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## The Impact of Mobile Phone Use on Sleep Quality Among College Students: The Mediating Role of Heart Rate and Negative Emotions

Huirong Zhang, Jiang Fang

\*School of Safety Science and Engineering, Henan Polytechnic University, Jiaozuo, 454003, China.

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**Abstract:** To explore the relationship between using mobile phones before going to bed and heart rate, negative emotions and sleep quality among college students. A field research method combining "physiology + psychology" was used to select 20 subjects who used mobile phones for 60 minutes before going to bed. Polar bracelets and heart rate belts were used to collect heart rate signals in real time during mobile phone use and sleep in the dormitory, and the Pittsburgh Sleep Scale and Mood State Scale were used to evaluate sleep quality and mood changes before and after sleep. The results showed that the negative emotions caused by using mobile phones for more than 60 minutes before going to bed played a mediating role between heart rate and sleep quality, and the confidence interval of Boot95%CI was [0.071,1.337]. This shows that using mobile phones for more than 60 minutes before going to bed increases the excitability of sympathetic nerve activity and does not directly lead to sleep problems, but rather induces negative emotions.

**Keywords:** Heart Rate; Sleep quality; Negative emotions; Cell phone

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### 1. Introduction

All content should be written in English and should be in Single column. The China Sleep Research Report (2024) pointed out that nearly two-thirds of Chinese people suffer from sleep problems, especially young people such as college students. The report pointed out that 70% of sleep disorders are closely related to the use of mobile phones before going to bed [1]. The impact of using mobile phones before going to bed on the physiological and mental health of individuals has gradually become the focus of public health research.

Using mobile phones for more than 60 minutes before going to bed is not only significantly related to the decline in sleep quality [2] but also closely linked to the phenomenon of emotional arousal [3]. When exploring the relationship between the use of mobile phones before bed, negative emotions and sleep quality, Ou Zixin et al. [4] found that the negative emotions of college students play a mediating role between long-term use of mobile phones before bed and sleep quality. Studies by Chen Wei et al. [5] and FENG ZY et al. [6] found that sleep quality plays a mediating role between college students' long-term use of mobile phones before going to bed and negative emotions. Wu Fang et al. [7] found that college students' long-term use of smartphones partially mediates the relationship between negative emotions and sleep quality. Although existing research has shown a relationship between cell phone use before bed, negative emotions, and sleep quality, these findings are inconsistent. In addition, these studies mainly use questionnaires to explore the relationship between psychological factors and sleep quality. However, mobile phone dependence will have a certain impact on physiology, and no research has yet comprehensively explored the mutual influence mechanism of psychological and physiological factors.



Based on the above analysis, this study takes college students as the research subjects, starts from the psychological and physiological perspectives, and adopts the "subjective + objective" field research method to explore the mediating role of heart rate and emotional factors between college students' long-term use of mobile phones before going to bed and sleep quality, in order to provide a reference for improving college students' sleep quality.

## 2. Materials and Methods

### Subjects

The basic information about the duration and content of college students' mobile phone use before going to bed was collected through a questionnaire survey. A total of 150 questionnaires were distributed, 136 were collected, and the recovery rate was 90.67%. The survey results showed that 86.54% of college students watched videos before going to bed. On a voluntary basis, 20 college students aged  $23 \pm 1.2$  years old who used mobile phones for 60 minutes before going to bed were selected as subjects. In the experiment, the content style of the subjects' mobile phone use before going to bed was roughly the same, and a seven-day interval was set between each group of experiments. The exclusions are as follows: 1) suffering from depression or cardiovascular disease; 2) having sleep disorders such as obstructive sleep apnea syndrome; 3) using drugs or hypnotics to assist sleep; 4) excessive intake of caffeine or alcohol. This study passed the ethical review of the Medical Ethics Committee of Henan Polytechnic University, and all subjects signed informed consent before collecting data.

