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BMJ Open Chronotypes and their association with sleep quality among Chinese college students of Anhui Province: a crosssectional study

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ABSTRACT

Objectives To describe the prevalence of chronotype and sleep quality among Chinese college students and explore the relationship between chronotype and sleep quality. **Design** A cross-sectional study.

Setting Four colleges and universities in Anhui, China, between November and December 2020.

Participants A total of 4768 college students were recruited using a stratified, multistage, cluster sampling survey.

Outcome measures Morningness-Eveningness Questionnaire 19 was used to determine the chronotype of the students and the Pittsburgh Sleep Quality Index (PSQI) was used to measure their sleep quality. The multiple logistic regression model was used to explore the potential association between chronotype and sleep quality.

Results The self-reported proportions of evening-type (E-type), neutral-type and morning-type among college students were 51.17%, 45.14% and 3.69%, respectively. The mean PSQI score was 4.97 ± 2.82 and the prevalence of poor sleep quality was 18.2%. After adjusting the covariates by multiple logistic regression analysis, E-type was positively associated with subjective sleep quality (OR=1.671, 95% Cl 1.414 to 1.975), sleep latency (OR=1.436, 95% Cl 1.252 to 1.647), sleep duration (OR=2.149, 95% Cl 1.506 to 3.067), habitual sleep efficiency (OR=1.702, 95% Cl 1.329 to 2.180), daytime dysfunction (OR=1.602, 95% Cl 1.412 to 1.818) and overall poor sleep quality (OR=1.866, 95% Cl 1.586 to 2.196).

Conclusions College students mainly exhibited Etype, and an elevated prevalence of poor sleep quality existed among these students. The E-type was positively associated with poor sleep quality.

INTRODUCTION

Sleep quality is defined as 'a complex assessment of satisfaction with one's sleep experience', including a subjective component assessing quality and an objective component that uses physiological data to assess.¹² The university years are a period of growth and development for adolescents. During this period, lifestyle habits, academic stress,

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ We selected a large group of students to analyse the relationship between chronotype and sleep quality among college students in China.
- ⇒ A cross-sectional study approach was adopted, thus causality cannot be clearly proven.
- ⇒ The study samples were all from one province (Anhui) in China, which may have introduced a selection bias.

diet and social relationships can significantly impact sleep quality.³ According to the 2021 Social Blue Book of the Chinese Academy of Social Sciences, sleep quality among college students is mediocre, with only approximately 24.6% reporting high satisfaction with their sleep quality.⁴ A meta-analysis of 82055 university students revealed a mean sleep duration of 7.08 hours/day, with 43.9% of students experiencing less than 7 hours/day of sleep.⁵ In addition, the prevalence of insomnia among college students is higher than that among the general population.⁶ Lack of sleep or poor sleep quality negatively impacts the physical and mental health of students, which can lead to cardiovascular diseases,⁷ anxiety and depression⁸; they can also significantly affect academic performance.9 10 Studies in the USA have indicated that students who regularly sleep for long durations achieve o higher exam scores.¹¹ Poor sleep quality among college students has become a global problem, and this issue deserves attention beyond academia to society-at-large.

Sleep chronotypes (hereafter called chronotypes) are a unique personal biological clock system that has arisen in organisms through natural selection.¹² The chronotype of a person is indicated by daytime activities and bedtime preferences, and mainly comprises morning-type (M-type),

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evening-type (E-type) and neutral-type (N-type).¹³ M-type, which is characterised by early bedtime and early rising, is more energetic during the day; E-type is characterised by late bedtime, late waking, and working better in afternoons and evenings.¹⁴ Finally, N-type sit in the middle of the continuum of the behavioural traits from M-type at one end to E-type at the other.¹⁵ A growing number of studies have shown that chronotypes are associated with depression, anxiety, quality of life, work stress and academic performance among adolescents.^{16–19} E-type individuals are more likely to have sleep-related problems than M-types. This includes a higher prevalence of sleep insufficiency and irregular sleep patterns, which may increase negative emotions such as stress and anxiety.^{20 21}

