The effect of mobile phone dependence on sleep quality in college students: The chain-mediated role of self-control and sleep procrastination

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ABSTRACT

Objective: This study, based on behavioral addiction and cognitive control theories, investigates the impact of smartphone dependence on the sleep quality of college students and the mediating roles of self-control and sleep procrastination. The aim is to provide recommendations for reducing smartphone dependence and improving sleep quality among college students. **Method:** The research utilized a questionnaire survey method, conducting an online survey of domestic college students through the Questionnaire Star platform, with a total of 317 valid responses. **Results:** (1) There were no significant differences in smartphone dependence, self-control, sleep procrastination, and sleep quality among college students based on demographic variables such as gender and hometown. Smartphone dependence was at a moderate level, while self-control and sleep procrastination were slightly above average. In comparison to the critical threshold for determining sleep problems, college students scored relatively high in sleep quality, indicating poor sleep quality. (2) Smartphone dependence showed a significant negative correlation with self-control and a significant positive correlation with sleep procrastination and sleep quality. Self-control exhibited a significant negative correlation with sleep procrastination and sleep quality. Sleep procrastination demonstrated a significant positive correlation with sleep quality. (3) Self-control and sleep procrastination played a chain-mediated role between smartphone dependence and sleep quality. **Conclusion** College students' smartphone dependence moderately reduces sleep quality, with self-control and sleep procrastination playing crucial mediating roles. Therefore, reducing smartphone dependence, enhancing self-control, and avoiding sleep procrastination are essential measures to improve sleep quality among college students.

KEYWORDS: mobile phone dependence; self-control; sleep procrastination; sleep quality; college student.

1. INTRODUCTION

Mobile phone dependence has become a hot research topic in recent years for psychologists, educators, and sociologists. It is a type of compulsive behavior that can directly affect an individual's physical and mental health(C. Chen & Zhang, 2021). The development of smartphones has brought us many conveniences, and nowadays, almost every college student has one or more phones, making them the primary user group of smartphones. However, contemporary college students are still in a period of physical and mental development, and they lack sufficient resistance to online products, making it easy for them to become addicted to their phones. This addiction not only affects their physical and mental health but also reduces their learning efficiency and social adaptability(Tian & Zhao, 2021).

Research indicates that excessive dependence on mobile phones is closely related to anxiety and insomnia. Prolonged use of mobile phones may lead to headaches, lack of concentration, and even physiological disorders(Söderqvist et al., 2008). Additionally, using a mobile phone before bedtime is linked to sleep quality; students with more severe mobile phone dependence are more likely to experience sleep problems, which can reduce sleep quality(Zhou et al., 2019).

Tan Shuhua and others proposed that self-control involves the inhibition of temptations and desires, changing bad habits, and shifting thinking patterns, all to achieve more long-term goals(Tan & Guo, 2008). The Self-Control Scale, developed by Tangney in 2004, is highly representative and is the most commonly used scale in

this field of research(Tangney et al., 2004). It has a wide range of applications and high standards of reliability and validity. Previous studies have revealed that self-control can significantly affect mobile phone addiction(Zhang et al., 2019). According to the self-control energy model, individuals can achieve self-control only by expending a certain amount of mental resources. However, these psychological resources are limited, and if the expenditure exceeds the limit, it will lead to control failure(Baumeister et al., 2007).

