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The relationship between chronotype, insomnia and depressive symptoms in Chinese male prisoners

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Abstract

Background This study aimed to estimate the prevalence of chronotypes among male prisoners in China and to examine the relationship between chronotype, insomnia, and depressive symptoms in this population.

Methods A total of 1609 male inmates participated in this cross-sectional study by completing the Morning and Evening Questionnaire-5 (MEQ-5), Insomnia Severity Index (ISI), and Patient Health Questionnaire-9 (PHQ-9). Age, time served, insomnia, and depressive symptoms were compared across chronotypes. Binary logistic stepwise regression was used to analyze factors influencing depression. Additionally, a simple mediation model incorporating MEQ-5, ISI, and PHQ-9 was analyzed, with age controlled as a covariate.

Results The prevalence of morning type (MT), neutral type (NT), and evening type (ET) was 47.2%, 46.7%, and 6.1%, respectively. Being an ET was significantly associated with younger age and increased symptoms of insomnia and depression ($P < 0.05$). The relative risk of depression was 2.970-fold higher (95% CI, 1.724 to 5.116; $P < 0.001$) for ET compared to MT. Mediation analysis revealed that insomnia partially mediated the relationship between chronotype and depression, while the direct effect of chronotype on depression was also significant (accounting for 50.51% of the total effect).

Conclusions The prevalence of ET is relatively low among male prisoners. Resetting ET tendencies may reduce depressive symptoms in this population.

Keywords Chronotype, Insomnia, Depressive symptoms, Prisoner, Mediating effect

Introduction

Circadian rhythm is an endogenous life process that fluctuates approximately a near-24-h cycle [1]. Influenced by the internal biological clock and external environment, the circadian rhythm is relatively consistent by a near-24-h sleep-wake circadian rhythm but vary among individuals [2]. These different rhythms are known as chronotypes [3]. Chronotype is an individual's preferred time of activity and sleep. While circadian preference (chronotype) exists on a continuum, it is commonly classified into three types: morning type (MT), neutral type (NT), and evening type (ET) [4]. MT individuals favor

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going to bed early and rising early, experiencing peak mental and physical performance in the early hours of the day. In contrast, ET individuals prefer going to bed and rising late, reaching their optimal performance toward the end of the day and during evening hours. NT individuals fall between these two conditions. Chronotype is a trait-like, and thus a relatively stable construct [5].

While the chronotype continues to function under constant conditions, it can be affected by environmental changes and spontaneous activities like light exposure, diet, exercise and social interactions [6, 7]. These external time cues are referred to as zeitgebers. With the increase in artificial light, the use of electronic devices, and social activities in the evening, modern technological lifestyles in recent years has led to a swift transition in our society towards a prevailing "eveningness" [8, 9]. Eveningness seems to have become more prevalent in recent decades [10].In a national study in Finland, ET subject was estimated to be 11-13% of the adult population [11]. A Chinese study found that the proportion of evening types was 14.64% [12].

In addition to differences in circadian rhythm, morning type (MT) and evening type (ET) also exhibit differences across various psychological dimensions [13]. Growing research indicates that individuals with evening chronotypes are at higher risk of developing mental disorder, particularly depression [9, 14, 15]. Conversely, an early diurnal preference acts as a protective factor against depression and contributes to overall well-being [16, 17]. Evening types are associated with poorer sleep quality and a range of sleep-related complaints [9, 11]. Eveningness is also correlated with elevated insomnia symptoms [18]. A study conducted in young Indian adults found relationship between a preference for eveningness and poor mental health outcomes was mediated by poor sleep quality [19]. This suggested the use of chronotype-based work schedules to improve sleep quality rather than aiming to shift diurnal preferences towards morningness for improving mental health. Thus, it is important to clarify whether the effect of chronotype on depression is entirely mediated by sleep quality.

