



Exercise-related tendencies, internet addiction, academic stress, and subjective sleep quality among junior high school students

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Abstract: This study examined the associations between physical exercise-related tendencies and subjective sleep quality and the roles of Internet addiction and academic stress in this relationship. A self-report survey was conducted with 740 Chinese junior high school students (54.5% female; mean age = 13.58 years, SD = 1.05). Path analysis indicated that physical exercise-related tendencies were positively associated with subjective sleep quality and negatively associated with Internet addiction and academic stress. Academic stress was negatively associated with subjective sleep quality, whereas Internet addiction was not independently associated with subjective sleep quality after accounting for academic stress. Bootstrapped indirect-effect analysis showed a significant indirect association through academic stress and a significant sequential indirect association through Internet addiction and academic stress, but the independent indirect association through Internet addiction was not significant. From a stress-related behavioural perspective, these findings suggest that adolescent sleep-related research and school health practice may benefit from considering exercise-related tendencies, problematic Internet use, and academic stress together. Findings should be interpreted as cross-sectional associations rather than causal effects.

Keywords: Physical exercise-related tendencies; subjective sleep quality; internet addiction; academic stress; sequential indirect association

Introduction

In adolescence, sleep is closely related to cognitive functioning, emotional regulation, and social adaptation (Chaput et al., 2016). However, sleep problems remain common among school-aged adolescents. In the digital age, insufficient sleep and sleep difficulties co-occur with factors such as screen-based media use, academic demands, and limited physical activity (Brosnan et al., 2024; Han et al., 2024; Zhang et al., 2022).

Internet addiction and academic stress are relevant correlates of adolescent sleep, yet their roles in the relationship between exercise-related tendencies and subjective sleep quality remain underreported in junior high school populations. Clarifying these associations may help inform research and school-based health practice.

Accordingly, the present study examined the roles of Internet addiction and academic stress in the relationship between physical exercise-related tendencies and subjective sleep quality among junior high school students. The study was designed to describe cross-sectional association patterns rather than to test causal mechanisms.

Physical exercise and sleep quality

Physical exercise-related tendencies refer to students' commitment to and adherence to regular physical exercise. Subjective sleep quality refers to an individual's global self-evaluation of recent sleep. Although sleep quality can be conceptualised as a multidimensional construct that includes sleep onset, duration, efficiency, disturbances, and daytime dysfunction (Buysse et al., 1989),

the present study focuses specifically on subjective sleep quality. Prior literature has linked physical activity and exercise-related engagement with sleep-related outcomes (Bello et al., 2023; Kredlow et al., 2015; Yan et al., 2025). Broader review evidence also links physical activity with adolescent mental health and well-being (Biddle & Asare, 2011). However, because the present study did not directly assess exercise dose or biological mechanisms, these explanations are used only as background for the hypothesised associations.

The mediating role of internet addiction

Internet addiction refers to a pattern of excessive or poorly controlled Internet use that may interfere with daily functioning (Young, 1998). In adolescent populations, exercise-related engagement and problematic Internet use may be inversely related. Earlier reviews linked screen-based media use with sleep-related outcomes in children and adolescents (Cain & Gradisar, 2010; Hale & Guan, 2015), and experimental work has examined sleep and circadian timing in relation to evening light-emitting device use (Chang et al., 2015). More recent adolescent research also links problematic Internet use with poorer sleep-related outcomes (Gong et al., 2024; Li et al., 2024). Together, this literature supports examining Internet addiction as a correlate of subjective sleep quality.

Recent youth-focused and updated reviews have described associations between bedtime or screen-based media use and sleep outcomes in children and adolescents (Brosnan et al., 2024; Han et al., 2024; Zhang et al., 2022).



Earlier reviews and meta-analyses report similar patterns across school-aged populations (Carter et al., 2016; Hale & Guan, 2015). These findings support the relevance of examining Internet addiction as a correlate of subjective sleep quality, although the present study does not test the mechanisms proposed in prior literature.

Mediating role of academic stress

Academic stress refers to perceived pressure, burden, and strain related to schoolwork, examinations, and academic expectations. Prior reviews indicate that physical activity is relevant to adolescent mental health and well-being (Biddle & Asare, 2011), suggesting that exercise-related variables and academic stress may be meaningfully connected in student populations.

The relationship between academic stress and sleep-related outcomes has been documented in student samples (Herawati & Gayatri, 2019; Huang et al., 2024; Wang & Fan, 2023). For example, students with poorer sleep quality have reported higher stress levels than those with better sleep quality (Herawati & Gayatri, 2019), and recent work with Chinese adolescents has described links between academic stress and sleep quality through anxiety- and burnout-related processes (Wang & Fan, 2023).

