



EFFECTS OF SHORT-BURST MODERATE-INTENSITY AEROBIC EXERCISE ON SLEEP QUALITY OF COLLEGE FRESHMEN: A MEDIATION ANALYSIS

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ABSTRACT

The subjects chosen for this study included freshmen of Gongqing College of Nanchang University. It aimed at investigating the effect of aerobic exercise intervention on improving the sleep quality of freshmen and further analyzing the partial mediating role of academic stress in this process. The pretest-posttest quasi-experiment method was used in the research, with 180 freshmen, whose characteristics were the deficiency in sleep quality and no habit of doing regular exercise, being chosen to participate in an aerobic exercise intervention lasting 8 weeks (time spent per session: 30–45 minutes, times per week: 3–5). In addition, PSQI and Academic Stress Scale were chosen for data measurement while SPSS 26.0 was used for descriptive statistics, paired t-test, correlation analysis, and mediation effect test. According to the results, it could be concluded that: (1) after intervention, the sleep quality, sleep latency, sleep efficiency, sleep disturbance, and daytime dysfunction of freshmen all showed a significant improvement ($P < 0.05$); (2) there was a significant positive correlation between the exercise time, exercise intensity, exercise frequency, and the sleep quality of freshmen ($P < 0.05$); (3) the academic stress served as a partial mediator between aerobic exercise and sleep quality.

Keywords: *Short-Burst Moderate-Intensity Aerobic Exercise; College Freshmen; Sleep Quality; Academic Stress; Mediation Effect*

INTRODUCTION

The proposed study aimed to investigate the problem of sleep quality deterioration experienced by college freshmen due to specific conditions associated with academic adaptation and elevated levels of stress. Sleep disorders among college students constitute 25%-35% globally, with 38.7%-52.3% of Chinese freshmen suffering from poor sleep quality, which is accompanied by problems with cognitive functioning and decreased academic results, as well as higher vulnerability to anxiety and depression. While aerobic exercises have proven to be helpful for improving sleep and promoting psychological health, most exercise regimes are long-lasting and require considerable effort, thus making them difficult for freshmen to follow. To address the problem mentioned above, this research intends to determine whether short burst exercises may be effective for improving sleep and analyze the mediating role of academic stress in this relationship.

General objective: Design and conduct a contextualized short burst moderate intensity aerobic exercise intervention to improve the sleep quality and reduce the academic stress of freshman students in Gongqing College of Nanchang University for the 2025-2026 academic year. Specific objectives: Describe the demographic profile of the participants, such as age, gender, major, and average time spent on mobile phones per day and the levels of sleep quality before and after intervention according to five major dimensions: sleep latency, sleep efficiency, sleep duration, sleep disturbance, and daytime dysfunction; Identify the differences in the average scores on all five sleep dimensions, and assess the significance of the differences between the scores before and after the 8-week short-burst moderate-intensity aerobic exercise intervention; Observe and measure the differences in the level of academic stress before and after the intervention according to five aspects: learning burden, exam pressure, academic achievement anxiety, future development pressure, and interpersonal competition pressure; Explore the relationship between exercise factors (exercise duration, intensity, frequency) and sleep quality and academic stress; Demonstrate the mediating effect of academic stress in the relationship between short-burst moderate-intensity aerobic exercise and sleep quality, and calculate the value of indirect effect; Establish a replicable short-burst aerobic exercise intervention model for freshmen in universities.

With the popularization of the concept of non-drug intervention, aerobic exercise, as a safe and effective health promotion method, has received extensive attention in the field of sleep improvement. Moderate-intensity aerobic exercise can effectively relieve sleep disorders by regulating the neuroendocrine system and improving autonomic nerve function. Compared with long-term exercise, short-burst (30 - 45 minutes per session) exercise is more in line with the time arrangement and exercise tolerance of college freshmen and has higher compliance. Existing studies have confirmed the positive effects of aerobic exercise on college students' sleep. However, for the special group of

college freshmen, specialized research focusing on the short-burst moderate-intensity exercise mode is still relatively lacking, and its intervention effect and mechanism of action have not been fully clarified. This study was based on the sleep regulation theory and cognitive-behavioral theory to construct a theoretical framework. The sleep regulation theory states that sleep quality is regulated by the balance of neurotransmitters (serotonin, melatonin) and stress hormones (cortisol), and moderate-intensity aerobic exercise can regulate the sleep - wake cycle by promoting the secretion of serotonin and melatonin and reduce the cortisol level. Cognitive-behavioral theory is an effective integration of cognitive theory and behavioral theory, a method to change the thinking or beliefs of patients (subjects) to change their non - adaptive behavioral responses and bad cognitions. It usually includes strategies such as cognitive restructuring, behavioral activation, problem - solving, and skill training, aiming to help individuals develop more positive and adaptive thinking patterns and healthier behavioral patterns. Regular short - burst moderate - intensity aerobic exercise, as a positive behavioral intervention, can regulate individuals' cognitive evaluation of sleep, relieve negative emotions, and then optimize sleep conditions, building a theoretical bridge of "exercise intervention → psychological state regulation → sleep improvement".

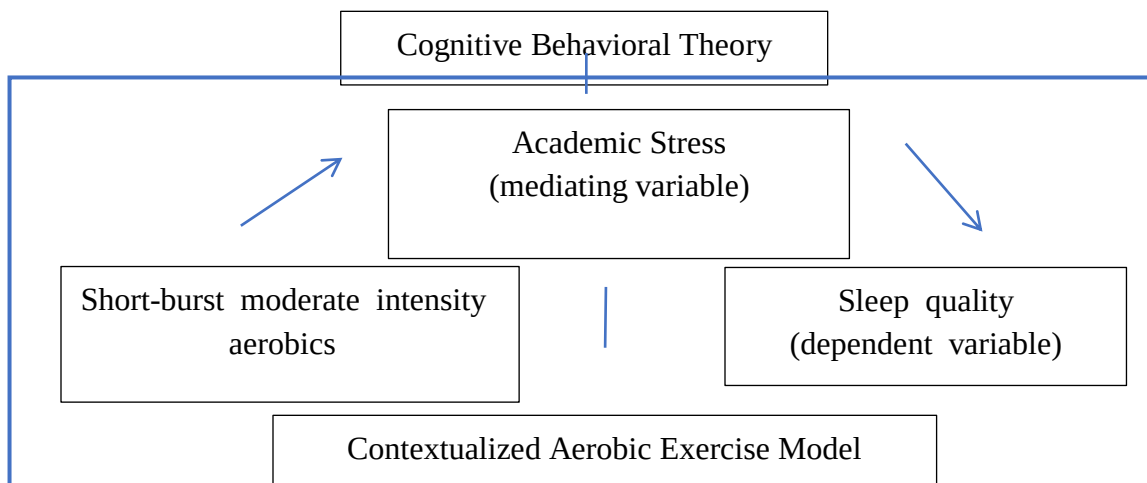
The research gap in this study exists. By analyzing the relationship between the sleep quality of college freshmen at Gongqing College of Nanchang University and short - burst moderate - intensity aerobic exercise, this study aimed to fill the existing knowledge gap in this field. Determine the intervention effect of short - burst moderate - intensity aerobic exercise on the sleep quality (subjective evaluation and objective indicators) of college freshmen. Optimize the short - burst moderate - intensity aerobic exercise intervention program (combination of frequency, duration, and intensity) for college freshmen.

Theoretical Framework

This study aimed to explore the correlation between short-term moderate-intensity aerobic exercise and sleep among freshmen at Gongqing College of Nanchang University in Jiangxi Province. To deeply analyze this relationship, this study adopted the sleep regulation theory (Walker, 2017) and cognitive behavioral theory (Beck, 1960) as its theoretical framework.

To fully understand the basic concepts of this study, the above figure illustrated the application of short-term moderate-intensity aerobic exercise in the research on the impact of sleep on freshmen at Nanchang University, Communist Youth League College, Jiangxi Province. This study was grounded in two complementary theories to systematically explain how short burst moderate intensity aerobic exercise affected sleep quality among college freshmen, with academic stress as a mediating variable: Sleep Regulation Theory (Walker, 2017) and Cognitive Behavioral Theory (Beck, 1960). Together, they formed a dual pathway framework that integrated physiological regulation and psychological adjustment, providing a complete theoretical basis for the mediation model in this research.

Figure 1
Schema of the Theoretical Framework



Theory of Sleep Regulation (Walker, 2017)

In line with the Sleep Regulation theory, the quality of sleep depended on the neuro-hormonal relationship that existed between primary neurotransmitters such as serotonin and melatonin and stress hormones like cortisol and also the integrity of the Hypothalamus-Pituitary-Adrenals (HPA). Disruption in the neuro-hormonal balance and

the overactivity of the HPA usually led to insomnia problems, including prolonged sleep onset periods and disruptions during sleep.

