Association between Nocturnal Sleep Status and Chronic Disease Comorbidity among Community-Dwelling Older Adults in China: Postprint

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Date: 2023-08-28T00:00:00+00:00

Abstract

Background With the rapid advancement of China' s aging wave, chronic disease multimorbidity has posed significant challenges to public health and clinical practice. Nocturnal sleep status (sleep duration and quality) is crucial for regulating bodily metabolism and physiological functions in older adults; however, current research on the relationship between nocturnal sleep status and chronic disease multimorbidity is limited to specific regions or young and middle-aged populations, and the association between nocturnal sleep status and the risk of developing chronic disease multimorbidity among community-dwelling older adults in China remains unclear.

Objective To explore the association between nocturnal sleep status and the risk of developing chronic disease multimorbidity among community-dwelling older adults in China.

Methods In April 2023, this study selected 11,917 community-dwelling older adults from the 2018 Chinese Longitudinal Healthy Longevity Survey and Happy Family Study (CLHLS-HF) data. Multivariate logistic regression analysis was used to explore the association between sleep duration, sleep quality, and the risk of chronic disease multimorbidity among community-dwelling older adults, expressed as odds ratios (OR) and 95% confidence intervals (95%CI); restricted cubic spline (RCS) analysis based on logistic regression was employed to examine the dose-response relationship between sleep duration and the risk of chronic disease multimorbidity in this population.

Results Among the 11,917 community-dwelling older adults, the mean age was 84.4$±$11.4 years, with an age range of 65.0-117.0 years. The study population

included 6,477 (54.35%) females and 5,440 (45.65%) males. Multivariate logistic regression analysis showed that after adjusting for covariates such as sex, age, region, and years of education, older adults with shorter nocturnal sleep duration (<6 h) had a higher risk of developing chronic disease multimorbidity compared to those with sleep duration of 6-8 h (OR=1.51, 95%CI=1.36-1.67); compared to older adults with good sleep quality, those with fair sleep quality (OR=1.34, 95%CI=1.22-1.46) and poor sleep quality (OR=2.14, 95%CI=1.91-2.40) were associated with a higher risk of chronic disease multimorbidity. RCS plot results indicated a U-shaped nonlinear association between sleep duration and the risk of chronic disease multimorbidity, with an optimal sleep duration of approximately 7 h.

Conclusion Community-dwelling older adults with sleep duration <6 h and fair or poor sleep quality are associated with an increased risk of chronic disease multimorbidity; the optimal sleep duration for community-dwelling older adults is approximately 7 h, and normal sleep duration and good sleep quality are of significant importance for preventing the occurrence of chronic disease multimorbidity.

Full Text

Abstract

Background

With the rapid progression of population aging in China, multimorbidity has become a significant public health and clinical challenge. Nocturnal sleep status, encompassing both sleep duration and quality, plays a crucial role in regulating metabolic and physiological functions among older adults. However, existing research on the relationship between nocturnal sleep status and multimorbidity has been limited to specific regions or middle-aged populations. The association between nocturnal sleep status and multimorbidity risk among community-dwelling older adults in China remains unclear.

Objective

To investigate the association between nocturnal sleep status and multimorbidity risk among community-dwelling older adults in China.

Methods

In April 2023, we selected 11,917 community-dwelling older adults from the 2018 wave of the Chinese Longitudinal Healthy Longevity and Happy Family Study (CLHLS-HF). Multivariate logistic regression analysis was employed to examine the association between sleep duration, sleep quality, and multimorbidity risk, with results expressed as odds ratios (OR) and 95% confidence intervals (95%CI). Additionally, restricted cubic spline (RCS) analysis based on logistic regression was used to explore the dose-response relationship between sleep duration and multimorbidity risk.

