

Pathway Analysis of the Effect of Social Networks on Multimorbidity in Older Adults: A Postprint Study on the Mediating Roles of Physical Activity and Sleep

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Abstract

Background In recent years, amid global population aging, the number of chronic disease patients in China has increased significantly, with multimorbidity becoming increasingly prevalent, posing a serious threat to the life safety and quality of life of older adults.

Objective To understand the current status of multimorbidity among older adults, explore the relationships and pathways of sleep, physical activity, and social networks with multimorbidity, and provide insights for the effective prevention of multimorbidity and improvement of health status among older adults.

Methods Older adults aged ≥ 60 years from the Community Health Behavior and Epidemiology Panel Study (CHBEPS) established by our research team were selected as survey subjects. A questionnaire survey was conducted using a self-designed basic information collection form to collect general data. Physical activity, social networks, and sleep quality were assessed using the International Physical Activity Questionnaire-Short Form (IPAQ-S-C), Lubben Social Network Scale (LSNS-6), and Pittsburgh Sleep Quality Index (PSQI), respectively. AMOS 28.0 statistical software was used to establish a structural equation model.

Results A total of 3,531 older adults aged ≥ 60 years were enrolled, and 3,392 valid questionnaires were collected, with an effective response rate of 96%. The mean total physical activity was $(2,426.42 \pm 3,053.09) MET - min/w$, the mean social network score was $(15.91 \pm 6.43) points$, and the mean sleep score was $(5.49 \pm 3.53) points$. Among the participants, 788 (23.23%) had insufficient social networks, and 353 (10.41%) had fair or poor sleep quality. The prevalence of multimorbidity was 41.13% (1,395/3,392). Correlation analysis showed that social

networks were negatively correlated with sleep grade ($r=-0.113$, $P<0.01$), positively correlated with physical activity ($r=0.073$, $P<0.01$), and negatively correlated with multimorbidity ($r=-0.049$, $P<0.01$). Multivariate logistic regression analysis indicated that physical activity of 0~600 MET-min/w (OR=0.576, 95%CI=0.342~0.970) and excellent sleep quality (OR=0.409, 95%CI=0.209~0.803) were protective factors against multimorbidity ($P<0.05$). Structural equation modeling results demonstrated that social networks influenced physical activity and sleep quality (standardized path coefficient =0.096, $t=4.982$, $P<0.001$; standardized path coefficient =-0.043, $t=-5.981$, $P<0.001$), while physical activity and sleep quality affected multimorbidity (standardized path coefficient =0.023, $t=5.280$, $P<0.001$; standardized path coefficient =0.111, $t=9.409$, $P<0.001$). Social networks had no direct effect on multimorbidity but exerted indirect effects through physical activity and sleep quality. The indirect effect of social networks on multimorbidity through physical activity accounted for 10% of the total effect, while the indirect effect through sleep quality accounted for 36.5% of the total effect.

Conclusion The prevalence of multimorbidity is high among older adults (41.13%). Appropriately expanding social networks among older adults and encouraging them to maintain adequate physical activity and good sleep quality may alleviate and prevent the occurrence of multimorbidity.

Full Text

Introduction

In recent years, against the backdrop of global aging, the number of chronic disease patients in China has increased significantly, with the coexistence of multiple diseases becoming increasingly common, seriously threatening the life safety and quality of life of older adults in China [?]. The primary consequences of multimorbidity include disability and functional decline, poor quality of life, and high medical expenses [?]. Research indicates that the prevalence of multimorbidity among older adults in Guangdong Province is 15.90%, with a chronic disease prevalence of 48.46%, and multimorbidity represents an important risk factor for physical and mental health loss [?]. Social isolation resulting from a lack of social networks reflects individuals' deficiency in connections and interactions with others, 预示着老年人社会联系的缺乏, 能够导致老年人身体虚弱 [?], indicating the importance of clarifying the relationship between social networks and multimorbidity.

Previous studies have shown that older adults with low-intensity physical activity constitute a high-risk population for multimorbidity, while older adults with greater social participation have a lower risk of developing multimorbidity [?]. Continuous changes in sleep duration among older adults exhibit a linear dose-response relationship with multimorbidity [?]. Additionally, sedentary behavior is significantly correlated with sleep quality in older adults, and appropriate physical activity can improve sleep quality [?]. Sleep quality is also associated

with social support, and expanding the scale of social support networks helps improve sleep quality among older adults [?]. Furthermore, research has found a bidirectional regulatory trend between social networks and physical activity participation [?].

Therefore, exploring the relationships among sleep, physical activity, social networks, and multimorbidity in older adults, and investigating the pathways of action among these variables, can inform more targeted interventions to reduce multimorbidity risk. This study surveyed older adults in Guangdong Province to understand the current status of multimorbidity in this population and examined influencing factors from the perspectives of sleep, physical activity, and social networks. A structural equation model was constructed to explore the pathways through which these factors affect multimorbidity, providing a reference for relevant departments to develop strategies for preventing multimorbidity among older adults.