### Measurements

#### Profile of Mood States (POMS)

The Brief Mood State Scale revised by Zhu Beili et al. [8] was used. The total Cronbach's coefficient of the scale was 0.74 ( $P < 0.01$ ). It consists of 40 emotional words and 7 different states, including tension, anger, fatigue, depression, energy, panic, and self-esteem. Energy and self-esteem are positive emotions. The higher the positive emotion score, the better the mood [9]; tension, anger, fatigue, depression, and panic are negative emotions. The higher the negative emotion score, the worse the mood.

#### Pittsburgh Sleep Quality Index (PSQI)

The scale was compiled using Buysse Daniel J[10]. The total Cronbach's coefficient of the scale was 0.89 ( $P < 0.01$ ). It consists of 19 self-assessment items and 6 dimensions, including sleep quality, sleep onset time, sleep duration, sleep efficiency, sleep disorders, and daytime dysfunction. The total PSQI score is obtained by summing up the 6 dimensions. The higher the total PSQI score, the worse the sleep quality.

#### Heart Rate (HR)

HR refers to the number of pulse beats per minute, which reflects the activity level of the sympathetic nervous system[11]. A Polar unite watch (Polar Electro Oy, Professoriintie5, FI-90440 KEMPELE, dimensions: 46x46x13mm, weight 66g) and a Polar H10 heart rate belt (Polar H10; dimensions: 34x65x10mm, weight 21g; sampling frequency 150HZ) were used to record HR in real time during the experiment.

#### Experimental process

The experiment was conducted in a standard four-person dormitory room ( $4\text{m} \times 1.5\text{m} \times 2\text{m}$ ), with the indoor temperature controlled at  $20^\circ\text{C}$ - $23^\circ\text{C}$  and the humidity maintained at 40%-50%. One week before the experiment, the subjects performed sleep control, with an average sleep time of  $6.92 \pm 0.5$  h. On the day of the experiment, the subjects began to wear Polar Unite watches and heart rate belts from 22:40. After turning off the lights at 23:00, the subjects began to use their mobile phones and used an alarm clock to control the time of using their mobile phones. After stopping using their mobile phones at 24:00 and waking up naturally the next day, the subjects filled in the POMS and PSQI questionnaires respectively.

#### Statistical analysis

First, use Polar FlowSync software to export the heartbeat interval, check the fluctuation of the heartbeat interval, and eliminate abnormal values caused by turning over during sleep or loose sensor connection; then, use Kubios HRV Standard software to calculate the heartbeat interval value based on the changes, and the average value is calculated every 5 minutes to obtain the HR index. Finally, SPSS.27 and SPSS PROCESS macro programs were used to perform statistical analysis on the data. A confidence interval that is not 0



indicates a significant effect.  $P < 0.05$  is considered a statistically significant difference and Origin 2021 software is used to draw a trend chart.

### 3. Results & Discussion

#### Common method deviation test

Harman single-factor factor analysis was used to conduct common method deviation test. The results show that there are 10 factor characteristic roots greater than 1 when not rotated, and the variable explained by the first factor is 26.41%, which is less than the critical standard of 40%, indicating that the data in this study are not affected by common method bias.

#### Descriptive statistics and correlation analysis

Controlling gender and age, the correlation analysis between variables is shown in Table 1. Among them, negative emotions and positive emotions are the differences before and after sleep. Through Spearman correlation analysis, it was found that there is a significant positive correlation between the HR of using mobile phones for 60 minutes before going to bed, the PSQI total score and negative emotions, and the negative emotions were significantly positively correlated with the PSQI total score; while the sleep time was significantly related to HR and negative emotions. There is a significant negative correlation, and there is no statistical significance among the other variables.

**Table 1:** Correlation analysis

variable	M	SD	1	2	3	4	5	6	7	8	9	10
HR	59.47	3.32	1									
Negative emotions	8.72	5.37	0.425*	1								
Positive emotions	8.215	1.23	-0.465	0.257	1							
Sleep quality	1.89	0.60	0.212*	0.699*	0.365	1						
Bedtime	1.33	0.58	0.467	0.587	0.674	0.254	1					
Sleep time	1.87	0.74	-	0.641*	0.475	-	0.376	1				
Sleep efficiency	1.33	0.58	-0.534	0.487	0.536	0.463	0.658	0.525	1			
Sleep disorders	1.00	0.58	-0.435	0.589	0.437	0.365	0.598	0.365	0.678	1		
Daytime dysfunction	2.00	1.00	-0.467	0.365	0.637	0.527	0.587	0.576	0.798	0.367	1	
PSQI Total Score	0.215	0.451	0.149	0.415*	0.265	0.146	0.246	0.416	0.248	0.145	0.256	1