Results

Among the 11,917 community-dwelling older adults, the mean age was 84.4$±$11.4 years (range: 65.0–117.0 years), with 6,477 (54.35%) females and 5,440 (45.65%) males. After adjusting for covariates including gender, age, region, and years of education, multivariate logistic regression revealed that older adults with short sleep duration (<6 h) had a higher multimorbidity risk compared to those with normal sleep duration (6–8 h) (OR=1.51, 95%CI=1.36–1.67). Similarly, individuals with fair sleep quality (OR=1.34, 95%CI=1.22–1.46) and poor sleep quality (OR=2.14, 95%CI=1.91–2.40) showed higher multimorbidity risk compared to those with good sleep quality. RCS analysis demonstrated a U-shaped nonlinear association between sleep duration and multimorbidity risk, with an optimal sleep duration of approximately 7 hours.

Conclusion
Community-dwelling older adults with sleep duration <6 h and fair or poor sleep quality are associated with increased multimorbidity risk. The optimal sleep duration for community-dwelling older adults is approximately 7 hours. Normal sleep duration and good sleep quality are important for preventing multimorbidity.

Keywords
Aged; Multimorbidity; Sleep duration; Sleep quality; Association study

Introduction

Multimorbidity is defined as the coexistence of two or more chronic conditions in an individual [1-2]. As global population aging accelerates, the disease burden of multimorbidity has risen significantly, with prevalence reaching 55%–98% among the general population aged over 60 years [3]. Compared with single disease conditions, multimorbidity is associated with longer hospital stays and higher mortality risk [4-5], posing important challenges to public health and clinical practice. Sleep is a fundamental human need that plays a vital role in regulating body metabolism and physiological functions. With advancing age, sleep patterns and architecture undergo changes [6]. Multiple studies have reported high prevalence of abnormal sleep duration and poor sleep quality among older adults [7], and both short sleep duration and poor sleep quality are associated with the development and progression of various chronic diseases including diabetes [8], hypertension [9], and cardiovascular disease [10]. Evidence from the Canadian Longitudinal Study on Aging indicates that self-reported short sleep duration and dissatisfaction with sleep quality among middle-aged and older adults are associated with increased risk of certain chronic diseases [11]. A longitudinal study in the United Kingdom also demonstrated that sleep duration in older adults is associated with increased risk of chronic diseases and subsequent multimorbidity [12]. While the association between nocturnal sleep status and chronic diseases has been well-established, research specifically examining the relationship between nocturnal sleep status and multimorbidity remains

limited. Current domestic studies have primarily focused on specific regions or middle-aged populations [13-14], leaving the relationship between nocturnal sleep status and multimorbidity risk among Chinese community-dwelling older adults unclear. Therefore, this study utilizes data from the Chinese Longitudinal Healthy Longevity and Happy Family Study (CLHLS-HF) [15] to explore the relationship between nocturnal sleep status and multimorbidity among Chinese community-dwelling older adults, aiming to provide new insights for reducing multimorbidity risk, alleviating chronic disease burden, and achieving healthy aging.

Methods

Data Source

The CLHLS-HF data were collected using a multistage, disproportionate target random sampling method. Previous studies have systematically evaluated the CLHLS-HF data, demonstrating high data quality and good population representativeness [16]. In April 2023, we selected cross-sectional survey data from the 2018 wave of the CLHLS-HF, which included 15,874 valid samples. The inclusion criteria were: (1) adults aged $ $65 years; (2) community-dwelling residents. Exclusion criteria were: (1) older adults residing in nursing institutions; (2) individuals with missing data on current disease status or key variables (living arrangement, sleep duration, or sleep quality). Based on these criteria, 103 individuals were <65 years old, 900 resided in nursing institutions or did not report living arrangements, and 3,698 did not report nocturnal sleep status or disease information. Ultimately, 11,917 community-dwelling older adults were included in the study. The CLHLS-HF was approved by the Biomedical Ethics Committee of Peking University (IRB00001052-13074), and all participants or their relatives provided written informed consent.