Prisoners are a special group, who are forced to follow a uniform routine. Their work and rest schedule is relatively consistent with the morning types. They wake up, eat, having physical activity and rest at the same time frame. This provieds an opportunity to evaluate the impact of manipulating zeitgebers on chronotype. Besides, prisoners commonly experience psychological distress including insomnia and depression [20]. Whether this consistent work and rest schedule affect the circadian rhythm preference of prisoners and thus affect the mental health of them is unknown. This is the first study to estimate the distribution and prevalence of chronotypes in a Chinese prisoner sample. Accordingly, this study examined the differences in insomnia and depressive symptoms between three chronotypes in Chinese male prisoners. We hypothesized that proportion of ET in the prison population is lower. Evening type was a risk factor for insomnia and depressive symptoms among prison inmates. We also tested whether chronotype had an independent effect on depressive symptoms. If so, strategies shift tendencies away from eveningness can thus reduce depressive symptoms.

Methods

Participants

Data for this study was collected through paper questionnaire. This study consisted of 1811 inmates in 8 prison supervision areas of a male prison in Hebei Province, China from October 20 to November 20, 2019. The prison schedule demand inmates waking up at 6 a.m and going to bed at 10 p.m. Three meals are served at 6:30 a.m, 12:00 a.m and 6:00 p.m.

Procedure

We distributed 1811 questionnaires. Individuals with severe mental disorders (schizophrenia, bipolar disorder etc.) who were managed separately and under the guardianship of prison staff were excluded. Questionnaires were collected according to the principle of voluntary participation. According to age 18–65 years old, Han nationality, literate to understand the questionnaire, then missing and invalid data was excluded, 1609 valid questionnaires(88.85%) were collected finally. The flow diagram of participants are shown in Figure. 1.

Prior to the initial survey, we conducted a preliminary study involving 200 prisoners to assess the questionnaire's difficulty and suitability for the inmate population. Simultaneously, eight researchers underwent questionnaire instruction language training. Furthermore, two independent researchers thoroughly examined all the questionnaires. The study received approval from ethics committee of the the second affiliated hospital of Xinxiang medical college(Ethics No: XYEFYLL-(keyan)-2020-23-2). All study participants signed a written informed consent form.

Measures

We used self-report questionnaires to collect information on demographic variables including age, race, education level, marital status, the length of prison term (≤ 3 years for short term, 3 ~ 10 years for medium term, > 10 years for long term), and the time served (calculated on a monthly basis).

Chronotype

Morning and Evening Questionnaire (MEQ) is a self-assessment scale used to assess chronotype [21].This

