Journal of Affective Disorders 296 (2022) 183–188

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Research paper

Association between sleep duration and depression in US adults: A cross-sectional study

Lu Dong [a], Yongwei Xie [b], Xiaohua Zou [a,*]

[a] The Affiliated Hospital of Guizhou Medical University, Guiyang, Guizhou, China
[b] Guizhou Plastic and Oral Cosmetic Surgery Hospital, Guiyang, Guizhou, China

ARTICLE INFO

Keywords:
Gender
Patient health questionnaire-9
Mental health
Sleep duration

ABSTRACT

Background: Evidence of an association between sleep duration and depression was inconsistent.
Methods: Adults who participated in the National Health and Nutrition Examination Survey (NHANES) from 2009 to 2016 were included. Multivariable logistic regression was used to evaluate the association between sleep duration and depression.
Results: Among the 25,962 participants (mean age 48.1 years; 49.2% male) in this study, 23,636 had a depression score <10 and 2,326 had a depression score ≥ 10. After adjustment for gender, age, race/ethnicity, education, marital status, and annual family income, BMI, alcohol status, and smoking status, hypertension, diabetes, dyslipidemia, work activity, and physical activity risk factors, participants who had short sleep duration had odds ratios (OR) of 1.86 (95% confidence interval 1.59, 2.17) and participants who had long sleep duration had OR of 1.49 (95% confidence interval 1.22, 1.83) for incident depression. Further analysis revealed a U-shaped association between sleep duration and incident depression. When sleep duration < 8 hours, increased sleep duration is associated with a significantly lower risk of incident depression (OR = 0.68 [95% CI 0.64, 0.71], P < 0.001). When sleep duration ≥ 8 hours, the risk of depression increased significantly with an increase in sleep duration (OR = 1.32 [95%CI 1.23, 1.41], P < 0.001).
Conclusions: Sleep duration were independently associated with a higher incident depression. Not only insufficient sleep but excessive sleep also increase the risk of depression.

1. Introduction

Depression is a common and disabling psychiatric condition worldwide. It continue to be a global burden affecting approximately 300 million people worldwide(Patel et al., 2016). It represents a significant obstacle to sustainable development in large parts of the world(Lund et al., 2018). Depression holding people back from their full potential, losses of investment in human capital, and is implicated in premature mortality from suicide and other disease(Patel et al., 2016). Nevertheless, little study has been designed to investigate the positive factor in the prevention of depression, and it still have been challenging.

Sleep is fundamental to a person's emotional and physical health. In general, optimal sleep duration connected with subjective well-being and mental health is 7 to 9 hours(Hirshkowitz et al., 2015). Notably, only 48% of adults in the US reported a habitual sleep time falling within this range(Covassin and Singh, 2016). Over the past decades, the similar trends of gradually decreases in sleep duration observed in multiple Western countries(Bin et al., 2012).

As we know, poor sleeping habits will bring some unhealthy effects. The relationship between sleep duration and health related conditions has been observed in several epidemiological studies, such as cardiovascular events(Daghlas et al., 2019; Tobaldini et al., 2019; Huang et al., 2020), mental disorders(Faulkner et al., 2019; Paksarian et al., 2020), and mortality(Wang et al., 2019; Butler et al., 2019). So far, the role of sleep duration in the development of depression has been conducted to investigate in many studies. Most studies seem to have consistently concluded that short sleep duration is a risk factor for depression. However, the role of long sleep duration in the development of depression is still controversial. This study mainly explores the relationship between sleep duration in weekdays (both insufficient and excessive sleep) and depression, to minimize the incident of depression to a certain extent.

* Corresponding author.
E-mail address: 562931613@qq.com (X. Zou).

https://doi.org/10.1016/j.jad.2021.09.075
Received 29 July 2021; Received in revised form 18 September 2021; Accepted 22 September 2021
Available online 28 September 2021

2. Methods

2.1. Study population

The National Center for Health Statistics ethics review board approved the National Health and Nutrition Examination Survey (NHANES) protocols with the written informed consent of all participants. In accordance with National Institutes of Health policy, such analysis involving de-identified data that was not directly in contact with participants was not considered human subjects study and was not subject to institutional review board review.

NHANES are representative cross-sectional surveys designed by the National Center for Health Statistics (NCHS)(Johnson et al., 2014). We acquired data of adult participants ($\geq$ 18 years) form NHANES III 2009-2016. We excluded participants without depression score and sleep duration information. Finally, 25,962 participants were analyzed (Fig. 1).

2.2. Measurement

2.2.1. Outcome ascertainment

The outcome of depression was assessed with the Patient Health Questionnaire (PHQ-9). This short screening questionnaire is an effective tool for evaluating depression. It scores the signs and symptoms of depression in the 9 Diagnostic Statistical Manual of Mental Disorders from "0" (not at all) to "3" (nearly every day)(Kroenke et al., 2001). The PHQ score for each participant is the sum of all answers to the PHQ question (range 0-27). PHQ-9 is a valid criteria instrument based on DSM-V. From a possible total score of 27, cut-off point $\geq$ 10 showed a sensitivity of diagnosing major depression is 88% and the specificity is 88%(Kroenke et al., 2001). Therefore, we divided the participants' PHQ-9 scores into $<$ 10 (no depression) and $\geq$ 10 (depression).