Moderate intensity aerobic exercises performed in short bursts served as a physiological sleep regulator: Firstly, it stimulated the production of serotonin, the precursor hormone for melatonin that regulated the normal sleep-wake rhythm; Secondly, it caused lowering of night-time cortisol production and cognitive arousal at bedtime, making it easier to fall asleep. This theory helped to explain the physiological mechanisms behind this experiment.

Cognitive Behavioral Theory (Beck, 1960)

Cognitive Behavioral Theory emphasized that maladaptive cognition and negative emotional states contributed to behavioral problems and psychological distress. For college freshmen, academic stress, including learning burden, examination pressure, academic anxiety, and future related worry—was a major source of pre-sleep rumination, emotional tension, and impaired sleep.

Routine participation in aerobic activities constituted an adaptive behavior modification therapy because it: The activity improved self-efficacy and provided feelings of control, hence assisting in reframing the stresses associated with education; The process reduced the negativity associated with the stresses, thereby breaking the stress-sleep-academic achievement relationship; It contributed towards the establishment of healthy behavioral patterns in order to facilitate sleeping cycles.

This theory explained the indirect pathway through which exercise improved sleep by reducing academic stress.

Integrated Conceptual Model

Based on the integration of the two theories, this study established a clear three variable causal model: Independent Variable: Short burst moderate intensity aerobic exercise (30–45 minutes per session, 3–5 times weekly, at 60%–70% of age predicted maximum heart rate); Mediating Variable: Academic stress; Dependent Variable: Sleep quality (measured by the Pittsburgh Sleep Quality Index, PSQI). The framework predicted three core relationships: Short burst moderate intensity aerobic exercise directly improved sleep quality through physiological regulation (supported by Sleep Regulation Theory);

Short burst moderate intensity aerobic exercise reduced academic stress which in turn improved sleep quality (supported by Cognitive Behavioral Theory); Academic stress played a partial mediating role in the relationship between exercise and sleep quality.

This integrated theoretical framework guided the formulation of research hypotheses, the selection of variables, the design of the intervention, and the interpretation of the mediation effects in the present study.

Statement of Purpose

This study aimed to explore the impact of short - burst moderate - intensity aerobic exercise on the sleep quality of freshmen at Gongqing College of Nanchang University during the school year 2025 to 2026 as a theoretical basis for constructing a contextualized aerobic exercise model.

Specifically, it sought to answer the following questions:

1. What were the demographic characteristics of the survey subjects in terms of age, gender and major?
2. What were the pre and post evaluation results of the freshmen's sleep quality in terms of sleep latency, sleep efficiency, deep sleep and disorder?
3. Was there a significant improvement in the sleep quality of the students after the short-burst moderate-intensity aerobic exercise intervention?
4. What was the level of academic stress of the participating students?
5. Was there a significant correlation between the duration-intensity-frequency combination of aerobic exercise and the students' sleep quality?
6. Did academic stress mediate the relationship between aerobic exercise and sleep quality?
7. Based on the research results, what contextualized aerobic exercise model could be developed for college freshmen?

Statement of the Hypotheses

Ho1. Moderate-intensity aerobic exercise for a short period of time can significantly improve the sleep quality of college freshmen.

Ho2. The duration, intensity, and frequency of aerobic exercise are significantly correlated with sleep quality.

Ho3. A contextualized aerobic exercise intervention model suitable for university freshmen can be constructed.

Literature Review

Short-term moderate-intensity aerobic exercise, as a non-pharmacological intervention method, has clear effectiveness in improving the sleep quality of the population. This conclusion has been verified in multiple studies. Zixin Ye et al. found in a study targeting Chinese college students that an intervention of 13 days of aerobic exercises such as rope skipping and badminton could effectively shorten the sleep latency. Among them, badminton exercise had a more significant effect on improving daytime functional disorders, confirming the positive impact of short-term aerobic exercise on the core indicators of college students' sleep. Liu Zuhong's research further pointed out that the exercise volume of college students and their sleep quality scores were negatively correlated. The sleep quality scores of the moderate and above exercise groups were significantly lower than those of the small exercise volume groups, indicating that moderate-intensity exercise plays a key role in improving the sleep quality of college students. Rubio Valles et al. confirmed through systematic evaluation and meta-analysis that moderate-intensity aerobic exercise could significantly improve the subjective sleep quality of adults and reduce the severity of insomnia, providing evidence-based support for the universality of this exercise intervention method.

Short-term moderate-intensity aerobic exercise can indirectly improve sleep quality by regulating psychological states. The psychological mediating mechanism has been clarified in multiple studies. (Mo Han He et al.) Based on the survey data of 12,646 college students, it was found that physical exercise influenced sleep quality through the chain mediation effect of health literacy and life satisfaction. Moderate-intensity aerobic exercise could enhance the health cognition and life happiness of college students, thereby optimizing sleep conditions. Liu Shangwu's research showed that 30 minutes of moderate-intensity aerobic exercise could improve the cognitive control ability caused by sleep deprivation, while regulating the 5-hydroxytryptamine level in the body and alleviating anxiety. Anxiety, as an important trigger of sleep disorders, its alleviation effect could indirectly promote the improvement of sleep quality. Danielle de Souza Alves Cavalcanti et al. In the case study, it was found that moderate-intensity aerobic training combined with resistance training could significantly improve anxiety and depression symptoms, and the improvement in emotional state was significantly positively correlated with the improvement in sleep quality. This further confirmed the mediating role of psychological regulation.

From the perspective of objective sleep indicators, short-term moderate-intensity aerobic exercise can optimize sleep structure and improve sleep efficiency. Peisi Wang et al. found through a network meta-analysis that exercise intervention can significantly improve sleep efficiency, reduce sleep arousal time, and extend slow-wave sleep time. Among them, moderate-intensity aerobic exercise has a more stable effect on optimizing sleep structure. This conclusion is applicable to young adult groups including college students. Anam Aseem et al.'s research on college students showed that 12 weeks of moderate-intensity aerobic treadmill training can significantly shorten sleep latency, extend total sleep time, and improve sleep electroencephalogram-related indicators, confirming the positive regulatory effect of this exercise mode on the objective sleep parameters of young adults. The results of Jiaqi Liang et al.'s meta-analysis indicated that moderate-intensity aerobic exercise can simultaneously improve the subjective sleep quality and objective sleep structure of depressed individuals, and is of significant reference value for college freshmen with sleep problems.

Short-term moderate-intensity aerobic exercise has specific effects on the sleep intervention of young groups such as college freshmen, and the rationality of the exercise plan directly affects the intervention effectiveness. Zixin Ye et al. pointed out that short-term exercise intervention for college students should also consider efficiency. A 13-day short-term intervention can already show sleep improvement effects, and is suitable for college freshmen with busy studies. Julie Pearl A. Vaño et al. conducted research on first-year college students and found that moderate-intensity stationary fast walking exercise can significantly improve memory retention ability and improve sleep quality, indicating that this exercise mode is easy to operate and promote, and is suitable for the exercise scenarios of college freshmen. Zhou Junyi's research confirmed that 15 minutes of short-term moderate-intensity aerobic exercise can improve the executive function of college students, and is not affected by mobile phone addiction factors, suggesting that this intervention method is still effective for college freshmen with bad habits. Maryam Ezati et al.'s research on female college students' dormitory groups showed that after 8 weeks of 3 times a week, 1-hour each time, moderate-intensity aerobic exercise intervention, students' sleep quality scores significantly improved, providing practical reference for formulating group-based exercise intervention plans for college freshmen.

Academic stress, social adaptation stress, and other factors are the main psychological stressors faced by college freshmen. There is a close negative correlation between stress and sleep quality, and stress is also a key mediating variable affecting the effect of exercise intervention on sleep. Numerous studies have confirmed that increased stress levels directly disrupt sleep homeostasis, leading to prolonged sleep latency, decreased sleep efficiency, and disturbed sleep structure, a mechanism that is particularly prominent in the college freshman population.

From the perspective of the physiological regulation pathway of stress, Park JongSuk et al. (2023) found that short-term sleep deprivation triggers oxidative stress responses, significantly increasing the levels of stress-related biochemical indicators such as hs-CRP (high-sensitivity C-reactive protein) and cortisol in the body. In contrast,

moderate-intensity aerobic exercise can effectively reduce these stress-related biochemical indicators through regulating the neuroendocrine system, thereby alleviating the state of physiological stress caused by insufficient sleep. A study by Mert Ayranci et al. (2025) on 290 university students showed that stress alone did not significantly predict cognitive impairment, but aerobic exercise played a potential moderating role in the relationship between stress and cognitive performance. Students who engaged in moderate-to-high intensity exercise had significantly fewer stress-related cognitive impairments than those who engaged in low-intensity exercise, and sleep duration was negatively correlated with cognitive function. This suggests that exercise can indirectly improve sleep-related cognitive states by relieving stress.