Sleep quality and the establishment of the circadian rhythm are crucial among college students. As reference dimensions for assessing sleep value among adolescents, sleep quality and chronotype have particular value.²² Jongte *et al* found that chronotype impacts the sleep quality and depression levels of students.²³ A recent study in China indicated that sleep quality is a mediating factor in the causal relationship of chronotype with the development of depression among adolescents.²⁴ As college students adapt to their new lifestyle, they seem to become susceptible to poor sleep quality and insufficient sleep due to their extensive daily academic and extracurricular activities. This potential crisis among Chinese college students cannot be ignored.

Several small-sample studies in the USA and India have demonstrated that E-type adolescents have significantly worse sleep quality and duration.^{23 25} Different countries have differences in chronotype and sleep quality.²⁶ At present, research on chronotype among Chinese college students mainly focuses on its correlation with mental health.^{16-18 27} Several studies have examined the correlation between chronotype and sleep quality among Chinese college students, but few are large-scale. In addition, the relationship between chronotype and sleep quality revealed in these studies has been inconsistent. Zhu et al found that the scores of chronotype were negatively correlated with the scores of sleep quality (r=-0.33).¹³ However, Wang *et al* indicated that E-types were associated with more insomnia symptoms, but with no significant difference between M-types and N-types in insomnia symptoms.²⁷ Thus, the association between chronotype and sleep quality remains unclear; further large-scale research is required to clarify the relationship between these two variables. Our initial focus was on the chronotypes of a special group of medical students from one medical college. Previous work found that the chronotypes of medical students was mainly E-type, and E-type students exhibited lower quality of life, which has fully reflected the sleep problems among medical students.²⁸ So, these have prompted us to think, what is the overall distribution of chronotypes among college students (medical and non-medical)? As one of the important sleep issues, what is the current situation of sleep quality among college students? How do different

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Study variables and measurement

A self-administered questionnaire was designed to collect data and it included sociodemographic characteristics, lifestyle habits, chronotype and sleep quality.

Sociodemographic characteristics included gender, age and grade. The participants were also asked to self-report their academic performance in their classes for the last half term, mobile phone usage duration per day and leaning burden.

Lifestyle habits included smoking, alcohol drinking, coffee drinking and milk tea drinking. A questionnaire developed by Kong *et al* was used, with two questions, 'Have you smoked in the last month?" and "In the last month, have you consumed alcohol?'²⁹ Coffee and milk tea drinking were measured with one question each ('Do you drink coffee?', 'Do you drink milk tea?'). If students drank coffee and milk tea at least two times a week, they were considered to drink tea and coffee regularly.

The Chinese self-reported version of Morningness-Eveningness Questionnaire 19 (MEQ-19) was used to assess the chronotypes among university students.³⁰ The MEQ-19 contains 19 multiple choice questions, covering sleep-wake times and preferred time for physical and mental activities. The overall score of the MEQ scale is between 16 and 86. The higher the score, the more the chronotype tends to be early morning. Based on the total score, the individuals were divided into three different categories: E-type (16–49 score), N-type (50–62 score) and M-type (63–86 score).³⁰ The MEQ-19 is reported to have good psychometric properties in Chinese populations and has been widely used in other populations as well.^{24,31–33} The Cronbach's α in this study was 0.708.

Sleep quality was assessed by the self-reported Pittsburgh Sleep Quality Index (PSQI).³⁴ The scale consists of seven components (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping medication and daytime dysfunction) with 19 items. Each component is scored on a scale of 0 to 3, with a single cut-off value above one indicating a sleep problem. The cumulative score for each component is the total PSQI score (0-21), with higher scores indicating poorer sleep quality. In this study, we defined an overall PSQI score above 7 as indicative of a sleep problem.^{13 34 35} The PSQI is a widely used tool for screening sleep disorders both in China and internationally, and its Chinese version has been shown to have good reliability in Chinese populations.^{36–39} In the current study, the Cronbach's α was 0.675.