2.2.2. Exposure measurement

Sleep duration on usual weekday or workday was self-reported by participants. In 2009-2014, sleep duration was created from a question asked to NHANES participants about the participants' routinely sleep hours: "How much sleep do you get (hours)?" In the 2015-2016 cycle, sleep duration was created from a question: "How much sleep do you usually get at night on weekdays or workdays?" Sleep duration was categorized as $<$ 7 hours, 7 to 9 hours, and $\geq$ 9 hours.

2.2.3. Covariate assessment

The selection of covariates is based on previous literature and substantive reasoning. Standardized questionnaires were used to collect information on age, sex, race/ethnicity, education, marital status, annual family income, smoking status, alcoholic intake, work activity and physical activity. Race/ethnicity was categorized as Mexican American, other Hispanic, non-Hispanic white, non-Hispanic black, or other. Education was classified as less than 9th grade, 9-11th grade, high school graduate or equivalent, some college or AA degree, and college graduate or above. Marital status was categorized as married, widowed, divorced, separated, never married, and living with partner. Participants were categorized as past smokers, and current smokers based on their responses to questions about smoking at least 100 cigarettes during their lifetime and whether they were currently smoking. Alcohol status was created from a question: "Had at least 12 alcohol drinks a year?" For work activity, inactive group was defined as those who did not report leisure time work activity, the moderate and vigorous activity groups were created based on a questions: "Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking or carrying light loads for at least 10 minutes continuously?" and "Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like carrying or lifting heavy loads, digging or construction work for at least 10 minutes continuously?" respectively. For physical activity, the inactive group was defined as those with no reported leisure time physical activity, the moderate and vigorous activity groups were created from a questions: "In a typical week do you do any moderate-intensity sports, fitness, or recreational activities that cause a small increase in breathing or heart

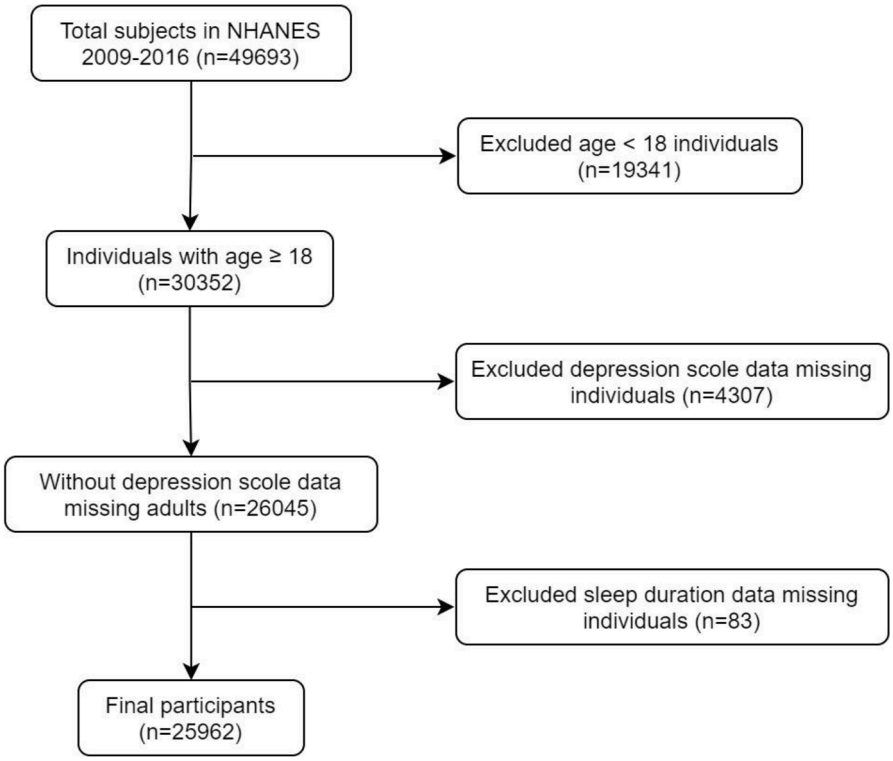

Fig. 1. Participants inclusion flowchart (National Health and Nutrition Examination Survey [NHANES]).

rate such as brisk walking, bicycling, swimming, or volleyball for at least 10 minutes continuously?" and "In a typical week do you do any vigorous-intensity sports, fitness, or recreational activities that cause large increases in breathing or heart rate like running or basketball for at least 10 minutes continuously?" respectively.