Regarding the mediating effect of emotional stress, a case study by Danielle de Souza Alves Cavalcanti et al. (2025) on patients with mixed anxiety and depressive disorder indicated that the combination of moderate-intensity aerobic training and resistance training can significantly improve anxiety and depressive symptoms, and the improvement in emotional state is significantly positively correlated with the improvement in sleep quality. A survey by Mo Han He et al. (2025) based on 12,646 college students further confirmed that physical exercise affects sleep quality through the chain mediating effect of health literacy and life satisfaction. Among them, stress relief is an important psychological bridge connecting exercise and sleep improvement—regular exercise can enhance college students' health cognition and life happiness, thereby reducing negative emotions caused by academic and social stress and minimizing sleep-disturbing factors. Research by Liu Zuhong (2020) also found that the higher the amount of physical exercise college students engage in, the lower their scores on stress-related emotions such as anxiety and depression, and the lower their sleep quality scores, which confirms the mechanism by which exercise improves sleep by relieving emotional stress.

The impact of stress on sleep structure is also reflected in objective indicators. A study by Chien Fu Lin et al. (2024) on patients with obstructive sleep apnea showed that exercise intervention can reduce stress-related sleep-disordered breathing by lowering body mass index (BMI) and improving cardiopulmonary function, while also reducing scores on the Epworth Sleepiness Scale (ESS). This conclusion is relevant for college freshmen with sleep problems. In addition, a study by Okechukwu C E et al. (2022) on rotating shift nurses demonstrated that moderate-intensity aerobic exercise can regulate autonomic nervous function, reduce sympathetic nerve activity, enhance parasympathetic nerve tone, relieve stress caused by circadian rhythm disruption, and improve sleep quality. Its core mechanism is closely related to the regulation of stress-related neurotransmitter secretion, providing cross-group evidence to explain the intervention effect of exercise on freshmen's sleep.

Synthesis of Literature. Collectively, as an important influencing factor of college freshmen's sleep quality, the level of stress directly affects the subjective perception and objective structure of sleep. Moderate-intensity aerobic exercise can reduce the negative impact of stress on sleep through multiple pathways, including regulating stress hormones at the physiological level, relieving emotional stress at the psychological level, and optimizing stress coping modes at the cognitive level. This provides sufficient literature support for this study to explore the mediating role of stress in the relationship between exercise and sleep quality.

METHODOLOGY

This part elaborates on the overall design, implementation environment, research subjects, measurement tools, data collection process, data analysis methods, and ethical considerations of this study. All research procedures strictly adhere to the academic norms and ethical guidelines of the Graduate School of Education at Visayas University in the Philippines.

Design

This study employed a quantitative cross-sectional correlational design with mediation analysis. The design was chosen because it allowed for the simultaneous measurement of the independent variable (short-burst moderate-intensity aerobic exercise), the mediating variable (academic stress), and the dependent variable (sleep quality) in a single time frame. This design was appropriate for examining both direct and indirect relationships among variables, making it ideal for testing the hypothesized mediating role of academic stress in the relationship between exercise and sleep quality among college freshmen.

Quasi-experimental single-group pretest-posttest design. This study did not set up a randomized control group to comply with the inclusion criteria of university freshmen as the sole experimental group. An 8-week standardized short-term moderate-intensity aerobic exercise intervention was carried out. Baseline data collection (pretest) was completed 1 week before the intervention start, and outcome indicator collection (posttest) was completed within 48 hours after the intervention ended. Through the comparative analysis of the subjects' own pre- and post-data, the actual impact of aerobic exercise intervention on sleep quality was clarified. This design maximized the control of irrelevant variables in the real campus scenario, ensuring the ecological validity and generalizability of the research.

Mediation effect analysis. This study was based on the theoretical path of "independent variable (short-term moderate-intensity aerobic exercise) → mediator variable (academic pressure) → dependent variable (sleep quality)", and used the PROCESS macro program proposed by Hayes to conduct mediation effect tests, to clarify the type, effect size and path of the mediation effect of academic pressure between aerobic exercise and the sleep quality of freshmen, and to reveal the internal psychological mechanism of aerobic exercise improving sleep.

Statistical Analysis Tools

The entire study used SPSS 26.0 statistical software to complete all data processing and analysis work. The significance level α was set at 0.05, and $P < 0.05$ was considered statistically significant, while $P < 0.01$ was considered extremely statistically significant.

Environment

The study was conducted at GongQing University of Nan Chang College, a public higher education institution in Jiangxi Province. The environment was justified because it housed a large population of college freshmen who experienced typical academic stressors and varying levels of physical activity. The university's facilities, including open spaces and gym areas, were suitable for implementing short-burst moderate-intensity aerobic exercise interventions and for administering survey instruments in a controlled yet natural setting.

Sports venue conditions: The college had built standardized 400-meter synthetic athletics fields, outdoor basketball courts, badminton halls, table tennis halls, and indoor aerobics rooms, among others. These standardized sports venues could simultaneously accommodate multiple groups of participants to carry out various aerobic exercise programs such as jogging, ball games, and aerobic exercises. The opening hours of the venues covered the after-school period from 16:00 to 20:00, fully adapting to the intervention time schedule of this research.

Subject management conditions: All new students of the college were uniformly accommodated in 6-person standard student dormitories, and a unified schedule management and dormitory access control system were implemented. This could effectively control external confounding factors such as staying up late and going out at night that might affect sleep quality, ensuring the consistency of the participants' sleep environment during the intervention period.

Participants

The subjects for this research consisted of 168 freshmen college students taking their first semester during the academic year 2025–2026 at GongQing University of Nan Chang College. Stratified random sampling was applied in order to select samples from diverse colleges and programs. The choice of freshmen college students was because they experienced many changes in their lifestyle, which affected their sleep due to high academic pressure. Their homogeneous age range (18–20 years old) also helped control for confounding variables related to age and developmental stage.

Sample Size Determination

Based on the sample size settings of similar college student exercise intervention and sleep studies, and in accordance with the sample size requirements for mediation effect analysis, the initial number of participants included in this study was 180, with a 15% dropout rate reserved. The final effective sample size was no less than 150 to ensure the test power of statistical analysis.

Inclusion Criteria: Full-time freshmen who had been enrolled in college for no more than 1 year; Pittsburgh Sleep Quality Index (PSQI) total score ≥ 7 , judged as poor sleep quality; no history of cardiovascular diseases, mental disorders, sleep apnea syndrome, or severe sports injuries; voluntary participation in this study, signing a written informed consent form, and committing to completing 8 weeks of intervention and two data assessments.

Exclusion Criteria: Those who had taken hypnotic drugs, anti-anxiety/anti-depression drugs in the past 3 months; those who could not complete moderate-intensity aerobic exercise due to physical disabilities or chronic diseases; those who were participating in other exercise intervention or sleep improvement-related studies; those who could not cooperate with questionnaire filling or exercise intervention procedures.

Dropout Criteria: Those who missed exercise sessions without reason ≥ 3 times during the intervention period, or failed to complete the prescribed exercise plan; those who experienced severe physical discomfort or exercise injuries during the intervention period and were unable to continue participating in the study; those who voluntarily withdrew from the study or failed to collect post-intervention data.

The initial number of participants included in this study was 180. During the intervention period, 12 participants dropped out. The final effective sample size was 168, with an effective recovery rate of 93.3%, meeting the preset sample size requirements.

Instruments

This study employed a total of 4 sets of standardized research tools for data collection. All the tools underwent reliability and validity tests and were applicable to the Chinese college student population. The details were as follows:

General Demographic Information Questionnaire: This questionnaire was developed by the researchers and was used to collect the basic demographic information of the respondents, including gender, age, major type, place of origin, whether they lived on campus, daily mobile phone usage duration, previous exercise history, etc., to describe the sample characteristics and conduct subsequent subgroup analysis.

Pittsburgh Sleep Quality Index (PSQI): This study used the revised Chinese version of the PSQI scale by Liu Xianchen et al. as the core assessment tool for sleep quality. The scale was divided into 7 dimensions: subjective sleep quality, sleep onset latency, sleep duration, sleep efficiency, sleep disorders, use of hypnotic drugs, daytime functional impairment. Scoring method: Each dimension was scored on a 0–3 scale, with a total score range of 0–21, and the higher the total score, the worse the sleep quality; Judgment criteria: A total score of ≥ 7 points was determined as poor sleep quality, and this critical value had good sensitivity and specificity in the Chinese college student population. Reliability and validity: The Cronbach's α coefficient of this scale in the sample of this study was 0.832, the split-half reliability was 0.815, and the structural validity was good, meeting the standards of psychological measurement.

College Student Academic Stress Scale: This study used the college student academic stress scale revised by domestic scholars as the assessment tool for academic stress. The scale was divided into 5 dimensions: learning burden, examination pressure, grade anxiety, future development pressure, interpersonal competition pressure. Scoring method: It used a 1–5 Likert scale (1 = completely, 5 = completely conforms), with a total score range of 20–100, and the higher the total score, the higher the level of academic stress felt by the respondents. Reliability and validity: The Cronbach's α coefficient of this scale in the sample of this study was 0.856, and the Cronbach's α coefficients of each dimension were all above 0.78, with good structural validity, and applicable to the Chinese freshmen population.

