories, coupled with academic stress, may exacerbate depressive symptoms and impair cognitive performance and quality of life. Hence, integrating health education on the risks of sedentary time with environmental modifications, such as height-adjustable desks and designated standing study zones, is urgently needed to mitigate these adverse effects through a systematic, dual-track intervention.

5.2 The mediation effect of sleep quality

As indicated by Hypothesis 2, our findings indicated that sleep quality mediated the relationship between sedentary time and depressive symptoms. Sedentary for a long time not only have an immediate effect on students' mental health, but also have an indirect effect through sleep quality, increasing their risk of depressive symptoms. Existing evidence indicates that sedentary time may increase the risk of sleep-related health issues. Multinational studies have demonstrated that sedentary behavior in adolescents can lead to sleep disorders, with this effect remaining even after adjusting for physical factors and activity levels (Vancampfort et al., 2019).

A randomized controlled trial assigned young adults to a week-long intervention designed to intentionally increase sedentary time, revealing significant declines in sleep quality among participants who increased their sitting duration(Liu et al., 2021). Poor sleep quality is closely linked to adverse mental health outcomes, particularly the consistency of daily sleep-wake cycles, a crucial predictor of mental well-being (Pye et al., 2021; Slavish et al., 2019). Notably, insomnia and irregular sleep patterns have been confirmed as risk factors for increased depressive symptoms(Bei et al., 2016; Lyall et al., 2018). Based on these findings, universities should prioritize improving students' sleep quality when addressing psychological health concerns. Implementing actionable and sustainable strategies to enhance sleep quality could help mitigate the detrimental effects of prolonged sitting on overall health.

5.3 The moderated effect of sports participation

Finally, our findings suggest that sports participation plays a crucial role in moderating the relationship between sedentary time and depressive symptoms. Although hypothesis H3c was not supported, the moderated mediation analyses demonstrated that sports participation moderated the strength of the indirect relationship between sedentary time and depressive symptoms mediated by sleep quality, thereby supporting hypotheses H3a and H3b. This finding suggests a sequential regulatory mechanism that sports participation may improve sleep quality that is disrupted by sedentary behavior, thereby breaking the chain of sedentary time, poor sleep quality and depressive symptoms. Given that sports

participation contributes to increased physical activity levels, our results converge with studies showing that physical acitivies buffers the mental health risks of sedentary behavior(Wang et al., 2025), but extend this line of research.

Given the high prevalence of mental health issues today, identifying supportive activities, interventions, and policies for adolescent well-being has become crucial (Patel et al., 2007), with sports participation serving as a protective factor. Current research indicates that youth engagement in physical activities can prevent psychological disorders[64] Organized sports programs, being community-based activities with extensive social attributes, are believed to support mental health through psychosocial processes like social support, personal agency, and social identity(Boelens et al., 2022). Aligning with psychosocial pathways, sports fulfill adolescents ' for belonging while exposing them to vital group relationships(Cruwys et al., 2013), thereby fostering positive interpersonal connections that promote mental wellness. To prevent and improve mental health issues among college students, university administrators should prioritize increasing sports participation participation. This can be achieved by establishing diverse sports clubs and organized athletic programs, providing adequate sports facilities and equipment, and offering varied sports options to actively encourage student involvement. Additionally, collaborating with off-campus sports clubs can expand students' access to broader platforms and resources, while professional guidance and training help ignite their passion for sports participation.

5.4 Limitations

This study still has several limitations. First, while adopting moderated mediation models to analyze established models with detailed examination of relationships between research variables, the cross-sectional design of this study we cannot confirm causal relationships among these variables. Future studies could consider longitudinal designs to track subjects over time, increase survey frequency for longitudinal data collection, and explore dynamic changes in sedentary time and sports participation participation to investigate whether their effects on sleep quality and depression also exhibit temporal dynamics. Second, due to budget and time constraints, the study was conducted at only one university, requiring cautious extrapolation of findings. Future efforts should expand geographical coverage, include more participants across different age groups, and enhance sample representativeness and diversity. Third, although self-report questionnaires showed no significant methodological bias in data analysis, potential subjective biases and social desirability effects remain. Fourth, while previous studies have validated the reliability of single-item measurements for sports participation assessment, future research should validate more reliable questionnaires for this purpose.

6. Conclusion

This study explored the relationship between sedentary time and depressive symptoms among university students by testing the mediating role of sleep quality and sports participation in thus relationship through a moderated mediation model. The results revealed a significant positive correlation between sedentary time and depressive symptoms in university students and sleep quality played a

mediating role in this relationship. Additionally sports participation moderated the indirect pathway through which sedentary time affected depressive symptoms via sleep quality, such that increasing sports participation effectively mitigated both the indirect negative effects of sedentary time on college students' mental health mediated by sleep. These findings provide empirical support for formulating targeted mental health intervention strategies in universities, such as promoting regular movement breaks to reduce prolonged sedentary behavior and integrating structured sports programs with sleep health education.

Declarations

7.1 Author contributions statement

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All authors have agreed to the content of the manuscript, given explicit consent to submit, and obtained approval from the responsible authorities at the institution where the work was carried out prior to submission.