In studies related to self-control and procrastination behavior, researchers have explored the relationship between self-control learning and academic procrastination(H. Li et al., 2019)(M. Chen et al., 2021). Kamphorst and others used event-based retrospection to study individuals' control over their desires. The results showed that the more often individuals control their desires during the day, the more likely they are to experience sleep procrastination at night(Kamphorst et al., 2018). Kühnel and others added the "yesterday" restriction to all items in the original BPS and reduced the number of items to six to assess the severity of sleep procrastination behavior using a 5-point scoring method(Kühnel et al., 2018). Kroes and others defined sleep procrastination as the phenomenon where individuals, despite scheduling a sleep time, continuously delay going to sleep due to various subjective and objective reasons, ultimately making procrastination a habitual behavior(Kroese, De Ridder, et al., 2014). Kroes and his team also developed the "Sleep Procrastination Scale" to measure the degree of individuals' sleep procrastination(Kroese, Evers, et al., 2014). This scale has high internal consistency, good item discrimination, and a suitable factor structure, making it effective for measuring individuals' sleep procrastination status(Ma et al., 2021). From the perspective of emotional regulation, Sirois and others proposed that sleep procrastination behavior is a form of short-term emotional repair, an inappropriate emotional regulation strategy(Sirois et al., 2018).

Regarding the issue of sleep procrastination, many scholars have analyzed its causes. This paper summarizes the following possible reasons through a review of relevant studies:
1. Self-Control: Research has found that those who tend to procrastinate on sleep often have poor self-control. These individuals expend significant mental resources during the day to resist temptations and regulate their behavior. By bedtime, their psychological resources are depleted, making them more susceptible to temptations, resulting in sleep procrastination.
2. Mobile Phone Dependence: Mobile phone dependence is a key factor in causing sleep procrastination(Lian et al., 2018). Many scholars have studied this, and research indicates that mobile phone dependence significantly predicts procrastination behavior(Z. Li et al., 2017). The more individuals are addicted to using their phones, the more likely they are to procrastinate on other tasks(Xie & Zou, 2018).

Regarding sleep quality issues, Buysse and others conducted an in-depth analysis of the characteristics of sleep quality, dividing it into seven dimensions. They also developed the Pittsburgh Sleep Quality Index (PSQI), which effectively measures and assesses sleep quality(Buysse et al., 1989).

Based on the issues pointed out in the above review of existing research, this study proposes the following hypotheses:
Hypothesis 1: Mobile phone dependence is significantly positively correlated with sleep quality scores.
Hypothesis 2: Self-control mediates the relationship between mobile phone dependence and sleep quality among college students.
Hypothesis 3: Sleep procrastination mediates the relationship between mobile phone dependence and sleep quality among college students.
Hypothesis 4: Self-control and sleep procrastination have a chain mediation effect between mobile phone dependence and sleep quality among college students.
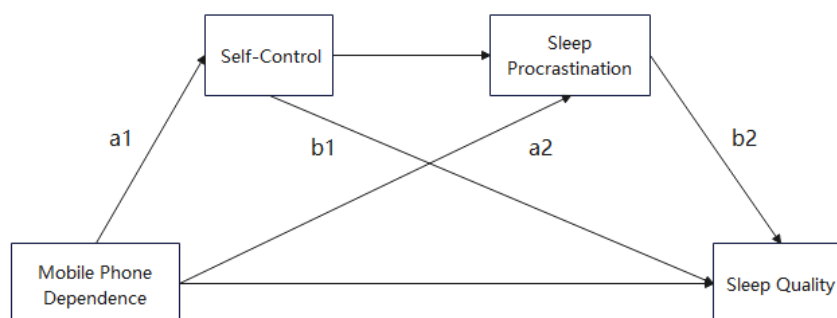

Figure 1. Theoretical Model

2. METHOD

2.1 Participants

This study conducted a questionnaire survey through the Wenjuanxing platform, randomly selecting 317 college students currently enrolled in school. Participants who were excluded from the study included those diagnosed with sleep disorders, those unwilling to participate, and those who had recently experienced significant life changes. The 317 participants came from various regions within the country, consisting of 147 males and 170 females, with 188 from rural areas and 129 from urban areas, making the sample relatively representative.

2.2 Research Tools

2.2.1 Mobile Phone Dependence Scale

This study used the Chinese version of the scale revised and compiled by Huang Hai et al., which can diagnose mobile phone addiction behaviors among college students and adolescents. It includes 17 items across 4 dimensions. Each item is scored, and the total score is calculated. Reliability and validity tests showed the consistency coefficients for the four dimensions were 0.81, 0.78, 0.75, and 0.75, respectively, with an overall internal consistency coefficient of 0.87.