Methods

1.1 Study Subjects

This study selected older adults aged ≥ 60 years from the Community Health and Behavior of the Elderly Panel Study (CHBEPS) established by our research team. In the first-phase baseline survey, four prefecture-level cities were randomly selected from 21 cities in Guangdong Province as primary units using random sampling. A multi-stage random sampling method was then employed to randomly select one district from each primary unit as a secondary unit. From each secondary unit, 2-6 communities or administrative villages were randomly selected, and eligible older adults in these communities were surveyed. Inclusion criteria were: age ≥ 60 years; clear consciousness and communication ability; and voluntary participation. Exclusion criteria included unwillingness to participate or severe cognitive dysfunction that prevented normal communication. CHBEPS was approved by the Ethics Committee of Southern Medical University (Approval No. [2022] No. 27), and all participants provided informed consent.

1.2 Survey Instruments

Questionnaires were administered to collect data, including: (1) General information collected through a self-designed basic information form covering personal demographics (gender, age, marital status, education level), socioeconomic status (pre-retirement occupation, monthly income, primary income source, medical insurance), and family relationships (empty nest status, current living arrangement, daily caregiver, relationship with children). Smoking and alcohol consumption were determined by asking about behaviors in the past month. (2) Validated scales were used to assess sleep, physical activity, and social networks. The International Physical Activity Questionnaire (IPAQ) is a recognized and widely used instrument for measuring physical ac-

tivity levels in adults (15-69 years) internationally, with demonstrated validity and reliability in Chinese populations [?]. This study used the short version (IPAQ-S-C), which consists of 7 items covering three intensity levels of physical activity (walking, moderate-intensity, and vigorous-intensity) in terms of duration (min/day) and frequency (days/week), plus one item assessing daily sedentary time. Metabolic equivalent (MET) values were assigned: 8.0 for vigorous-intensity, 4.0 for moderate-intensity, and 3.3 for walking. Physical activity level was calculated as: duration per day \times frequency per week \times MET value for each activity. Based on MET values, participants were divided into 8 intervals, with higher MET values indicating higher physical activity levels [?]. The Lubben Social Network Scale-6 (LSNS-6) measures individuals' networks with family members and friends, with higher scores indicating better social network levels. The scale comprises two components (family network and friend network) with 6 items total (3 for each), scored 0-5 points per item (total range 0-30). Scores <12 indicate insufficient social networks (social isolation). The Chinese version of LSNS-6 has content validity of 0.84-0.96 [?], with a Cronbach's α coefficient of 0.870 in this study. The Pittsburgh Sleep Quality Index (PSQI) assesses sleep quality across 7 components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, daytime dysfunction, and sleep medication use, each scored 0-3 points (total range 0-21), with higher scores indicating poorer sleep quality [?]. Sleep scores were categorized into 4 levels: 1=very good (0-5 points), 2=fairly good (6-10 points), 3=fair (11-15 points), and 4=very poor (16-21 points). Chronic disease status was assessed by asking about physician-diagnosed conditions including coronary heart disease, atherosclerosis, arrhythmia, hypertension, hyperlipidemia, chronic bronchitis, asthma, cataract, glaucoma, chronic gastritis, COPD, chronic hepatitis/fatty liver, chronic nephritis, rheumatoid/rheumatic arthritis, gout, osteoporosis, sciatica, stroke, dementia/cerebral atrophy/Parkinson's disease, emotional or mental problems, diabetes, hyperthyroidism/hypothyroidism, malignant tumors, chronic anemia/iron deficiency anemia, and others. Multimorbidity was defined as having ≥ 2 chronic diseases.

1.3 Quality Control

Trained interviewers administered questionnaires face-to-face with older adults. After completion, two quality supervisors independently reviewed questionnaires for logical consistency and invalid values. Questionnaires with missing data for $\geq 30\%$ of indicators were considered invalid. A total of 3,531 older adults aged ≥ 60 years were surveyed, yielding 3,392 valid questionnaires (effective response rate: 96%).

1.4 Statistical Analysis

SPSS 24.0 was used to establish the database and perform data entry. Descriptive analyses were conducted using SPSS, and AMOS 28.0 was used to construct the structural equation model, evaluate model fit, and perform modifications.

Statistical significance was set at $P < 0.05$.