The height, weight, and blood pressure were measured in accordance with standardized protocols. Body mass index (BMI) was calculated by dividing weight in kilograms by height in meters squared (kg/m^2). According to the 2017 American College of Cardiology/American Heart Association hypertension guidelines, hypertension was defined as being currently taking antihypertensive drugs, or if not, having systolic blood pressure level $\geq$ 130 mmHg and/or diastolic blood pressure level $\geq$ 80 mmHg(Whelton et al., 2018). Diabetes was defined as having been diagnosed with diabetes or currently taking insulin or taking diabetes pills, or having a hemoglobin A_{1c} level $\geq$ 6.5% or fasting plasma glucose level $\geq$ 126 mg/dl(Menke et al., 2015). Prediabetes was defined as the absence of diabetes but a hemoglobin A_{1c} level of 5.7% to 6.4%, a fasting plasma glucose level of 100 mg/dl to 125 mg/dl, or a 2-hour plasma glucose level of 140 mg/dl to 199 mg/dl(Menke et al., 2015). Dyslipidemia was defined as having a doctor's diagnosis or currently taking cholesterol-lowering drugs, or having a triglyceride level $\geq$ 150 mg/dl or high-density lipoprotein cholesterol level <40 mg/dl based on recommendations by the National Cholesterol Education Program Adult Treatment Panel III (Dipak, 2002).

2.3. Statistical analysis

Data are expressed as mean ± standard deviation (SD) of continuous variables and frequency or percentage of categorical variables. For baseline characteristics analysis, the statistical differences between depression score < 10 and depression score $\geq$ 10 were tested with one-way ANOVA for continuous variables and chi-square test for categorical variables. Odds ratios (ORs) and 95% CIs were calculated for incident depression with sleep using Logistic regression models. We used unadjusted and multivariate adjusted models. In this study, the Logistic models were adjusted for sex, age, race, education, marital status, and annual family income, BMI, alcohol status, and smoking status, hypertension, diabetes, dyslipidemia, work activity, and Physical activity. Tests for trend were conducted with linear regression by dividing sleep duration into three groups (< 7 hours, 7 to 9 hours, and $\geq$ 9 hours) as a continuous variable in the models.

A generalized additive model was used to evaluate the nonlinear relationship between sleep duration and incident depression. Based on the smoothing curve, we further developed a two-piecewise linear regression model to identify the threshold effect and adjust for potential confounders. The threshold level of sleep duration was determined using a recurrence method, including selecting the turning point along a predefined interval and choosing the turning point that yielded the maximum likelihood model. A log-likelihood ratio test was used to compare the two-piecewise linear regression model with the one-line linear model.

All the analyses were performed with the statistical software packages R (http://www.R-project.org, The R Foundation) and Free Statistics software versions 1.2. A two-sided P value <0.05 was considered to be statistically significant.

3. Results

Among the 25,962 participants from the study, 12,764 male and 13,198 female were recruited. Participants with higher PHQ-9 scores were more likely to be female, low annual family income, smokers, non-hypertensive, non-diabetic, non-hyperlipidemic and to drink more alcohol. Short sleep duration patients have higher PHQ-9 scores. The subjects' baseline characteristics are summarized in Table 1.

Table 2 presents the association between sleep duration and depression. ORs (95% CI) of depression are presented for short and long

Table 1
Baseline characteristics of the study participants.

Characteristics	All participants (n = 25962)	PHQ < 10 (n = 23636)	PHQ ≥ 10 (n = 2326)	P - value
Male, no. (%)	12764 (49.2)	11916 (50.4)	848 (36.5)	
Age (years), Mean ± SD	48.1 ± 18.5	48.0 ± 18.7	48.4 ± 17.3	0.258
BMI (kg/m^2), Mean ± SD	29.2 ± 7.1	29.0 ± 6.9	31.1 ± 8.5	< 0.001
Race/ethnicity, n (%)				< 0.001
Mexican American	3897 (15.0)	3544 (15)	353 (15.2)	
Other Hispanic	2660 (10.2)	2349 (9.9)	311 (13.4)	
Non-Hispanic White	10301 (39.7)	9350 (39.6)	951 (40.9)	
Non-Hispanic Black	5640 (21.7)	5140 (21.7)	500 (21.5)	
Other Race	3464 (13.3)	3253 (13.8)	211 (9.1)	
Education, n (%)				< 0.001
Less than 9th grade	2277 (9.3)	1968 (8.8)	309 (13.9)	
9-11th grade	3260 (13.3)	2820 (12.6)	440 (19.8)	
High school graduate or equivalent	5562 (22.6)	5040 (22.5)	522 (23.5)	
Some college or AA degree	7539 (30.7)	6831 (30.6)	708 (31.8)	
College graduate or above	5947 (24.2)	5700 (25.5)	247 (11.1)	
Marital status, n (%)				< 0.001
Married	12427 (50.5)	11668 (52.2)	759 (34.1)	
Widowed	1891 (7.7)	1654 (7.4)	237 (10.6)	
Divorced	2729 (11.1)	2344 (10.5)	385 (17.3)	
Separated	838 (3.4)	682 (3)	156 (7)	
Never married	4630 (18.8)	4148 (18.5)	482 (21.6)	
Living with partner	2076 (8.4)	1868 (8.4)	208 (9.3)	
Annual family income (dollar), Median (IQR)	7.0 (5.0, 13.0)	7.0 (5.0, 14.0)	5.0 (3.0, 8.0)	< 0.001
Smoking status, n (%)				< 0.001
Current smoking	10896 (42.9)	9575 (41.4)	1321 (57.7)	
Former smokers	14505 (57.1)	13537 (58.6)	968 (42.3)	
Alcohol status, n (%)				0.422
Yes	14619 (70.8)	13291 (70.7)	1328 (71.7)	
No	6020 (29.2)	5495 (29.3)	525 (28.3)	
Hypertension, n (%)				< 0.001
Yes	9144 (35.3)	8042 (34.1)	1102 (47.5)	
No	16783 (64.7)	15564 (65.9)	1219 (52.5)	
Diabetes, n (%)				< 0.001
Yes	3372 (13.0)	2896 (12.3)	476 (20.5)	
No	21933 (84.5)	20152 (85.3)	1781 (76.7)	
Prediabetes	643 (2.5)	578 (2.4)	65 (2.8)	
Dyslipidemia, n (%)				< 0.001
Yes	8446 (35.6)	7497 (34.7)	949 (45.1)	
No	15270 (64.4)	14116 (65.3)	1154 (54.9)	
Work activity, n (%)				0.242

