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REVIEW ARTICLE

The Relationship of Sleep Duration, Chronotype, Social Jet Lag and the Risk of Depression: A Systematic Review and Meta-Analysis

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Abstract

Depression is one of the greatest health challenges worldwide, and sleep is a major influencing factor in depression. This meta-analysis aimed to systematically integrate existing evidence by analyzing 38 observational studies from five electronic databases. Results revealed that short sleep duration (OR=1.78, 95% CI: 1.61-1.97), long sleep duration (OR=1.17, 95% CI: 1.02-1.34), neutral chronotype (N-type) (OR=1.27, 95% CI: 1.06-1.51), evening chronotype (OR=2.09, 95% CI: 1.64-2.68), 1-2 hours of social jet lag (OR=1.11, 95% CI: 1.04-1.19), and ≥2 hours of social jet lag (OR=1.58, 95% CI: 1.4-1.78) were associated with an increased risk of depression. Specifically, short sleep duration, evening chronotype, and ≥2 hours of social jet lag were more significantly associated with the risk of depression. This meta-analysis demonstrated that both short and long sleep durations, evening chronotype, and social jet lag exceeding two hours are associated with an elevated risk of depression. Due to substantial heterogeneity among studies, the evidence base remains limited. Future research should employ standardized methods, longitudinal designs, and investigate contextual factors to clarify underlying mechanisms.

Keywords

Sleep duration, Chronotype, Social jet lag, Depression, Meta-analysis

Introduction

Depression is one of the greatest health challenges worldwide [1]. It affects more than 300 million people globally [2]. According to statistics from the World Health Organization (WHO), depression is one of the leading causes of disability worldwide, and its disease burden is projected to become the highest by 2030 [3]. The treatment and prevention of depression have become a global public health concern. Sleep, as a major influencing factor of depression, has recently attracted increasing attention from scholars.

Our daily lives are regulated by at least three "clocks": the social clock, the solar clock, and the biological clock [4]. The biological clock is the 24-hour internal time-keeping system, entrained to the environmental light-dark cycle [5]. The human circadian clock controls various physiological process and is particularly noticeable in regulating sleep and wakefulness. Chronotype refers to an individual's preference for the timing of the sleep-wake cycle, also known as circadian preference. Chronotype can be viewed as a biological construct [4]. It is largely regulated by the biological clock. Both

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genetic variation in clock genes and environmental factors contribute to the distribution of chronotype in the population [6]. Chronotype is typically divided into three categories: morning chronotype, composed of individuals who prefer to go to bed early and rise early; evening chronotype, those who prefer to go to bed late and wake up late; and neutral chronotype [7].

In modern society, the social schedule often conflicts with circadian preferences.

Since the social clock has not adapted to the significant delays observed in most biological clocks, the discrepancy between them has increased substantially [4]. Researchers have proposed the concept of social jet lag [6] which describes and quantifies the chronic mismatch between an individual's biological clock and the social clock. Typically, social jet lag is more pronounced in evening chronotypes, as morning chronotypes are often forced to stay up late due to social norms. Consequently, neutral chronotypes exhibit the lowest levels of social jet lag [4]. Social jet lag is usually measured as the absolute difference between the midpoint of sleep on free days (MSF) and that on workdays (MSW) [4]. In contemporary society, most individuals, particularly those with evening chronotypes, experience social jet lag. They are required to wake up relatively early on weekdays due to work or school commitments, leading to sleep deprivation. As a result, they attempt to compensate for accumulated sleep debt on weekends or leisure days [4]. Nearly two-thirds of adults in Europe experience at least one hour of social jet lag [8], while approximately 22.95% of adults in Southern China experience more than one hour of social jet lag [9].

Sleep alterations are common in patients with depression. Both long and short sleep durations are frequently observed in individuals with depression. Previous research has predominantly identified short sleep duration as a risk factor for depressive symptoms. However, recent studies have demonstrated that both long and short sleep durations can serve as risk factors for depression [10,11].

Circadian rhythm disturbances are common in patients with depression. In recent years, research on the relationship between chronotype, social jet lag, and depression has garnered significant attention. Individuals with evening chronotypes are at an increased risk for emotional problems, including depressive symptoms. Studies have found that circadian preference is associated with sleep and mental health outcomes in a dose-response manner [12]. Additionally, evening chronotype has been linked to depressive symptoms [13]. Social jet lag has also been positively associated with an elevated risk of depressive symptoms [9,14]. However, a study conducted in the Netherlands found no significant difference in social jet lag between individuals with major depressive disorder and healthy controls [15].

Although the associations between sleep duration, chronotype, social jet lag, and depression have been studied, the findings have been inconsistent. This systematic review and meta-analysis aims to synthesize the relationships between sleep duration, chronotype, social jet lag, and the risk of depression, thereby providing guidelines for the prevention and treatment of depression.

Methods

This systematic review and meta-analysis was conducted in accordance with the Meta-analysis of Observational Studies in Epidemiology (MOOSE) checklist [16] and the Preferred Reporting Items for Systematic Reviews and Meta- Analyses (PRISMA) statement [17]. The study was registered in the International Prospective Register of Ongoing Systematic Reviews (PROSPERO; CRD4202455876).

Database searching

We systematically searched the following five databases from their inception to June 2024: PubMed, Web of Science, Embase, PsycINFO, Scopus. The search strategy included the following terms: (sleep duration or chronotype or diurnal preference or circadian rhythm or circadian preference or social jet lag or social jet- lag or social jetlag) and (depression or depressive symptom* or depressive disorder or depressive syndrome* or depression emotional).