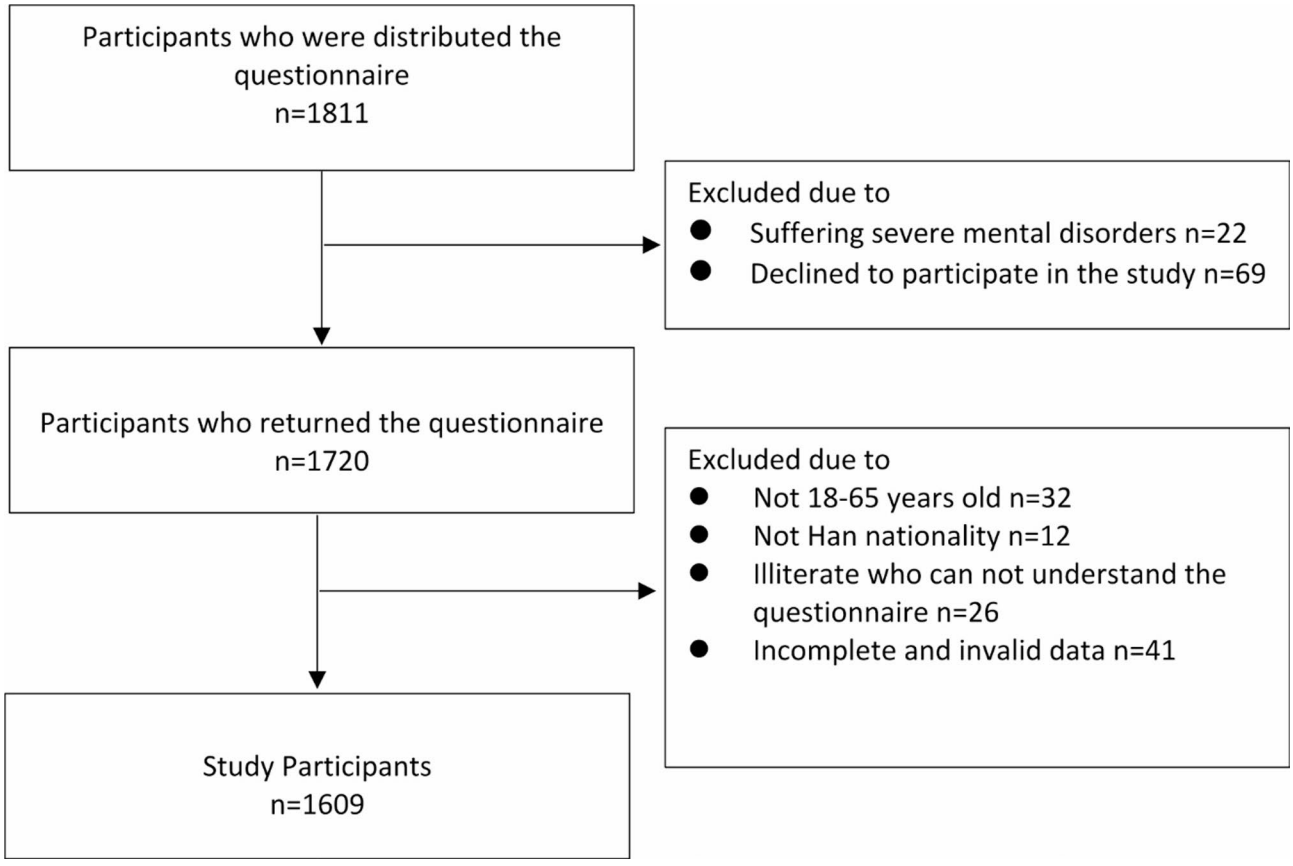

Fig. 1 Flow diagram of participants

study employed the MEQ-5, a simplified version of MEQ, demonstrating robust test-retest reliability and satisfactory construct validity [22]. The MEQ-5 only consists of 5 entries and participants express their responses on a self-assessment scale (e.g. "during the first half hour after you wake up in the morning, how was your feeling?": "very tired", "fairly tired", "fairly refreshed" and "very refreshed"). Higher score indicate morningness in the participants. Scores range from 4 to 25, and the total scores categorize individual into three groups: evening type (4–11), neutral type (12–17), and morning type (18–25) [23]. Cronbach's α of MEQ-5 was 0.81 in the present study.

Depressive symptom

The Patient Health Questionnaire-9(PHQ-9) is a widely utilized, straightforward, and validated self-rated scale for assessing depression, comprising 9 items. Each item offers four options and is rated from 0 to 3 (not at all to almost every day), with higher scores indicating more severe depressive symptoms. The total scores range from 0 to 27. Based on the overall score, depressive symptoms are categorized as follows: no depression(0–4), mild depression(5–9), moderate depression(10–14), moderate to severe depression(15–19), and severe depression(20–27) [24]. In this study, a PHQ-9 cutoff of ≥10 was employed to identify clinically significant depressive symptoms. Cronbach's α of PHQ-9 was 0.84 in the present study.

Insomnia symptom

Insomnia Severity Index(ISI) is a 7-item self-report questionnaire designed to assess the severity of insomnia by evaluating subjective nighttime symptoms and potential daytime repercussions. Scores on the scale range from 0 to 28, and the interpretation is as follows: an absence of clinically significant insomnia(0–7), presence of subthreshold insomnia(8–14), suggestive of clinical insomnia with moderate severity(15–21), indicative of clinical insomnia with severe intensity(22–28). ISI score ≥ 8 may suggest that the participant is experiencing symptoms associated with subthreshold to clinical insomnia. The diagnostic sensitivity and specificity in detecting insomnia cases in the community are reported as 95.8% and 78.3% [25]. In this study, an ISI cutoff of ≥ 8 was utilized to identify the presence of insomnia. Cronbach's α of ISI was 0.93 in the present study.