(continued on next page)

Table 1 (*continued*)

Characteristics	All participants (n = 25962)	PHQ < 10 (n = 23636)	PHQ ≥ 10 (n = 2326)	P - value
Inactive	15308 (59.0)	13910 (58.9)	1398 (60.1)	
Moderate	5497 (21.2)	6896 (29.2)	628 (27)	
Vigorous	3129 (12.1)	2829 (12)	300 (12.9)	
Physical activity, n (%)				< 0.001
Inactive	13205 (50.9)	11614 (49.1)	1591 (68.4)	
Moderate	8634 (33.3)	8093 (34.2)	541 (23.3)	
Vigorous	4123 (15.9)	3929 (16.6)	194 (8.3)	
Sleep duration on weekdays (hours), n (%)				< 0.001
< 7	8494 (32.7)	7455 (31.5)	1039 (44.7)	
7 - 9	13773 (53.1)	12893 (54.5)	880 (37.8)	
≥ 9	3695 (14.2)	3288 (13.9)	407 (17.5)	

Abbreviations: BMI, body mass index. PHQ-9: Patient Health Questionnaire-9.

sleep duration compared to the mid-range sleep duration category. In the non-adjusted model, participants who had short sleep duration had a 121% increased risk in the odds of the development of depression (OR = 2.21 [95% Cl 1.9, 2.56]), and long sleepers had a 97% increased risk compared to participants with normal sleep duration(OR = 1.97 [95% CI 1.62, 2.38]). After adjustment for confounding factors in Table 1, the odds ratios were 1.86 (1.59, 2.17) and 1.49 (1.22, 1.83) respectively ($p < 0.001$).

Fig. 2 presents a U-shaped association between incident of depression and sleep duration after adjusting for potential confounding factors. The risk of developing depression was negatively correlated with the sleep duration until it bottoms out at 8 hours (OR = 0.68 [95% CI 0.647, 0.713]). However, when the sleep duration was higher than 8 hours, the risk of developing depression increased significantly (OR = 1.318 [95% CI 1.233, 1.41]). (Table 3)

In the Fig. 2, the solid line indicates the estimated risk of incident depression, and the dotted lines represent point-wise 95% confidence interval adjusted for sex, age, race, education, marital status, and annual family income, BMI, alcohol status, and smoking status, hypertension, diabetes, dyslipidemia, work activity, and physical activity.

4. Discussion

In this population-based cross study, sleep duration was found to be independent associated with an elevated risk of the incidence of depression. We further revealed a nonlinear relationship between sleep duration and risk of depression. The relationship was characterized as follows: the risk of developing depression increased significantly with an extreme sleep duration. The optimal sleep duration in weekdays to reduce the risk of depression was 8 hours. Not only short sleep duration, but long sleep duration would also increasing incidence of depression.

Most of the previous researches had examined that short sleep duration was significantly associated with increased risk of depression (Koo et al., 2021; Berger et al., 2019; Ogawa et al., 2019; Ojio et al., 2016; Sun et al., 2018). While much is known about the negative health implications of insufficient sleep, relatively little pay attention to risks associated with excessive sleep. Only few scholars have examined that not only short sleep duration, but long sleep duration also increased occurrence of depression(Reis et al., 2018). And we got the same conclusion as the author. Some scholars believed that long sleep duration did not increase risk of depression(Matsui et al., 2020; Ouyang and Sun, 2019). Potential reasons for the conflicting results could be that: (1) the potential confounders adjusted for were different in each study ; (2) the definition of sleep duration is inconsistent; (3) the age group of participants varied from study to study.