Variables

Outcome Variable Based on data availability and general evaluation methods for multimorbidity [17], this study assessed multimorbidity using 19 chronic conditions: hypertension, diabetes, heart disease, stroke, respiratory diseases (bronchitis, emphysema, pneumonia, asthma), tuberculosis, cataract, glaucoma, cancer, gastric or duodenal ulcer, Parkinson' s disease, arthritis, dementia, epilepsy, cholecystitis or cholelithiasis, hematologic diseases, rheumatism or rheumatoid disease, chronic nephritis, and hepatitis. Older adults with $ $2 chronic conditions were classified as having multimorbidity and included in the multimorbidity group, while others were placed in the non-multimorbidity group.

Nocturnal Sleep Status Variables Nocturnal sleep status was assessed through two variables: sleep duration and sleep quality. Following previous studies [18-19], self-reported sleep duration from the question "How many hours

do you generally sleep per day?" was categorized into three groups: <6 h (short sleep duration), >8 h (long sleep duration), and 6–8 h (normal sleep duration). Sleep quality was based on self-reported responses to "How is your current sleep quality?" and categorized as good, fair, or poor.

Covariates Based on previous research on multimorbidity risk factors and data availability [13], we a priori assessed covariates including sociodemographic characteristics, health status, and lifestyle variables. Sociodemographic variables comprised age (65–79, 80–94, and $ $95 years), gender (male and female), ethnicity (Han and minority), marital status (married and cohabiting with spouse, widowed, unmarried or separated), years of education (no education, 1–6 years, $ $7 years), residence [urban (town) and rural], living arrangement (living alone and living with family), occupation rate economic status (wealthy, average, and poor). Health status and lifestyle variables included smoking (never, 18.5 kg/m^{2}, normal : 18.5–23.9 kg/m^{2}{2}$, overweight/obese: $ $24.0), and self-rated health status (good, average, and poor).

Statistical Analysis

Data processing and analysis were performed using R version 4.2.2, with packages including "rms," "Comparegroups," "forestplot," and "ggplot2." Categorical variables were presented as frequencies and compared using chi-square tests. Normality of continuous variables was assessed using the Shapiro-Wilk test, with normally distributed variables presented as mean ± standard deviation. Multivariate logistic regression analysis was used to examine the association between nocturnal sleep status and multimorbidity risk, with results expressed as odds ratios (OR) and 95% confidence intervals (95%CI). Stratified analyses were conducted by age, gender, residence, years of education, marital status, self-rated economic status, BMI, and self-rated health status. Statistical significance was set at $P<0.05$. The dose-response relationship between sleep duration and multimorbidity risk was analyzed using restricted cubic spline (RCS) models based on logistic regression, with optimal knot selection determined by Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

Results

Basic Characteristics of Study Participants

A total of 11,917 community-dwelling older adults were included, with a mean age of 84.4$±$11.4 years (range: 65.0–117.0 years). The sample comprised 6,477 (54.35%) females and 5,440 (45.65%) males. Regarding residence, 6,492 (54.48%) lived in urban areas and 5,425 (45.52%) in rural areas. Ethnically, 11,312 (94.92%) were Han Chinese and 605 (5.08%) were minorities. Marital status distribution showed 6,510 (54.62%) widowed, 5,103 (42.82%) married and cohabiting with spouse, and 304 (2.56%) unmarried or separated. For living arrangements, 2,014 (16.90%) lived alone and 9,903 (83.10%) lived with