Statistical analysis

Statistical analysis was conducted utilizing SPSS version 25.0. The age comparison across the three groups was executed using one-way analysis of variance. For the assessment of time served among the three chronotypes, the Kruskal-Wallis non-parametric test was applied.Incidence comparisons of depression and insomnia among different chronotypes were performed using the Chi-square test. Subsequently, controlling for the influencing factors of age through covariance analysis, depressive and insomnia symptom scores were compared among the three chronotypes. Predictors of depression were identified using binary logistic stepwise regression analysis. To assess the robustness of the mediating effect, the Bootstrap method was utilized, implementing Bootstrap mediation analysis via the PROCESS toolbox. Process Model4 was utilized for testing the mediation effect, employing 5000 bootstrap samples for coefficient and effect estimation. The significance of the effect was determined based on whether the 95% confidence intervals (CIs) included zero. Significance level was set at $P < 0.05$.

Results

Demographic and clinical characteristics

Table 1 presents the characteristics of the participants. All of the participants involved were male. The average age of the sample was 39 years(SD10.5, range18–65). Participants with junior high school education or below accounted for 77.5%. According to the length of prison term, short term (≤ 36 months), medium term (36–120 months) and long term (> 120 months), account for 21.3%, 49% and 29.8% respectively. Nearly 90% of the participants have served 12 months or more.47.2% of the sample was classified as having a morning-type(MT), 46.7% was neutral-type (NT), and 6.1% was evening-type(ET). 367 (22.8%) participants reported clinically significant depressive symptoms, and 705 (43.8%) participants reported insomnia.

Table 1 Summary of demographic and clinical characteristics

Variable	Mean ± SD/ Median (1st quartile – 3rd quartile)	*N*	%
Age	39 ± 10.5	1609	
Educational level			
Primary school and below		566	35.2
Junior high school and below		681	42.3
High school and below		230	14.3
College degree and above		132	8.2
Marital status			
Unmarried		382	23.7
Married		885	55
Others(divorced or widowed)		342	21.3
Prison term	72(42,132)		
Short-term(≤36 months)		342	21.3
Mid-term(36–120 months)		788	49
Long-term(>120 months)		479	29.8
Time Served	39(22,69)		
≤ 12 months		174	10.8
12–36 months		601	37.4
36–60 months		363	22.6
> 60 months		471	29.3
Chronotype			
ET		98	6.1
NT		752	46.7
MT		759	47.2
Depressive symptoms			
No(0–4)		831	51.6
Mild(5–9)		411	25.5
Moderate and above(≥ 10)		367	22.8
Insomnia symptoms			
No(0–7)		904	56.2
Yes(≥ 8)		705	43.8

Abbreviations: SD, standard deviation; MT, Morning type; NT Neutral type; ET, Evening type

Relationship between chronotype and age, the time served

The disparity in age across chronotypes was statistically significant($p < 0.001$), with the mean age of MT is older than that of NT($p < 0.001$), and the age of the NT is older than that of ET($p < 0.05$). No significant difference was observed in the time served among individuals with different chronotypes($Z = 1.003, p = 0.606$).The differences between chronotype on age and the time served are shown in Table 2.

Abbreviations: PHQ-9, Patient health questionnaire-9; ISI, Insomnia severity index; MT, Morning type; NT Neutral type; ET, Evening type; a, One-way analysis of variance; b, Kruskal-Wallis test; c, χ^2test.

Relationship between chronotype and depression and insomnia

There was a significant difference in the incidence rate of clinically significant depressive symptoms, which was 41.8% in the ET group, 28.9% in the NT group, and 14.4% in the MT group($P < 0.001$). This suggests a higher likelihood of individuals with an evening chronotype being identified as experiencing depression. The significant difference in mean depression scores among chronotypes persisted when controlling for age as a covariate ($P < 0.001$). Evening types reported significantly higher depression scores compared to both neutral ($P < 0.05$) and morning types ($P < 0.001$), while neutral types were also more prone than morning types to report more severe depressive symptoms ($P < 0.001$).