The mechanisms underlying the association between short sleep duration and depression may be relative to inflammation. Irwin and Opp (2017) suggested that sleep disturbance may increase the vulnerability to depression by augmenting affective sensitivity to cytokines and possibly by altering neural sensitivity to inflammation. Sleep disturbance serves as a vulnerability factor and that subsequent exposure to heightened inflammatory states such as an infectious challenge or psychological stress triggers increase in depressive symptoms. It suggested that inflammation might also serve as a vulnerability factor, in which subsequent exposure to sleep disturbance triggers increase in depressive symptoms(Cho et al., 2016).

Excessive sleep can also increase the risk of depression. The possible mechanisms include: (1) Prolonged time in bed is associated with increased sleep fragmentation, wake after sleep onset (WASO) and sleep latency(Youngstedt and Kripke, 2004), each occurs when the sleep period is interrupted by countless intervals of wakefulness. In particular, sleep fragmentation has been linked with a quantity of negative health outcomes, including decreased energy and vitality and increased role limitations(Bennett et al., 1999). (2) Long sleep duration has been correlated to low physical activity, which has been found to be conducive in reducing the incidence of depression by increasing the levels of neurotransmitters (particularly dopamine and serotonin) and enhancing brain aminergic synaptic transmission(Weicker and Struder, 2001), increasing the secretion of endorphin(Janal et al., 1984), distracting from stressful stimuli(Salmon, 2001), or improving self-efficacy and self-esteem. (3) Long sleepers are particularly susceptible to mental illness, especially emotional and anxiety problems (Zhai et al., 2015). Long sleepers might be more likely to be described as 'worriers' and were generally not as successful as short sleepers(Patel et al., 2006). Long sleepers are more susceptible to a number of stress factors, which may be linked to an increase in depression. (4) Long sleep may be caused by stress or stressful events. The link between long sleep and depression may first be driven by factors that lead to long sleep, such as difficulty coping with stress(Zhai et al., 2015).

The strengths of our research included the relatively large sample size, and adjusting the influence of various degrees of work and

Table 2
Association between sleep duration and depression in multiple regression model.

	Non-adjusted Model OR (95% CI)	P-value	Model I OR (95% CI)	P-value	Model II OR (95% CI)	P-value	Model III OR (95% CI)	P-value
Sleep duration Hours of Sleep	0.86 (0.82, 0.90)	<0.001	0.86 (0.83, 0.90)	<0.001	0.87 (0.84, 0.91)	<0.001	0.88 (0.84, 0.91)	<0.001
< 7	2.21 (1.90, 2.56)	<0.001	2.03 (1.74, 2.36)	<0.001	1.92 (1.65, 2.24)	<0.001	1.86 (1.59, 2.17)	<0.001
7 – 9	Ref		Ref		Ref		Ref	
≥ 9	1.97 (1.62, 2.38)	<0.001	1.62 (1.33, 1.97)	<0.001	1.57 (1.29, 1.92)	<0.001	1.49 (1.22, 1.83)	<0.001

Model I: Adjust for sex, age, race, education, marital status, and annual family income.
Model II: Adjust for the variables in Model I plus BMI, alcohol status, and smoking status.
Model III: Adjust for the variables in Model II plus hypertension, diabetes, dyslipidemia, work activity, and Physical activity.

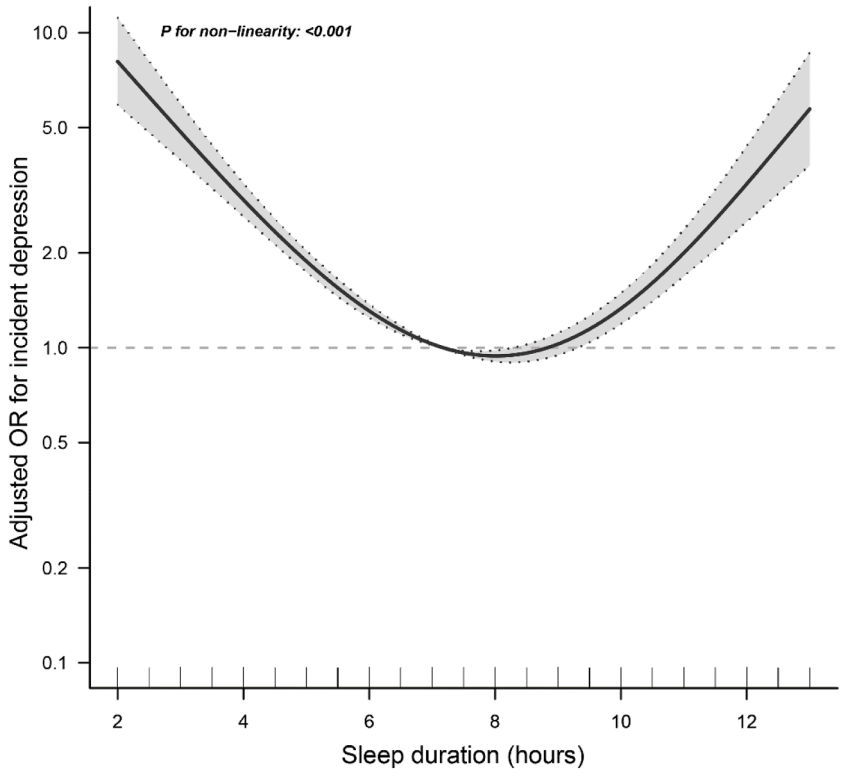

Fig. 2. Non-linear relationship of sleep duration and depression.