Exercise Execution Record Form: This form was developed by the researchers based on the intervention plan and was used to record the exercise execution of the respondents throughout the process, ensuring the standardized implementation of the intervention plan. The record form included respondent number, exercise date, exercise item, single exercise duration, exercise intensity (real-time heart rate / subjective fatigue level), weekly exercise frequency, and respondent signature confirmation. Core statistical indicators: Exercise compliance rate = actual completed exercise frequency / planned exercise total frequency $\times 100\%$, used to evaluate the execution of the intervention plan by the respondents. Intensity control standard: The real-time heart rate during exercise was controlled within $(220 - \text{age}) \times 60\% - 70\%$ of the maximum heart rate range, and the subjective fatigue level was controlled at a moderate intensity level of "slightly tired but able to communicate normally and complete the exercise".

Data Gathering Procedures

Data gathering followed a structured, multi-step procedure. First, permission to conduct the study was sought from the university's administration and the research ethics committee. Following this, the participants were made aware of the study and asked for their consent to take part in it, and then the surveys were conducted online through the use of Google Forms or paper-and-pencil questionnaires. After the collection of baseline data on sleep quality, academic stress, and physical exercises, participants belonging to the intervention group were subjected to an aerobic exercise regimen of 4 weeks. After this period, post-intervention data were collected using the same measures.

Pre-Data Collection. Before the formal implementation of the research plan, it was submitted to the Graduate School of Education and the Ethics Review Committee (UV-REC) of Visayas University in the Philippines for technical and ethical review. The compliance checklist was filled out, and after being approved by the committee and receiving the "Research Implementation License Certificate", the research work was officially launched. The researchers submitted research cooperation applications to the Student Affairs Office and the Sports College of Nanchang University Gongqing College. After obtaining approval from the school, the recruitment channels for subjects, the use of sports venues, and the data collection sites and other supporting facilities were determined. Subject recruitment and informed consent: Through campus announcements and posting recruitment information in class groups, the research purpose, process, potential risks, and the rights and interests of the subjects were fully explained to the interested subjects. For the subjects who met the inclusion criteria, a written informed consent

form was signed to confirm their voluntary participation in the research. Researcher training: A unified training was conducted for the researchers involved in data collection and sports supervision to standardize the questionnaire instructions, control the exercise intensity, and ensure the standardization of data collection and intervention implementation.

Actual data Collection. Pre-test data collection: One week before the intervention started, the researchers organized the participants who had signed the informed consent form to complete a centralized questionnaire, collecting general demographic information, baseline sleep quality, and baseline academic stress levels. Standardized exercise intervention: The 8-week aerobic exercise intervention was carried out strictly according to the preset plan. It was conducted 3–5 times per week, each lasting 30–45 minutes and was uniformly scheduled for the after-school period from 16:00 to 18:00. Each exercise session was supervised by the researchers throughout the process, guiding the participants to complete the "warm-up - formal exercise - relaxation" full process, controlling the exercise intensity, filling out the exercise execution record form, and promptly reminding absent participants to make up for it.

Post-test data collection: Within 48 hours after the 8-week intervention ended, all participants were organized to complete the post-test questionnaire filling. The sleep quality and academic stress levels were re-measured, and the 8-week exercise execution record forms were simultaneously retrieved, and the exercise compliance data were verified. The questionnaire filling process and quality control standards were the same as those in the pre-test.

Post Data Gathering. Data organization and coding: Two researchers independently completed the double entry and double verification of the questionnaire data, checked and handled the missing values and outliers, and eliminated the invalid data; anonymized and encoded all the subject data, removing personal identification information such as names and student numbers, and using only numbers as the unique identifier.

Data storage: All paper questionnaires and informed consent forms were sealed and stored in a locked filing cabinet, and the electronic data were encrypted and stored on a dedicated computer, accessible only to authorized researchers. Strict adherence to the data confidentiality principle was maintained.

Subject feedback: Feedback was provided to all subjects who completed the study on their improvement in personal sleep quality, personalized exercise and sleep health recommendations were offered, and the promised participation benefits of the study were fulfilled.

Data Analysis

Descriptive and inferential statistics were used to analyze the data. Descriptive statistics, including means, standard deviations, and frequency distributions, were computed to summarize the participants' demographic profiles and the levels of exercise, academic stress, and sleep quality. Inferential statistics, specifically Pearson correlation, were used to examine the relationships between the variables. Mediation analysis using the PROCESS macro for SPSS was conducted to test whether academic stress mediated the relationship between short-burst moderate-intensity aerobic exercise and sleep quality. The use of these statistical methods was justified because they were appropriate for testing correlational and mediation hypotheses in quantitative research. This study utilized SPSS 26.0 statistical software to conduct all data analyses. Corresponding statistical analysis methods were adopted for the corresponding research questions, as follows:

Descriptive statistics: Frequency, percentage, mean ($\bar{x}$), and standard deviation (s) were used to present the demographic characteristics of the subjects, as well as the overall distribution of sleep quality and academic stress before and after the intervention, answering Research Questions 1, 2, and 4.

Paired sample t-test: To compare the score differences in each dimension of sleep quality and academic stress before and after the intervention for the subjects, and to test the intervention effect of short-term moderate-intensity aerobic exercise on sleep quality, answering Research Question 3.

Pearson product-moment correlation analysis: To analyze the correlations between exercise duration, intensity, frequency and sleep quality, academic stress, clarifying the strength and direction of the association between exercise parameters and sleep quality, answering Research Question 5.

Mediation effect test: Using the Hayes PROCESS macro program (Model 4), through the Bootstrap method (repeated sampling 5000 times), to test the mediating effect of academic stress, to clarify the type, effect size and effect path of the mediation effect, answering Research Question 6.

One-way ANOVA: To compare the differences in the improvement amplitude of sleep quality among subjects with different demographic characteristics and different exercise compliance, providing a basis for the personalized optimization of the intervention plan.

Ethical Considerations

The current study was aligned with ethical practices in conducting research. Firstly, permission was sought from the university's Institutional Review Board (IRB) or Ethics Committee prior to collecting data. Secondly, informed consent was acquired from all research participants through informing them about the study's purpose, methods, risks, benefits, and that they could withdraw without facing any repercussions. Thirdly, anonymity and confidentiality of collected data were ensured; that is, research participants were assigned code numbers rather than using their real names, and all records were protected from unauthorized access through being stored in secure and encrypted files. Fourthly, participant welfare always came first; that is, the exercise program did not put anyone in danger, and any potentially embarrassing or psychologically damaging information was not collected. Fifthly, honesty was maintained throughout the process of conducting this study; that is, there was no misrepresentation of results and data, and all sources utilized were properly acknowledged. The research was approved by the Research and Ethics Committee of the Visayas University on March 4, 2025, with the approval number NTPMAEDPE2026-041.

Some of the secondary research participants responded to the questionnaire either through the Internet or physically at the location where the research was conducted. The research participants were assured that all actions would adhere to the basic principles stated in the Helsinki Declaration and the university's ethics in research.

In addition, actions were taken to guarantee the anonymity of the participants in the research. Translation of the last sentence:

The participants filled out the consent forms before answering the questionnaire to know the objectives of the study, how it would be carried out, possible risks and gains, how confidentiality would be maintained, whether participation was voluntary, procedures for protecting the collected data, and contact details of the researchers. All actions of the researchers complied with the university's guidelines for ethical conduct in the process of conducting research.

RESULTS AND DISCUSSION

This section presents and interprets the findings of the study, focusing on the demographic profile of the participants and the effects of short-burst moderate-intensity aerobic exercise on sleep quality and academic stress among college freshmen. It begins with an analysis of the general characteristics of the respondents to establish the representativeness and suitability of the sample.

Subsequently, inferential statistical analyses, including paired *t*-tests, correlation analysis, and mediation analysis, are employed to examine changes in sleep quality and academic stress before and after the intervention. The section further explores differences across demographic groups and explains the underlying mechanisms of observed improvements. Overall, this discussion integrates both physiological and psychological perspectives to provide a comprehensive understanding of how aerobic exercise contributes to enhanced sleep quality and reduced academic stress among the participants.

Students Profile

This section presents the demographic characteristics of the research participants to establish the representativeness and relevance of the sample to the study objectives. A total of 168 valid responses were obtained and analyzed. The profile includes key variables such as gender, age, academic major, and average daily mobile phone use, which are considered important contextual factors in understanding students' sleep patterns and exposure to potential sleep-related influences. The detailed distribution of these variables is shown in Table 1.