family. Education levels were: 5,056 (42.43%) with no formal education, 4,758 (39.93%) with 1-6 years, and 2,103 (17.64%) with $ $7 years. Occupation before age 60 was farming for 8,718 (73.16%) and other occupations for 3,199 (26.84%). Self-rated economic status was wealthy for 2,371 (19.90%), average for 8,298 (69.63%), and poor for 1,248 (10.47%). BMI categories included 2,028 (17.02%) underweight, 6,213 (52.13%) normal weight, and 3,676 (30.85%) overweight/obese. Sleep duration distribution was <6 h for 2,198 (18.44%), 6–8 h for 6,570 (55.14%), and >8 h for 3,149 (26.42%). Sleep quality was good for 6,332 (53.13%), fair for 3,796 (31.85%), and poor for 1,789 (15.02%). Smoking status showed 8,177 (68.62%) never smokers, 1,830 (15.36%) former smokers, and 1,910 (16.02%) current smokers. Alcohol consumption was never for 8,668 (72.74%), former for 1,416 (11.88%), and current for 1,833 (15.38%). Physical activity was never for 8,668 (72.74%), former for 976 (8.11%), and current for 2,282 (19.15%). Self-rated health status was good for 5,634 (47.28%), average for 4,629 (38.84%), and poor for 1,654 (13.88%).

Comparison of Basic Characteristics Between Multimorbidity and Non-Multimorbidity Groups

Significant differences between multimorbidity and non-multimorbidity groups were observed in age, gender, marital status, residence, ethnicity, years of education, occupation before age 60, self-rated economic status, BMI, sleep duration, sleep quality, smoking status, alcohol consumption, physical activity, and self-rated health status (all $P<0.05$). No significant difference was found in living arrangement between groups ($P>0.05$) .

Association Between Sleep Duration and Multimorbidity Risk

Using multimorbidity status as the dependent variable and sleep duration as the independent variable, multivariate logistic regression analysis showed that after adjusting for covariates (age, gender, marital status, residence, ethnicity, living arrangement, years of education, occupation before age 60, self-rated economic status, BMI, smoking status, alcohol consumption, physical activity, and self-rated health status), older adults with sleep duration <6 h had higher multimorbidity risk compared to those with 6–8 h sleep duration ($P<0.05$) .

Stratified analysis revealed that among older adults with 1–6 years of education, poor self-rated economic status, and poor self-rated health status, sleep duration >8 h was associated with increased multimorbidity risk ($P<0.05$). Across different age groups, genders, residences, education levels, self-rated economic statuses, BMI categories, self-rated health statuses, and marital statuses (married/cohabiting or widowed), sleep duration <6 h was consistently associated with increased multimorbidity risk ($P<0.05$) [Figure 1: see original paper]. Dose-response analysis using RCS showed a U-shaped nonlinear association between sleep duration and multimorbidity risk (P_{nonlinear}<0.001), with an optimal sleep duration of approximately 7 hours [Figure 2: see original paper].

Association Between Sleep Quality and Multimorbidity Risk

Using multimorbidity status as the dependent variable and sleep quality as the independent variable, multivariate logistic regression analysis demonstrated that after adjusting for covariates, older adults with fair sleep quality (OR=1.34, 95%CI=1.22–1.46) and poor sleep quality (OR=2.14, 95%CI=1.91–2.40) had higher multimorbidity risk compared to those with good sleep quality (P<0.05) .

Stratified analysis showed that among older adults aged $ $95 years, living in rural areas, with $ $7 years of education, widowed, with average economic status, and poor self-rated health status, fair sleep quality was associated with increased multimorbidity risk (P<0.05). Poor sleep quality was associated with increased multimorbidity risk across different age groups, genders, residences, education levels, self-rated economic statuses, BMI categories, self-rated health statuses, and marital statuses (married/cohabiting or widowed) (P<0.05) [Figure 3: see original paper].

Discussion

This study examined the association between nocturnal sleep status and multimorbidity risk among Chinese community-dwelling older adults. The findings indicate that short sleep duration (<6 h) is associated with higher multimorbidity risk, consistent with a German cross-sectional study showing that short sleep duration in women was associated with increased multimorbidity risk [20]. A longitudinal study in Luxembourg also demonstrated a linear association between short sleep duration and number of chronic diseases [21]. The dose-response analysis revealed an optimal sleep duration of approximately 7 hours, with a U-shaped relationship between sleep duration and multimorbidity risk.

