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Long-term use of Mobile Phones: Effects on Heart Rate, Sleep Quality and Mood

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Abstract**—** *Objective To explore the mechanism of the psychological and physiological effects of long-term use of mobile phones before going to bed on college students. Methods A field research method combining "physiology + psychology" was adopted, and 20 subjects were selected to participate in three groups of experiments (30min group, 60min group and 120min group using mobile phones before going to bed). Polar bracelets and heart rate belts were used to collect real-time ECG signals during mobile phone use and sleep in the dormitory, and the Pittsburgh Sleep Scale and Mood State Scale were combined to evaluate sleep quality and emotional changes before and after sleep. Results 1) Compared with the other two groups (60min and 120min), the group using mobile phones for 30 minutes before going to bed had statistical significance in terms of positive emotions, negative emotions and subjective sleep quality (P<0.05), while the 60min group and the 120min group had statistically significant differences in positive emotions, negative emotions and subjective sleep quality (P<0.05). There is no statistical significance between these indicators (P>0.05). 2) During sleep, the average heart rates of the three groups gradually increased, and there was statistical significance among the average heart rates of the three groups (P<0.05). Conclusion: Using it for more than 60 minutes before bedtime has no significant impact on subjective sleep quality and mood, but has a greater impact on the excitability of sympathetic nerve activity.*

Keywords**—** *Heart Rate; Sleep quality; Mood Cell phone.*

I. INTRODUCTION

The "China Sleep Research Report (2023)" pointed out that nearly two-thirds of Chinese people are troubled by sleep problems, especially the young group of 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 bed on an individual's physical and mental health 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]. Domestic and foreign scholars [4-10] found through questionnaire surveys that college students using mobile phones for more than 60 minutes before going to bed will lead to poor sleep quality. In addition, G James Rubin et al. [11] also found through PSG research in the laboratory that excessive exposure to the electromagnetic field of mobile phones may reduce the sleep quality of teenagers, and using mobile phones for a long time before going to bed may also induce negative emotions. The questionnaire survey results of IKEDA K et al. [12] support this point, showing that college students using mobile phones for more than 60 minutes before going to bed can easily induce negative emotions. In addition, Wang Yuzhu[13] found that when college students use mobile phones for more than 60 minutes before going to bed, negative emotions positively affect sleep quality. 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 object. From a psychological and physiological perspective, it adopts a "subjective + objective" field research method to explore the impact of long-term use of mobile phones before going to bed on college students' sleep quality and mood, with a view to improving college students' sleep quality. Provide reference for sleep quality.

II. MATERIALS AND METHODS

A. Research subjects

A questionnaire survey was conducted to collect basic information about the duration and content of college students' mobile phone use before going to bed. A total of 150 questionnaires were issued, and 136 were collected, with a recovery rate of 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±1.2 years old were selected as subjects, and they participated in three different experiments: using mobile phones for 30 minutes, 60 minutes, and 120 minutes before going to bed. In the three experiments, 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 exclusion conditions are as follows: 1) suffering from depression or cardiovascular disease; 2) having sleep disorders such as obstructive sleep apnea syndrome; 3) using drugs or hypnotic agents to assist sleep; 4) excessive intake of caffeine or alcohol.

B. Research tools

1 Profile of Mood States (POMS)

The Brief Mood States Scale revised by Zhu Beili et al. [14] was used. The scale consists of 40 emotional words and covers 7 emotional states, including tension, anger, fatigue, depression, energy, panic, and self-esteem. The total Cronbach's alpha of the scale was 0.74 ($P < 0.01$). Among them, energy and self-esteem represent positive emotions; the higher the score, the better the emotional state[15]; while

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tension, anger, fatigue, depression and panic are negative emotions; the higher the score, the worse the emotional state.

2 Pittsburgh Sleep Quality Index (PSQI)

The scale developed by Buysse Daniel J [16] was used, with an overall Cronbach's alpha of 0.89 (P < 0.01). The scale contains 19 self-assessment items covering 6 dimensions: sleep quality, sleep onset time, sleep duration, sleep efficiency, sleep disorders, and daytime dysfunction. The total PSQI score is obtained by adding up the scores of each dimension. The higher the total PSQI score, the worse the sleep quality.

3 Heart rate (HR)

HR refers to the number of pulse beats per minute, reflecting the activity level of the sympathetic nervous system [17]. This study used a Polar Unite watch (Polar Electro Oy, Professoriintie 5, FI-90440 KEMPELE, size: 46x46x13mm, weight 66g) and a Polar H10 heart rate belt (size: 34x65x10mm, weight 21g, sampling frequency 150Hz) to monitor heart rate in real time and record changes in HR during the experiment.