Data collection procedures

Data were collected using a paper-and-pencil selfadministered questionnaire by the trained investigators. The cross-sectional field investigation was carried out between November and December 2020. The investigator, with the help of counsellors, used students' self-study time to gather students from each class (approximately 30 students) in designated classrooms. All students were informed that participating in the field investigation was voluntary and anonymous. After the investigators read out the unified guidance and told the students to fill in the precautions, the students completed the paper-andpencil survey anonymously in the designated classroom in approximately 20–30 min. After completing the questionnaire, students hand it over to the investigators on-site.

Quality control

The investigators are composed of undergraduate and graduate students majoring in preventive medicine at Wannan Medical College. Before participating in the survey, they receive unified training and develop standardised guidelines to reduce interviewer bias. Before the survey, the investigator introduced the purpose of the study to the students by using the unified guidelines, 8 and emphasised the principles of anonymity and confidentiality of the survey, so as to obtain the cooperation of students and improve the effectiveness of the questionnaire. Students were required to independently complete questionnaires based on their actual situation. During the filling process, students are reminded in real time that they are not allowed to discuss or exchange questionnaires with each other, and investigators are always avail- 9 able to answer questions from survey respondents. These can reduce potential information bias from respondents. All the questionnaires were checked by the investigators on-site. If any omissions were found, students were required to fill them out completely on-site.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Statistical analysis

The Epidata 3.1 software was used to create the database, and the SPSS V.26 for Windows was used for statistical analysis. Descriptive analysis was performed using mean (SD) for measurement data and percentage for count data. The prevalence of poor sleep quality was compared between different groups using the χ^2 test.

To study the effect of chronotype on sleep quality, multiple logistic regression analysis was performed with sleep quality indicators as dependent variables and the chronotype (E-type, N-type and M-type) as the independent variable controlled for univariate variables with a $p \le 0.1$.^{40 41} Among these, sleep quality indicators included PSQI and seven dimensions of PSQI. ORs and 95% CIs were calculated to examine the associations between sleep quality and chronotype adjusted for confounding factors. According to the results of the χ^2 test, the adjusted variables for each dependent variable were listed in online supplemental table 1. A value of p<0.05 (two-tailed) was considered statistically significant.

PSQI components	Group	Number	Prevalence (%)	95% CI of prevalence
Subjective sleep quality	Poor	791	16.6	15.5 to 17.6
	Good	3977	83.4	-
Sleep latency (≥30 min)	Poor	1301	27.3	26.0 to 28.6
	Good	3467	72.7	-
Sleep duration(<6 hours)	Poor	164	3.4	2.9 to 4.0
	Good	4604	96.6	-
Habitual sleep efficiency	Poor	324	6.8	6.1 to 7.5
	Good	4444	93.2	-
Sleep disturbances	Poor	513	10.8	9.9 to 11.6
	Good	4255	89.2	-
Use of sleeping medication	Poor	108	2.3	1.8 to 2.7
	Good	4660	97.7	-
Daytime dysfunction	Poor	1816	38.1	36.7 to 39.5
	Good	2952	61.9	-
Overall PSQI	Poor	869	18.2	17.1 to 19.3
	Good	3899	81.8	-
2SQI, Pittsburgh Sleep Quality Index.				
ESULTS		(10.8	3%), poor habitual slee	p efficiency (6.8%), slee

RESULTS

Characteristics of participants

In total, 4768 students (males: 2059, females: 2709) participated in this study, with a mean age of 19.14 (SD=1.11). The characteristics and group variations in each dimension of the PSQI for the 4768 participants are presented in online supplemental table 2. Of the respondents, 2260 (47.40%) were freshmen, 1842 (38.63%) were sophomores and 666 (12.08%) were juniors. In terms of academic performance, 53.38% of the students had a general academic standing, 34.54% had a good standing and 12.08% had a poor standing. And, 56.86% of students reported that their learning burden is moderate. With respect to lifestyle habits, the vast majority of students reported not drinking coffee or only rarely drinking coffee (90.75%), whereas 79.91% of students reported using their mobile phones for more than 3 hours/day. Other basic information regarding these students is listed in online supplemental table 2.