The difference in the proportion of insomnia among the three groups was also statistically significant ($P < 0.001$), with rates of 55.1% in the ET group, 50.4% in the NT group, and 35.8% in the MT group. When adjusting for age as a covariate, severity of insomnia exhibited significantly different between chronotypes ($P < 0.001$), with ET group reporting poorer sleep than both NT group ($P < 0.001$) and MT group ($P < 0.001$). Additionally, NT group was more likely than MT to report poorer sleep ($P < 0.001$). Refer to Table 2; Fig. 2 for difference between chronotypes concerning depression and insomnia.

Predictors of depression in prisoners

Binary logistic stepwise regression analysis revealed that two factors significantly predicted depression(PHQ-9 ≥ 10): ISI(95%CI, 1.176 to 1.227;$P < 0.001$) and chronotype. The relative risk of depression was 2.970-fold (95%CI, 1.724 to 5.116; $P < 0.001$)higher for ET compared to MT. While NT was associated with an increased risk of depression by 2.076-fold (95%CI, 1.536 to 2.804; $P < 0.001$) compared with MT(Table 3). Age, marital status, educational level, prison term, and time served did not emerge as significant predictors.

Mediating effects of insomnia between chronotype and depression

The bootstrap test was used to test the hypothesis of the mediating effect of insomnia between chronotype and depression, while controlling age for covariate. The number of iterations was set to 5000, with a 95% confidence interval. The results revealed that the 95% confidence intervals for both the direct effect (chronotype → depression), and indirect effect (chronotype → insomnia → depression) did not contain zero. This indicated that there was a partial intermediary effect between insomnia and depression, and the intermediary effect value is -0.242, accounting for 49.49% of the total effect, as shown in Table 4; Fig. 3.

Discussion

This study is the largest of its kind to explore chronotype, insomnia and depression in a large, male sample of Chinese prisoners. We demonstrated that nearly half of our sample(47.2%) was classified into MT, while ET(6.1%) is the least. Merikanto used the National FINRISK Study 2007 Survey data on 3696 women and 3162 men, representative of the Finnish population aged 25 yrs and older, for the assessment of chronotype. ET, NT and MT of men

Table 2 Age, time served, depression, insomnia by chronotype

		ET *N* = 98	NT *N* = 752	MT *N* = 759	F/H/ χ^2	*P*-value
Age		34.77 ± 8.82	37.90 ± 10.24	41.27 ± 10.50	30.381[a]	< 0.001
	18–30(*n* = 348)	35	197	116	63.201[c]	< 0.001
	30–40(*n* = 619)	44	297	278		
	40–50(*n* = 367)	12	155	200		
	> 50(*n* = 275)	7	103	165		
Time Served		36(25,63)	38(23,70)	39(21,66)	1.003[b]	0.606
Depression	PHQ-9 < 10	57(58.2%)	535(71.1%)	650(85.6%)	66.538[c]	< 0.001
	PHQ-9 ≥ 10	41(41.8%)	217(28.9%)	109(14.4%)		
Insomnia	ISI < 8	44(44.9%)	373(49.6%)	487(64.2%)	37.939[c]	< 0.001
	ISI ≥ 8	54(55.1%)	379(50.4%)	272(35.8%)		

