Comorbid Diabetes and Depression in Middle-aged and Older Adults: Impacts of Sleep, Physical Activity, and Social Activities (Postprint)

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Abstract

Background: Diabetes and depression are global public health problems. Diabetes is significantly correlated with depression; therefore, monitoring and intervention for diabetes, depression, and their comorbidity in middle-aged and elderly populations are crucial.

Objective: To investigate the prevalence of diabetes, depressive status, and their comorbidity among middle-aged and elderly adults, and the effects of sleep, physical activity, and social activities on them.

Methods: Based on the 2018 China Health and Retirement Longitudinal Study, middle-aged and elderly individuals aged $ $45 years were included as study subjects. General information, prevalence of diabetes and depressive status, sleep duration, physical activity, and social activities were collected. A multivariate Logistic regression model was used to study the association between sleep, physical activity, and social activities and the comorbidity of diabetes and depressive status, and the product of nap duration and nighttime sleep duration was included in the regression model for interaction analysis.

Results: A total of 11,177 subjects were included, with a diabetes prevalence of 13.95% (1,559/11,177), a depressive status prevalence of 24.85% (2,777/11,177), and a comorbidity prevalence of diabetes and depressive status of 14.64% (1,636/11,177). Multinomial Logistic regression results showed that nighttime sleep duration of 7-9 h (OR=0.337, 95%CI=0.296-0.384), nighttime sleep duration >9 h (OR=0.509, 95%CI=0.374-0.692), and nap duration $ $90 min (OR=0.792, 95%CI=0.666-0.941) were all protective factors for the comorbidity of diabetes and depressive status (P<0.05); high levels of social activity could also reduce the risk of comorbidity (OR=0.778, 95%CI=0.686-0.882, P<0.05). Interaction analysis results showed that maintaining 7-9 h of nighttime sleep duration could effectively prevent the comorbidity of diabetes and depressive

status regardless of nap duration (P<0.001); if nighttime sleep duration was <7 h, nap duration of 60-<90 min could reduce the risk of comorbidity (OR=0.740, 95%CI=0.577-0.950, P<0.05); with nighttime sleep duration >9 h, not napping (OR=0.270, 95%CI=0.125-0.581) or maintaining nap duration of 60-<90 min (OR=0.165, 95%CI=0.040-0.674) could also reduce the risk of comorbidity (P<0.05).

Conclusion: The comorbidity prevalence of diabetes and depressive status is relatively high among middle-aged and elderly adults in China. Nighttime sleep duration exceeding 7 h, nap duration exceeding 90 min, and high levels of social activity can effectively reduce the risk of comorbidity of diabetes and depressive status, and moderate-level physical activity can reduce the risk of diabetes and depressive status respectively. Nap serves as a compensatory mechanism to help compensate for insufficient nighttime sleep; if nighttime sleep duration is less than 7 h, controlling nap duration at 60-<90 min can also reduce the risk of comorbidity of diabetes and depressive status.

Full Text

Comorbidity of Diabetes and Depression in Middle-Aged and Elderly People: The Impact of Sleep, Exercise, and Social Activities