Inclusion and exclusion criteria

Studies were eligible if they fulfilled the following criteria: (1) Population: Participants were relatively healthy individuals of any age. Studies involving shift workers were excluded. (2) Exposure: Sleep duration was divided into at least three groups (e.g., long sleep group, short sleep group, normal sleep group), studies where sleep duration was divided into two or no groups were excluded; Chronotype was divided into at least three groups (e.g., morning chronotype, evening chronotype, neutral chronotype), studies where chronotype divided into two or no groups were excluded; Social jet lag was divided into at least three groups (e.g., <1 hour, 1-2 hours, ≥2 hours), studies where social jet lag divided into two or no groups were excluded. (3) Outcome: Studies using depressive symptoms as primary or secondary outcome were included. (4) Study design: The included studies were prospective cohort study or cross-sectional studies. (5) Statistical data: Studies were included if they provided adjusted or unadjusted odds ratios (ORs), hazard ratios (HRs), or relative risks (RRs) and their corresponding 95% confidence intervals (CIs) or sufficient data to calculate them.

Data collection

A data collection form was created by the first author and reviewed by the second author. Two authors independently extracted data from the included articles and recorded this information into the collection form.

The following information from the included studies was collected: the first author, year of publication, country, study population, sample size, study design, participants' average age or age range, participants' gender, sleep indicators and their measurement methods, depression measurement methods, effect estimates, and their corresponding 95% confidence intervals (CIs).

Study quality assessment

Two authors independently evaluated the methodological quality of the included prospective cohort studies using the Newcastle-Ottawa Scale (NOS). For the included cross-sectional studies, the methodological quality was assessed using a quality assessment tool for analytical cross-sectional studies consisting of eight items. Two authors made judgments of "yes," "no," "unclear," or "inadaptation" for each evaluation item respectively and determined whether to include or exclude the study after discussion. The NOS comprises eight items, divided into three categories: selection, comparability, and outcome. Study quality scores ranged from zero to nine. Studies with scores above six were classified as high quality, scores of five and six were classified as medium quality, and scores below five were classified as low quality.

Meta-analysis

Meta-analysis was performed using Stata/MP version 18.0. A random-effects meta-analysis model was adopted to investigate the relationships of sleep duration, chronotype, and social jet lag with the risk of depression separately. The odds ratio (OR) was used as the effect estimate to assess the association between sleep duration, chronotype, social jet lag, and depression. Analyses of adjusted or unadjusted ORs, hazard ratios (HRs), or relative risks (RRs) and their corresponding 95% confidence intervals (CIs) were conducted separately. When available, multivariable-adjusted ORs were preferentially pooled. If adjusted estimates were unavailable, unadjusted estimates were pooled. In sensitivity analysis, the leave-one-out method was applied to examine the influence of individual studies on the pooled ORs. Heterogeneity was quantified using I^2statistics, with values less than 25%, between 25% and 50%, and greater than 75% representing low, moderate, and high levels of heterogeneity, respectively. Subgroup analysis and meta-regression analysis were performed to explore potential sources of heterogeneity. Publication bias was evaluated using funnel plots and Egger's tests.

Results

Literature search

A total of 2,994 records were identified through database searches, with 833 from PubMed, 368 from Web of Science, 814 from Embase, 175 from PsycINFO, and 371 from Scopus. After removing duplicate records, 1,415 records remained. Following the screening of titles and abstracts, 94 full-text articles were retrieved. After reviewing the full-text articles, 11 review articles, 17 irrelevant studies, and 21 studies that did not provide sufficient data to calculate risk estimates were excluded. Additionally, sleep indicators in four studies were divided into two groups, the subjects of two studies were shift workers, and one study was a pilot study. Finally, 38 studies were included in the meta-analysis: four longitudinal studies on sleep duration, 16 cross-sectional studies on sleep duration, 14 cross-sectional studies on chronotype, and four cross-sectional studies on social jet lag. Figure 1 illustrates the flowchart of the article selection process.

Study characteristics

The characteristics of the included studies were displayed in Table 1. The meta- analysis included 755,646 participants. Sample sizes ranged from 200 [18] to 225,915 (Um et al., 2023) [19]. Four longitudinal studies [19-22] included 254,271 participants, sixteen cross-sectional studies [23-38] included 227,028 participants, fourteen cross-sectional studies on chronotype [12,18,39-50] included 233,761 participants, four cross-sectional studies on social jet lag [9,51-53] included 40,586 participants. Among the included studies, four longitudinal studies on sleep duration were conducted in Asia, while four cross-sectional studies on social jet lag were also conducted in Asia. Among sixteen cross-sectional studies on sleep duration, twelve were conducted in Asia, two in Europe, and two in North America. Among fourteen cross-sectional studies on chronotype, nine were conducted in Asia, four in Europe, and one in South America. All studies measured sleep duration, chronotype, and social jet lag using self-report questionnaires or scales, and depression was assessed using the same method.

Study quality

According to the NOS, among the included longitudinal studies, three were of moderate quality, and one was of weak quality. The quality scores of the included cross-sectional studies are presented in Table 2.

Data synthesis

Longitudinal study results

The longitudinal study results showed that short sleep duration was associated with an increased risk of depression compared to the normal sleep group (OR=1.24, 95% CI: 1.06-1.46, I^2= 62.1%). However, long sleep duration was not found to increase the risk of depression (OR=0.92, 95% CI: 0.79-1.08, I^2= 84.6%).

Cross-Sectional study results (sleep duration)

As shown in Figure 2, the cross-sectional study results indicated that both short sleep duration (OR=1.78, 95% CI: 1.61-1.97, I^2= 94.0%) and long sleep duration (OR=1.17, 95% CI: 1.02-1.34, I^2=90.9%) were associated