More broadly, perceived stress has been associated with poorer sleep quality among students, and psychological symptoms may be relevant correlates in this association (Herawati & Gayatri, 2019; Huang et al., 2024; Wang & Fan, 2023). Together, these findings support examining academic stress as a correlate within the present model.

Chain mediation of internet addiction and academic stress

Prior work suggests that problematic Internet use is associated with stress-related outcomes in adolescent and student populations (Salmela-Aro et al., 2017; Younes et al., 2016). More recent studies have similarly linked problematic Internet use with sleep-related and health-related outcomes among adolescents (Gong et al., 2024; Li et al., 2024). These variables may therefore form part of the same association network as exercise-related tendencies and sleep-related outcomes. However, the direction and temporal ordering of these relationships cannot be established from cross-sectional data.

Prior work has also indicated that problematic Internet use and screen-related exposure are linked to poorer sleep-related outcomes (Brosnan et al., 2024; Gong et al., 2024; Li et al., 2024). Academic stress-related experiences have likewise been associated with sleep quality and sleep-related outcomes in student samples (Herawati & Gayatri, 2019; Huang et al., 2024; Wang & Fan, 2023). On this basis, it is reasonable to examine whether the association between physical exercise-related tendencies and subjective sleep quality includes indirect associations involving both Internet addiction and academic stress.

Goal of the study

The present study examined the association between physical exercise-related tendencies and subjective sleep quality in junior high school students and the roles of Internet addiction and academic stress in that relationship.

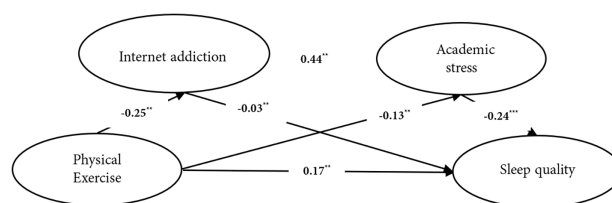


Figure 1. Statistical indirect-association model. *Note.* ** $p < 0.01$, *** $p < 0.001$.

Based on the literature review and conceptual framework (see Figure 1), the following hypotheses were tested in a sample of junior high school students:

Hypothesis 1: Physical exercise-related tendencies are associated with higher subjective sleep quality.

Hypothesis 2: Internet addiction shows an indirect association between physical exercise-related tendencies and subjective sleep quality.

Hypothesis 3: Academic stress shows an indirect association between physical exercise-related tendencies and subjective sleep quality.

Hypothesis 4: Internet addiction and academic stress show a sequential indirect association between physical exercise-related tendencies and subjective sleep quality among junior high school students.

Method

Participants and procedures

A questionnaire survey was conducted among junior high school students using stratified cluster sampling. Of 775 survey forms distributed, 740 valid responses were retained after excluding invalid questionnaires with conventional answers or missing data, yielding an effective response rate of 95.5%. The sample consisted of 337 males and 403 females (54.5% female). Participants ranged in age from 12 to 15 years ($M = 13.58$, $SD = 1.05$). The sample included 315 first-year students, 199 second-year students, and 226 third-year students.

In accordance with the Declaration of Helsinki, this study was approved by the Academic Committee of the School of Physical Education and Health, Zhaoqing University (No. 2025029). All participants were informed of the purpose and nature of the study and signed an informed consent form. Participation was voluntary and confidentiality was guaranteed. Consent was obtained from teachers and students during the testing process.

Measures

Physical exercise

The revised Physical Exercise Scale for College Students by Wu (2016), adapted from the Physical Exercise Commitment Intention Scale developed by Chen et al. (2006), was used to assess physical exercise-related tendencies. This measure reflects exercise-related tendencies rather than objective exercise behaviour such as frequency, duration, or intensity. The scale consists of eight items covering physical exercise commitment (e.g., "It is difficult to ask me to withdraw from physical exercise.") and physical exercise adherence (e.g., "I do a good job of staying physically active."). A 5-point Likert scale was used

Table 1. Correlation analysis of study variables

Variable	M	SD	1	2	3	4
1. Physical exercise-related tendencies	26.71	6.10	1			
2. Internet addiction	2.43	1.04	−0.24**	1		
3. Academic stress	10.07	4.26	−0.26**	0.47**	1	
4. Subjective sleep quality	3.09	0.65	0.23**	−0.19**	−0.30**	1

Note. N = 740; ** $p < 0.01$.

(1 = strongly disagree, 5 = strongly agree), and higher total scores indicated stronger exercise-related commitment and adherence tendencies. In this study, Cronbach's alpha was 0.91.