C. Test process

This experiment was conducted in a standard four-person room (4m × 1.5m × 2m) in the dormitory. The indoor temperature was controlled at 20℃-23℃, and the humidity was maintained at 40%-50%. One week before the test, the subjects underwent sleep control, and the average sleep time was 6.92±0.5 h. On the day of the experiment, the subjects began to wear Polar Unite watches and heart rate monitors from 22:40. After the lights were turned off at 23:00, the subjects began to use their mobile phones and used the alarm clock to control the time of mobile phone use. The subjects filled out the POMS and PSQI questionnaires immediately after stopping using their mobile phones and after waking up naturally the next day.

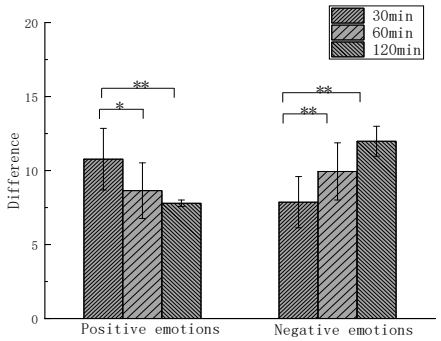
D. Data processing

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.

III. Results

A. Subjective questionnaire analysis

The difference in POMS before and after sleep under the three experimental conditions is shown in Figure 1. It can be seen from Figure 1 that 1) positive emotions gradually decrease with the increase of usage time; negative emotions gradually increase with the increase of usage time; 2) positive emotions are statistically significant between the 30min group and the 60min group (t=2.086, P＜0.05), the 30min group and the 120min group (t=2.656, P＜0.01), and negative emotions are statistically significant between the 30min group and the 60min group (t=7.269, P＜0.01), and the 30min group and the 120min group (t=5.626, P ＜ 0.01); there is no statistical significance between the 60min group and the 120min group in terms of positive emotions (t=0.463, P>0.05) and negative emotions (t=0.498, P>0.05).



注：*0.01<P<0.05 **P<0.01

Fig. 1. Changes in POMS differences before and after sleep under three experimental conditions

The comparative analysis of PSQI values before and after sleep under the three experimental conditions is shown in Table 1. It can be seen from Table 1 that: 1) The six dimensions of sleep quality, sleep time, sleep time, sleep efficiency, sleep disorders, daytime functional disorders and PSQI total score show an increasing trend with the increase of mobile phone use time before bedtime; 2) There is a statistical significance between the 30min group and the 60min group (t=6.251, P ＜ 0.01), and the 30min group and the 120min group (t=5.602, P＜0.01) in sleep quality and PSQI total score (P ＜ 0.01); there is no statistical significance between the 60min group and the 120min group (P>0.05).

TABLE 1. Comparative analysis of PSQI values before and after sleep under the three experimental conditions (M±SD)

Question	M±SD			Paired t-test		
	30	60	120	30vs60	30vs120	60vs120
Sleep quality	1.67±0.58	2.00±0.78	2.22±0.44	0.000**	0.002**	0.051
Bedtime	1.33±0.58	2.17±1.59	2.33±0.71	0.503	0.611	0.141
Sleep time	0.89±0.60	1.00±0.58	1.17±0.00	0.602	0.639	0.282
Sleep efficiency	1.33±0.58	1.58±0.90	1.89±0.93	0.503	0.305	0.824
Sleep disorders	1.00±0.58	1.42±0.67	2.00±0.71	0.702	0.060	0.095
Daytime dysfunction	2.00±1.00	2.50±0.52	2.56±0.53	0.840	0.074	1.000
PSQI Total Score	8.67±2.31	10.05±1.83	11.89±1.54	0.000**	0.001**	0.133

Note：0.01<P<0.05*, P<0.01**

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B. HR analysis

The time trend of mobile phone use before bedtime and HR during sleep (0-420min) under the three experimental conditions is shown in Figure 2. The 0 point in the figure indicates the time when the subjects stopped using mobile phones. The average HR of the three groups 30min before bedtime was 64.2±2.1bpm (30min group and 60min group, t=0.345, P>0.05; 30min group and 120min group, t=0.645, P>0.05; 60min group and 120min group, t=0.567, P>0.05). As can be seen from Figure 2, the HR of the subjects gradually decreased after they stopped using mobile phones at 0 o'clock. Among them, the HR of the 30min group from 0 to 330min was lower than that of the other two groups, and the HR from 330 to 420min gradually increased. The HR of the 60min group from 0 to 175min was lower than that of the 120min group, while the HR from 175 to 420min was higher than that of the 120min group. The average values of HR during sleep (0-420 min) are shown in Figure 3. As can be seen from the figure, the average values of HR between the 30 min group and the 60 min group (t=2.900, P<0.01), the 120 min group (t=5.899, P<0.01), and the 60 min group and the 120 min group (t=3.425, P<0.01) were statistically significant, and the HR average values were ranked as 55.9430 min group <58.8460 min group <60.56120 min group.