2.2.2 Self-Control Scale

This scale comprises 19 items across 5 dimensions, using a Likert 5-point scoring method, with the highest and lowest scores being 5 and 1, respectively, representing "very true" and "not at all true." Some items are scored positively, while others are scored negatively. The scores for each item are summed and averaged to give a total score for the scale, ranging from 1 to 5. There is a significant positive correlation between the score and self-control ability. The scale's Cronbach's α coefficient is 0.850.

2.2.3 Sleep Procrastination Scale

This scale includes 9 items, using a Likert 5-point scoring method, with the highest and lowest scores being 5 and 1, representing "always" and "never." Some items are scored positively, while others are scored negatively. Each item is scored, and the total score is calculated and averaged to give a total score for the scale. There is a significant positive correlation between the total score and the degree of sleep procrastination; the higher the score, the higher the degree of procrastination. The Cronbach's α coefficient for this scale is 0.920, indicating high applicability.

2.2.4 Pittsburgh Sleep Quality Index (PSQI)

This scale comprises 18 items designed from 7 aspects, measuring subjective sleep quality, sleep disorders, etc., using a Likert 5-point scoring method, with the highest and lowest scores being 5 and 1. The scale includes both multiple-choice questions scored by the Likert method and some open-ended questions scored based on their components. Each component can be scored from 0 to 3, with different scores corresponding to different levels. The total score is calculated by summing the scores of each item, and there is a significant negative correlation between the total score and sleep quality; the higher the total score, the poorer the sleep quality. The scale has an α coefficient of 0.84, split-half reliability of 0.87, and test-retest reliability of 0.81.

2.3 Data Processing and Statistical Analysis

This study utilized SPSS statistical software and the PROCESS macro to perform various statistical analyses on the questionnaire data. These analyses included descriptive analysis, independent samples t-tests, one-way ANOVA, Pearson correlation analysis, and mediation effect testing. Through these analyses, the study aimed to understand the conditions of mobile phone dependence, self-control, sleep procrastination, and sleep quality among college students.

3. RESULTS

3.1 Common Method Bias Test

To check for the presence of common method bias, this study utilized Harman's single-factor test. All items from the four scales were analyzed. The results indicated that there were six factors with eigenvalues greater than 1. The first factor explained 27.95% of the variance, which is below the critical value of 40%. Thus, the common method bias in this study is within an acceptable range.

3.2 Basic Conditions and Correlations of Variables

Descriptive statistical analysis revealed that the average score for mobile phone dependence among college students was 3.24, slightly above the median of 3, indicating a certain degree of mobile phone dependence. Among the four dimensions of mobile phone dependence, withdrawal had the highest score, close to 3.3, suggesting that most college students experience negative emotions and withdrawal symptoms when they cannot

use their phones normally. The average score for self-control was 3.62, with similar scores across its dimensions, indicating a moderately high level of self-control among college students. The average score for sleep procrastination was 3.41, indicating a moderately high level of sleep procrastination among college students.

The PSQI index was used to analyze sleep quality, with a critical value of 7 points. The study found that the average PSQI score was 9.96, significantly higher than the critical value of 7 points, revealing relatively poor sleep quality among college students in China. Key factors affecting sleep quality included long sleep latency, slight use of hypnotic medication, and daytime dysfunction.