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Abstract

Background Diabetes and depression are global public health issues. There is a significant correlation between diabetes and depression. Therefore, monitoring and intervening in diabetes, depression, and their comorbidity among middle-aged and elderly people is crucial. **Objective** To explore the prevalence of diabetes and depression, as well as their comorbidity, among the elderly population, and the impact of sleep, exercise, and social activities on these conditions. **Methods** Based on the 2018 China Health and Retirement Longitudinal Study, 11,177 participants who met the research criteria were included as subjects. A multifactorial Logistic regression analysis model was employed to investigate the association between sleep, exercise, and social activities with the comorbidity of diabetes and depression. Subsequently, the product of nap duration and nighttime sleep duration was incorporated into the regression model for interaction analysis. **Results** A total of 11,177 subjects were included in the study, with a prevalence of diabetes of 13.95% (1,559/11,177), a prevalence of depressive status of 24.85% (2,777/11,177), and a comorbidity prevalence of both diabetes and depressive status of 14.64% (1,636/11,177). The results of the multinomial Logistic regression analysis indicated that a nighttime sleep duration of 7 to 9 hours (OR=0.337, 95%CI=0.296-0.384), a nighttime sleep duration greater than 9 hours (OR=0.509, 95%CI=0.374-0.692), and a nap duration greater than 90 minutes (OR=0.792, 95%CI=0.666-0.941) were all protective factors for the comorbidity of diabetes and depressive status. High levels of social interaction were also found to reduce the risk of comorbidity (OR=0.778, 95%CI=0.686-0.882, P<0.05). The interaction analysis results showed that maintaining a nighttime sleep duration of 7 to 9 hours, regardless of nap duration, was effective in preventing the comorbidity of diabetes and depressive status (P<0.001). If the nighttime sleep duration is less than 7 hours, a nap duration of 60 to 90 minutes can also reduce the risk of comorbidity (OR=0.740, 95%CI=0.577-0.950, P<0.05). In the case of a nighttime sleep duration greater than 9 hours, not taking a nap (OR=0.270, 95%CI=0.125-0.581) or maintaining a nap duration of 60 to 90 minutes (OR=0.165, 95%CI=0.040-0.674) can also reduce the risk of comorbidity. **Conclusion** The comorbidity prevalence of diabetes and depressive status among middle-aged and elderly people in China is relatively high (14.64%). Nighttime sleep duration of more than 7 hours, nap duration of more than 90 minutes, and a high level of social interaction can all effectively reduce the risk of comorbidity of diabetes and depressive status. Moderate levels of physical activity can reduce the risks of diabetes and depressive status respectively. Napping serves as a compensatory mechanism, helping to make up for insufficient nighttime sleep. If nighttime sleep is less than 7 hours, controlling the nap duration to 60 to 90 minutes can also reduce the risk of comorbidity of diabetes and depressive status.

Keywords Diabetes mellitus; Depression; Multiple chronic conditions; Sleep; Physical exertion; Social activity; Health management

Introduction

Diabetes and depression represent prevalent public health problems that pose serious threats to human physical and mental health. According to *The Lancet*, as of 2022, approximately 828 million adults worldwide had diabetes, with China accounting for about 148 million adult diabetic patients—18% of the global total and ranking second worldwide. Moreover, the incidence of diabetes continues to rise annually, with the total prevalence projected to exceed 10% by 2045. Diabetic patients face risks of complications including heart disease, stroke, and renal failure, which not only threaten individual health but also create substantial socioeconomic burdens. Depression similarly negatively impacts physical and mental health and may increase all-cause mortality. WHO statistics indicate that approximately 280 million people (3.8%) globally suffer from depression, with 5.7% among those aged 60 and above. Diabetes and depression are significantly correlated, with diabetic patients being 2-3 times more likely to develop comorbid depressive symptoms than non-diabetic individuals. Consequently, attending to mental health issues among middle-aged and elderly individuals has become an urgent priority.

Current research on the pathophysiological mechanisms of diabetes with comorbid depression primarily focuses on insulin resistance, oxidative stress, inflammatory responses, and nervous system dysfunction. Influencing factors for the comorbidity include obesity, female gender, lower education and income levels, smoking, sedentary lifestyle, low levels of daily activity, insufficient physical activity, inadequate sleep duration, and social isolation. Improving behavioral lifestyles and controlling these risk factors can effectively reduce the incidence of diabetes-depression comorbidity. Among these factors, sleep, exercise, and social activities are relatively amenable to intervention. However, current domestic and international research on diabetes with comorbid depression remains limited, with most studies focusing on general populations rather than middle-aged and elderly subgroups. Additionally, existing research has emphasized nighttime sleep while neglecting the interaction between nap duration and nighttime sleep duration. Therefore, investigating the prevalence of diabetes, depression, and their comorbidity in middle-aged and elderly populations, along with the effects of sleep, exercise, and social activities, holds important practical significance for improving health management in this group.

This study aims to: (1) systematically assess the prevalence of diabetes-depression comorbidity in middle-aged and elderly populations; (2) explore the impacts of sleep, exercise, and social activities on this comorbidity; and (3) analyze potential interaction effects between nap duration and nighttime sleep duration.