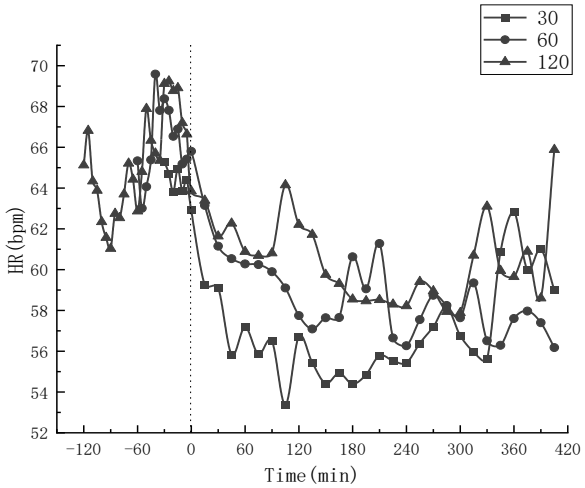
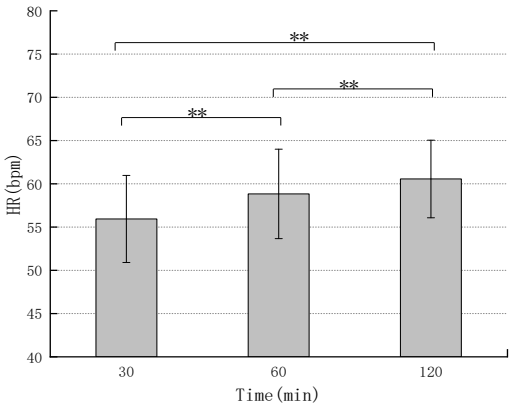


Fig. 2. Heart rate (HR) trend over time



注：**P<0.01

Fig. 3. Average heart rate (HR) during sleep (0-420min)

IV. Discussion

Using mobile phones before bed can have an impact on an individual's mood[18]. Ha[19] conducted a questionnair e survey analysis on Korean students and showed that the longer they use mobile phones before going to bed, the less positive emotions they have. Xu Ziwen[20] conducted a study on 400 college students and found that the longer they use mobile phones before going to bed, the stronger the students' negative emotions. Research by Ye, Xin et al. [21] also showed that using mobile phones for more than 60 minutes before going to bed will increase negative emotions. In this study, it was found that there was statistical significance between positive emotions and negative emotions between the 30min group and the other two groups (P<0.05), while there was no statistical significance between positive emotions and negative emotions between the 60min group and the 120min group (P>0.05), indicating that although the increase in mobile phone use time before bed is related to the decrease in positive emotions and the increase in negative emotions, when the use time exceeds 60 minutes, the impact on mood is not significant.

Excessive use of mobile phones after lights out will affect sleep quality, especially among college students who often stay up late, leading to impaired sleep quality[22-23]. For example, Wu Jihui[24] found that college students using mobile phones before going to bed led to poor subjective sleep quality. The results of this study show that the longer you use mobile phones before going to bed, the worse your sleep quality will be. Compared with the other two groups, the group using mobile phones for 30 minutes before going to bed had a statistically significant improvement in subjective sleep quality (P<0.05), while there was no statistical significance between the 60-minute group and the 120-minute group (P>0.05). It shows that increasing the time of using mobile phones before going to bed usually reduces sleep quality, but more than 60 minutes has no obvious impact on subjective sleep quality. In terms of physiological parameters, studies have shown [25-26] that good sleep quality is associated with lower HR. The results of this study revealed that as the time spent using mobile phones before bed increases, the average HR during sleep shows a gradually increasing trend. There was statistical significance in the average HR between the 30min group and 60min group, the 30min group and the 120min group, and the 60min group and the 120min group before bedtime (P<0.05). However, the difference between the 60min group and the 120min group was 1.72, which was a relatively small improvement compared to the difference of 2.90 between the 30min group and the 60min group. It shows that the longer you use your mobile phone before going to bed, the stronger your sympathetic nerve activity will be. However, when the use time exceeds 60 minutes, the activation of sympathetic nerves will weaken.

V. Conclusion

This study focuses on college students, using PSQI and POMS subjective scales to assess subjective sleep quality and

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emotional state, and using Polar bracelets and heart rate monitors to collect ECG signals to explore the physiological and psychological impact of long-term use of mobile phones before going to bed. The research conclusions are as follows: Long-term use of mobile phones before bed will lead to a decrease in positive emotions, an increase in negative emotions, and a decrease in subjective sleep quality, but this effect is not significant after the use time exceeds 60 minutes.

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