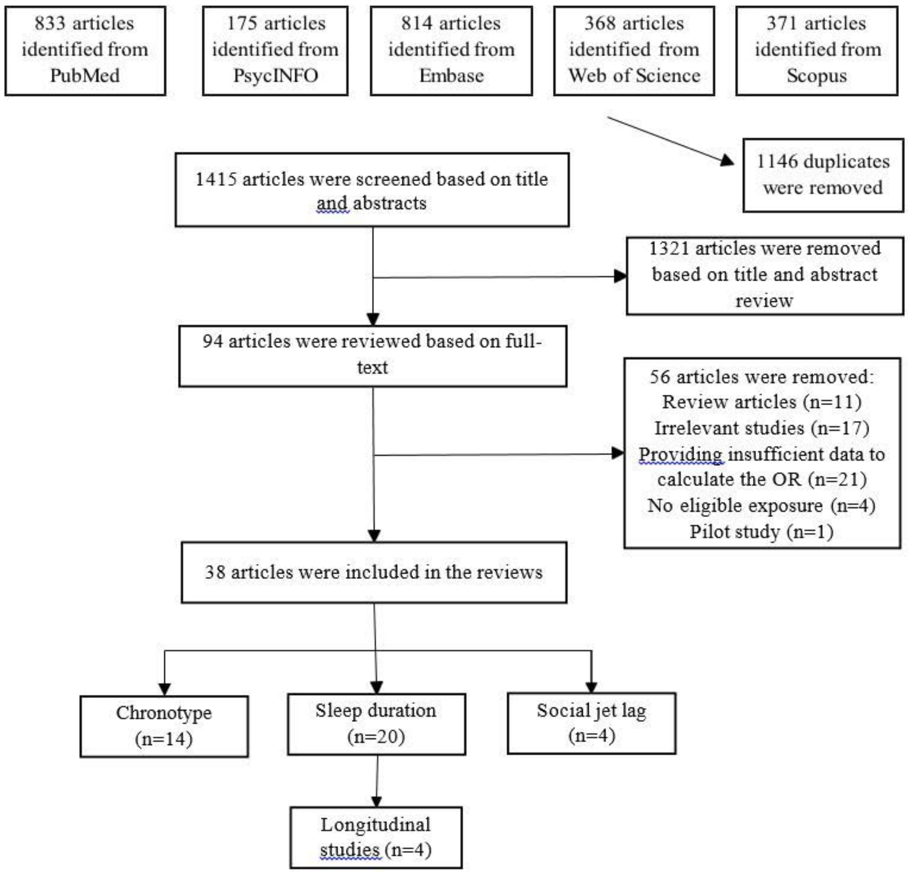

Figure 1: PRISMA flowchart of literature search

with an increased risk of depression compared to the normal sleep group. Notably, short sleep duration was more significantly associated with the risk of depression.

Cross-Sectional study results (chronotype)

As shown in Figure 3, the cross-sectional study results revealed that both neutral chronotype (N-type) (OR=1.27, 95% CI: 1.06-1.51, I^2=84.1%) and evening chronotype (E-type) (OR=2.09, 95% CI: 1.64-2.68, I^2= 93.3%) were associated with an increased risk of depression compared to morning chronotype (M-type). Furthermore, evening chronotype was more significantly associated with the risk of depression.

Cross-Sectional study results (Social Jet Lag)

The cross-sectional study results demonstrated that both 1-2 hours of social jet lag (OR=1.11, 95% CI: 1.04-1.19, I^2= 0) and ≥2 hours of social jet lag (OR=1.58, 95% CI: 1.4-1.78, I^2=18.5%) were associated with an increased risk of depression compared to the <1 hour social jet lag group. Moreover, ≥2 hours of social jet lag was more significantly associated with the risk of depression.

Subgroup analyses

Subgroup analyses of sleep duration and risk of depression

In subgroup analyses of sleep duration and the risk of depression, the pooled ORs slightly varied by geographic location, participants' mean age, gender, and sample size. Geographic location may be a source of heterogeneity for both short sleep duration and long sleep duration, while age may be a source of heterogeneity only for long sleep duration ($p < 0.05$).

Subgroup analyses of chronotype and risk of depression

In subgroup analyses of chronotype and the risk of depression, the pooled ORs slightly varied by geographic location, participants' mean age, gender, and sample size. However, no significant sources of heterogeneity were identified ($p > 0.05$).

Meta-regression analysis

Meta-Regression analysis of sleep duration and risk of depression

In the meta-regression analysis of sleep duration and the risk of depression, sample size, participants' mean age, gender, and geographic location were included as covariates. However, no significant sources of heterogeneity were identified.

Meta-Regression analysis of chronotype and risk of depression

In the meta-regression analysis of chronotype and the risk of depression, sample size, participants' mean age, gender, and geographic location were included as covariates. However, no significant sources of heterogeneity were identified.