Methods

Study Population This study utilized data from the 2018 China Health and Retirement Longitudinal Study (CHARLS), which employs multistage proba-

bility proportionate sampling covering 150 counties/districts and 450 communities/villages across 28 provinces (municipalities/autonomous regions), representing 12,400 households and 19,000 respondents nationwide. The final sample included 11,177 participants meeting the following criteria: (1) aged $ $45 years; (2) complete and valid questionnaire responses; (3) no logical inconsistencies within the questionnaire. Exclusion criteria comprised: (1) missing demographic data, outliers, or refusal to respond; (2) selection of "don't know" or "refusal" on the Center for Epidemiologic Studies Depression Scale (CES-D); and (3) nighttime sleep duration $ $22 hours.

Measurement of Variables **Diabetes**: Diabetes status was extracted from the "Health Status and Functioning" section of the CHARLS questionnaire, specifically the "Zdisease" and "DA007" items. Zdisease reflects whether respondents had diabetes in previous waves, while DA007 asks whether a doctor ever told them they had diabetes or elevated blood glucose (including impaired glucose tolerance and elevated fasting glucose). An answer of "yes" was classified as having diabetes.

Depressive Status: The CES-D scale, developed in 1977 and validated in China, was used to assess depressive symptoms. The scale comprises 10 items: (1) bothered by little things; (2) difficulty concentrating; (3) feeling depressed; (4) everything feeling effortful; (5) feeling hopeful about the future; (6) feeling fearful; (7) poor sleep; (8) feeling happy; (9) feeling lonely; and (10) inability to continue life. Response options are graded across four levels: rarely/none (<1 day); not much (1-2 days); sometimes/half the time (3-4 days); and most of the time (5-7 days). Items are scored 0-3, with items 5 and 8 reverse-scored. Total scores range from 0-30, with $ $10 indicating depressive status. The Cronbach's α coefficient for CES-D in this study was 0.899.

Sleep: Nap duration was measured by asking "In the past month, how long did you usually nap?" and categorized as 0, <30, 30-<60, 60-<90, or $ $90 minutes. Nighttime sleep duration was measured by asking "In the past month, how many hours did you actually sleep per night on average (which may be less than time spent in bed)?" and categorized as <7, 7-9, or >9 hours.

Physical Activity: The questionnaire classified physical activity intensity into high, medium, and low levels, inquiring about duration and frequency for each intensity. Activity duration was categorized as 0, 10-29, 30-119, 120-239, or $ $240 minutes, with midpoint values used for calculations. Metabolic equivalent (MET) values were assigned according to the International Physical Activity Questionnaire (IPAQ): 3.3 for low intensity, 4.0 for moderate intensity, and 8.0 for high intensity. Weekly physical activity energy expenditure was calculated as: MET intensity × activity days × daily duration. Activity levels were classified as low (<600 METS/week), moderate (600-3,000 METS/week), and high (>3,000 METS/week). The Cronbach's α coefficient for IPAQ in this study was 0.647.

Social Activity: Social activity was measured by asking "In the past month, did you engage in the following social activities?" with 11 activity options. Each activity scored 1 point for "yes" and 0 for "no," with frequency further coded as 1 (not often), 2 (almost weekly), or 3 (almost daily). The product of activity participation and frequency yielded each activity's score, with the sum across 11 activities representing total social activity score (theoretical range 0-33). The actual range in this study was 0-21, dichotomized as low (0-2) and high (3-21) social activity.

Covariates: Additional data collected included age, gender, education level, marital status, residence, income, smoking, and alcohol consumption.

Statistical Analysis SPSS 26.0 was used for statistical analysis. Categorical data were analyzed using ^{2} tests. Multinomial Logistic regression examined associations between sleep, exercise, and social activity with diabetes-depression comorbidity. The product of nap duration and nighttime sleep duration was included in the Logistic regression model for multiplicative interaction analysis. Statistical significance was set at $P<0.05$.