#### Mediation analysis

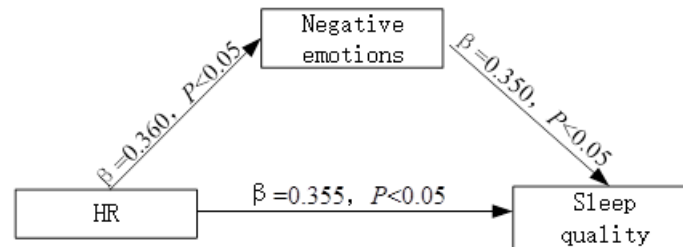
Under the conditions of controlling gender and age, the mediating role of negative emotions caused by continuous use of mobile phones for 60 minutes before going to bed in the impact of HR on sleep quality was analyzed (see Table 2, Figure 1). The results show that HR has a significant direct predictive effect on sleep quality ( $\beta = 0.355$ ,  $P < 0.05$ ), and HR has a significant predictive effect on negative emotions ( $\beta = 0.360$ ,  $P < 0.05$ ). When HR and negative emotions simultaneously predict sleep When it comes to sleep quality, HR has a significant predictive effect on sleep quality ( $\beta = 0.242$ ,  $P < 0.05$ ), and the predictive effect of negative emotions on sleep quality is still significant ( $\beta = 0.350$ ,  $P < 0.05$ ). The analysis of the mediation effect results showed that negative emotions play a mediating role in the impact of HR on sleep quality, with the confidence interval of Boot95% CI being [0.071, 1.337].

**Table 2:** Regression analysis of mediating effect

Outcome Variable		Overall fit index		Regression coefficient analysis		
		R <sup>2</sup>	F	$\beta$	t	P
Sleep quality	Gender	0.445	4.812	0.271	0.879	0.393
	Age			0.066	0.268	0.792



	HR			0.335	2.097	0.020*
Negative emotions	Gender	0.04	30.209*	0.263	0.936	0.364
	Age			0.039	0.174	0.864
	HR			0.360	3.631	0.013*
Sleep quality	Gender	0.01	27.877*	0.204	1.857	0.082
	Age			0.056	0.226	0.825
	HR			0.242	6.540*	0.024*
	Negative emotions			0.350	5.648*	0.016*



**Figure 1:** Model diagram of the mediating effect of negative emotions on HR and sleep quality

#### 4. Discussion

Liu Qingqi [12] and Wang Jishen et al. [13] both found that emotions mediate the relationship between mobile phone addiction and sleep quality, especially negative emotions such as anxiety mediate the relationship between excessive mobile phone use and sleep quality. These studies together show that emotions are the key factor between long-term mobile phone use before bedtime and sleep quality. Research has found [14] that college students may use their mobile phones at night to seek relaxation and happiness due to the heavy academic pressure during the day. However, excessive mobile phone use before bedtime may induce a psychological state of reflection and self-blame, such as regret and a strong desire for compensation. This state may prompt them to have more negative emotions, such as anxiety, panic, stress and depression. Our study found that negative emotions mediate the relationship between HR and sleep quality when using mobile phones for 60 minutes before bedtime. The increase in HR when using mobile phones for 60 minutes before bedtime does not directly lead to a decrease in sleep quality, but indirectly affects sleep quality by increasing negative emotions.

#### 5. Conclusion

This study focused on college students, using the PSQI and POMS subjective scales to assess subjective sleep quality and emotional state, and using Polar bracelets and heart rate belts to collect ECG signals to explore the mediating role of emotions and heart rate between using mobile phones before bed and sleep quality. The research conclusions are as follows: Although long-term use of mobile phones can cause HR to rise, this physiological change does not directly affect sleep quality, but indirectly affects sleep quality by exacerbating negative emotions.

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