Table 1. Descriptive Statistics of Variables and Their Dimensions

Variable	Dimension	N	MIN	MAX	M	SD
Mobile Phone Dependence		317	1.29	4.82	3.24	0.94
	Uncontrolled	317	1.14	4.86	3.24	0.97
	Withdrawal	317	1.25	5.00	3.28	1.03
	Avoidance	317	1.00	5.00	3.20	1.08
	Inefficiency	317	1.00	5.00	3.22	1.09
Self-Control		317	1.26	4.58	3.62	1.00
	Impulse Control	317	1.17	4.83	3.61	1.06
	Healthy Habits	317	1.00	5.00	3.63	1.11
	Resisting Temptation	317	1.00	5.00	3.61	1.09
	Concentration on Work	317	1.00	5.00	3.64	1.14
	Moderation in Entertainment	317	1.00	5.00	3.63	1.08
Sleep Procrastination		317	1.33	4.78	3.41	0.99
PSQI		317	0.00	21.00	9.96	5.78
	Subjective Sleep Quality	317	0.00	3.00	1.39	1.10
	Sleep Latency	317	0.00	3.00	1.55	0.93
	Total Sleep Time	317	0.00	3.00	1.26	1.13
	Sleep Efficiency	317	0.00	3.00	1.20	1.12
	Sleep Disturbances	317	0.00	3.00	1.45	1.05
	Medication for Sleep	317	0.00	3.00	1.50	1.05
	Daytime Dysfunction	317	0.00	3.00	1.61	0.98

This study used Pearson's correlation coefficient to analyze the relationships between variables. The results show a significant positive correlation between mobile phone dependence and PSQI scores ($r = 0.37$, $p < 0.01$), indicating that higher levels of mobile phone dependence are associated with poorer sleep quality. There is a significant negative correlation between self-control and mobile phone dependence ($r = -0.39$, $p < 0.01$), meaning that higher levels of mobile phone dependence are associated with lower levels of self-control. Mobile phone dependence is significantly positively correlated with sleep procrastination ($r = 0.35$, $p < 0.01$), suggesting that individuals with higher mobile phone dependence are more likely to procrastinate sleep. Sleep procrastination is significantly positively correlated with PSQI scores ($r = 0.33$, $p < 0.01$), indicating that greater sleep procrastination is associated with poorer sleep quality. There is a significant negative correlation between self-control and sleep procrastination ($r = -0.37$, $p < 0.01$), suggesting that individuals with higher self-control are more likely to go to bed on time. Self-control is also significantly negatively correlated with PSQI scores ($r = -0.36$, $p < 0.01$), meaning that individuals with lower self-control have poorer sleep quality. These results emphasize the close relationship between mobile phone dependence, self-control, and sleep, highlighting their significant impact on individual sleep quality.

Table 2. Correlation Coefficients Among Variables

Variable	Mobile Phone Dependence	Self-Control	Sleep Procrastination	Sleep Quality
Mobile Phone Dependence	1			
Self-Control	-0.39**	1		
Sleep Procrastination	0.35**	-0.37**	1	
Sleep Quality	0.37**	-0.36**	0.33**	1

*Note: *p < 0.05, **p < 0.01, ***p < 0.001

3.3 Demographic Differences Among Variables
3.3.1 Gender Differences in Variables

Table 3. Gender Differences in Variables

	Male(N=147)		Female(N=170)			
Variable	M	SD	M	SD	t	P
Mobile Phone Dependence	3.22	0.92	3.26	0.97	-0.37	0.71
Self-Control	3.60	1.00	3.64	1.02	-0.28	0.78
Sleep Procrastination	3.36	0.99	3.46	1.00	-0.87	0.39
Sleep Quality	9.51	5.76	10.34	5.79	-1.28	0.20

As shown in Table 3, there are no significant gender differences in mobile phone dependence, self-control, sleep procrastination, and sleep quality.

3.3.2 Differences in Variables by Place of Origin

According to Table 4, this study used place of origin as the independent variable, with mobile phone dependence, self-control, sleep procrastination, and sleep quality as dependent variables, and conducted a differential test.

Table 4. Differences in Variables by Place of Origin

	Rural (N=188)		Urban (N=129)			
Variable	M	SD	M	SD	t	P
Mobile Phone Dependence	3.17	0.98	3.33	0.88	-1.46	0.15
Self-Control	3.68	0.97	3.53	1.06	1.29	0.20
Sleep Procrastination	3.44	0.96	3.38	1.04	0.55	0.58
Sleep Quality	9.88	5.77	10.07	5.83	-0.29	0.77

As shown in Table 4, there are no significant differences in mobile phone dependence, self-control, sleep procrastination, and sleep quality by place of origin.