Results

Demographic Characteristics of Diabetes-Depression Comorbidity The study included 11,177 participants, with diabetes prevalence of 13.95% (1,559/11,177), depressive status prevalence of 24.85% (2,777/11,177), and comorbidity prevalence of 14.64% (1,636/11,177). The age groups 45-54 and 55-64 comprised the largest proportions at 30.21% (3,377/11,177) and 35.06% (3,919/11,177), respectively. The sample included 5,452 males (48.78%) and 5,725 females (51.22%). Most participants had primary school education or below (6,643 cases, 59.44%), were married and living with spouses (9,122 cases, 81.61%), and resided in rural areas (8,063 cases, 72.14%). The majority never smoked (96.01%, 10,731/11,177) or drank alcohol (97.73%, 10,923/11,177). Nighttime sleep duration was most commonly <7 hours (6,209 cases, 55.55%) followed by 7-9 hours (4,512 cases, 40.37%). Regarding napping, 4,029 participants (36.05%) had no napping habit, while 2,768 (24.76%) napped 60-90 minutes. High-level physical activity was most common (6,655 cases, 59.54%), while low-level social activity predominated (7,031 cases, 62.91%).

Except for smoking and alcohol consumption, differences in age, gender, education, marital status, residence, income, nighttime sleep duration, nap duration, physical activity, and social activity were all statistically significant across groups with diabetes, depressive status, and comorbidity ($P<0.05$) .

Multifactor Analysis of Diabetes, Depressive Status, and Comorbidity After controlling for confounders, multinomial Logistic regression analysis examined associations between sleep, exercise, and social activity (independent variables) and diabetes, depressive status, and comorbidity (dependent variables, with no disease as reference). Results showed that compared to <7 hours,

nighttime sleep duration of 7-9 hours was protective against diabetes, depressive status, and comorbidity (P<0.05), while >9 hours was protective against depressive status and comorbidity (P<0.05). Compared to no napping, nap duration $ $90 minutes was protective for comorbidity (P<0.05). Regarding physical activity, moderate-level activity was protective against diabetes and depressive status compared to high-level activity (P<0.05), while low-level activity was a risk factor for depressive status (P<0.05). High social activity was protective against depressive status and comorbidity compared to low social activity (P<0.05) .

Multiplicative Interaction Analysis of Sleep Factors in Diabetes-Depression Comorbidity After controlling for confounders, interaction analysis incorporating the product of nap duration and nighttime sleep duration in the multinomial Logistic regression model revealed that maintaining 7-9 hours of nighttime sleep effectively prevented comorbidity regardless of nap duration. With nighttime sleep <7 hours, nap duration of 60-<90 minutes reduced comorbidity risk (P<0.05). When nighttime sleep exceeded 9 hours, either no napping or maintaining 60-<90 minutes of napping effectively prevented comorbidity (P<0.05). Among all protective combinations, nighttime sleep >9 hours combined with 60-<90 minutes of napping was most effective, with comorbidity risk only 0.165 times that of the combination of <7 hours nighttime sleep and no napping .

Discussion

This study examined the prevalence of diabetes-depression comorbidity and the effects of sleep, exercise, and social activities, particularly analyzing the multiplicative interaction between nighttime and nap sleep durations. The 2018 CHARLS data revealed a comorbidity prevalence of 14.64% in the total population, with 51.2% of diabetic patients experiencing depressive status—higher than the approximately 30% reported in domestic and international epidemiological studies, where about 10% have moderate-to-severe depression and diabetic patients face double the depression risk of non-diabetic individuals. This discrepancy may reflect our focus on middle-aged and elderly populations, among whom increasing life expectancy and deepening aging contribute to higher diabetes and depression incidence. Therefore, attention to mental health in elderly diabetic patients and strengthened prevention, early screening, and intervention for comorbidity can help reduce its burden and improve health outcomes.

Adequate nighttime sleep effectively reduces comorbidity risk. This study found 7-9 hours of nighttime sleep optimal for preventing diabetes-depression comorbidity, consistent with joint consensus statements from the American Academy of Sleep Medicine and Sleep Research Society. Research indicates sleep deprivation disrupts endocrine systems, potentially involving abnormal cortisol and adrenaline secretion, while chronic insulin insensitivity or resistance from insufficient sleep may cause pancreatic β-cell dysfunction, increasing comorbid-

ity risk. However, our finding that >9 hours of nighttime sleep is protective contradicts some previous research defining >9 hours as oversleeping with increased all-cause mortality risk. This may be because our middle-aged and elderly participants experience age-related metabolic decline and altered sleep patterns, including difficulty falling asleep, early awakening, light sleep, and frequent dreaming, compounded by nocturia and polydipsia from diabetes that significantly reduce sleep quality. For this population, appropriately extended nighttime sleep may improve sleep quality and prevent comorbidity. We therefore recommend maintaining >7 hours of sleep, with 7-9 hours being optimal.

