Associations between physical activity, mental health, and subjective sleep quality in community-dwelling older adults undergoing rehabilitation

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Abstract

This study aimed to identify the factors associated with subjective sleep quality in community-dwelling older adults receiving community rehabilitation services. The Athens Insomnia Scale (AIS) was used to categorize the participants into good sleepers (AIS ≤ 3) and poor sleepers (AIS ≥ 4), suggesting insomnia. Locomotive activities, mental health using the mental component summary (MCS), activities of daily-living using the functional independence measure (FIM), and depression using the geriatric depression scale (GDS) were evaluated, and sleep-related participant characteristics were collected using a questionnaire. Relevant variables were selected using Lasso regression and were further analyzed using logistic regression. Poor sleepers accounted for 66.7% of the participants. The LASSO regression analysis identified age, daily-living physical activity, MCS, and pain scores as the predictive variables. A logistic regression analysis revealed that higher levels of daily-living activities (OR = 0.08, p = 0.006) and MCS (OR = 0.23, p = 0.030) were significantly associated with a reduced risk of poor sleep, whereas older age (OR = 3.87, p = 0.051) and higher pain scores (OR = 3.75, p = 0.080) were associated with an increased risk. These findings suggest that subjective sleep quality in older adults requiring long-term care may be strongly influenced by daily-living physical activity, mental well-being, and pain. Therefore, in addition to psychological support and pain management, interventions that emphasize the promotion of daily-living physical activity may be effective in maintaining good sleep quality.

Key words

physical activity, sleep quality, mental health, older adults, community rehabilitation

1. Introduction

Sleep disorders are highly prevalent among older adults, with more than 50 % of individuals reportedly experiencing sleep-related issues (Foley et al., 1995). As people age, changes in the sleep architecture, such as reduced sleep duration and depth and increased nighttime awakenings, become more common (Buysse, 2014).

Particularly in older adults requiring long-term care, sleep quality is often compromised by a combination of factors, including physical decline, chronic health conditions, pain, cognitive impairment, and psychological stress (Gureje et al., 1998; Miner and Kryger, 2017). In addition, reduced daytime activity and limited social engagement can disrupt the circadian rhythms and contribute to sleep disorders (Dzierzewski et al., 2014).

Sleep disturbances can lead to a decline in the health-related quality of life (QOL), increased depressive symptoms, a higher fall risk, and cognitive deterioration, ultimately undermining independence in daily-life (Yaffe et al., 2011; Stone et al., 2008). Consequently, it is crucial to evaluate the sleep quality and identify the modifiable factors in this population to inform effective interventions.

Previous research has shown that physical activity improves the sleep quality, with moderate aerobic exercise enhancing sleep depth and duration (Reid et al., 2010). Psychological factors such as depression and anxiety are strongly associated with insomnia in older adults (Baglioni et al., 2011; Riemann et al., 2015). However, most studies have focused on healthy older adults or those with mild care needs, leaving uncertainty about the relationships among frail community-dwelling older adults receiving home-visit rehabilitation services.

In this group, structured exercise may be difficult to sustain, underscoring the potential importance of routine lifestyle activities (e.g., household chores, mobility, and social interaction) (Yasunaga et al., 2009; Shibata et al., 2018). Pain, hypnotic use, caffeine intake, and nocturia may also contribute to sleep disturbance; however, these factors have not been fully assessed in prior studies.

Therefore, this study aimed to identify the key factors associated with subjective sleep quality in community-dwelling older adults receiving community rehabilitation using the Athens Insomnia Scale (AIS) and to analyze the physical and psychological factors through the least absolute shrinkage and selection operator (LASSO) and logistic regression models.

2. Methods

2.1 Study design and participants

This cross-sectional study included community-dwelling older adults aged ≥ 65 years who received community reha-

bilitation services (either home-visits or outpatient rehabilitation) under the Japanese long-term care insurance system from the Health Science University Rehabilitation Clinic between September 20, 2018, and March 2023. The inclusion criteria were the absence of diagnosed dementia or aphasia, and not being bedridden. All the participants provided written informed consent. The study was approved by the Ethics Committee of the Health Science University (approval number: H30-018).

2.2 Measurements

Subjective sleep quality was assessed using the AIS, a validated 8-item questionnaire that evaluates the sleep quality and functional impact. Each item is rated from 0 to 3 points, with a total score of ≥ 4 suggesting insomnia (Soldatos et al., 2000).