Results

2.1 Basic Characteristics of Participants

Among the 3,392 older adults aged ≥ 60 years, 1,490 (43.93%) were male and 1,902 (56.07%) were female. Ages ranged from 60-96 years: 1,731 (51.03%) were 60-69 years, 1,288 (37.97%) were 70-79 years, 346 (10.20%) were 80-89 years, and 27 (0.80%) were ≥ 90 years. Most participants (1,860, $54.83 \pm 3,053.09$) MET-min/week, average social network score was (15.91 ± 6.43), and average sleep score was (5.49 ± 3.53).

2.2 Prevalence of Multimorbidity

The prevalence of multimorbidity among participants was 41.13% (1,395/3,392). Significant differences in multimorbidity prevalence were observed across gender, age, monthly income level, residential area, smoking status, alcohol consumption, family history, education level, marital status, and empty nest status ($P < 0.05$), as shown in Table 1.

2.3 Correlations Among Sleep Quality, Physical Activity, Social Network and Multimorbidity

Spearman rank correlation analysis revealed that sleep quality level was negatively correlated with physical activity ($r = -0.057$, $P < 0.01$) and social network ($r = -0.113$, $P < 0.01$), but positively correlated with multimorbidity ($r = 0.157$, $P < 0.01$). Physical activity was positively correlated with social network ($r = 0.073$, $P < 0.01$) and multimorbidity ($r = 0.080$, $P < 0.01$). Social network was negatively correlated with multimorbidity ($r = -0.049$, $P < 0.01$).

2.4 Effects of Sleep Quality, Physical Activity, and Social Network on Multimorbidity

Multivariate logistic regression analysis was performed with multimorbidity as the dependent variable (assignment: multimorbidity=1, no multimorbidity=0) and sleep quality, physical activity, and social network as independent variables, controlling for gender, age, monthly income level, residential area, smoking status, alcohol consumption, eating regularity, family history, education level, marital status, and empty nest status. The results showed that physical activity of 0-600 MET-min/week (OR=0.576, 95%CI=0.342-0.970) and good sleep quality (OR=0.409, 95%CI=0.209-0.803) were protective factors against multimorbidity ($P < 0.05$), as presented in Table 2. Basic characteristics including gender, age, monthly income level, eating regularity, and marital status did not affect multimorbidity risk. However, older adults living in urban areas had lower multimorbidity risk (OR=0.687, 95%CI=0.579-0.814); current smokers had lower risk (OR=0.772, 95%CI=0.619-0.964); those who had quit alcohol had higher risk (OR=1.471, 95%CI=1.141-1.897); those without

formal education, with primary school, junior high, or high school/technical secondary education (OR=2.908/2.782/2.528/2.519, 95%CI=1.629-5.192/1.588-4.872/1.433-4.431/1.433-4.428), absolute empty nest status (OR=1.397, 95%CI=1.137-1.718), and family history of disease (OR=2.471, 95%CI=1.757-3.475) had higher multimorbidity risk.

2.5 Structural Equation Model Analysis of Factors Influencing Multimorbidity

Based on previous literature and theoretical background [?], an initial model was constructed including an exogenous latent variable (social network) and endogenous observed variables (multimorbidity status, physical activity, sleep quality level), with family network and friend network as indicators of social network. Using AMOS 28.0, the initial model was repeatedly adjusted, evaluated, and modified based on path significance. After removing invalid paths with $\beta' = 0$, a well-fitting revised model was obtained, as shown in Figure 1 [Figure 1: see original paper]. Model fit indices were: $\chi^2/df=4.256$, $P=0.002$, root mean square error of approximation (RMSEA)=0.031, goodness-of-fit index (GFI)=0.998, adjusted goodness-of-fit index (AGFI)=0.993, normed fit index (NFI)=0.986, relative fit index (RFI)=0.966, incremental fit index (IFI)=0.990, Tucker-Lewis index (TLI)=0.974, comparative fit index (CFI)=0.989, meeting acceptable standards (reference criteria: $\chi^2/df < 5$, RMSEA < 0.08 , GFI, AGFI, NFI, RFI, IFI, TLI, CFI > 0.90), indicating good model fit. Results showed that social network influenced physical activity and sleep quality (standardized path coefficient=0.096, $t=4.982$, $P < 0.001$; standardized path coefficient=-0.043, $t=-5.981$, $P < 0.001$), while physical activity and sleep quality influenced multimorbidity (standardized path coefficient=0.023, $t=5.280$, $P < 0.001$; standardized path coefficient=0.111, $t=9.409$, $P < 0.001$).

The structural equation model revealed that social network had no direct effect on multimorbidity in this study, but exerted indirect effects through two mediators: physical activity and sleep. The indirect effect of social network on multimorbidity through physical activity accounted for 10% of the total effect, while the indirect effect through sleep accounted for 36.5%, as shown in Table 3.