Healthy napping behavior also reduces comorbidity risk. This study found nap duration >90 minutes protective against diabetes-depression comorbidity, consistent with previous research. Interaction results showed that when nighttime sleep is insufficient (<7 hours), 60-<90 minutes of napping can compensate; when nighttime sleep exceeds 9 hours, either no napping or maintaining 60-<90 minutes of napping effectively prevents comorbidity. Studies demonstrate napping improves sleep quality, reduces daytime sleepiness, consolidates memory, enhances executive function, and improves emotional stability, benefiting mental health even after adequate nighttime sleep. Napping serves as a compensatory mechanism for insufficient nighttime sleep, as shorter nighttime sleep and insomnia increase depression risk, and reduced time in one sleep behavior must be compensated by increased time in another (e.g., midday sleep). However, some studies suggest longer napping increases hypertension and diabetes risk, with 30-60 minutes showing lowest depression detection rates. Overall, we recommend daily napping for middle-aged and elderly individuals, adjusting duration based on nighttime sleep and health status.

Moderate physical activity and high-level social interaction positively impact diabetes and depression separately. While physical activity did not significantly affect comorbidity in this study, it showed protective effects against diabetes and depressive status individually, consistent with previous research. Notably, moderate-intensity activity better prevented diabetes compared to high-intensity activity, possibly because vigorous exercise consumes substantial energy, causing hypoglycemia and stress responses with increased growth hormone, leading to rebound hyperglycemia. High social activity effectively prevented comorbidity and positively impacted depressive status alone. Retirement represents a new life stage where loss of former social identity and restructured relationships can create feelings of abandonment and depression. Active social participation reduces social distance, builds networks, and increases communication, helping elderly individuals regulate emotions and reduce depression risk. Considering cultural contexts, positive social interaction patterns also promote self-management behaviors in diabetic patients. We recommend maintaining high-level social activity, exploring diverse social activity types, increasing social interaction frequency, and leveraging peer support for diabetes management.

Regarding recommendations for reducing comorbidity risk: at the individual level, adopt healthy lifestyles with adequate nighttime sleep and napping habits,

moderate physical exercise, and active social engagement. At the family level, while attending to physical health, prioritize mental health by creating supportive family environments and encouraging social participation. At the societal level, strengthen health lifestyle education, improve community sports facilities, develop diverse and engaging activities for elderly individuals, and address mental health needs of retirees.

This study utilized 2018 CHARLS data, a large-scale nationally representative dataset with prospective cohort design, ensuring reliability. Our focus on middle-aged and elderly populations—who face higher comorbidity risk—addresses a research gap. Methodologically, we integrated sleep duration, physical activity, and social activity into a unified analytical framework and examined their interaction effects, providing novel insights. However, limitations include: (1) all information being self-reported, particularly diabetes status lacking biochemical verification, potentially missing undiagnosed cases; (2) cross-sectional design limiting causal inference; (3) inability to exclude unknown confounding factors despite controlling for multiple covariates; and (4) data from 2018 may be somewhat dated. Future research should incorporate updated data, additional covariates, and longitudinal cohort analysis to clarify causal relationships.

Conclusion

The prevalence of diabetes-depression comorbidity is high among middle-aged and elderly Chinese. Nighttime sleep >7 hours, nap duration >90 minutes, and high-level social activity effectively reduce comorbidity risk, while moderate physical activity reduces diabetes and depression risks separately. Napping serves as a compensatory mechanism for insufficient nighttime sleep; when nighttime sleep is <7 hours, 60-<90 minutes of napping also reduces comorbidity risk. Developing healthy sleep habits (both nighttime and daytime), maintaining high-level social activity, and engaging in moderate physical exercise hold significance for early prevention and control of diabetes-depression comorbidity in middle-aged and elderly populations.

Author Contributions

Fu Rong conceptualized the study, designed the research protocol, drafted the manuscript, performed data cleaning and statistical analysis, created tables and figures, and revised the manuscript. Shi Lei was responsible for overall study design and quality control. He Feiying supervised the research, provided guidance and critical revision, and takes overall responsibility for the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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Note: Figure translations are in progress. See original paper for figures.