3.4 Chained Mediation Analysis of Self-Control and Sleep Procrastination Between Mobile Phone Dependence and Sleep Quality

The Bootstrap test procedure was used, with 5000 repeated samples, selecting model 6 in the PROCESS macro to test the chained mediation effect, and setting a 95% confidence interval. Mobile phone dependence was used as the independent variable, self-control and sleep procrastination as the mediating variables, and sleep quality as the dependent variable, controlling for demographic variables in this study. The specific results are shown in

Table 5.
Table 5. Bootstrap Test of Mediation Effects

	Effect Size	Standard Error	Lower Limit	Upper Limit
Total Effect	0.33	0.05	0.24	0.42
Direct Effect	0.20	0.05	0.10	0.30
Total Indirect Effect	0.13	0.03	0.08	0.18
Mobile Phone Dependence → Self-Control → Sleep Quality	0.07	0.02	0.03	0.12
Mobile Phone Dependence → Sleep Procrastination → Sleep Quality	0.04	0.01	0.01	0.07
Mobile Phone Dependence → Self-Control → Sleep Procrastination → Sleep Quality	0.02	0.01	0.01	0.03

The analysis results show that the total effect of mobile phone dependence on sleep quality is significantly positive (LLCI=0.24, ULCI=0.42), indicating that mobile phone dependence can significantly predict sleep quality. The 95% confidence intervals for all three indirect paths do not include zero, indicating significant indirect effects.

Specifically, Tables 5 and 6 show that self-control plays a significant mediating role between mobile phone dependence and sleep quality. Mobile phone dependence significantly negatively predicts self-control (t = -7.41, p < 0.001), indicating that mobile phone dependence can indirectly affect sleep quality through mediating factors.

Between mobile phone dependence and sleep quality, sleep procrastination also has a significant mediating effect. From the perspective of sleep procrastination, mobile phone dependence significantly positively influences it (t = 4.51, p < 0.001). Regarding PSQI scores, sleep procrastination also significantly negatively affects sleep quality (t = 3.11, p < 0.01), indicating that sleep procrastination can indirectly mediate the relationship between mobile phone dependence and sleep quality.

Regarding sleep procrastination, self-control significantly negatively affects it (t = -4.99, p < 0.001), demonstrating that mobile phone dependence not only directly influences sleep quality but also indirectly affects sleep quality through the chained mediation effect of self-control and sleep procrastination.

The results indicate that factors affecting the sleep quality of college students are multifaceted. Mobile phone dependence can affect sleep quality directly and also indirectly through other pathways.

Table 6. Significance Test of Regression Coefficients

Dependent Variable	Independent Variable		β	Standard Error	t
Self-Control	Mobile Phone Dependence		-0.41	0.06	-7.41***
Sleep Procrastination	Mobile Phone Dependence		0.26	0.06	4.51***
	Self-Control		-0.27	0.05	-4.99***
Sleep Quality	Mobile Phone Dependence		0.20	0.05	4.18***
	Self-Control		-0.17	0.05	-3.70***
	Sleep Procrastination		0.14	0.05	3.11**

*Note: *p < 0.05, **p < 0.01, ***p < 0.001

The regression analysis reveals that:

With self-control as the dependent variable, mobile phone dependence negatively predicts self-control levels (β = -0.41, p < 0.001).

With sleep procrastination as the dependent variable, both mobile phone dependence (β = 0.26, p < 0.001) and self-control (β = -0.27, p < 0.001) predict sleep procrastination.