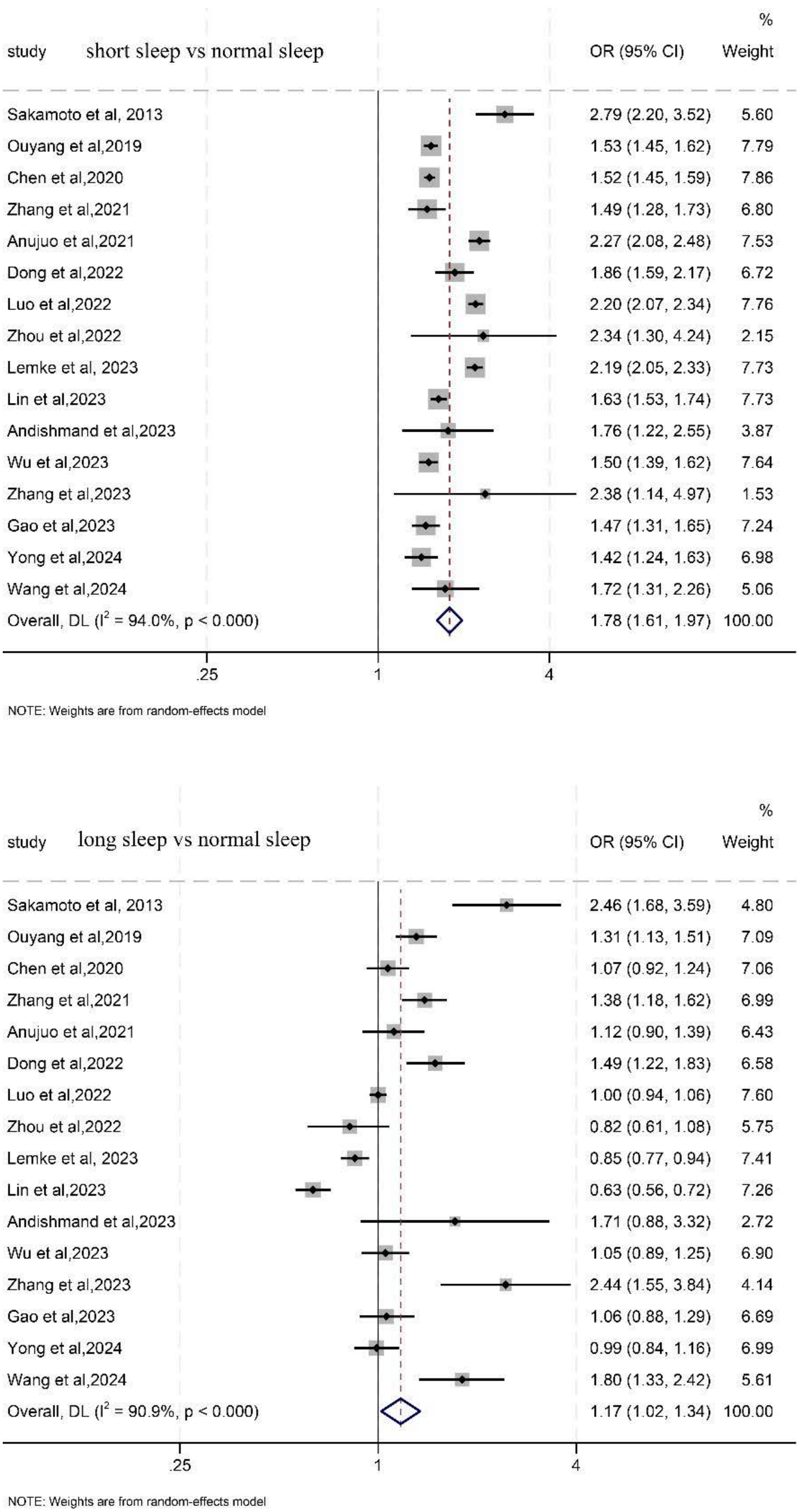

Figure 2: Forest plot of cross-sectional studies on sleep duration

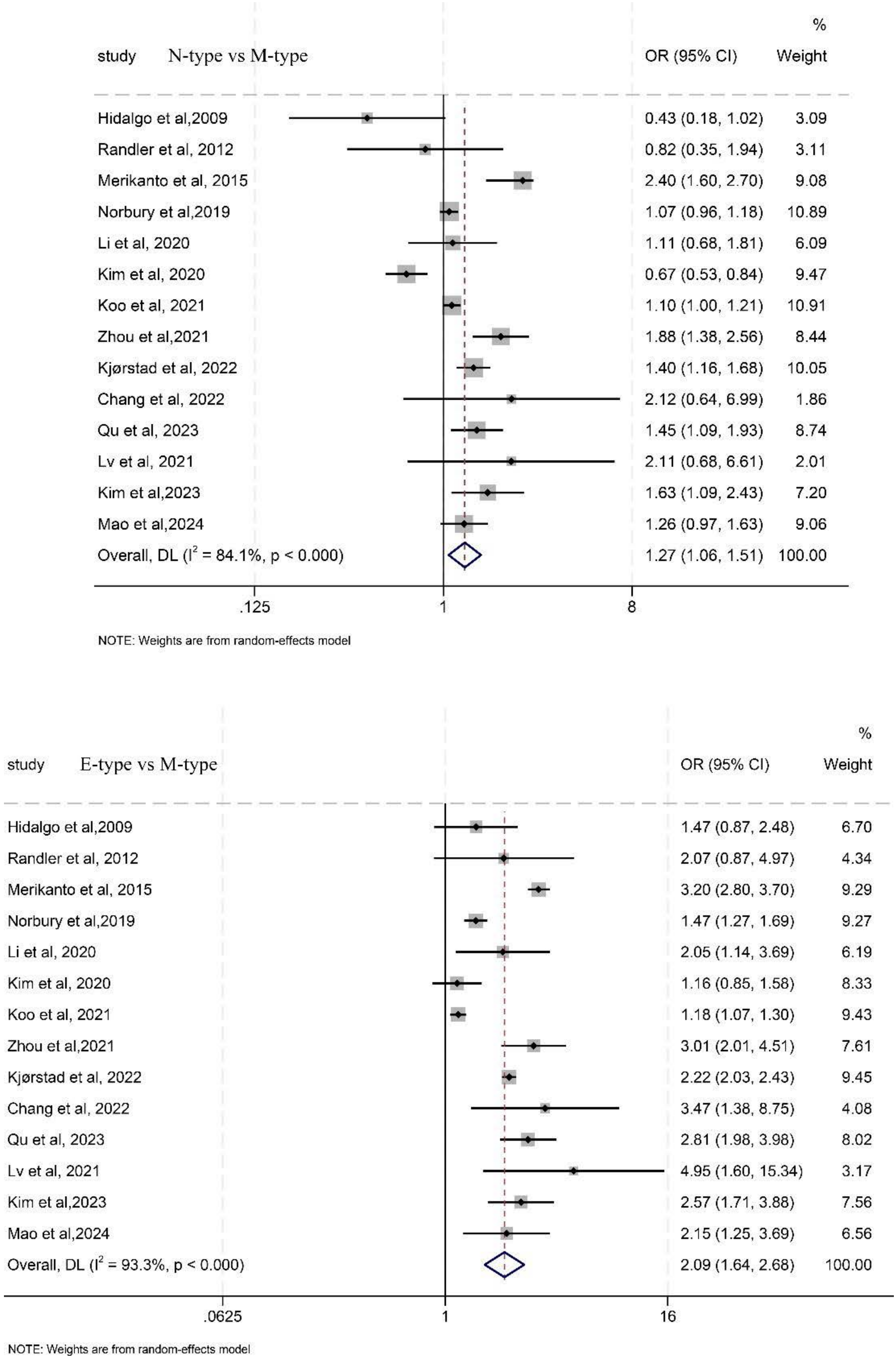

Figure 3: Forest plot of cross-sectional studies on chronotype

Table 1: Characteristics of included studies in the meta-analysis

Author, year	Country	Population	sample size	study design	Gender Female (%)	Age (years)	Sleep indicator measurement	Depression measurement
Islam, et al., 2020	Japan	non-shift workers	1404	C-S	15.2	44.8± 9.8	SJL, SRQ	CES-D
Tamura, et al., 2023 [52]	Japan	junior high school students	1493	C-S	52.4	13.6 ± 0.9	SJL, MCTQ	DSRS-C
Feng, et al., 2023 [9]	China	residents aged 18 years	5818	C-S	53.8	46.0 ± 53.8	SJL, SRQ	PHQ-9
Zhang, et al., 2023 [36]	China	junior high students	31871	C-S	46.0	13.5 ± 0.8	SJL, MCTQ	PHQ-2
Qu, et al., 2023 [48]	China	college students	1042	C-S	61.9	18-22	CT, MEQ-5	PHQ-9
Kjørstad, et al., 2022 [12]	Norway	university students	169572	C-S	66.5	26.1 ± 7.3	CT, MEQ	HSCL-25
Li, et al., 2020 [43]	China	university students	1135	C-S	61.9	18.8 ± 1.2	CT, MEQ	PHQ-9
Koo, et al., 2021 [42]	Korea	high-school students	8655	C-S	47.9	16.8 ± 0.9	CT, MEQ	BDI
Zhou, et al., 2021 [50]	China	freshman college students	4531	C-S	29.8	19.2 ± 1.8	CT, MEQ	DASS21
Norbury, et al., 2019 [47]	United Kingdom	community- dwelling individuals aged 40-69 years	5360	C-S	51.3	55.7 ± 7.5	CT, MEQ	PHQ
Chang, et al., 2022 [39]	China	medical college students	2231	C-S	55.0	19.1± 1.13	CT, MEQ-19	PHQ-2
Mao, et al., 2024 [45]	China	local residents aged 18 years or older	12544	C-S	46.6	≥18	CT, MEQ-5	PHQ-9
Hidalgo, et al., 2009 [18]	Brazil	community residents aged 18 years or older	200	C-S	59.0	34.4± 16.4	CT, MEQ	MADRS
Randler, et al., 2012 [49]	Spain	apparently healthy female university students	277	C-S	100.0	22.3± 2.5	CT, CSM	PHQ-9
Merikanto, et al., 2015[46]	Finland	residents aged 25–74 years	10503	C-S	54.6	50.6± 13.9	CT, MEQ	SRQ
Lv, et al., 2021 [44]	China	university students	8244	C-S, L: no data	48.3	18.0± 0.7	CT, MEQ	PHQ-9
Kim, et al., 2023 [41]	Korea	wage earners aged 19 years or older	3917	C-S	46.7	43.4± 11.9	CT, MEQ	PHQ-9
Kim, et al., 2020 [40]	Korea	non-shift workers aged 19–80 years	5550	C-S	58.1	46.7± 0.4	CT, MCTQ	PHQ-9