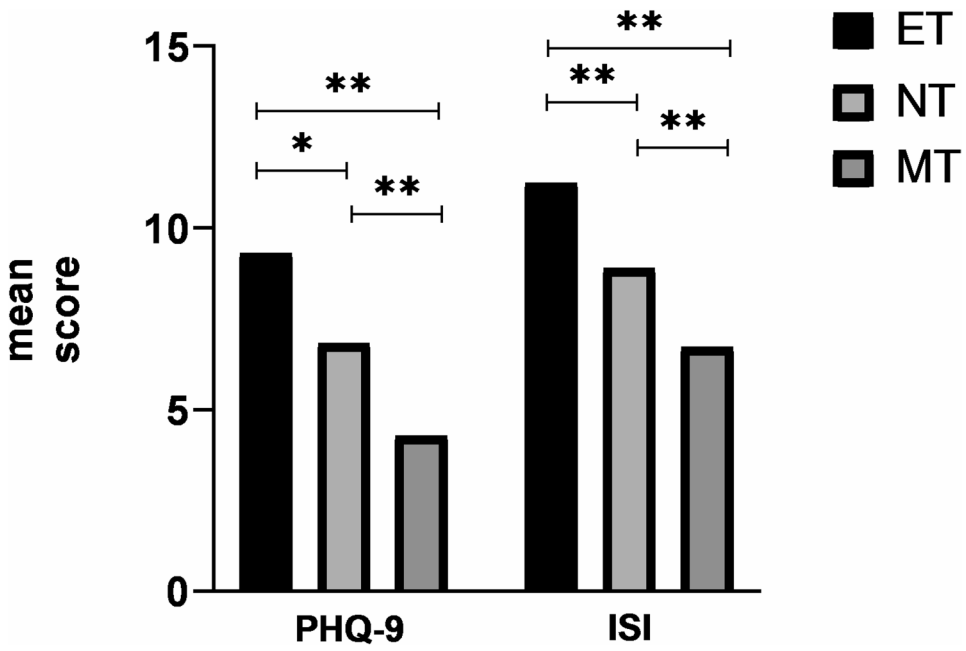

Fig. 2 Comparison of depression and insomnia scores between different chronotype groups
Note: *$P < 0.05$ **$P < 0.001$

Table 3 Binary logistic regression analysis of factors affected depression

Factor		B	SE	Wald	OR	*P*-value
ISI		0.183	0.011	297.272	1.201(1.176–1.227)	< 0.001
Chronotype	MT as a reference	-	-	-	-	-
	ET	1.089	0.277	15.392	2.970(1.724–5.116)	< 0.001
	NT	0.730	0.154	22.626	2.076(1.536–2.804)	< 0.001
Constant		-3.530	0.172	420.790	-	< 0.001

Abbreviations: ISI, Insomnia severity index; MT, Morning type; NT Neutral type; ET, Evening type; -, not applicable

Table 4 Bootstrap tests of mediating effect between chronotype and depression in prisoners

	Estimate	S.E.	95%CI	Effect ratio
Total effect	-0.489	0.043	-0.597~-0.405	-
Direct effect	-0.247	0.034	-0.314~-0.180	50.51%
Indirect effect	-0.242	0.030	-0.301~-0.183	49.49%

Abbreviations:-, not applicable

were respectively 11%,38% and 51% according to MEQ score [11]. In recent years, Liu performed a chronotype survey using MEQ, reporting chronotype distribution in the Chinese population. They found that percentage of men with ET, NT and MT was 19.3%,68.2% and 12.5% [26]. In our study, the chronotype distribution of Chinese male prisoner is different from previous survey of general population, mainly reflected in the relatively low proportion of ET.

Next, we hope to explore what factors are associated with chronotype within this population. Firstly, Chronotype is closely related to age. It is commonly observed that the peak tendency toward lateness in chronotype occurs during late adolescence or early adulthood at around the age of 20 years. Subsequently, adult chronotypes tend to shift towards morningness [27, 28, 29, 30]. In our study, only adult population(18–65) was included, the age of MT group was significantly older than that of NT group, and NT group older than ET group. It was further confirmed that ET was more common among the younger adult prisoners, while circadian preference towards MT was more common among the older adult prisoners. Secondly, the individual difference of chronotype is based on the intrinsic biological rhythm and also influenced by the environment. Outside prison people who frequently expose themselves to zeitgeber signals that delay sleep-wake rhythms, such as working late at night, nighttime light exposure, nighttime social or physical activity, can aggravate eveningness tendencies. In the prison, environmental zeitgeber factors are controlled, inmates are forced to keep early hours, this might lead to a situation where in the study sample relatively low prevalence of ET. The chronotype can be adjusted by regular sleep and activity schedule. Based on this, we naturally thought whether the time served is related to chronotype, that is the more inclined to the early morning type