7.2 Acknowledgments

Thank for all participants in this study.

7.3 Declaration of interest statement

The authors declare that they have no competing interests.

7.4 Funding

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7.5 Data availability statement

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

7.6 Ethics approval and consent to participate

This study was approved by the Nantong University Research Ethics Committee(no.2020-12). All procedures performed in this study involving human participants were in accordance with the ethical standards of the Research Ethics Committee of Nantong University and with the principles of the Declaration of Helsinki. As described in Section 3.1 Participants, all potential participants received detailed explanations regarding the objectives, the confidential nature, and the voluntary basis of the study prior to the survey. Voluntary informed consent was obtained from all participants before data collection.

7.7 Consent to publish

All authors have agreed to the publication of this manuscript and confirm that the published content does not involve any copyright disputes or privacy issues.

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Figures

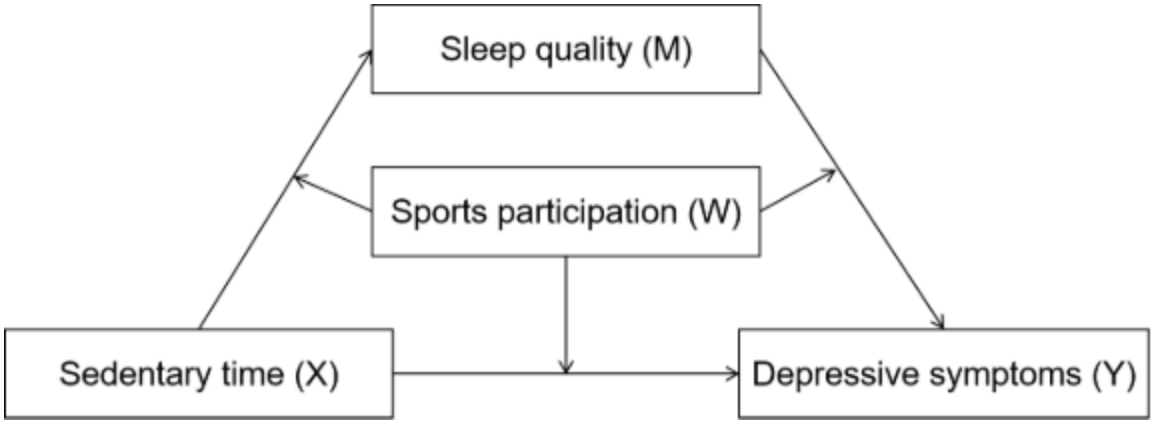

Figure 1

A hypothetical model of the relationship between sedentary time, sleep quality, physical activity and depressive symptoms

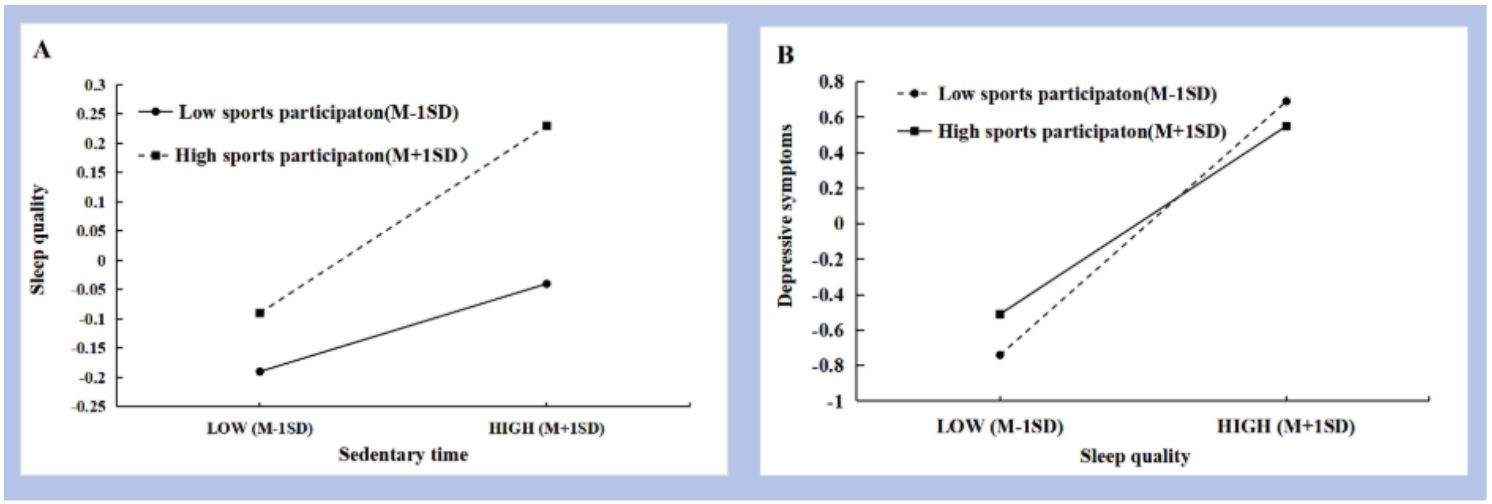

Figure 2

Simple slopes of sedentary time on sleep quality (A) and sleep quality on depressive symptoms(B) at different levels of sports participation.