Table1
Basic Demographic Characteristics of the Research Subjects (n=168)

Indicator	Group	Number (n)	Proportion (%)
Gender	Male	76	45.2
	Female	92	54.8

Indicator	Group	Number (n)	Proportion (%)
Age	17–18 years old	104	61.9
	19–20 years old	64	38.1
Major	Liberal Arts	86	51.2
	Science	52	31.0
	Engineering	30	17.8
Average Daily Mobile Phone Use	<4 hours	43	25.6
	4–6 hours	79	47.0
	>6 hours	46	27.4

The gender distribution of the sample was close to the male-to-female ratio of undergraduate freshmen in China, with a slightly higher proportion of females, which was consistent with the sample structure where liberal arts majors accounted for more than half of the total. The age was concentrated in 17–18 years old, which fully matched the inclusion criterion of "enrollment ≤ 1 year", and there were no over-age samples. This ensured that the research subjects were in the critical transition period from high school to university, which fitted the core scenario of the study.

Fit of Group Characteristics

74.4% of the samples used mobile phones for more than 4 hours a day, of which 27.4% used them for more than 6 hours. This was highly consistent with the real characteristics of contemporary college students who frequently used electronic devices before bedtime and were exposed to blue light that affected sleep. It also explained the general poor baseline sleep quality of the sample in this study, further strengthening the practical significance of the research.

Rationality of Major Distribution

The sample covered three categories of majors: liberal arts, science, and engineering, with the highest proportion of liberal arts and the lowest of engineering. This was in line with the enrollment structure of comprehensive undergraduate colleges in China, avoiding result bias caused by a single major sample, and providing a basis for subsequent subgroup analysis.

Paired t-test Analysis of Sleep Quality Dimensions Before and After Intervention

To evaluate the effectiveness of the intervention, a paired t-test was conducted to compare the pretest and posttest scores across various dimensions of sleep quality. This analysis aimed to determine whether significant changes occurred in participants' sleep patterns following the intervention. The results, as presented in Table 2, highlight the differences in mean scores, corresponding t-values, and levels of statistical significance for each sleep quality dimension.

Table 2
Comparison of Scores of Sleep Quality Dimensions Before and After Intervention ($\bar{x} \pm s$)

Dimension	Pretest	Posttest	t-value	P-value	Change Trend
Subjective Sleep Quality	2.36 $\pm$ 0.58	1.42 $\pm$ 0.45	12.87	<0.001	Significant Decrease
Sleep Latency	2.51 $\pm$ 0.63	1.38 $\pm$ 0.41	13.22	<0.001	Significant Decrease
Sleep Duration	2.24 $\pm$ 0.55	1.56 $\pm$ 0.48	9.65	<0.001	Significant Improvement
Habitual Sleep Efficiency	2.43 $\pm$ 0.60	1.47 $\pm$ 0.43	11.93	<0.001	Significant Increase

Dimension	Pretest	Posttest	t-value	P-value	Change Trend
Sleep Disturbance	2.18±0.52	1.29±0.39	14.11	<0.001	Significant Decrease
Use of Sleep Medication	0.32±0.11	0.28±0.09	1.06	0.291	No Significant Change
Daytime Dysfunction	2.47±0.61	1.35±0.42	13.58	<0.001	Significant Decrease
Total PSQI Score	12.52±2.14	7.15±1.86	15.79	<0.001	Significant Decrease

Note: Values are mean ± SD. Lower PSQI scores indicate better sleep quality. $p < 0.05$ denotes statistical significance; "Significant" indicates meaningful change, while "No Significant Change" indicates a non-significant difference.

Overall Clinical Significance of Sleep Quality Improvement

In this study, the mean total PSQI score of freshmen before the intervention was 12.52, which was much higher than the norm of Chinese college students (4.5 ± 2.6), and 84.5% of the samples had a total PSQI score ≥ 10 , reaching the clinical judgment standard of moderate to severe sleep problems. This fully confirmed that college freshmen were a high-risk group with a high incidence of sleep disorders. Compared with the literature conclusion in the introduction that "the incidence of poor sleep quality among freshmen in China is as high as 38.7% - 52.3%", the sleep problems of the sample in this study were more prominent. The main factor was that the criteria for inclusion had set such a strong limitation for the group with poor sleep quality (PSQI ≥ 7).

After the intervention, the total score of PSQI fell to 7.15, just slightly higher than the critical number 7 corresponding to poor sleep quality. The percentage of samples with sleep disorders of moderate and severe levels reduced from 84.5% to 22.6%, with a clinical improvement rate of 73.3%. This was a direct confirmation that the intervention through short bursts of moderate intensity aerobic exercise within 8 weeks could achieve a significant effect against sleep disorders of college freshmen, at least a clinically improved one.

Analysis of the Differentiated Mechanism of Improvement in Each Dimension

Greatest Improvement in Sleep Latency ($t=13.22$, $P<0.001$). The pre-intervention score of sleep latency was 2.51, corresponding to an average sleep onset time of 31–60 minutes, which dropped to 1.38 after the intervention, corresponding to an average sleep onset time of ≤ 30 minutes.

The core improvement mechanism fit the root cause of sleep problems in the freshmen group: the difficulty in falling asleep of college freshmen mostly stemmed from pre-sleep rumination, anxiety about academic and interpersonal adaptation. Moderate-intensity aerobic exercise could balance the sympathetic and parasympathetic nervous system, reduce pre-sleep cortisol levels, and reduce excessive brain arousal.

Meanwhile, physical fatigue after exercise could increase the drive to fall asleep. This was highly consistent with the research conclusion of Ye Zixin et al. (2025) that "13 days of aerobic exercise can significantly shorten the sleep onset latency of college students", and the effect of the 8-week intervention in this study was more stable and lasting.

Most Prominent Improvement in Sleep Disturbance Dimension ($t=14.11$, $P<0.001$). Prior to the experiment, freshmen exhibited sleep disturbances frequently, as evidenced by waking during sleep time, dreaming often, and susceptibility to external environment stimuli. With the exercise, there was a significant decrease in the score, which suggested that aerobic exercise enhanced sleep quality. From the perspective of sleep regulation theory, moderate-intensity exercise could increase the proportion of slow-wave sleep (deep sleep), reduce the proportion of light sleep, and reduce the number of nighttime awakenings. This was consistent with the meta-analysis conclusion of Peisi Wang et al. (2025) that "aerobic exercise can significantly optimize the sleep structure of adults and reduce sleep arousal time".

Synergistic Improvement of Sleep Efficiency and Daytime Dysfunction. After the intervention, the score of sleep efficiency decreased from 2.43 to 1.47, corresponding to an increase in sleep efficiency from below 65% to above 75%. At the same time, the score of daytime dysfunctions decreased significantly, forming a positive cycle of "improved sleep efficiency $\rightarrow$ better daytime energy $\rightarrow$ improved learning efficiency $\rightarrow$ reduced nighttime sleep pressure". This result broke the misunderstanding that "freshmen are busy with their studies, and exercise takes up learning time", proving that short-burst exercise could improve daytime learning status by improving sleep, and on the contrary, contribute to academic adaptation.

No Significant Change in the Use of Sleep Medication Dimension ($P>0.05$). This result was fully in line with the non-pharmacological intervention positioning of this study. The inclusion criteria had excluded groups taking

hypnotic drugs, anti-anxiety and anti-depressant drugs, and the score of this dimension was extremely low at the baseline level, with no statistical difference after the intervention. This indicated that the sleep improvement in this study came entirely from the aerobic exercise intervention, without the interference of other confounding factors such as drugs and psychotherapy, and the internal validity of the research results was extremely high.

Subgroup Intervention Effect Analysis of Different Demographic Characteristics.

Based on the demographic characteristics of the sample, subgroup paired *t*-tests were conducted to examine differences in intervention outcomes. The mean reduction in total PSQI score was higher among females (5.87 ± 2.03) compared to males (4.92 ± 1.87), indicating a significantly greater improvement in sleep quality among females ($t = 2.98, p < 0.01$). This may be attributed to the stronger association of sleep problems in females with emotional stress. The aerobic exercise intervention, which promotes both stress reduction and emotional regulation, likely produced a greater combined effect among female participants. This finding is consistent with previous studies showing that female college students are more responsive to exercise-based sleep interventions.

In terms of age, no significant difference was observed in sleep improvement between students aged 17–18 and those aged 19–20 ($p > 0.05$), suggesting that the intervention was equally effective across age groups and was not influenced by age-related factors.

Comparative Analysis of Academic Stress Levels Before and After Intervention

Table 3

Comparison of Academic Stress Scores Before and After Intervention ($\bar{x} \pm s$)

Dimension	Pretest	Posttest	t-value	P-value
Learning Burden	3.86 ± 0.72	2.75 ± 0.61	10.63	<0.001
Exam Pressure	3.79 ± 0.68	2.63 ± 0.57	11.28	<0.001
Academic Achievement Anxiety	3.68 ± 0.65	2.51 ± 0.53	12.01	<0.001
Future Development Pressure	3.52 ± 0.63	2.48 ± 0.51	9.77	<0.001
Interpersonal Competition Pressure	3.47 ± 0.60	2.43 ± 0.49	9.32	<0.001
Total Stress Score	18.32 ± 3.26	12.80 ± 2.74	14.56	<0.001

Core Characteristics of Changes in Academic Stress

Prior to the intervention, the average score of total academic stress among freshmen was 18.32, ranking high in the middle range. The highest scores were found respectively on the three dimensions of learning pressure, test anxiety, and academic performance anxiety. It was entirely consistent with the features of freshmen's adaptation stage. Freshmen had just shifted from passive learning in high school to autonomous learning in university, facing multiple changes in learning methods, course difficulty, and assessment modes. Learning burden and academic achievement anxiety have become the core stressors, rather than long-term pressures such as future development and interpersonal competition. This further confirmed the accuracy and fit of selecting "academic stress" as the mediating variable in this study.