Physical activity was measured using a triaxial accelerometer (Omron HJA-750C Active Style Pro), which differentiated between locomotive activities and daily-living activities. Locomotive activities mainly represent walking and other movements involving displacement, whereas daily-living activities primarily reflect low-intensity movements performed during everyday life, such as housework and indoor activities. Data were expressed as Ex units (calculated as METs × hours). The accelerometer was worn for seven consecutive days. To ensure accurate measurement, participants were provided with written instructions on device use and received verbal explanations from the research staff. Days with over one hour of non-wear time were excluded (Ohayon et al., 2004; van den Berg et al., 2008).

The mental health status was assessed using the mental component summary (MCS) of the Short Form-8 Health Survey [SF-8] (Fukuhara and Suzukamo, 2004). Depressive symptoms were assessed using the 15-item geriatric depression scale (GDS), with a score of ≥ 5 indicating depressive tendency (Sheikh and Yesavage, 1986).

Physical function was evaluated using the short physical performance battery, which included balance, gait speed, and chair stand tests. Each item is scored from 0 to 4, with a total possible score of 0 to 12 (Guralnik et al., 1994).

ADLs were assessed using the functional independence measure (FIM), which consists of 13 motor and 5 cognitive items, each scored from 1 (completely dependent) to 7 (completely independent), with a total possible score of 18-126 (Keith et al., 1987).

The cognitive function was assessed using the mini-mental state examination (MMSE), with a score < 24 indicating cognitive decline (Folstein et al., 1975).

The additional variables included hypnotic use, evening caffeine intake, evening television viewing, habitual exercise (at least once per week), and pain score (0-10 numeric rating scale) assessed using a standard 11-point scale commonly applied in chronic pain research (Farrar et al., 2001).

In addition, duration of service use (time since initiation of community rehabilitation services), living arrangements (living alone or with others), and level of long-term care need were collected as participant characteristics.

Physical and functional assessments were conducted by physical therapists or occupational therapists involved in the rehabilitation services. Participant characteristics and lifestyle-related variables were collected using a self-administered questionnaire or through face-to-face interviews when participants had difficulty completing the questionnaire independently.

2.3 Statistical Analysis

To identify the factors associated with poor subjective sleep quality (defined as AIS ≥ 4 suggesting insomnia), variable selection was conducted using LASSO regression. LASSO regression was chosen because of its ability to perform variable selection and regularization simultaneously, which is especially useful in models with numerous candidate predictors relative to the sample size (Tibshirani, 1996). The optimal penalty parameter (λ) was determined using 10-fold cross-validation to minimize the prediction error.

Subsequently, the variables selected using LASSO were entered into a multivariate logistic regression model with poor sleep as the dependent variable. Odds ratios (ORs) and 95% confidence intervals (CIs) were also determined. All statistical analyses were conducted using JMP Pro (SAS Institute Inc., Cary, NC, USA), with the statistical significance set at $p < 0.05$.

3. Results

A total of 54 participants were included, with a mean age of 77.6 ± 6.2 years (38.0 %, male). Based on the AIS scores, 18 participants (33.3 %) were classified as good sleepers, and 36 participants (66.7 %) were classified as poor sleepers (Table 1).

The LASSO regression identified four predictors of poor sleep: age, daily-living activities, MCS, and pain score. Other variables, such as locomotive activities, GDS, FIM, and hypnotic use, were excluded because of their negligible coefficients (Table 2).

A logistic regression analysis showed that higher daily-living activities (odds ratio [OR] = 0.08, $p = 0.006$) and MCS scores (OR = 0.23, $p = 0.030$) were associated with a lower risk of poor sleep. In contrast, older age (OR = 3.87, $p = 0.051$) and higher pain scores (OR = 3.75, $p = 0.080$) were associated with increased risk (Table 3).