Table 3
Threshold effect analysis of sleep duration on incident depression.

Outcome	OR (95% CI)	P value
One - line linear regression model	0.88 (0.84, 0.91)	< 0.001
Two - piecewise linear regression model		
Sleep duration < 8 hours	0.68 (0.64, 0.71)	< 0.001
Sleep duration ≥ 8 hours	1.32 (1.23, 1.41)	< 0.001
Log - likelihood ratio test	< 0.001	

Notes: adjusted for sex, age, race, education, marital status, and annual family income, BMI, alcohol status, and smoking status, hypertension, diabetes, dyslipidemia, work activity, and Physical activity.

recreational activities as the activities was closely related to depression (Choi et al., 2019). Our study also has some limitations. Firstly, due to the cross-sectional nature of our analysis, we are unable to infer causality from the results. Because the relationship between sleep time and depression seems to be bidirectional(Sun et al., 2018), additional study is needed to better understanding the extent to which sleep duration may determine or is influenced by one's depression. Furthermore, we were incapable of examining the reasons behind why people experience short or long sleep or the different types of sleep disorders they experience, because our research included only one program that asked about average hours of sleep duration. The different causes of insufficient sleep may further be related to different demographic or personality characteristics such as low socioeconomic status or high Neuroticism. Further researches on these nuanced factors are needed to develop more relevant and effective sleep health interventions.

In conclusion, sleep duration were independently associated with a higher incidence of depression in this cross study based on the National Health and Nutrition Examination Survey From 2009 to 2016. Not only insufficient sleep but excessive sleep also increase the risk of depression.

Author statement

Contributors: Each author contributed substantially to the paper. Lu Dong and Xiaohuan Zou conceived the study hypothesis. Yongwei Xie performed data analysis and Lu Dong drafted the manuscript. Xiaohua Zou revised it critically for important intellectual content, and supervised the writing of the manuscript. All authors approved the final version of the manuscript.

Declaration of Competing Interest

The authors declare that they have no competing interests. We declare that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

Acknowledgements

The authors want to express their sincere gratitude to all participants and the schools for their participating in the study. In addition, we gratefully thank Dr. Jie Liu of Department of Vascular and Endovascular Surgery, Chinese PLA General Hospital for his contribution to the statistical support, study deign consultations and comments regarding the manuscript.

References

Bennett, L.S., Barbour, C., Langford, B., Stradling, J.R., Davies, R.J., 1999. Health status in obstructive sleep apnea: relationship with sleep fragmentation and daytine sleepiness, and effects of continuous positive airway pressure treatment. Am. J. Respir. Crit. Care Med. 159 (6), 1884–1890. http://doi.org/10.1164/ajrccm.159.6.9808107.

Berger, A.T., Wahlstrom, K.L., Widome, R., 2019. Relationships between sleep duration and adolescent depression: a conceptual replication. Sleep Health 5 (2), 175–179. http://doi.org/10.1016/j.sleh.2018.12.003.

Bin, Y.S., Marshall, N.S., Glozier, N., 2012. Secular trends in adult sleep duration: a systematic review. Sleep Med. Rev. 16 (3), 223–230. http://doi.org/10.1016/j.smrv.2011.07.003.

Butler, M.P., Emch, J.T., Rueschman, M., Sands, S.A., Shea, S.A., Wellman, A., Redline, S., 2019. Apnea-hypopnea event duration predicts mortality in men and women in the sleep heart health study. Am. J. Respir. Crit. Care Med. 199 (7), 903–912. http://doi.org/10.1164/rccm.201804-0758OC.

Cho, H.J., Eisenberger, N.I., Olmstead, R., BREEN, E.C., Irwin, M.R., 2016. Preexisting mild sleep disturbance as a vulnerability factor for inflammation-induced depressed mood: a human experimental study. Transl. Psychiatry 6 (3), e750. http://doi.org/10.1038/tp.2016.23.

Choi, K.W., Chen, C.Y., Stein, M.B., Klimentidis, Y.C., Wang, M.J., Koenen, K.C., Smoller, J.W., 2019. Assessment of bidirectional relationships between physical activity and depression among adults: a 2-sample mendelian randomization study. JAMA Psychiatry 76 (4), 399–408. http://doi.org/10.1001/jamapsychiatry.2018.4175.