Sleep quality

Subjective sleep quality was measured using the single global subjective sleep quality item from the Pittsburgh Sleep Quality Index (PSQI) developed by Buysse et al. (1989). The item asks: "During the past month, how would you rate your sleep quality overall?" In the original questionnaire, 1 = very good, 2 = fairly good, 3 = fairly bad, and 4 = very bad. For ease of interpretation, the item was reverse scored so that higher scores indicated better subjective sleep quality. This item captures only respondents' global subjective evaluation of sleep and does not represent the full multidimensional PSQI construct.

Internet addiction

The short version of the Internet Addiction Diagnostic Questionnaire developed by Young (1998) consists of eight items (e.g., "Feeling that I need to spend more time online to be fulfilled"). Items were scored on a 6-point Likert scale (1 = not at all, 6 = completely). Mean scores were used, with higher scores indicating greater Internet addiction tendencies. In this study, Cronbach's alpha was 0.92.

Academic stress

Academic stress was assessed using the Academic Stress Scale from the Chinese Secondary School Students' Mental Health Scale developed by Wang et al. (1997). This scale consists of six items (e.g., "I feel a heavy burden of study."). Items were scored on a 5-point Likert scale (1 = never, 5 = severe). Higher total scores indicated greater academic stress. In this study, Cronbach's alpha was 0.88.

Data analyses

Descriptive analysis, Pearson correlation analysis, independent-samples *t*-tests, one-way ANOVA, multiple regression analysis, and chain mediation analysis using PROCESS were performed in SPSS 26.0. Differences were considered statistically significant at $p < 0.05$. Age and gender were controlled for in the analyses. BMI, socioeconomic status, mental health, and actual device-use indicators were not collected and therefore could not be included as covariates.

Results

Common method bias test

Harman's single-factor test was used as a preliminary assessment of common method variance. Five factors had eigenvalues greater than 1, and the first factor explained 34.49% of the variance, below the conventional 40% threshold. Nevertheless, because all variables were collected by self-report at a single time point, common method bias cannot be fully excluded.

Descriptive statistics and correlation analysis

As shown in Table 1, the correlations among physical exercise-related tendencies, Internet addiction, academic stress, and subjective sleep quality were statistically significant. Physical exercise-related tendencies were negatively correlated with Internet addiction and academic stress and positively correlated with subjective sleep quality. Internet addiction was positively correlated with academic stress and negatively correlated with subjective sleep quality, and academic stress was negatively correlated with subjective sleep quality. These findings provided preliminary support for the proposed association pattern.

Path analysis and statistical indirect associations

The mediation analysis was conducted using the non-parametric percentile bootstrap method proposed by Hayes (2017) with PROCESS macro Model 6, a 95% confidence interval, and 5000 bootstrap samples. Given the cross-sectional design, the mediation results are interpreted as statistical indirect associations rather than evidence of causal mechanisms.

We first examined the direct association between physical exercise-related tendencies and subjective sleep quality. The direct path was significant ($\beta = 0.17$, $p < 0.01$, 95% CI [0.08, 0.26]), supporting Hypothesis 1. Physical exercise-related tendencies were negatively associated with Internet addiction ($\beta = -0.25$, $p < 0.01$, 95% CI [−0.34, −0.17]), whereas Internet addiction was not significantly associated with subjective sleep quality after accounting for the other variables in the model ($\beta = -0.03$, $p > 0.05$, 95% CI [−0.13, 0.06]); therefore, Hypothesis 2 was not supported. Physical exercise-related tendencies were negatively associated with academic stress ($\beta = -0.13$, $p < 0.01$, 95% CI [−0.21, −0.05]), and academic stress was negatively associated with subjective sleep quality ($\beta = -0.24$, $p < 0.01$, 95% CI [−0.34, −0.14]), supporting Hypothesis 3. Internet addiction was positively associated with academic stress ($\beta = 0.44$, $p < 0.01$, 95% CI [0.36, 0.52]), supporting Hypothesis 4. The bootstrap analysis showed a significant indirect association through academic stress and a significant sequential

Table 2. Statistical indirect associations and effect sizes

Paths	Indirect effect	Relative indirect effect	95% CI
Physical exercise-related tendencies → Internet addiction → Subjective sleep quality	0.008	0.008/0.066 = 12.12%	[−0.02, 0.03]
Physical exercise-related tendencies → Academic stress → Subjective sleep quality	0.031	0.031/0.066 = 46.97%	[0.01, 0.06]
Physical exercise-related tendencies → Internet addiction → Academic stress → Subjective sleep quality	0.027	0.027/0.066 = 40.91%	[0.01, 0.04]
Total effect	0.066		[0.04, 0.10]

indirect association through Internet addiction and academic stress, whereas the independent indirect association through Internet addiction was not significant (Table 2).