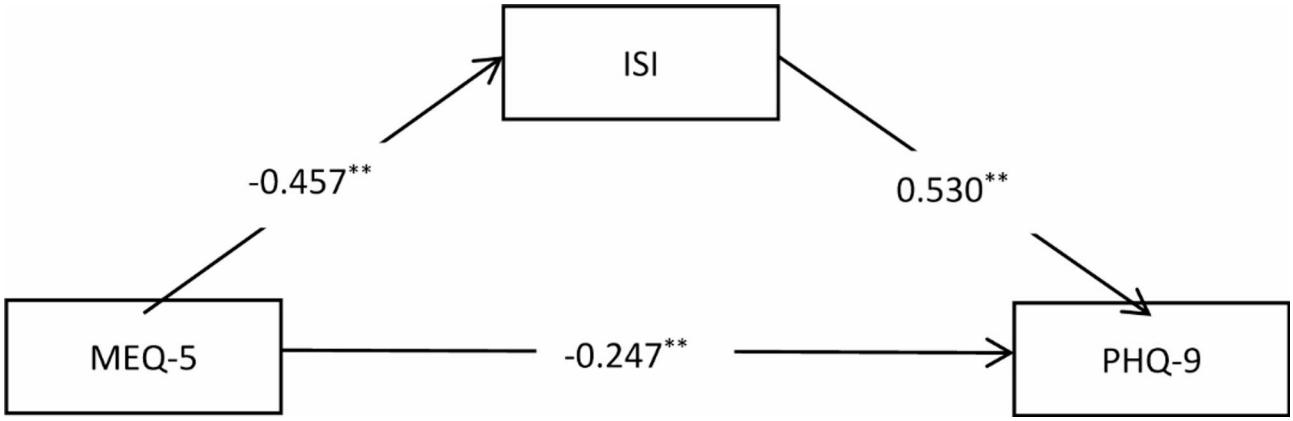

Fig. 3 Simple mediation model for the effect of insomnia on the relationship between chronotype and depressive symptoms
Abbreviations: MEQ-5, Morning and evening questionnaire-5; PHQ-9, Patient health questionnaire-9; ISI, Insomnia severity index
Note: shown are unstandardised path coefffcients, *$P < 0.05$, **$P < 0.001$

in prisoners, the longer the time served.However, no difference in the time served was found in the comparison of the three chronotypes.Considering nearly 90% of the participants have served 12 months or more. The lack of differences in the time served in prison across chronotype is likely due a short acclimation period given the strict prison schedule.This need to be confirmed by further research in the future.

Our findings provide further evidence that evening chronotype is associated with increased risk for insomnia and depression, morning chronotype is protective for insomnia and depression. ET has been associated with insufficient sleep [11]. Eveningness is also associated with lower subjective sleep quality and various sleep complaints [18]. However, there are conflicting findings, such as those found in the study by Taillard and colleagues. In their research, both morningness and eveningness were linked to a higher frequency of self-reported morbidity related to sleep problems [31]. In our present study, insomnia rate and ISI score of ET was the highest, MT was the lowest. Mismatch between the sleep-wake schedule and circadian preference can lead to insufficient sleep time. Eveningness predisposes prisoners to insomnia. The association of ET with depression has been shown in a number of independent studies [15, 32, 33]. In the general population, eveningness is associated with increased depressive symptoms or diagnosis of depression [34, 35]. Early diurnal preference is protective for depression [16, 17].In our present sample, clinically significant depression rate and PHQ-9 score of ET was the the highest among three groups, while morning chronotype was associated with decreased symptoms of depression. The relative risk of depression was 2.970-fold higher for ET compared to MT. While NT was associated with increased risk of depression by 2.076-fold compared with MT. Our study extends this work by further testing these relationships among prison inmates.