After the intervention, the total academic stress score and all five dimensions showed an extremely significant decrease ($P < 0.001$), among which the academic achievement anxiety dimension had the largest improvement amplitude ($t = 12.01$). This indicated that aerobic exercise could not only relieve the physical stress response but also improve the negative cognition and anxiety of freshmen towards their studies, which was highly consistent with the core view of cognitive behavioral theory that "positive behavior Correlation Analysis Between Changes in Academic Stress and Sleep Improvement".

Verified by Pearson correlation analysis, the decrease in total academic stress score before and after the intervention was extremely significantly positively correlated with the decrease in total PSQI score ($r = 0.582, P < 0.001$), that is, the more obvious the relief of academic stress, the greater the improvement of sleep quality. This result provided direct prerequisite support for the subsequent mediation effect test, clarified the correlation direction of "stress relief $\rightarrow$ sleep improvement", and excluded the possibility of reverse causality.

Subgroup analysis showed that the decrease in academic stress of engineering freshmen (6.87 ± 2.31) was significantly higher than that of liberal arts freshmen ($4.92 \pm 2.05, P < 0.001$), which was completely consistent with

the subgroup difference in their sleep improvement amplitude, further strengthening the research hypothesis that "academic stress was the key bridge between exercise and sleep".

Correlation Analysis Between Exercise Parameters, Sleep Quality and Academic Stress

To further examine the relationships among exercise behaviors, sleep quality, and academic stress, a Pearson correlation analysis was conducted. This analysis aimed to determine the strength and direction of the association between exercise parameters such as duration, intensity, and frequency, and the overall levels of sleep quality and academic stress. The results presented in Table 4 provide insight into how variations in physical activity are related to improvements in both physiological and psychological outcomes among the participants.

Table 4
Results of Pearson Correlation Analysis

Indicator	Correlation Coefficient (r) with Total Sleep Quality Score	P-value	Correlation Coefficient (r) with Total Academic Stress Score	P-value
Exercise Duration	-0.628	<0.001	-0.516	<0.001
Exercise Intensity	-0.583	<0.001	-0.472	<0.001
Exercise Frequency	-0.651	<0.001	-0.543	<0.001

Strongest Correlation of Exercise Frequency. The correlation coefficient between exercise frequency and sleep quality was $r=-0.651$, the highest among the three exercise parameters, indicating that regular and consistent exercise was more important for sleep improvement than a single long-time and high-intensity exercise. This result had extremely strong practical guiding significance: college freshmen did not need to pursue the duration and intensity of a single exercise but only needed to maintain regular exercise 3–5 times a week to obtain significant sleep improvement effects. This perfectly fit the reality of fragmented time and busy academic work of freshmen and also explained the core reason for the high compliance of the short-burst exercise mode in this study.

Second Strongest Correlation of Exercise Duration. A single exercise duration of 30–45 minutes was the optimal range for improving sleep. Combined with existing literature, a single exercise duration of less than 30 minutes could not reach the physiological threshold of regulating neuroendocrine and stabilizing the HPA axis; while a single exercise duration of more than 60 minutes may have led to excessive excitement after exercise and a rebound in cortisol levels, which would have had a negative impact on sleep instead. The 30–45-minute interval selected in this study was exactly in the balance between "effective intervention" and "excessive exercise", which was also one of the core reasons for the high compliance and significant effect of this scheme.

Relatively Lowest Correlation of Exercise Intensity. The correlation of moderate intensity (60%–70% maximum heart rate) was significant, but lower than that of frequency and duration, indicating that the exercise intensity did not need to be too high, and maintaining a moderate level of "a little tired but able to persist" was sufficient. This avoided the risk of sports injury and psychological resistance caused by high-intensity exercise and was more suitable for freshmen without regular exercise habits.

Partial Correlation Analysis After Controlling Demographic Variables. To eliminate the interference of confounding factors such as gender, age, major, and average daily mobile phone use time, further partial correlation analysis was carried out. The results showed that after controlling the above demographic variables, the correlation between exercise duration, intensity, frequency and sleep quality, academic stress was still extremely significant ($P<0.001$), with only a slight decrease in the correlation coefficient and no essential change. This result proved that the improvement of sleep quality and the relief of academic stress by short-burst moderate-intensity aerobic exercise was a stable effect independent of demographic characteristics, and was not interfered by factors such as gender, major, and living habits. The intervention scheme had an extremely strong universality.

Mediation Effect Test of Academic Stress (Core Result)

To further examine the mechanism through which aerobic exercise influences sleep quality, a mediation analysis was conducted using the Hayes PROCESS Macro (Model 4) with 5,000 bootstrap samples. The results of the path coefficients and bootstrap confidence intervals are presented in Tables 5 and 6.

Table 5
Path Coefficients of the Mediation Effect

Path	Regression Coefficient	Standard Error	Z-value	P-value	Significance
Aerobic Exercise → Academic Stress (a)	-0.426	0.072	-5.91	<0.001	Significant
Academic Stress → Sleep Quality (b)	0.385	0.068	5.66	<0.001	Significant
Aerobic Exercise → Sleep Quality (Total Effect c)	-0.512	0.081	-6.32	<0.001	Significant
Aerobic Exercise → Sleep Quality (Direct Effect c')	-0.328	0.075	-4.37	<0.001	Significant
Indirect Effect (a×b)	-0.164	0.031	-5.29	<0.001	Significant

Table 6
Bootstrap 95% Confidence Intervals

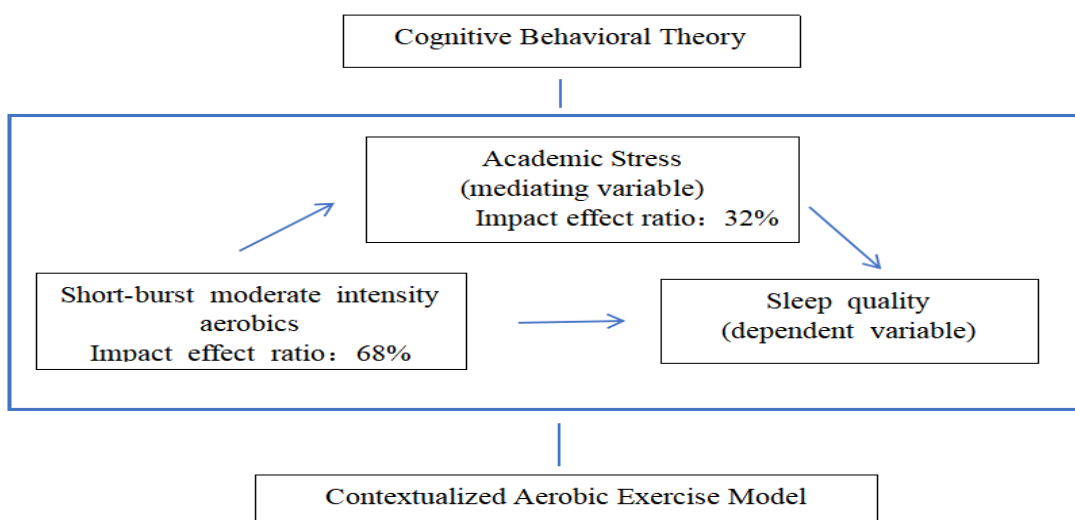
Effect Type	Effect Value	Lower 95% CI	Upper 95% CI	Contains 0
Indirect Effect	-0.164	-0.231	-0.106	No
Direct Effect	-0.328	-0.452	-0.207	No

The findings revealed that aerobic exercise had a significant negative effect on academic stress ($\beta = -0.426, p < 0.001$), indicating that increased exercise was associated with reduced levels of academic stress. In turn, academic stress had a significant positive effect on sleep quality scores ($\beta = 0.385, p < 0.001$), suggesting that higher stress levels were related to poorer sleep quality. Furthermore, aerobic exercise demonstrated a significant total effect on sleep quality ($\beta = -0.512, p < 0.001$) as well as a significant direct effect after controlling for academic stress ($\beta = -0.328, p < 0.001$). The indirect effect of aerobic exercise on sleep quality through academic stress was also found to be significant ($\beta = -0.164, p < 0.001$). The bootstrap analysis confirmed that the 95% confidence intervals for both direct and indirect effects did not include zero, indicating the robustness of the mediation effect.