Discussion

3.1 The Prevalence of Multimorbidity Requires Attention

This study found a multimorbidity prevalence of 41.13% among 3,392 older adults, lower than the 50%-77% reported in international studies of older adults with ≥ 2 chronic diseases [?] and the 42.33% found in Nanjing, China [?], but higher than the 15.90% reported for Guangdong Province [?] and 20.95% for Taiyuan [?]. Effective prevention and management of multimorbidity should be prioritized through shifting healthcare service focus, emphasizing prevention, strengthening community and rural health education, and improving health in-

insurance coverage, clinical-preventive integration, and multidimensional management of older adults with multimorbidity to safeguard their health and achieve precision health management [?]. In healthcare policy development, management, and medical research, multimorbidity should be considered [?].

Among older adults with higher social network scores, walking was the most frequent exercise type, highlighting the need to construct age-friendly walking spaces. International studies indicate that multimorbidity risk increases significantly with age and is associated with education level and employment status [?], with additional risk factors including smoking, physical inactivity, and BMI, and low education level in men predicting multimorbidity [?]. Our findings are similar: older adults living in rural areas, those who had quit alcohol, absolute empty nesters, those with family history of disease, and those with education below college/technical secondary level were more likely to develop multimorbidity, consistent with Ma et al. [?] but differing from Liu et al. [?] who found urban older adults had higher multimorbidity risk, and from Zhang et al. [?] who found no education-level differences. These discrepancies may reflect rural residents' weaker health awareness and poorer medical conditions [?], particularly rural older adults' tendency to seek medical care only after symptoms appear, leading to delayed detection and disease progression. Higher education level may enable better health awareness and healthcare utilization. The higher prevalence among those who quit alcohol may reflect behavior change after multimorbidity diagnosis. Absolute empty nesters are vulnerable due to lack of intergenerational support [?], highlighting the need to address empty nest issues and aging trends in empty nest families. Family history indicates genetic predisposition, enabling early risk identification and preventive intervention.

This study found no gender difference in multimorbidity prevalence, contrasting with research showing higher relative risk for certain multimorbidity patterns in women [?]. The finding that current smokers had lower multimorbidity risk differs from studies identifying smoking as a risk factor for hypertension, diabetes, and chronic diseases [?], possibly due to this cross-sectional design's inability to establish causality or exclude behavior change after disease onset. While some studies report similar findings [?], future cohort studies should explore causal relationships.

3.2 Social Network Indirectly Affects Multimorbidity Through Physical Activity Mediation

This study found that older adults' social networks negatively predicted multimorbidity through physical activity mediation. Social networks and physical activity show bidirectional regulation [?]: as social networks expand, physical activity increases and multimorbidity risk decreases. Li et al. [?] found chronic disease is a risk factor for social isolation, complementing our findings and suggesting a potential bidirectional relationship between social networks and multimorbidity. As social networks expand, social activities increase, leading to higher physical activity levels that delay physical decline [?] and reduce mul-

timorbidity risk. Interventions should prevent social isolation, expand social networks, and leverage peer influence to increase activity participation, thereby reducing multimorbidity incidence.

3.3 Social Network Indirectly Affects Multimorbidity Through Sleep Mediation

This study found that older adults' social networks negatively predicted multimorbidity through sleep quality mediation. Social isolation is associated with sleep quality [?], and expanding social support networks improves sleep [?]. Correlation analysis showed social network was negatively correlated with sleep level: as social networks increased, sleep quality improved and multimorbidity risk decreased. Previous research demonstrates significant relationships between positive psychological states and good sleep [?]. Although social networks had no direct effect on multimorbidity, increased social activity may enhance overall sleep quality, mental health, and physical fitness despite occupying some personal time, thereby reducing multimorbidity risk. The impact of social networks on multimorbidity through sleep should be prioritized, with targeted measures to improve sleep quality and prevent multimorbidity.

In conclusion, multimorbidity prevalence is high among older adults, with social networks exerting indirect effects through physical activity and sleep quality. Health management should focus on expanding social networks to maintain good mental health, improve sleep quality, and sustain adequate physical activity to prevent multimorbidity. This study examined influencing factors and pathways using a structural equation model, but limitations include its cross-sectional design without longitudinal analysis. Future research should conduct extensive, in-depth longitudinal follow-up surveys across Guangdong Province to explore more causal relationships and expand generalizability.

Author Contributions: Zhang Mengjie and Zhang Chichen conceptualized the study and designed the research; Zhang Mengjie conducted literature review, drafted the manuscript, performed data analysis and statistical processing, and created tables and figures; Zhang Mengjie, Zheng Xiao, and Liao Yanming collected data; Zhang Mengjie, Zheng Xiao, Liao Yanming, Qian Juan, and Zhou Jiexing revised the manuscript; Zhang Chichen and Zheng Xiao supervised quality control and provided overall supervision.

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

References: (The reference list is preserved as in the original text, with citations numbered accordingly.)

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