4. Discussion

In the present study, the mean locomotive activities level was 0.17 ± 0.13 METs × h/day, whereas the mean daily-living activities level was 1.36 ± 0.64 METs × h/day. Direct comparison of these activity levels with previous studies is chal-

Table 1: Demographic and clinical characteristics of the participants (n = 54)

Variable	Value
Age (years)	77.28 ± 6.95
Sex (Male/Female)	23 (42.3 %) / 31 (57.7 %)
Living with family (Yes %)	90.4
Care level	3.01 ± 0.91
Duration of service use (days)	297.44 ± 260.40
Hypnotic use (Yes %)	24.5
Evening television viewing (Yes %)	78.3
Caffeine intake (Yes %)	64.2
Exercise habit (Yes %)	32.6
Pain score	1.75 ± 0.95
MMSE	26.44 ± 2.52
FIM	89.44 ± 18.82
GDS	5.33 ± 2.95
PCS	43.59 ± 5.15
MCS	44.90 ± 4.79
SPPB	4.71 ± 2.57
Locomotive activities (METs*h/day)	0.17 ± 0.13
Daily-living activities (METs*h/day)	1.36 ± 0.64
AIS total	3.77 ± 2.49
Good sleepers (AIS ≤ 3)	18 (33.3 %)
Poor sleepers (AIS ≥ 4)	36 (66.7 %)

Note: Values are presented as mean ± standard deviation or percentage, unless otherwise indicated. AIS, Athens Insomnia Scale; MMSE, Mini-Mental State Examination; FIM, Functional Independence Measure; GDS, Geriatric Depression Scale; PCS, Physical Component Summary; MCS, Mental Component Summary; SPPB, Short Physical Performance Battery; Ex, exercise unit. Good sleepers were defined as AIS ≤ 3, and poor sleepers as AIS ≥ 4.

Table 2: Lasso regression results

Variable	Coefficient
Age	0.087
Pain score	0.088
FIM	0.094
MCS	–0.140
SPPB	0.026
Daily-living activities	–0.217
Locomotive activities	0.015

Note: Lasso regression was used to select variables associated with poor sleep (AIS ≥ 4). The coefficients represent penalized estimates. Variables with negligible coefficients are excluded from the model.

Table 3: Logistic regression results

Variable	OR	95% CI	p-value
Age	3.87	[0.99, 15.03]	0.051
Pain	3.75	[0.85, 16.44]	0.080
FIM	2.67	[0.39, 18.32]	0.316
MCS	0.23	[0.06, 0.87]	0.030
SPPB	3.85	[0.40, 37.06]	0.243
Daily-living activities	0.08	[0.01, 0.49]	0.006
Locomotive activities	1.21	[0.23, 6.50]	0.824
Constant	0.87	–	–

Note: Logistic regression was performed with poor sleep (AIS ≥ 4) as the dependent variable. OR = Odds ratio; CI = Confidence interval. The variables included were those selected using LASSO regression. The statistical significance was set at $p < 0.05$.

lenging, as only a limited number of studies have reported mean values using the same metric (METs × h). However, the observed locomotive activities level corresponds to approximately 3-4 minutes of walking per day when converted to walking at a normal pace (3 METs), indicating an extremely low level of locomotive activity. Similarly, although daily-living activities were relatively higher than locomotive activities, they still reflected a low overall level of physical activity embedded in daily life. These findings are consistent with the relatively high level of care required among the participants (mean long-term care level: 3.01 ± 0.91) and are considered to reflect the activity profile of older adults receiving community rehabilitation services.

This study identified daily-living activities, MCS, age, and pain as the key factors associated with poor subjective sleep among older adults undergoing community rehabilitation. The protective effect of daily-living activities is consistent with previous research, highlighting the importance of routine activities in this population (Shibata et al., 2018). The significant association with MCS underscores the impact of psychological well-being on sleep, consistent with previous findings that psychological distress, such as depression and anxiety, is closely linked to sleep problems (Baglioni et al., 2011; Riemann et al., 2015).

Furthermore, the influence of pain on sleep quality aligns with previous studies reporting that chronic pain impairs sleep continuity and increases the risk of insomnia in older adults (Gureje et al., 1998; Yamada et al., 2019).

Although factors such as locomotive activities, GDS, FIM, and hypnotic use were excluded by the LASSO regression, this likely reflects their lower predictive power than mental health and pain in this context (Tibshirani, 1996; Zou and Hastie, 2005). Future studies should consider more detailed medication data to explore these relationships further. The relatively low coefficient of locomotive activities suggests that daily-living activities, including continuous low-intensity movements and social engagement, may have a stronger influence on circadian rhythm stability and sleep quality.

Despite limitations, such as small sample size and reliance on subjective sleep measures, several important sleep-related confounding factors, including bedroom environment, napping habits, and detailed medication use, were not fully assessed. Therefore, the findings should be interpreted with caution, particularly regarding their generalizability. Future studies should incorporate larger sample sizes, objective sleep assessments, longitudinal analyses, and intervention trials that integrate psychological support, the promotion of daily-living activities, and pain management.

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