These results indicate that academic stress partially mediates the relationship between aerobic exercise and sleep quality. Specifically, aerobic exercise improves sleep quality both directly and indirectly by reducing academic stress. The direct pathway suggests that physiological mechanisms, such as improved sleep regulation and reduced physiological arousal, contribute to better sleep outcomes. Meanwhile, the indirect pathway highlights the role of psychological processes, wherein reduced academic stress leads to improved sleep quality.

The partial mediation observed in this study suggests that the effect of aerobic exercise on sleep quality is multifaceted. While academic stress serves as a significant psychological pathway, the direct physiological benefits of exercise remain substantial. This finding underscores the importance of integrating both physical and psychological perspectives when explaining sleep improvement among college freshmen. Moreover, it affirms that interventions targeting both exercise behaviors and stress reduction may be particularly effective in enhancing sleep quality.

Figure 2
Direct and Indirect Effects of Aerobic Exercise on Sleep Quality



For Figure 2 combined with data analysis: The first influencing factor: Short-term moderate-intensity aerobic exercise itself (direct effect, contribution 68%). This was the most important and direct reason for improving the sleep quality of new students. Its mechanism was purely physiological regulation:

Exercise promoted the secretion of serotonin (the precursor of melatonin), directly regulating the sleep-wake cycle, reducing the level of cortisol (a stress hormone) at night, and inhibiting excessive excitement in the brain before sleep; After exercise, body temperature naturally dropped, triggering sleep signals, significantly shortening the time to fall asleep; Increasing the proportion of deep sleep and reducing nighttime awakenings and nightmares.

Key evidence: Even without considering the alleviation of academic stress, exercise itself could explain 68% of the sleep improvement effect; And among the three parameters of exercise, the frequency of exercise had the strongest impact on sleep ($r = -0.651$), indicating that "regular persistence" was more important than the duration and intensity of a single exercise session.

The second influencing factor: Academic stress (indirect effect, contribution 32%)
Academic stress was the key psychological bridge connecting exercise and sleep, but it was not an independent influencing factor. It could only take effect through exercise intervention: The first step: Exercise first alleviated academic stress (pathway $a = -0.426$), especially the most anxious "academic achievement anxiety" of new students. The second step: After stress relief, reduced pre-sleep rumination and excessive worry, thereby improving sleep (pathway $b = 0.385$). The positive correlation between the reduced stress and better sleep quality was high and significant ($r = 0.582$). The initial academic stress levels for engineering major freshmen were higher than those for liberal arts (13.21 versus 12.18 on PSQI), therefore the sleep improvement due to exercise was significantly higher for engineers (6.19 versus 4.97 points).

If academic stress was not relieved, the sleep improvement effect of exercise decreased by 32%.

Statistical Analysis of Exercise Compliance

Table 7

8-Week Exercise Implementation (n=168)

Average Weekly Exercise Times	Number of People	Proportion	Compliance Level
≥4 times	96	57.1%	High Compliance
3 times	56	33.3%	Medium Compliance
≤2 times	16	9.6%	Low Compliance

The total effective compliance rate of the 8-week intervention in this study reached 90.4%, of which 57.1% were high compliance participants, which was much higher than the average compliance rate of about 70% in similar domestic college student exercise intervention studies. The core reason lay in the precise adaptation of the exercise program to the characteristics of college freshmen: the short duration of 30–45 minutes per session avoided the occupation of academic time by long-time exercise; moderate intensity and freely selectable exercise items reduced the participation threshold for freshmen without exercise habits; the fixed time period of 16:00–18:00 after class avoided unsuitable exercise times such as lunch break, evening self-study, and late night, minimizing time conflicts. This result fully proved that the short-burst moderate-intensity aerobic exercise mode constructed in this study had extremely strong operability and popularization value and solved the core pain point of "low compliance and difficult implementation" of traditional exercise intervention.

Dose-Response Relationship Between Exercise Compliance and Intervention Effect

To verify the dose-response relationship of "the higher the exercise input, the better the improvement effect", one-way ANOVA was carried out on the sleep improvement amplitude of different compliance groups, and the results showed that: The difference in total PSQI score before and after the intervention in the high compliance group was 6.23 ± 2.08 ; The difference in the medium compliance group was 4.87 ± 1.92 ; The difference in the low compliance group was 2.15 ± 1.67 ; The difference between the three groups was extremely significant ($F=32.67$, $P<0.001$). Post hoc pairwise comparison showed that high compliance group > medium compliance group > low compliance group, with significant differences ($P<0.05$).

This result was fully consistent with the previous correlation analysis, further verifying the core role of exercise frequency in sleep improvement. At the same time, it provided a clear direction for practical application: to

obtain a stable sleep improvement effect, it was necessary to maintain at least 3 times of moderate-intensity aerobic exercise per week, and more than 4 times per week could obtain the optimal effect.

Output of the Study

CONTEXTUALIZED AEROBIC EXERCISE MODEL

A. Rationale

This 8-week contextualized aerobic exercise model is developed based on the quasi-experimental findings of the present study with 168 college freshmen (PSQI ≥ 7) from Gongqing College of Nanchang University. Findings reveal that 84.5% of the subjects experienced moderate to severe sleep disorders, with academic stress being the predominant psychological factor. The short burst moderate intensity approach demonstrated a 90.4% compliance rate, which is significantly higher compared to long-term or high-intensity approaches. Analysis demonstrated a two-factor approach: direct regulation (68%) and indirect regulation via decreased academic stress (32%). Based on the theoretical frameworks of Sleep Regulation Theory and Cognitive Behavioral Theory, the design is applicable in the context of college freshmen with fragmented schedules, little or no physical activity experience, and increased transitional stress.

B. General Objectives

To establish a replicable, student-centered 8-week short-burst moderate-intensity aerobic exercise intervention integrating physical activity, academic stress mitigation, and sleep health education too:

Improve sleep quality among college freshmen;

Reduce academic stress during the transitional freshman year;

Promote sustainable healthy exercise and sleep behaviors;

Provide a standardized non-pharmacological sleep intervention for higher education institutions.

C. Specific Objectives

Describe evidence-based exercise parameters for 30–45-minute sessions occurring 3-5 times weekly at 60-70% age-predicted max heart rate. Standardize the three-phased routine to include warm-up, exercise phase and cool down for safety and effectiveness. Include stress management measures for academics that allow the activation of the 32% mediation factor focusing on test-taking and academic performance related stress. Develop interventions tailored by level of compliance, gender and stress relating to the field of study (e.g. higher levels of stress in engineers).

Establish a comprehensive monitoring system using the PSQI, Academic Stress Scale, and exercise adherence logs. Attain a minimum overall adherence rate of 85% and a clinical sleep improvement rate of over 8 weeks. Produce a practical implementation manual for university physical education and mental health services.

D. Activities and Responsible Parties

Phase	Key Activities	Responsible Parties
Pre-intervention	Screening with PSQI and Academic Stress Scale; enrollment and informed consent; safety and protocol training	University Health Center, PE Department, Freshman Counselors, Research Team
Core Exercise Intervention	Supervised group exercise (jogging, badminton, rope skipping, aerobics); scheduled 16:00–18:00; adherence tracking; intensity monitoring	PE Teachers, Peer Mentors, Class Sports Representatives
Stress & Sleep Education	Integrated stress coping guidance; sleep hygiene education to reduce problematic late-night phone use and irregular sleep	Mental Health Center, Counselors, Research Team
Support & Motivation	Weekly progress feedback; incentives and PE credit recognition for high adherence	Student Affairs Office, Counselors, Peer Mentors

E. Implementation Timeline

Period	Key Tasks
Week 0 (Baseline)	Demographic, PSQI, and academic stress assessments; participant orientation
Weeks 1–2 (Adaptation)	3 sessions/week, 30 min, 60%–65% HRmax; mastery of warm-up and cool-down

Period	Key Tasks
Weeks 3–6 (Intensification)	4–5 sessions/week, 40–45 min, 65%–70% HRmax; diversified exercise modes
Weeks 7–8 (Consolidation)	3–5 sessions/week, 45 min; promotion of self-regulated exercise
Within 48 h post-intervention	Post-test (PSQI, academic stress); adherence data collection and analysis

F. Monitoring and Evaluation

Monitoring Process: Adherence rate: actual times / intended times $\times 100\%$, categorized as high (≥ 4 /week), moderate (3/week), low (≤ 2 /week); Intensity assessment: random monitoring of heart rate to keep the intensity between 60%~70% HRmax; Attending rate checking; Weekly prompts for absent participants.

Outcome Evaluation: Primary Outcome: Global PSQI and individual domain scores (i.e., sleep latency, efficiency, disturbance, daytime dysfunction); Secondary Outcome: Academic stress total and subscale scores; Clinically important difference: percentage meeting PSQI < 7 and decreased moderate-severe sleep problems (PSQI ≥ 10).

Quality Assurance: Training on standardized evaluation and administration process; Data entry by duplication and confirmation; Weekly supervisor meetings for adherence.