With PSQI score as the dependent variable, both mobile phone dependence (β = 0.20, p < 0.001) and sleep procrastination (β = 0.14, p < 0.01) positively predict PSQI scores. The scores are negatively correlated with sleep quality, indicating that higher scores in mobile phone dependence and sleep procrastination are associated with poorer sleep quality.
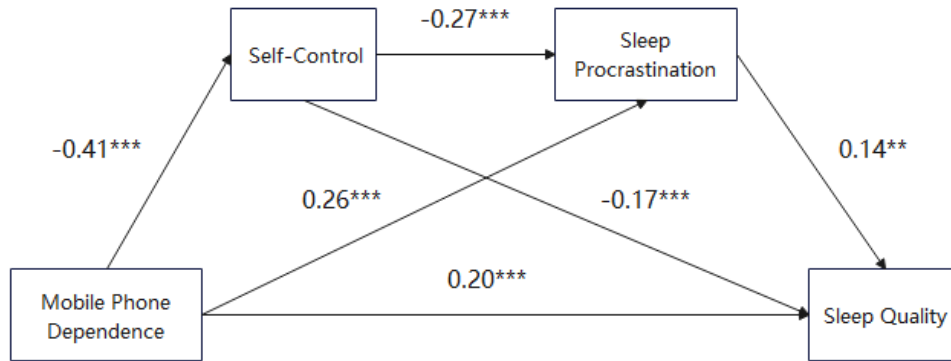

Figure 2. Chained Mediation Effect
*Note: *p < 0.05, **p < 0.01, ***p < 0.001

Figure 2 illustrates that mobile phone dependence can directly affect sleep quality or influence it through the individual mediating effects of self-control and sleep procrastination. Additionally, it can negatively impact sleep quality through the chained mediation effect of "self-control → sleep procrastination."

4 DISCUSSION

4.1 The Prominent Issue of Sleep Quality Among College Students

This study found that mobile phone dependence among college students is significant, with the average score for mobile phone dependence being higher than the median. This indicates that most college students have difficulty adapting when their phones are not functioning properly, which may have potential impacts on mental health and daily life(X. Zhou et al., 2022). Despite the issue of mobile phone dependence, college students generally exhibit a moderately high level of self-control. This provides a potential opportunity to address mobile phone dependence and other negative behaviors by enhancing self-control capabilities(You et al., 2020). The average score for sleep procrastination among college students is relatively high, indicating that many students find it difficult to fall asleep quickly after going to bed. This may be related to factors such as academic pressure and social media use, negatively impacting students' sleep quality. Analysis using the PSQI index reveals that the overall sleep quality of college students is generally poor, significantly higher than the threshold. Long sleep onset latency, frequent use of sleep medication, and daytime dysfunction are key factors contributing to the issue, which can have profound effects on students' academic performance and overall quality of life(Hu et al., 2021).

4.2 The Relationships Among Mobile Phone Dependence, Self-Control, Sleep Procrastination, and Sleep Quality

The study found a complex relationship among mobile phone dependence, sleep procrastination, and sleep quality. First, mobile phone dependence is significantly positively correlated with PSQI scores, suggesting that an increase in mobile phone dependence may lead to a decrease in sleep quality. This finding is consistent with previous research on the relationship between mobile phone dependence and sleep quality(Gao et al., 2021).

The study found that frequent use of mobile phones before bed is associated with prolonged sleep onset latency among college students. The various content pushed by mobile phones can elicit different emotional experiences, potentially keeping the brain in a state of continuous excitement, which is not conducive to creating optimal conditions for falling asleep. Additionally, mobile phones push content based on user interests, stimulating a desire to continue searching, further delaying sleep onset and ultimately affecting sleep quality. This phenomenon is also related to the Zeigarnik effect, which further exacerbates the decline in sleep quality.

Secondly, the study found significant negative correlations between self-control, mobile phone dependence, and sleep quality. According to cognitive neuroscience theory, addictive behaviors may lead to dysfunction in the prefrontal cortex, reducing self-control among college students. Individuals with high mobile phone dependence likely have lower levels of self-control, which in turn negatively predicts poor sleep quality. Furthermore, mobile phone dependence is significantly positively correlated with sleep procrastination, and the degree of sleep procrastination is positively correlated with PSQI scores. Individuals with strong time management skills exhibit lower mobile phone dependence and a stronger sense of time efficacy. However, individuals with low time efficacy may seek continuous stimulation from their phones, losing track of time, which delays sleep onset(He et al., 2019). This procrastination behavior can increase psychological stress and may even lead to insomnia, further harming physical health.