Furthermore, our results show that fair or poor sleep quality is associated with increased multimorbidity risk. A cross-sectional survey in Cyprus found that poor sleep quality was associated with higher risk of multiple chronic diseases [22], aligning with our findings. A community-based cross-sectional study in China also reported similar results, observing higher prevalence of cardiovascular diseases (arrhythmia, hypertension, cerebral hemorrhage, migraine, and hyperlipidemia) among patients with insomnia [23].

The mechanisms linking sleep disorders to multimorbidity development have been extensively studied, with inflammatory responses potentially playing a crucial role. A meta-analysis of 72 studies indicated that sleep disorders and abnormal sleep duration are associated with increased inflammatory markers such as C-reactive protein (CRP) and interleukin-6 (IL-6) [24]. Evidence from the US Health and Retirement Study showed that CRP and glycated hemoglobin are significantly associated with multimorbidity risk in older adults [25]. Longitudinal data from the US Midlife Development Study further demonstrated that IL-6, CRP, and fibrinogen mediate multimorbidity development in middle-aged and older adults [26]. A 9-year longitudinal study found that older adults

with high baseline IL-6 levels and rapid cumulative IL-6 progression had higher multimorbidity risk [27]. Additionally, short sleep duration may co-occur with behavioral risk factors such as smoking, alcohol consumption, and physical inactivity [21,28], which may further increase multimorbidity risk. The causal associations and mechanisms between sleep disorders and multimorbidity require further investigation.

The prevalence of sleep disorders is high among Chinese older adults [29]. With advancing age, physiological decline makes older adults more susceptible to sleep problems such as shortened sleep duration and insomnia. Sleep issues in older adults warrant greater attention, and community health service institutions should implement comprehensive psychological and exercise interventions along with appropriate health guidance to improve sleep quality. Incorporating sleep pattern assessment into community public health services and clinical history-taking could help identify high-risk individuals for multimorbidity and reduce disease burden.

This study utilized CLHLS-HF data to examine the association between multimorbidity and nocturnal sleep status among Chinese community-dwelling older adults, providing a theoretical basis for developing prevention and control strategies. The RCS analysis precisely characterized the dose-response relationship between sleep duration and multimorbidity risk, offering more targeted intervention strategies and health guidance for improving nocturnal sleep status in community-dwelling older adults. However, due to data availability limitations, this cross-sectional analysis cannot establish causal relationships between nocturnal sleep status and multimorbidity risk, and prospective multicenter studies are needed to confirm these findings. Additionally, sleep duration and quality were based on self-reported data, which may introduce assessment bias.

In conclusion, community-dwelling older adults with sleep duration <6 h and fair or poor sleep quality are associated with increased multimorbidity risk. The optimal sleep duration for community-dwelling older adults is approximately 7 hours. Normal sleep duration and good sleep quality are important for preventing multimorbidity.

Author Contributions: Xia Gaoyan was responsible for data curation, interpretation and analysis of results, and manuscript writing and revision. Liu Ming contributed to study implementation and feasibility analysis, with overall responsibility and supervision of the article. Qi Yuxin and Xiao Peigen performed data quality control. Ding Xiaojiao and Ning Rongrong revised the overall manuscript. Ye Xianfeng was responsible for study conception and design, final version revision, and overall accountability for the manuscript.

Conflict of Interest: The authors declare no conflict of interest.

References

[1] PAREKH A K, BARTON M B. The challenge of multiple comorbidity for the US health care system[J]. JAMA, 2010, 303(13): 1303-1304.

DOI:10.1001/jama.2010.381.

[2] MCDAID O, HANLY M J, RICHARDSON K, et al. The effect of multiple chronic conditions on self-rated health, disability and quality of life among the older populations of Northern Ireland and the Republic of Ireland: a comparison of two nationally representative cross-sectional surveys[J]. BMJ Open, 2013, 3(6): e002571. DOI:10.1136/bmjopen-2013-002571.