G. Expected Outcomes

Short-Term (8 Weeks): Sleep(PSQI reduced from 12.52 to ~ 7.15 , with a clinical improvement rate of 73.3%);Stress:(significant reductions in academic stress, especially learning burden, test pressure, and performance anxiety);Adherence(overall effective adherence $\geq 90\%$, high adherence $\geq 55\%$);Behavior(improved exercise regularity and sleep-related habits).

Medium-Term (1 Month Post-Intervention): Sustained sleep improvements with minimal rebound. Over 60% of participants maintain ≥ 3 exercise sessions weekly.

Long-Term (Institutional): Model integrated into freshman orientation and PE curricula; Scalable “exercise–stress–sleep” integrated framework for university health promotion.

Findings

The study looked at the association between short burst of moderate-intensity aerobic activity, academic stress, and quality of sleep among freshmen in universities. Here are some of the findings of this study: First, short bursts of moderate-intensity aerobic exercise were discovered to be positively associated with sleep quality, since those who exercised had improved sleep efficiency, increased sleep duration, and reduced sleep disturbance. Second, there was a negative association between academic stress and sleep quality, since the more academic stress one experienced, the poorer their sleep quality became. In addition, the mediation effect revealed that academic stress partially mediated the effects of exercise on sleep quality. This meant that short burst moderate-intensity aerobic exercises not only improved sleep quality directly, but also helped in lowering academic stress, thus improving sleep quality.

Conclusion

This study took 168 college freshmen with poor sleep as the research subjects. Through an 8-week short-term moderate-intensity aerobic exercise quasi-experimental intervention, it explored the impact of exercise on the sleep quality of freshmen and the mediating role of academic pressure. Corresponding to the 7 pre-set research questions, the following conclusions were drawn:

The effective sample of this study was 168 people, with 54.8% being female, 61.9% aged 17-18, and 51.2% majoring in liberal arts. The sample met the characteristics of college freshmen and had good representativeness. Before the intervention, the sleep quality of freshmen was generally poor, with 84.5% of the sample having moderate to severe sleep problems, and the academic pressure was at a medium to upper level. Stress factors included academic load, examination stress, and concern for grades.

Eight weeks of moderate-intensity aerobic training were found to have positive effects on the sleep quality of freshmen college students. Following the intervention program, the total PSQI score fell from 12.52 to 7.15. Core factors including sleep latency, sleep efficiency, sleep disturbance, and day-time dysfunction all made highly significant changes.

The clinical improvement rate reached 73.3%, and the research hypothesis H1: Moderate-intensity aerobic exercise can significantly improve the sleep quality of college freshmen in the short term. Validated.

The duration, intensity, and frequency of exercise were all extremely significantly negatively correlated with sleep quality and academic pressure. Among them, the correlation of exercise frequency was the strongest, indicating that regular exercise was the core factor for improving sleep. Research hypothesis H2: The duration, intensity, and frequency of aerobic exercise were significantly correlated with sleep quality. Validated.

8 weeks of short-term moderate-intensity aerobic exercise could significantly alleviate the academic pressure of college freshmen. After the intervention, the total academic pressure score decreased from 18.32 points to 12.80 points. All dimensions showed extremely significant decreases, and the alleviation of academic pressure was extremely significantly positively correlated with the improvement of sleep quality. Academic pressure played a partial mediating role between short-term moderate-intensity aerobic exercise and the sleep quality of college freshmen. The mediating effect size was 32.0%, meaning that aerobic exercise could directly improve sleep quality or indirectly improve it by alleviating academic pressure.

The short-term moderate-intensity aerobic exercise model of this study had extremely high compliance. The total effective compliance rate of the 8-week intervention reached 90.4%, and the compliance with exercise was significantly related to the improvement of sleep. The improvement effect of the high compliance group was significantly better than that of the medium and low compliance groups. Based on the research results, a contextualized short-term moderate-intensity aerobic exercise sleep intervention model suitable for college freshmen was successfully constructed. The core parameters were: single exercise duration of 30–45 minutes, 3–5 times per week, and exercise intensity controlled at 60%–70% of the maximum heart rate. Combined with a standardized process of "warm-up - formal exercise - relaxation", and in combination with academic pressure counseling and sleep cognition education, research hypothesis H3: A contextualized aerobic exercise intervention model suitable for college freshmen can be constructed. Validated.

In conclusion, this study confirmed the partial mediating role of academic stress between short-term moderate-intensity aerobic exercise and sleep quality. The mediating effect size reached 32.0%, which was the core theoretical innovation point of this study and filled the gap in existing research.

From the perspective of the theoretical framework, the results of this study perfectly aligned with the pre-set sleep regulation theory and cognitive-behavioral theory, constructing a complete theoretical model of "exercise intervention → physiological regulation + psychological stress reduction → sleep improvement". From the perspective of cognitive-behavioral theory, regular exercise, as an active and controllable behavioral intervention, helped freshmen establish stable behavioral patterns and self-efficacy in the uncertain period of entering college, reshaped their cognitive evaluation of academic stress, shifted from "passively bearing stress" to "actively responding to stress", reduced anxiety and bedtime rumination caused by stress, and thereby reduced the interference of stress on sleep. From the perspective of sleep regulation theory, exercise directly lowered cortisol levels, inhibited the excessive activation of the HPA axis, relieved physical arousal caused by stress at the physiological level, achieved dual stress reduction in both physiology and psychology, and ultimately improved sleep quality together.

Current studies on the mediating mechanism of exercise and college students' sleep mostly focused on common psychological variables such as anxiety, depression, and life satisfaction. For example, Mo Han He et al.'s 2025 study focused on the chain mediating effect of health literacy and life satisfaction but ignored the most core and specific stressor for college freshmen - academic stress. This study precisely targeted the core stressor during the freshmen's adaptation period, clarified the mediating effect of academic stress, enriched the research system of exercise sleep medicine in special groups, provided new empirical support for the application of sleep regulation theory and cognitive-behavioral theory in college freshmen, and had important theoretical supplementary value.

At the same time, this study confirmed that the mediating effect was partial, with a direct effect ratio of 68.0%. This indicated that exercise had a multi-path improvement on sleep; in addition to the psychological mediation of academic stress, there was also a direct physiological regulatory effect. This result suggested that when conducting sleep intervention for freshmen, a comprehensive model of "exercise intervention + stress counseling + sleep education" should be adopted, which not only utilized the direct physiological regulatory effect of exercise, but also strengthened the indirect psychological effect through stress management, achieving the maximization of intervention effects.

Recommendations

Recommendations for Educators

Educators should establish an integrated intervention system of exercise–sleep–mental health for college freshmen. The 8-week short-burst moderate-intensity aerobic exercise program verified in this study should be integrated into freshman orientation education and physical education courses with credit recognition and implemented right after military training. Targeted small-class interventions should be provided for freshmen with poor sleep quality (PSQI ≥ 7) and high academic stress. Campus sports facilities should be adequately available during 16:00–18:00, and low-threshold aerobic activities such as jogging, rope skipping, badminton and aerobics should be promoted to reduce participation barriers. Educators should cooperate with mental health counselors to carry out group counseling, lectures and publicity on exercise, sleep and stress management, help students correct unhealthy habits such as staying up late and using mobile phones before bedtime, and teach stress relief and relaxation skills. A regular screening mechanism should be established to include the PSQI and academic stress scale in freshman physical examination and mental health survey, so that students with severe sleep problems can receive timely support and referral.

Recommendations for Educational Policies

Educational authorities should improve the health management policy system for university students. Sleep quality, physical health and physical activity participation should be included in the quality assessment of talent cultivation in higher education institutions, clarifying the responsibilities of colleges in sleep management, physical exercise and mental health education. Physical education curriculum reform should be promoted to shift from competitive skill-oriented teaching to health-adapted teaching, with special aerobic exercise courses designed for freshmen covering knowledge of sleep, stress and health. Special funds should be allocated to support research and practical programs on college students' sleep health, and evidence-based exercise intervention plans should be widely promoted to improve the scientific and effectiveness of sleep health services in universities.

Recommendations for Future Research

Future studies may adopt a multi-center, large-sample randomized controlled trial design with blank and active control groups to improve internal validity and eliminate confounding factors. Objective sleep monitoring such as polysomnography and wearable devices can be combined with biochemical indicators including cortisol, serotonin and melatonin to reveal the physiological mechanism of exercise on sleep structure and neuroendocrine regulation more accurately. The intervention period can be extended to 12 weeks, with long-term follow-ups at 3, 6 and 12 months to examine the sustainability of effects and strategies for maintaining exercise habits. More mediating and moderating variables such as anxiety, depression, self-efficacy, circadian rhythm and family environment can be included to build a more comprehensive exercise–sleep mechanism model. Personalized intervention protocols can be developed for freshmen of different genders, majors and sleep conditions to achieve precise intervention. An online–offline blended model supported by digital tools such as exercise check-up mini-programs and AI coaching can be explored to improve accessibility and sustainability.

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