Finally, self-control is significantly negatively correlated with sleep procrastination. Mobile phone users may find it difficult to divert their attention away from their phones, leading to delayed sleep. Some individuals may find it hard to translate their intention to sleep into action at night due to the depletion of self-control resources. The theory of limited self-control suggests that while regular sleep has long-term benefits, some individuals are more inclined to pursue the immediate gratification provided by mobile phones, neglecting the long-term value of sleep. This phenomenon can lead to sleep procrastination(Jiang et al., 2017).

4.3 Mediation Effect Analysis

4.3.1 The Mediating Effect of Self-Control Between Mobile Phone Dependence and Sleep Quality

This study found that self-control partially mediates the relationship between mobile phone dependence and sleep quality. Individuals with high mobile phone dependence have lower self-control abilities, which impairs their ability to effectively regulate their sleep, leading to a decline in sleep quality. According to the theory of reciprocal determinism, both individual and environmental factors jointly influence behavior. Smartphones are ubiquitous in social life, providing various information and entertaining content. College students, being curious and sensitive to phone content, are prone to developing mobile phone dependence, which gradually weakens their self-control abilities. This dependence damages physiological structures, affecting brain areas related to self-control. Additionally, limited psychological resources are consumed by mobile phone use, leaving individuals unable to effectively control and regulate their own behavior.

4.3.2 The Mediating Effect of Sleep Procrastination Between Mobile Phone Dependence and Sleep Quality

This study found that sleep procrastination partially mediates the relationship between mobile phone dependence and sleep quality. College students with high mobile phone dependence are likely to become engrossed in phone usage, leading to sleep procrastination and a corresponding reduction in sleep time, which subsequently affects sleep quality. The increase in mobile phone dependence negatively predicts the degree of sleep procrastination, and it may even lead to insomnia. Watching content on phones consumes psychological

resources, leaving fewer resources available for other activities, thereby continuously delaying sleep onset.

The study also confirmed that delaying sleep time significantly reduces sleep quality. Although various factors influence sleep quality, the impact of sleep procrastination is the most significant. College students are busy with tasks during the day and have limited discretionary time, making the evening a time for leisure and entertainment, or even compensation. However, the behavior of staying up late to use the phone negatively impacts physical and mental health and is difficult to control. The negative emotions triggered by failure in behavioral control further affect sleep quality(Liu et al., 2020), resulting in irrational procrastination, cognitive conflict, and ultimately impacting the ability to fall asleep.

4.3.3 The Chained Mediation Effect of Self-Control and Sleep Procrastination Between Mobile Phone Dependence and Sleep Quality

This study indicates that mobile phone dependence not only directly affects sleep quality but also has an indirect impact through three pathways, with self-control and sleep procrastination acting as chained mediators. Specifically, mobile phone dependence negatively predicts self-control ability, and good self-control ability helps reduce sleep procrastination.

The study found that both behavioral addiction and substance addiction directly influence neurophysiological mechanisms. Mobile phone dependence, as a relatively persistent and stable addictive behavior, may affect brain areas related to self-control, weakening the ability of these areas to inhibit undesirable behaviors. According to the theory of limited self-control, individuals with strong self-control are able to fall asleep on time and effectively translate motivation into action. Conversely, individuals with poor self-control are more inclined to pursue immediate pleasure, neglecting long-term health, and continuously delaying sleep onset. This procrastination behavior disrupts the body's biological clock, potentially leading to sleep disorders or daytime dysfunction. Sleep procrastination, as a novel form of procrastination, is a specific manifestation of self-control failure, causing psychological conflict and negative emotions, thereby affecting sleep quality and efficiency.

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