Lemke, et al., 2023 [28]	Sweden	elementary and junior high school students	8449	C-S	50.8	14.0 ± 0.7	SD, KSQ	BDI-II
Dong, et al., 2022 [26]	USA	NHANES III, adult participants	25962	C-S	50.8	48.1 ± 18.5	SD, SRQ	PHQ-9
Chen, et al., 2020 [25]	China	community- dwelling residents aged 18 years or older	13768	C-S	47.8	18-85	SD, SRQ	PHQ-9
Zhang, et al., 2023 [36]	China	resident villagers aged 35 years or older	9104	C-S	54.7	53.5± 10.3	SD, interviews	PHQ-9

Ouyang, et al., 2019 [31]	China	CHARLS, residents aged 45 years or older	9529	C-S	66.6	60.2± 9.2	SD, SRQ	CES-D
Yong, et al., 2024 [35]	China	junior and senior high school students	2660	C-S	50.3	<18	SD, SRQ	PHQ-9
Sakamoto, et al., 2013 [32]	Japan	daytime workers	1197	C-S	14.0	44.3± 10.8	SD, SRQ	CES-D
Wang, et al., 2024 [33]	USA	NHANES, aged 18 years or older,	10044	C-S	51.3	47.5	SD, SRQ	PHQ-9
Luo, et al., 2022 [30]	China	elderly adults from eight health centers in six provinces	49317	C-S	37.7	67.6± 6.6	SD, SRQ	PHQ-9
Zhou, et al., 2022 [38]	China	CFPS, children aged 11-19 years	3724	C-S	48.0	14.9± 2.6	SD, SRQ	CES-D
Lin, et al., 2023 [29]	China	junior and senior high school students	7330	C-S	48.6	15.1 ± 1.8	SD, SRQ	CES-D
Gao, et al., 2023 [27]	China	Han ethnicity permanent residents aged 30-79 years	42242	C-S	54.3	51.3± 12.0	SD, interviews	PHQ-2, DSM-IV
Andishmand, et al., 2023	Iran	freshman students of NUMS	471	C-S	62.4	22	SD, PSOI	BDI-II
Wu, et al., 2023[34]	China	CHARLS, residents aged 45 years or older	10228	C-S	53.1	≥55	SD, SRQ	CES-D 10
Zhang, et al., 2021 [37]	China	CCSSNNS, residents aged 55 years or older	11931	C-S	57.0	≥55	SD, SRQ	GDS
Anujuo, et al., 2021 [24]	Netherlan ds	the HELIUS study□ individuals aged 18–71 years	21072	C-S	57.5	44.3±13.6	SD, SRQ	PHQ-9
Jing, et al., 2020 [21]	China	CHARLS, residents aged 60-89 years	22847	L	49.2	67.8±6.4	SD, SRQ	CES-D-10
Um, et al., 2023 [19]	Korea	Korean adults without depression at baseline	225915	L	41.8	38.5±7.9	SD, PSQI	CES-D
Chen, et al., 2023 [20]	China	CHARLS, residents aged 45 years or older	4337	L	45.1	57.0±8.1	SD, SRQ	CESD-10
Li, et al., 2022 [22]	China	CFPS, children aged 10-15 years	1172	L	60.3	12.3±1.6	SD, SRQ	CES-D