Covassin, N., Singh, P., 2016. Sleep duration and cardiovascular disease risk: epidemiologic and experimental evidence. Sleep Med. Clin. 11 (1), 81–89. http://doi.org/10.1016/j.jsmc.2015.10.007.

Daghlas, I., Dashti, H.S., Lane, J., ARAGAM, K.G., Rutter, M.K., Saxena, R., Vetter, C., 2019. Sleep duration and myocardial infarction. J. Am. Coll. Cardiol. 74 (10), 1304–1314. http://doi.org/10.1016/j.jacc.2019.07.022.

Dipak, A.F., Third report of the National cholesterol education program (NCEP), 2002. Expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult treatment panel III) final report. Circulation 106 (25), 3143–3421.

Faulkner, S.M., Bee, P.E., Meyer, N., Dijk, D.J., Drake, R.J., 2019. Light therapies to improve sleep in intrinsic circadian rhythm sleep disorders and neuro-psychiatric illness: a systematic review and meta-analysis. Sleep Med. Rev. 46, 108–123. https://doi.org/10.1016/j.smrv.2019.04.012.

Hirshkowitz, M., Whiton, K., Albert, S.M., Alessi, C., Bruni, O., Doncarlos, L., Hazen, N., Herman, J., Katz, E.S., Kheirandish-Gozal, L., Neubauer, D.N., O'Donnell, A.E., Ohayon, M., Peever, J., Rawding, R., Sachdeva, R.C., Setters, B., Vitiello, M.V., Ware, J.C., Adams, H.P., 2015. National Sleep Foundation's sleep time duration recommendations: methodology and results summary. Sleep Health 1 (1), 40–43. https://doi.org/10.1016/j.sleh.2014.12.010.

Huang, T., Mariani, S., Redline, S., 2020. Sleep irregularity and risk of cardiovascular events: the multi-ethnic study of atherosclerosis. J. Am. Coll. Cardiol. 75 (9), 991–999. https://doi.org/10.1016/j.jacc.2019.12.054.

Irwin, M.R., Opp, M.R., 2017. Sleep health: reciprocal regulation of sleep and innate immunity. Neuropsychopharmacology 42 (1), 129–155. https://doi.org/10.1038/npp.2016.148.

Janal, M.N., Colt, E., Clark, C.W., Glusman, M., 1984. Pain sensitivity, mood and plasma endocrine levels in man following long-distance running: effects of naloxone. Pain 19 (1), 13–25. https://doi.org/10.1016/0304-3959(84)90061-7.

Johnson, C.L., Dohrmann, S.M., Burt, V.L., Mohadjer, L.K., 2014. National health and nutrition examination survey: sample design, 2011–2014. Vital Health Stat. 2 (162), 1–33.

Koo, D.L., Yang, K.I., Kim, J.H., Kim, D., Sunwoo, J.S., Hwangbo, Y., Lee, H.R., Hong, S. B., 2021. Association between morningness-eveningness, sleep duration, weekend catch-up sleep and depression among Korean high-school students. J. Sleep Res. 30 (1), e13063. https://doi.org/10.1111/jsr.13063.

Kroenke, K., Spitzer, R.L., Williams, J.B., 2001. The PHQ-9: validity of a brief depression severity measure. J. Gen. Intern. Med. 16 (9), 606–613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x.

Lund, C., Brooke-Sumner, C., Baingana, F., Baron, EC, Breuer, E., Chandra, P., Haushofer, J., Herrman, H., Jordans, M., Kieling, C., Medina-Mora, M.E., Morgan, E., Omigbodun, O., Tol, W., Patel, V., Saxena, S., 2018. Social determinants of mental disorders and the Sustainable Development Goals: a systematic review of reviews. Lancet Psychiatry 5 (4), 357–369. https://doi.org/10.1016/S2215-0366(18)30060-9.

Matsui, K., Kuriyama, K., Yoshiike, T., Nagao, K., Ayabe, N., Komada, Y., Okajima, I., ITO, W., Ishigooka, J., Nishimura, K., Inoue, Y., 2020. The effect of short or long sleep duration on quality of life and depression: an internet-based survey in Japan. Sleep Med. 76, 80–85. https://doi.org/10.1016/j.sleep.2020.10.012.

Menke, A., Casagrande, s., Geiss, l., Cowie, C.C., 2015. Prevalence of and trends in diabetes among adults in the United States, 1988-2012. JAMA 314 (10), 1021–1029. https://doi.org/10.1001/jama.2015.10029.

Ogawa, S., Kitagawa, Y., Fukushima, M., Yonehara, H., Nishida, A., Togo, F., Sasaki, T., 2019. Interactive effect of sleep duration and physical activity on anxiety/depression in adolescents. Psychiatry Res. 273, 456–460. https://doi.org/10.1016/j.psychres.2018.12.085.

Ojio, Y., Nishida, A., Shimodera, S., Togo, F., Sasaki, T., 2016. Sleep duration associated with the lowest risk of depression/anxiety in adolescents. Sleep 39 (8), 1555–1562. https://doi.org/10.5665/sleep.6020.