[3] MARENGONI A, ANGLEMAN S, MELIS R, et al. Aging with multimorbidity: a systematic review of the literature[J]. Ageing Res Rev, 2011, 10(4): 430-439. DOI:10.1016/j.arr.2011.03.003.

[4] NUNES B P, FLORES T R, MIELKE G I, et al. Multimorbidity and mortality in older adults: a systematic review and meta-analysis[J]. Arch Gerontol Geriatr, 2016, 67: 130-138. DOI:10.1016/j.archger.2016.07.008.

[5] ZHAO Y, ZHANG P H, OLDENBURG B, et al. The impact of mental and physical multimorbidity on healthcare utilization and health spending in China: a nationwide longitudinal population-based study[J]. Int J Geriatr Psychiatry, 2021, 36(4): 500-510. DOI:10.1002/gps.5445.

[6] LI J X, VITIELLO M V, GOONERATNE N S. Sleep in normal aging[J]. Sleep Med Clin, 2022, 17(2): 161-171. DOI:10.1016/j.jsmc.2022.02.007.

[7] 孟德清, 艾自胜. 上海市真新社区正常老年人群睡眠质量与肥胖相关性研究 [J]. 同济大学学报: 医学版, 2023, 44(1): 116-125. DOI:10.12289/j.issn.1008-0392.22041.

[8] OHKUMA T, FUJII H, IWASE M, et al. U-shaped association of sleep duration with metabolic syndrome and insulin resistance in patients with type 2 diabetes: the Fukuoka Diabetes Registry[J]. Metabolism, 2014, 63(4): 484-491. DOI:10.1016/j.metabol.2013.12.001.

[9] GUO X F, ZHENG L Q, WANG J, et al. Epidemiological evidence for the link between sleep duration and high blood pressure: a systematic review and meta-analysis[J]. Sleep Med, 2013, 14(4): 324-332. DOI:10.1016/j.sleep.2012.12.001.

[10] YIN J W, JIN X L, SHAN Z L, et al. Relationship of sleep duration with all-cause mortality and cardiovascular events: a systematic review and dose-response meta-analysis of prospective cohort studies[J]. J Am Heart Assoc, 2017, 6(9): e005947. DOI:10.1161/JAHA.117.005947.

[11] NICHOLSON K, RODRIGUES R, ANDERSON K K, et al. Sleep behaviours and multimorbidity occurrence in middle-aged and older adults: findings from the Canadian Longitudinal Study on Aging (CLSA)[J]. Sleep Med, 2020, 75: 156-162. DOI:10.1016/j.sleep.2020.07.002.

[12] SABIA S, DUGRAVOT A, LÉGER D, et al. Association of sleep duration at age 50, 60, and 70 years with prevalence of multimorbidity in the UK: 25-year follow-up of the Whitehall II cohort study[J]. PLoS Med, 2022, 19(10): e1004109. DOI:10.1371/journal.pmed.1004109.

[13] 张国珍, 田恬, 裴华莲, 等. 新疆和田地区墨玉县 35~74 岁人群睡眠状况与慢性病共病关系的研究 [J]. 新疆医科大学学报, 2019, 42(10): 1244-1248, 1254. DOI:10.3969/j.issn.1009-5551.2019.10.002.

[14] HE L, BIDDLE S J H, LEE J T, et al. The prevalence of multimorbidity and its association with physical activity and sleep duration in middle aged and elderly adults: a longitudinal analysis from China[J]. Int J Behav Nutr Phys Act, 2021, 18(1): 77. DOI:10.1186/s12966-021-01150-7.

[15] 健康老龄与发展研究中心. CLHLS 数据介绍 [EB/OL]. [2023-03-21]. http://chads.nsd.pku.edu.cn/sjzx/index.htm.