Note: C-S: Cross-sectional, L: Longitudinal, SJL: Social jet lag, CT: Chronotype, SD: Sleep duration, CES-D: The Center for Epidemiologic Studies Depression, DSRS-C: The Birleson Depression Self-Rating Scale for Children, PHQ: The Patient Health Questionnaire, HSCL: The Hopkins Symptoms Checklist, BDI: The Beck Depression Inventory, DASS: Depression, Anxiety, and Stress Scale, MADRS: The Montgomery–Asberg Depression Rating Scale, DSM-IV: The Diagnostic and Statistical Manual of Mental Disorders Fourth Edition, GDS: Geriatric depression scale, MEQ: The Morning and Evening Questionnaire, PSQI: Pittsburgh Sleep Quality Index, MCTQ: Munich Chronotype Questionnaire, KSQ: The Karolinska Sleep Questionnaire, MESC: The morningness/eveningness scale for children, CSM: The Composite Scale of Morningness, CHARLS: The China Health and Retirement Longitudinal Study, NHANES: National Health and Nutrition Examination Survey, CFPS: The China Family Panel Study, NUMS: Neyshabur University of Medical Sciences, HELIUS, Healthy Life in an Urban Setting, CCSSNNS: The Community Cohort Study of Specialized Nervous System Diseases, SRQ: Self-report questionnaire.

Sensitivity analysis

In the sensitivity analysis, the leave-one-out method was adopted to examine the influence of individual studies on the pooled odds ratios (ORs). For sleep duration and risk of depression: In cross-sectional studies, the pooled ORs for depression ranged from 1.73 (95% CI: 1.57-1.92) to 1.81 (95% CI: 1.63-2.01) for short sleep duration and from 1.12 (95% CI: 0.99-1.28) to 1.21 (95% CI: 1.08-1.37) for long sleep duration. The results indicated that none of the individual studies had an excessive influence on the pooled effect estimates. For chronotype and risk of depression: The pooled ORs for depression ranged from 1.19 (95% CI: 1.02-1.39) to 1.36 (95% CI: 1.15-1.60) for neutral chronotype and from 1.98 (95% CI: 1.57-2.5) to 2.21 (95% CI: 1.71-2.86) for evening chronotype. The results demonstrated that

Table 2: Quality assessment of included cross-sectional studies

Study	①	②	③	④	⑤	⑥	⑦	⑧
Islam, et al., 2020	A	A	A	D	A	A	A	A
Tamura, et al., 2023 [52]	B	A	A	D	A	A	A	A
Feng, et al., 2023 [9]	A	A	A	D	A	A	A	A
Qu, et al., 2023 [48]	B	A	A	D	A	A	A	A
Zhang, et al., 2023 [36]	A	A	A	D	A	A	A	A
Kjørstad, et al., 2022 [12]	B	A	B	D	B	B	B	A
Li, et al., 2020 [43]	B	A	A	D	A	A	A	A
Koo, et al., 2021 [42]	A	A	A	D	A	A	A	A
Lemke, et al., 2023 [28]	A	A	A	D	A	A	A	A
Zhou, et al., 2021 [50]	A	A	A	D	B	B	A	A
Norbury, et al., 2019 [47]	B	B	B	D	A	A	A	A
Chang, et al., 2022 [39]	A	A	A	D	B	B	A	A
Mao, et al., 2024 [45]	B	A	A	D	A	A	A	A
Hidalgo, et al., 2009 [18]	A	A	A	D	A	A	A	A
Randler, et al., 2012 [49]	B	B	A	D	B	B	A	A
Merikanto, et al., 2015 [46]	C	B	A	D	A	A	B	A
Lv, et al., 2021 [44]	A	A	A	D	B	B	A	A
Kim, et al., 2023 [41]	A	A	A	D	A	A	A	A
Kim, et al., 2020 [40]	A	A	A	D	A	A	A	A
Dong, et al., 2022 [26]	A	A	B	D	A	A	A	A
Chen, et al., 2020 [25]	B	A	B	B	A	A	A	A
Zhang, et al., 2023 [36]	A	A	B	A	A	A	A	A
Ouyang, et al., 2019 [31]	A	A	B	B	A	A	A	A
Yong, et al., 2024 [35]	A	A	B	C	A	A	A	A
Sakamoto, et al., 2013 [32]	A	A	B	C	A	A	A	A
Wang, et al., 2024 [33]	A	C	B	B	A	A	A	A
Luo, et al., 2022 [30]	A	A	B	B	B	B	A	A
Zhou, et al., 2022 [38]	A	A	B	B	A	A	A	A
Lin, et al., 2023 [29]	B	A	B	B	A	A	A	A
Gao, et al., 2023 [27]	B	A	B	A	A	A	A	A
Andishmand, et al., 2023 [23]	B	A	B	B	A	A	A	A
Wu, et al., 2023 [34]	B	A	B	B	A	A	A	A
Zhang, et al., 2021 [37]	A	A	B	B	A	A	A	A
Anujuo, et al., 2021 [24]	A	A	B	B	A	A	A	A

Note: ①Are the inclusion criteria for the sample clearly defined? ②Are the study subjects and study sites described in detail?③Is the measurement of exposure factors reliable and valid?④Is there an objective, consistent standard for defining a disease or health problem?⑤Are confounders identified?⑥Are measures in place to control confounders?⑦Are the outcome measures reliable and valid?⑧Is the data analysis method appropriate? A=Yes, B=No, C=Nuclear, D=Inadaptation

none of the individual studies overly influenced the pooled effect estimates.