Ouyang, P., Sun, W., 2019. Depression and sleep duration: findings from middle-aged and elderly people in China. Public Health 166, 148–154. https://doi.org/10.1016/j.puhe.2018.10.007.

Paksarian, D., Rudolph, K.E., Stapp, E.K., Dunster, G.P., He, J., Mennitt, D., Hattar, S., Casey, J.A., James, P., Merikangas, K.R., 2020. Association of outdoor artificial light at night with mental disorders and sleep patterns among US adolescents. JAMA Psychiatry 77 (12), 1266–1275. https://doi.org/10.1001/jamapsychiatry.2020.1935.

PATEL, S.R., MALHOTRA, A., GOTTLIEB, D.J., WHITE, D.P., HU, F.B., 2006. Correlates of long sleep duration. Sleep 29 (7), 881–889. https://doi.org/10.1093/sleep/29.7.881.

Patel, V., Chisholm, D., Parikh, R., Charlson, F.J., Degenhardt, L., Dua, T., Ferrari, A.J., Hyman, S., Laxminarayan, R., Levin, C., Lund, C., Medina, M.M., Petersen, I., Scott, J., Shidhaye, R., VIJAyakumar, L., Thornicroft, G., Whiteford, H., 2016. Addressing the burden of mental, neurological, and substance use disorders: key messages from disease control priorities, 3rd edition. Lancet 387 (10028), 1672–1685. https://doi.org/10.1016/S0140-6736(15)00390-6.

Reis, C., Dias, S., Rodrigues, A.M., Sousa, R.D., Gregorio, M.J., Branco, J., Canhao, H., Paiva, T., 2018. Sleep duration, lifestyles and chronic diseases: a cross-sectional population-based study. Sleep Sci. 11 (4), 217–230. https://doi.org/10.5935/1984-0063.20180036.

Salmon, P., 2001. Effects of physical exercise on anxiety, depression, and sensitivity to stress: a unifying theory. Clin. Psychol. Rev. 21 (1), 33–61. https://doi.org/10.1016/s0272-7358(99)00032-x.

Sun, Y., Shi, L., Bao, Y., Sun, Y., Shi, J., Lu, L., 2018. The bidirectional relationship between sleep duration and depression in community-dwelling middle-aged and elderly individuals: evidence from a longitudinal study. Sleep Med. 52, 221–229. https://doi.org/10.1016/j.sleep.2018.03.011.

Tobaldini, E., Fiorelli, E.M., Solbiati, M., Costantino, G., Nobili, L., Montano, N., 2019. Short sleep duration and cardiometabolic risk: from pathophysiology to clinical evidence. Nat. Rev. Cardiol. 16 (4), 213–224. https://doi.org/10.1038/s41569-018-0109-6.

Wang, C., Bangdiwala, S.I., Rangarajan, S., Lear, S.A., Alhabib, K.F., Mohan, V., Teo, K., Poirier, P., Tse, L.A., Liu, Z., Rosengren, A., Kumar, R., Lopez-Jaramillo, P., Yusoff, K., Monsef, N., Krishnapillai, V., Ismail, N., Seron, P., Dans, A.L., Kruger, L., Yeates, K., Leach, L., Yusuf, R., Orlandini, A., Wolyniec, M., Bahonar, A., Mohan, I., Khatib, R., Temizhan, A., Li, W., Yusuf, S., 2019. Association of estimated sleep duration and naps with mortality and cardiovascular events: a study of 116 632 people from 21 countries. Eur. Heart J. 40 (20), 1620–1629. https://doi.org/10.1093/eurheartj/ehy695.

Weicker, H., Struder, H.K., 2001. Influence of exercise on serotonergic neuromodulation in the brain. Amino Acids 20 (1), 35–47. https://doi.org/10.1007/s007260170064.

Whelton, P.K., Carey, R.M., Aronow, W.S., Casey, D.J., Collins, K.J., Dennison, H.C., Depalma, S.M., Gidding, S., Jamerson, K.A., Jones, D.W., Maclaughlin, E.J., Muntner, P., Ovbiagele, B., Smith, S.J., Spencer, C.C., Stafford, R.S., Taler, S.J., Thomas, R.J., Williams, K.S., Williamson, J.D., Wright, J.J., 2018. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: executive summary: a report of the American college of cardiology/American heart association task force on clinical practice guidelines. J. Am. Coll. Cardiol. 71 (19), 2199–2269. https://doi.org/10.1016/j.jacc.2017.11.005.

Youngstedt, S.D., Kripke, D.F., 2004. Long sleep and mortality: rationale for sleep restriction. Sleep Med. Rev. 8 (3), 159–174. https://doi.org/10.1016/j.smrv.2003.10.002.

Zhai, L., Zhang, H., Zhang, D., 2015. Sleep duration and depression among adults: a meta-analysis of prospective studies. Depress. Anxiety 32 (9), 664–670. https://doi.org/10.1002/da.22386.