Distribution characteristics of chronotypes and poor sleep quality

The distribution of chronotypes among the college students was: M-type 3.69%, N-type 45.14% and E-type 51.17% (online supplemental table 2). Table 1 demonstrates the overall prevalence of poor sleep quality and each PSQI component. The overall mean PSQI score was 4.97±2.82. There were 869 students with poor sleep quality, and the overall prevalence of poor sleep quality was 18.2% (table 1). Among the seven components of PSQI, the prevalence ranged from high to low: daytime dysfunction (38.1%), sleep latency (\geq 30min) (27.3%), poor subjective sleep quality (16.6%), sleep disturbances

(10.8%), poor habitual sleep efficiency (6.8%), sleep duration (<6 hours) (3.4%) and use of sleeping medication (2.3%) (table 1).

6 text The overall prevalence of poor sleep quality in the M-type, N-type and E-type was 11.93%, 13.10% and and 23.20%, respectively; 23.20% of those with E-type exhibited poor sleep quality compared with 11.93% of those a with M-type and 13.10% of those with N-type (p<0.001). In-depth analysis of the association of chronotype with the PSQI components showed that significant differences were found in the distribution of chronotypes in five Al training, and components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency and daytime dysfunction (all p<0.001, online supplemental table 2).

Characteristics of participants with poor sleep quality

We analysed the characteristics of all participants with poor sleep quality (online supplemental table 2). The overall prevalence of poor sleep quality among females (19.82%) was higher than that among males (16.12%)(p=0.001). Statistically significant differences were found between the two groups (poor sleep quality and good sleep quality) with respect to the following characteristics (all p<0.05): academic performance, grade, learning **3** burden, alcohol drinking, mobile phone usage duration per day and coffee drinking.

Regarding the seven dimensions of PSQI, the difference between having sleep problems and not having sleep problems was found to be statistically significant with respect to the following characteristics (all p<0.05): (1) subjective sleep quality: academic performance, grade, learning burden, mobile phone usage duration per day and coffee drinking; (2) sleep latency (≥30 min): gender academic

Table 2 Logistic regression analysis of chronotype associated with poor sleep quality among college students								
PSQI and PSQI components*	Chronotype†	Beta	SE	Wald	Ρ	OR (95% CI)		
Subjective sleep quality	N-type	Ref.						
	E-type	0.513	0.085	36.228	<0.001	1.671 (1.414 to 1.975)		
	M-type	-0.136	0.254	0.286	0.593	0.873 (0.530 to 1.437)		
Sleep latency	N-type	Ref.						
	E-type	0.362	0.070	26.652	<0.001	1.436 (1.252 to 1.647)		
	M-type	-0.276	0.208	1.763	0.184	0.759 (0.505 to 1.141)		
Sleep duration	N-type	Ref.						
	E-type	0.765	0.182	17.756	<0.001	2.149 (1.506 to 3.067)		
	M-type	0.052	0.530	0.010	0.921	1.054 (0.373 to 2.980)		
Habitual sleep efficiency	N-type	Ref.						
	E-type	0.532	0.126	17.763	<0.001	1.702 (1.329 to 2.180)		
	M-type	0.270	0.308	0.769	0.380	1.311 (0.716 to 2.398)		
Sleep disturbances	N-type	Ref.						
	E-type	-0.120	0.099	1.458	0.227	0.887 (0.739 to 1.078)		
	M-type	-0.289	0.264	1.202	0.273	0.749 (0.447 to 1.256)		
Use of sleeping medication	N-type	Ref.						
	E-type	-0.052	0.207	0.063	0.802	0.950 (0.633 to 1.424)		
	M-type	-0.494	0.546	0.819	0.366	0.610 (0.209 to 1.780)		
Daytime dysfunction	N-type	Ref.						
	E-type	0.471	0.064	53.469	<0.001	1.602 (1.412 to 1.818)		
	M-type	-0.308	0.189	2.665	0.103	0.735 (0.507 to 1.064)		
Overall PSQI	N-type	Ref.						
	E-type	0.624	0.083	56.355	<0.001	1.866 (1.586 to 2.196)		
	M-type	-0.114	0.245	0.218	0.641	0.892 (0.552 to 1.441)		

*Dependent variable. +Independent variable.