Publication bias

The funnel plots of cross-sectional studies on sleep duration and chronotype showed basic symmetry on both sides (Figure 4, Figure 5). The results of Egger's test (P = 0.04) indicated slight publication bias for the analysis of the association between short sleep duration and the risk of depression in cross-sectional studies. In addition, the results of Egger's test showed no evidence of publication bias for the analyses of short sleep duration in longitudinal studies (P = 0.09), long sleep duration in cross-sectional studies (P = 0.60) and longitudinal studies (P = 0.95), neutral chronotype (P = 0.40), evening chronotype (P = 0.50), 1-2 hours of social jet lag (P = 0.34), or ≥2 hours of social jet lag (P = 0.25) and their respective associations with the risk of depression.

Discussion

This meta-analysis investigated both longitudinal and cross-sectional associations between sleep duration, chronotype, social jet lag, and the risk of depression, highlighting the critical role of sleep-related factors in depression development. However, due to the limited number of longitudinal studies on sleep duration (n=4) and cross-sectional studies on social jet lag (n=4), these findings require further validation to strengthen their reliability.

Sleep duration and the risk of depression

Longitudinal studies demonstrated that short sleep duration was significantly associated with an increased risk of depression (OR=1.24, 95% CI: 1.06-1.46), whereas \long sleep duration did not appear to elevate this risk (OR=0.92, 95% CI: 0.79-1.08). These findings suggested that sleep deprivation may have acted as a risk factor for depression, potentially mediated by

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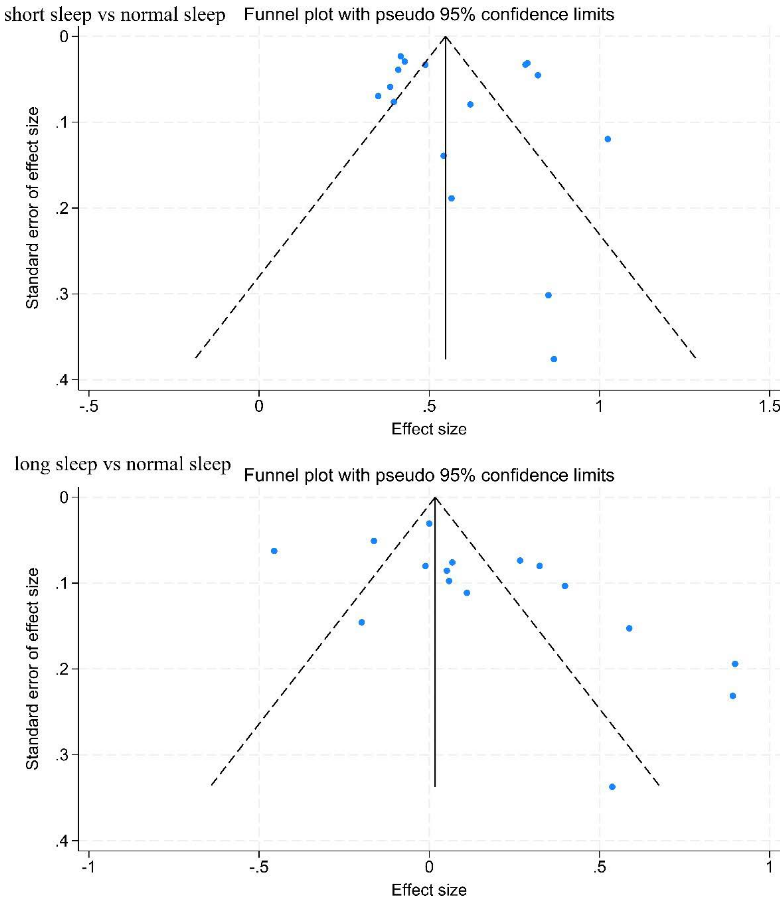

Figure 4: Funnel plot of cross-sectional studies on sleep duration

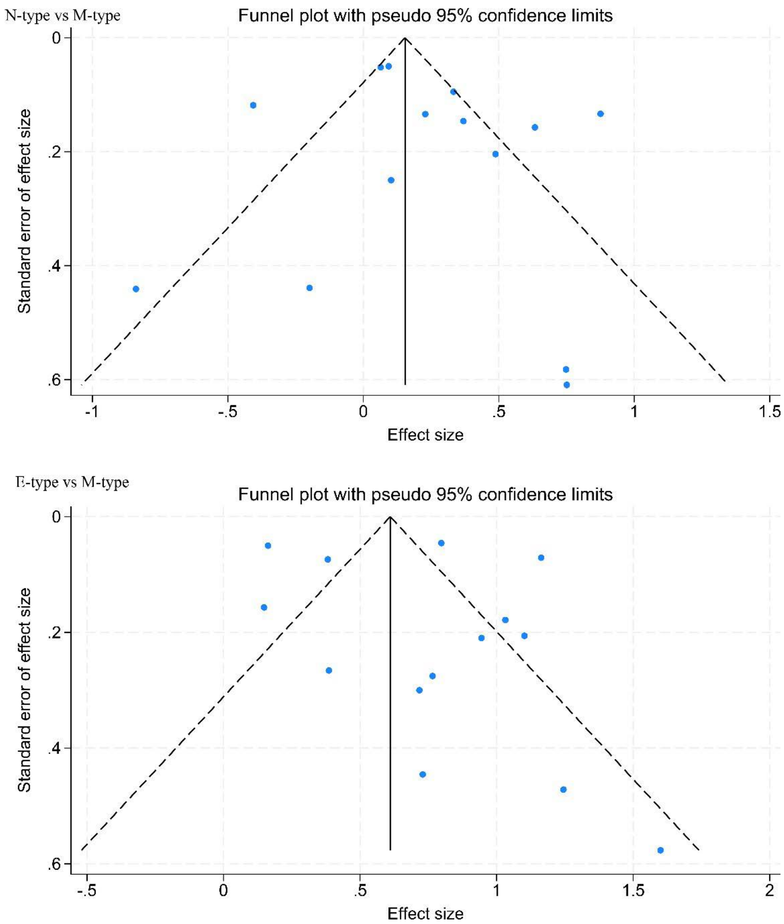

Figure 5: Funnel plot of cross-sectional studies on chronotype

neuroendocrine dysfunction [54], impaired emotional regulation [55], and cognitive decline [56]. In contrast, cross-sectional studies indicated that both short sleep duration (OR=1.78, 95% CI: 1.61-1.97) and long sleep duration (OR=1.17, 95% CI: 1.02-1.34) were associated with a higher risk of depression. Together, these results suggested a potential U-shaped relationship between sleep duration and depression risk, where deviations from the average sleep duration-both shorter and longer-may have increased vulnerability to depression.