When investigating the mediating effects of insomnia on the association between chronotype and depression, our findings indicated that insomnia plays a mediating role; however, it emerged as a partial mediator. Logistic regression analysis showed that chronotype and insomnia were predictors of depression. Individuals with an Evening type (ET) typically exhibit a tendency for late bedtime, prolonged sleep latency, and a shorter overall sleep duration [36, 37], These factors collectively could contribute to a higher incidence of sleep problems and poor sleep quality, subsequently elevating the risk of depression [38]. Horne et al. [13] observed an link between eveningness and heightened depressive symptoms in a healthy sample and this relationship was found to be partially mediated by sleep quality. However, in female participants, sleep quality has been reported to completely mediate the impact of eveningness on acute stress [39] and psychosocial function regardless of chronotype [40]. The depression scale includes a sleep component, which may inflate the correlation between insomnia and depression. Our study identified independent effect of chronotype and mediating effect of insomnia on depression. Our results suggest that evening type can lead to depression, partly through the direct effect on depression and partly through the mediating effect of insomnia. Chronotype play an important role in depression.

This study showed that the prevalence of evening chronotype in male prisoner was relatively low, while eveningness was associated with depressive symptoms. The main difference between prison inmates and the general population is the fixed sleep and activity schedule, this may contribute to the morningness preference thus reducing depressive symptoms in prisoners. Besides, our finding support a direct association between eveningness and depression, not being completely mediated by insomnia. This provide evidence that improving sleep (through addressing insomnia) may subsequently

improve depression symptoms experienced by those with biological ET, and that finding a way to phase-advance individuals (such as melatonin, light therapy) could also make them less prone to depression in prison population.

Conlusion

Our findings provide further evidence that evening chronotype is associated with an increased risk for depression. This study extends the existing research to a population of prison inmates. The implications of these findings could have significant benefits across various settings. In the general population, where a significant proportion of individuals exhibit evening chronotypes, establishing a regular sleep schedule could modity eveningness through controlled zeitgebers, serving as a potential preventive measure against depressive symptoms. In clinical settings, addressing insomnia in individuals with biological ET might help reduce depressive symptoms, while implementing circadian adjustment strategies also shows potential therapeutic benefits. These results suggest that chronobiological could play a valuable role in the prevention and management of depressive disorders. However, as this is a preliminary exploration among a prison population, further rigorous research is needed to validate the efficacy of these interventions and assess their generalizability across diverse populations and settings.

Limitations

The effect of served time on chronotype has not been verified, and we speculated that it is related to a short acclimation period given the strict prison schedule, but this is based on our own speculation and needs to be verified by further research in the future. This study is a large-scale questionnaire survey based on subjective morning-eveningness preference. Considering the feasibility of implementation, no objective circadian rhythm indicators were evaluated. The questionnaire survey lacks information about pre-existing mental health conditions. It is important to note that the validity of the MEQ and ISI in a forced schedule environment may be limited, as these tools have not been fully validated in such a sample. Therefore, we advise caution in extrapolating the conclusions and emphasize the need for further research to confirm these findings.

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Author contributions
Hengfen Li and Jin He conceived and designed this study. Shuqi Zhang, Daoli Liu and Qingzhen Yang performed collecting the data. Weixia Xiao and Daoli Liu check the data. Jin He, Weixia Xiao and Mufan Zheng analyzed the data. Jin He drafted and edited the initial manuscript. Hengfen Li revised the manuscript. All authors edited and approved the final manuscript. This manuscript has not been published and is not under consideration for publication elsewhere.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The study was conducted in accordance with the Declaration of Helsinki. The study received approval from the Ethics Committee of the Second Affiliated Hospital of Xinxiang Medical College (Ethics No: XYEFYLL-(keyan)-2020-23-2). Clinical trial number: not applicable. All study participants signed a written informed consent form.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Conflict of interest
All authors declared no conflict of interest.

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