E-type, evening-type; M-type, morning-type; N-type, neutral-type; PSQI, Pittsburgh Sleep Quality Index.

performance, grade, learning burden and mobile phone usage duration per day; (3) sleep duration (<6 hours): gender, academic performance, grade, smoking alcohol drinking and coffee drinking; (4) habitual sleep efficiency: grade and student status; (5) sleep disturbances: academic performance, grade, learning burden, smoking, alcohol drinking, mobile phone usage duration per day, coffee drinking and student status and (6) use of sleeping medication: academic performance, grade, learning burden, smoking, alcohol drinking, mobile phone usage duration per day and coffee drinking. The distinction between poor and good daytime function was found to be statistically significant with respect to all characteristics except alcohol drinking and smoking (online supplemental table 2).

Logistic regression analysis of chronotype associated with sleep quality

The variables (online supplemental table 2) that had a $p \le 0.10$ on χ^2 test were entered into the multiple logistic regression used to calculate the ORs for poor sleep quality (table 2). After controlling for confounding

Protected by copyright, including for uses related to text and data mining, AI training, factors, multiple regression analysis showed that students with E-type were more likely to have poor sleep quality, mainly in subjective sleep quality (OR=1.671, 95% CI 1.414 to 1.975), sleep latency (OR=1.436, 95% CI 1.252 to 1.647), sleep duration (OR=2.149, 95% CI 1.506 to 3.067), habitual sleep efficiency (OR=1.702, 95% CI similar technologies 1.329 to 2.180), daytime dysfunction (OR=1.602, 95% CI 1.412 to 1.818) and overall poor sleep quality (OR=1.866, 95% CI 1.586 to 2.196) (table 2).

DISCUSSION

The main findings of this study were as follows: (1) selfreported proportions of E-type, N-type and M-type among college students were 51.17%, 45.14% and 3.69%, respectively; (2) the overall mean PSQI score was 4.97±2.82 and the prevalence of poor sleep quality was 18.2% and (3)E-type was positively associated with poor sleep quality.

Approximately one-third of a person's life is spent sleeping; sleep is crucial for maintaining physical health. Sleep disorders among college students including chronic

sleep deprivation and davtime sleepiness not only affect their physical health but also carry consequences such as inattention and lack of motivation. These disorders can also result in psychological and behavioural problems that seriously endanger their physical and mental health, including anxiety, depression and suicide.^{7 42} In the present study, the prevalence of poor sleep quality was 18.2%. Among the seven components of sleep quality, daytime dysfunction and sleep latency ($\geq 30 \min$) exhibited the highest detection rates. The results of this study suggest that sleep quality problems are significantly more prevalent among college students than among the general population.⁴³ This may directly correlate with the high academic performance pressure on college students, which includes the pressure of intense professional courses. Previous studies have indicated that poor sleep quality prevalence among different groups of college students in China is ranging from 15.97% to 30.1%.44 45 A recent study from Anhui Medical University found that 74.3% of students were experiencing poor sleep quality (much higher than the prevalence we observed).⁸ In a study conducted by Chen *et al*, the criterion for poor sleep quality was a PSQI score $\geq 5.^{8}$ All participants were medical students. In China, medical students carry heavier courseloads and experience higher stress levels than the other students, which can affect their sleep quality deeply.^{3 46} Poor sleep quality among college students is a global problem. The prevalence of poor sleep quality (PSQI score >7) among medical students was 30% in India and 25.3% in Nepal.^{47 48} Based on the above results, poor sleep quality among college students has become a common threat to student health, attracting widespread attention from all sectors of society and leading to targeted guidance for college students.