[16] YAO Y, CHEN H S, CHEN L L, et al. Type of tea consumption and depressive symptoms in Chinese older adults[J]. BMC Geriatr, 2021, 21(1): 331. DOI:10.1186/s12877-021-02203-z.

[17] BARNETT K, MERCER S W, NORBURY M, et al. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study[J]. Lancet, 2012, 380(9836): 37-43. DOI:10.1016/S0140-6736(12)60240-2.

[18] LI J, CAO D H, HUANG Y, et al. Sleep duration and health outcomes: an umbrella review[J]. Schlaf Atmung, 2022, 26(3): 1479-1501. DOI:10.1007/s11325-021-02458-1.

[19] WINER J R, DETERS K D, KENNEDY G, et al. Association of short and long sleep duration with amyloid-β burden and cognition in aging[J]. JAMA Neurol, 2021, 78(10): 1187-1196. DOI:10.1001/jamaneurol.2021.2876.

[20] HELBIG A K, STÖCKL D, HEIER M, et al. Relationship between sleep disturbances and multimorbidity among community-dwelling men and women aged 65-93 years: results from the KORA Age Study[J]. Sleep Med, 2017, 33: 151-159. DOI:10.1016/j.sleep.2017.01.016.

[21] RUIZ-CASTELL M, MAKOVSKI T T, BOCQUET V, et al. Sleep duration and multimorbidity in Luxembourg: results from the European Health Examination Survey in Luxembourg, 2013-2015[J]. BMJ Open, 2019, 9(8): e026942. DOI:10.1136/bmjopen-2018-026942.

[22] KYPRIANIDOU M, PANAGIOTAKOS D, KAMBANAROS M, et al. Quality of sleep in the Cypriot population and its association with multimorbidity: a cross-sectional study[J]. Front Public Health, 2021, 9: 693332. DOI:10.3389/fpubh.2021.693332.

[23] WANG Y M, SONG M, WANG R, et al. Insomnia and multimorbidity in the community elderly in China[J]. J Clin Sleep Med, 2017, 13(4): 591-597. DOI:10.5664/jcsm.6550.

[24] IRWIN M R, OLMSTEAD R, CARROLL J E. Sleep disturbance, sleep duration, and inflammation: a systematic review and meta-analysis of cohort

studies and experimental sleep deprivation[J]. Biol Psychiatry, 2016, 80(1): 40-52. DOI:10.1016/j.biopsych.2015.05.014.

[25] BOTOSENEANU A, MARKWARDT S, QUIÑONES A R. Multimorbidity and functional disability among older adults: the role of inflammation and glycemic status—an observational longitudinal study[J]. Gerontology, 2023, 69(7): 826-838. DOI:10.1159/000528648.

[26] FRIEDMAN E M, CHRIST S L, MROCZEK D K. Inflammation partially mediates the association of multimorbidity and functional limitations in a national sample of middle-aged and older adults: the MIDUS study[J]. J Aging Health, 2015, 27(5): 843-863. DOI:10.1177/0898264315569453.

[27] FABBRI E, AN Y, ZOLI M, et al. Aging and the burden of multimorbidity: associations with inflammatory and anabolic hormonal biomarkers[J]. J Gerontol A Biol Sci Med Sci, 2015, 70(1): 63-70. DOI:10.1093/gerona/glu127.

[28] GUBELMANN C, HEINZER R, HABA-RUBIO J, et al. Physical activity is associated with higher sleep efficiency in the general population: the CoLaus study[J]. Sleep, 2018, 41(7). DOI:10.1093/sleep/zsy070.

[29] 王振杰, 赵蔓, 陈婷蔚, 等. 中国老年人睡眠障碍患病率的 Meta 分析 [J]. 中国全科医学, 2022, 25(16): 2036-2043. DOI:10.12114/j.issn.1007-9572.2022.0151.

(Received: May 15, 2023; Revised: August 21, 2023)

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