Discussion

Physical exercise and sleep quality

The results showed that physical exercise-related tendencies were positively associated with subjective sleep quality among junior high school students, supporting Hypothesis 1. This finding is broadly consistent with previous literature linking physical activity and exercise-related engagement with sleep-related outcomes (Bello et al., 2023; Kredlow et al., 2015; Yan et al., 2025). It is also consistent with broader review evidence on physical activity and adolescent mental-health outcomes (Biddle & Asare, 2011). However, because the present study used a cross-sectional self-report design and did not assess objective exercise dose or biological processes, the observed association should not be interpreted as evidence that exercise caused better sleep in this sample.

Independent mediating effects of internet addiction

Physical exercise-related tendencies were negatively associated with Internet addiction, but the independent indirect association through Internet addiction was not significant. Prior studies have linked problematic screen-based media use with sleep outcomes (Brosnan et al., 2024; Han et al., 2024). Other adolescent research has similarly linked problematic Internet use with poorer sleep-related outcomes (Gong et al., 2024; Li et al., 2024). However, the present model suggests that Internet addiction may be related to subjective sleep quality mainly when considered together with academic stress rather than as a stand-alone pathway. This interpretation remains tentative because the present design cannot establish temporal order or directionality.

Independent mediating effects of academic stress

Academic stress showed a significant indirect association between physical exercise-related tendencies and subjective sleep quality, supporting Hypothesis 3. This pattern is consistent with prior evidence that physical activity is relevant to adolescent mental health (Biddle & Asare, 2011). It also aligns with research linking stress to sleep-related outcomes in student populations (Herawati & Gayatri, 2019; Huang et al., 2024; Wang & Fan, 2023). The present findings suggest that academic stress may be an especially relevant correlate within this association network, although causal interpretation is not warranted.

Chain mediation of internet addiction and academic stress

The sequential indirect association through Internet addiction and academic stress was significant. This finding is consistent with prior research suggesting that stress-related experiences and problematic Internet use are related in adolescents and students (Gong et al., 2024; Salmela-Aro et al., 2017; Younes et al., 2016). It is also consistent with evidence linking problematic Internet use and academic stress to sleep-related outcomes (Han et al., 2024; Li et al., 2024; Wang & Fan, 2023). Statistically, the present pattern is possible because Internet addiction was strongly associated with academic stress, and academic stress in turn was associated with subjective sleep quality, while the direct association between Internet addiction and subjective sleep quality was weak after other variables were considered. The result therefore indicates a conditional association structure within the specified model rather than proof of a causal chain.

Practical implications

This study contributes cross-sectional evidence on the association pattern among physical exercise-related tendencies, Internet addiction, academic stress, and subjective sleep quality in Chinese junior high school students. By examining these variables together in this population, the study offers a context-specific association pattern that may inform future longitudinal tests of adolescent sleep-related processes. The findings align with recent research on adolescent sleep and problematic Internet use (Gong et al., 2024; Han et al., 2024). They also connect with work on academic stress and exercise-related sleep outcomes (Wang & Fan, 2023; Yan et al., 2025). These results may help guide future longitudinal and intervention studies, but they should not be taken as direct evidence that modifying any single variable will necessarily improve sleep quality.

Limitations and future directions

Several limitations should be considered. First, the cross-sectional design precludes conclusions about temporal order, directionality, or causality; future longitudinal and experimental studies are needed. Second, subjective sleep quality was measured with a single PSQI item rather than the full multidimensional instrument. This approach captures only a global self-evaluation of sleep and may reduce reliability, omit important dimensions such as sleep latency, duration, efficiency, and disturbances, and limit the generalisability of the findings. Third, all variables were collected by self-report at a single time point. Although

Harman's single-factor test did not indicate severe common method variance, this procedure cannot fully rule out common method bias. Fourth, potentially important confounders, including BMI, socioeconomic status, mental health, and actual device use, were not collected and therefore could not be controlled. Future work should use more comprehensive sleep measures, multi-method assessment, and designs capable of testing temporal and causal processes.

Conclusion

In conclusion, physical exercise-related tendencies were positively associated with subjective sleep quality among junior high school students. Academic stress showed a significant indirect association in this relationship, and a sequential indirect association involving Internet addiction and academic stress was also observed. By contrast, the independent indirect association through Internet addiction was not significant. These findings describe a cross-sectional association pattern and should be interpreted cautiously rather than as evidence of causal pathways.

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Availability of Data and Materials: Individual-level data generated and analysed during the current study are not publicly available because the study involved junior high school students and the informed consent procedures required anonymous data handling and aggregate reporting. No supplementary data files are available for this study.

Ethics Approval: This study was reviewed and approved by the Academic Committee of the School of Physical Education and Health, Zhaoqing University (No. 2025029). Informed consent was obtained from all individual participants included in the study. For participants who were under 16 years of age, informed consent was obtained from their parents or legal guardians.

Conflicts of Interest: The authors declare no conflicts of interest.

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