Self-reported proportions of E-type, N-type and M-type among college students were found to be 51.17%, 45.14% and 3.69%, respectively. The proportion of E-type in the present study is higher in college students than that in non-medical students (31.7%).49 One possible reason is that 67.01% of the students in the present study came from medical schools. Medical students, a special group of college students, participate in long-school hours learning and perform heavy academic tasks. Thus, their chronotypes become dominated by E-type, with a small proportion of students retaining M-type.¹⁷ Another possible reason may be the prolonged lockdown of students in schools and the various isolation policies implemented during the COVID-19 outbreak, which resulted in delayed bed and waking times.⁵⁰ Chronotypes vary throughout the ontogeny process and are mainly influenced by factors including sex, age and grade.^{26 51 52} Chronotype is not fixed throughout life.²⁶ Yi et al found that the chronotypes in 7472 freshmen were mainly E-type (54.73%), with M-type accounting for 2.25%, similar to the results of this study.³³ Another study from China found an N-type proportion of 75.5% among 5497 college students, with more N-type students than M-type students, which is not in line with our findings.⁵³ This

BMJ Open: first published as 10.1136/bmjopen-2023-076782 on 19 may be caused by different scoring standards. In the study reported by Sun *et al*,⁵³ the score range for the N-type was 42–58 points, while in this study, the score for the N-type Multiple logistic regression analysis showed that E-type was positively associated with poor sleep quality. Compared with N-type and M-type students, E-type students were more likely to experience poor sleep quality. E-type students were more likely to experience problems with sleep duration (<6 hours), sleep latency - $(\geq 30 \text{ min})$ and daytime dysfunction. Lang *et al* concluded **2** that as the amount of time spent sleeping late increased, the likelihood of poor sleep quality and emotional disorders among participants increased, consistent with our 2 conclusions.⁵⁴ Sleep latency measures the length of time it **8** takes to fall asleep in minutes, from the moment a person tries to fall asleep to the moment they actually fall asleep. Higher scores indicate longer sleep latencies, which are Higher scores indicate longer sleep latencies, which are considered to indicate poor sleep quality. A systematic review and meta-analysis including 43 studies indicated a moderate positive correlation between E-type sleep and ٥

was 50-62 points.

review and meta-analysis including 43 studies indicated a moderate positive correlation between E-type sleep and in the procrastination, consistent with our findings.⁵⁵ Sleep duration is the measure of the total amount of sleep durations, which are associated with poorer health outcomes. A recent study showed that E-type students reported the worst sleep quality and the highest levels of bedtime procrastination.¹³ Increased levels of bedtime procrastination, reduce sleep duration as university students wake up at relatively uniform times. Daytime dysfunction reflects how awake/alert a participant is during the dysfunction, including lack of concentration during the dysfunction, including lack of concentration during the dysfunction, including lack of concentration during the dysfunction, including factor to influence the impact of the procosite of depression in adolescents and can also act as a amediating or moderating factor to influence the impact strengthen student management of work and rest balance, promoting the benefits of M-type, achieving interventions by changing the chronotypes of students and improving the scientific basis for improving sleep quality among solven systems. Some shortcomings in this study must be taken into account when interpreting these findings. First, the cross-sectional design cannot determine a causal association between chronotype and poor sleep quality. Therefore, these results need to be validated in

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prospective cohort studies. Second, the study samples were all from one province (Anhui) in China, which may have introduced a selection bias. A nationwide survey of several provinces is needed in a future study. Third, the information obtained in this study came from the selfreports of students. Thus, some information bias is inevitable. Fourth, although this study adjusted for multiple confounding factors, there may have been some residual confounding factors that were not considered, such as the different majors of students from different schools, epidemic-related factors and psychological-related factors (eg, stress and depression).

CONCLUSION

The college students in this study mainly exhibited the E-type chronotype, and an elevated prevalence of poor sleep quality existed among these students. The E-type was positively associated with poor sleep quality. Longitudinal studies are required to clarify whether the relationship between chronotype and poor sleep quality is causal.

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