Chronotype and the risk of depression

Cross-sectional studies revealed that both neutral chronotype (N-type) (OR=1.27, 95% CI: 1.06-1.51) and evening chronotype (E-type) (OR=2.09, 95% CI: 1.64-2.68) were significantly associated with an increased risk of depression, with the evening chronotype posing a higher risk. This finding may be related to the greater susceptibility of evening-type individuals to social jet lag. Social jet lag refers to the mismatch between an individual's biological clock and societal schedules. Evening chronotype individuals often find their inherent biological clocks mismatched with the work and sleep schedules of modern society [6]. This misalignment can lead to chronic sleep deprivation and disruptions in circadian rhythms. Furthermore, nighttime exposure to artificial light, particularly the blue light emitted by electronic devices, suppresses the secretion of melatonin, further exacerbating circadian rhythm disturbances [57]. Research has shown that circadian rhythm disruption is closely associated with the onset of depression, placing evening chronotype individuals at a higher risk of mental health issues.

Social jet lag and the risk of depression

Cross-sectional studies further revealed that both 1-2 hours of social jet lag (OR=1.11, 95% CI: 1.04-1.19) and ≥2 hours of social jet lag (OR=1.58, 95% CI: 1.4-1.78) were significantly associated with an increased risk of depression. Moreover, the risk of depression rose significantly as the duration of social jet lag increased. These findings highlight the importance of synchronizing daily schedules with biological rhythms for mental health. Social Jet Lag refers to the discrepancy in sleep timing between workdays and rest days for individuals. This misalignment may disrupt the circadian rhythm system [58], impair neuroendocrine functions (e.g., melatonin and cortisol secretion) [6], and affect the functioning of brain regions associated with emotion (e.g., the amygdala and prefrontal cortex) [59]. Such dysfunction may ultimately lead to an increase in depressive symptoms [60].

A meta-analysis has revealed significant heterogeneity in the relationship between sleep duration, chronotype, and social jetlag with the risk of depression. This heterogeneity may stem from variations in study design, sample characteristics, and research environments. In terms of study design, most studies predominantly employed subjective methods to measure sleep metrics and depressive symptoms. Sleep metrics were assessed through questionnaires such as the Munich Chronotype Questionnaire (MCTQ), self-reported questionnaires, and the Morning and Evening Questionnaire (MEQ). Similarly, the evaluation of depressive symptoms relied on various scales, such as Patient Health Questionnaire-9 (PHQ-9), the Beck Depression Inventory (BDI), and the Center for Epidemiologic Studies Depression (CES-D). Differences in the scoring criteria and sensitivity of these scales may have influenced the consistency of the results. Meanwhile, variations in sample characteristics further contributed to the diversity of the findings. For instance, the studies encompassed a wide age range from adolescents to adults, with subgroup analyses indicating that prolonged sleep duration was associated with an increased risk of depression only in individuals aged 30 and above, while no such association was observed in those under 30. Additionally, the geographical distribution of the samples was diverse, spanning regions such as Asia, Europe, and North America. Subgroup analyses showed that the association between long sleep duration and depression risk was significant only in North America, while no significant association was found in Asia or Europe. This phenomenon may be related to differences in lifestyle habits, cultural backgrounds, and societal pressures across regions, which could modulate the relationship between social jetlag and depressive symptoms.

This study provided preliminary evidence regarding the relationship between sleep duration, chronotype, and social jet lag with the risk of depression; however, some notable limitations should be acknowledged. Firstly, data on sleep duration, chronotype, and social jet lag were collected based on participants' self-reported questionnaires or scales, a method that may have been subject to recall bias and measurement bias. Due to the lack of objective measurement tools, the estimation of the true associations between these factors and depression risk may have been affected by misclassification. Therefore, future studies were suggested to prioritize the use of standardized and objective measurement methods (e.g., actigraphy or polysomnography) to assess sleep indicators more accurately. Secondly, the majority of studies included in this meta-analysis were cross-sectional in design, a type of study that could not establish causal relationships between variables. To gain a deeper understanding of these associations, future research was recommended to incorporate more longitudinal designs to verify the causal pathways between sleep indicators and depression risk.

Conclusion

This meta-analysis revealed that sleep duration is associated with an increased risk of depression, with both short and long sleep durations showing elevated risks. Among all chronotypes, the evening chronotype was most strongly linked to a higher likelihood of depression. Additionally, social jet lag was found to increase depression risk, particularly when it exceeded two hours. Although these findings provide preliminary evidence, significant heterogeneity among studies and a limited evidence base suggest caution in interpretation. Future research should prioritize standardized and objective measurement methods, incorporate longitudinal designs, and investigate demographic, environmental, and cultural factors to better understand the mechanisms underlying the relationships between sleep duration, chronotype, social jet lag, and depression risk. Such efforts will inform more effective prevention and intervention strategies for depressive symptoms.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical approval

The methodology we used in this study was primarily based on data from published articles, with secondary analyses of existing clinical study reports. As our work did not involve any form of new data collection and all original data had been published by the original authors and had been treated with appropriate privacy protections, the Ethics Approval Committee determined that the project was not subject to the standard ethics approval process and granted a waiver prior to the commencement of this meta-analysis project, in accordance with relevant ethical guidelines and the agency's requirements. However, in order to ensure the integrity and transparency of our research, we strictly follow the relevant ethical norms of the medical and scientific community regarding data processing and the protection of personal privacy throughout the process.

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