European Journal of Clinical Medicine
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Age Variation in the Associations between Musculoskeletal Impairments and Sleep in Older Adults

Yumiko Ishikawa and Akemi Marui

ABSTRACT

Background: **Poor sleep shortens healthy life expectancy. However, little is known about the potential link between age-related differences in poor sleep quality and musculoskeletal impairments. This study explored the association between sleep quality and musculoskeletal impairments among community-dwelling older adults in Japan.**

Methods: **We conducted a cross-sectional study targeting the whole community-dwelling older adults aged ≥60 years in a town, Tochigi, Japan. Poor sleep quality was defined as Pittsburgh Sleep Quality Index of >5. Presence of musculoskeletal impairments was based on the participants' self-report of a prior diagnosis and treatment received. The association between musculoskeletal impairments and the risk of poor sleep quality was determined via multivariable logistic regression with known confounding variables, after stratification for age (60-74 and ≥75 years).**

Results: **Of 985 participants, 341 (34.6%) reported poor sleep quality, and 137 (13.9%) had musculoskeletal impairments. Musculoskeletal impairments were significantly associated with poor sleep quality (adjusted odds ratio [aOR],=1.87; 95% confidence interval [CI], 1.16-3.00). When stratified by age, this association only remained significant among those aged 60-74 years: the ORs for poor sleep quality in participants aged 60-74 and ≥75 years were 2.07 (95% CI, 1.14-3.77) and 1.59 (95% CI, 0.70-3.64), respectively.**

Conclusions: **Musculoskeletal impairments were associated with poor sleep quality in a Japanese population, and this relationship was more pronounced in those aged 60-74 years. The prevention and management of musculoskeletal impairments might be further emphasized to promote sleep quality among young-old adults.**

Keywords: Independent living, musculoskeletal impairment, older adults, sleep quality.

Published Online: May 22, 2023

ISSN: 2736-5476

DOI:10.24018/ejclinicmed.2023.4.3.266

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I. Introduction

Sleep is a fundamental determinant of health in older adults. It is estimated that approximately 15% - 65% of older adults worldwide have poor sleep depend on the definition [1], [2] which results in a lethargic lifestyle, cognitive decline, social isolation, and cardiopulmonary dysfunction [3], [4]. Indeed, several longitudinal studies have concluded that older adults with poor sleep have a higher risk of mortality [3]-[7]. Therefore, a number of studies have aimed to identify modifiable risk factors for poor sleep quality among older adults for primary prevention in Japan.

The musculoskeletal impairments have been considered to be a potentially modifiable risk factor for poor sleep quality. The results of population-based cohort studies conducted in Norway and the UK suggested an association between musculoskeletal complaints and poorer sleep quality [8], [9]. In Japan, musculoskeletal impairments are prevalent in older adults, with approximately 67% having at least one impairment, such as osteoarthritis, osteoporosis, or lumbar spondylosis [10] and a prospective study also reported an association between musculoskeletal pain and new-onset of sleep disturbances [11].

However, evidence for age differences in poor sleep quality associated with musculoskeletal impairments among older adults has been scarce. In a large-scale population-based study of patients with arthritis in Canada, middle (45-64 years) and young-old adults (65-74 years) reported a lot of sleep limitation compared to old-old adults (≥75 years) [12]. This contradicts the general expectation that as older individuals become, they are more heavily impacted by the adverse effects of musculoskeletal impairments on sleep quality. A previous study conducted among Great East Japan Earthquake survivors suggested that the association between musculoskeletal pain and the new-onset of sleep disturbances was stronger among those aged ≥65 years compared to those aged 18-64 years [11], which does not fully explain older adults' sleep difficulties, and the results may have been biased due to internal and external factors associated with the post-disaster environment such as living in temporal housing

and experienced strong psychological stress.

Japanese medical insurance expenditure is rapidly increasing. To allocate medical and social services effectively, the insurance system divides the older population into two groups: young- old adults (<75 years) and old-old adults (≥75 years) [13]. Another reason to assess the older population as two groups is that health status and social characteristics may differ by age. In addition, the number of older workers is expected to increase due to the current trend of older people continuing to work [14]. Therefore, the objective of this study was to examine the age-specific association between sleep quality and musculoskeletal impairments among community-dwelling older adults in Japan.

II. Method

A. Data Source and Study Participants

We enrolled the whole older adults aged ≥60 years who were independently living in the area in a town, Tochigi, Japan, which counted for 1,921. At the end of April 2016, the total population in the area was 5,155 (proportion of older adults, 31.8%). First, we contacted community organizations called "Jichikai" in the area and invited them to participate in the study. Jichikai is an independent neighborhood association, in which all residents join and work together on community safety, environmental protection, and festival activities [15].

We distributed self-administered questionnaires regarding sleep quality, musculoskeletal impairments, and other background characteristics to a total of 1,921 older adults (aged ≥60 years), recruited through the Jichikai, from June to November 2015. Participation was voluntary, and informed consent was obtained when respondents returned the questionnaires. This study complies with the Helsinki Declaration through-out planning, conducting, and reporting. The study protocol was approved by the ethical committees of Teikyo Heisei University (No: R03-001) and Dokkyo Medical University (No: 27007).

De-identified responses were obtained from 1,062 of the 1,921 eligible participants (response rate: 55.2%). We further excluded those who did not respond about basic information such as age, gender, sleep quality, and presence of musculoskeletal impairments (n=77); therefore, the responses from 985 participants (mean age ± standard deviation: 71.7 ± 6.5 years) were included in the final analyses.

B. Sleep Quality

The Japanese version of the Pittsburgh Sleep Quality Index (PSQI) [16], [17] was used to assess participants' sleep quality within the previous month. The PSQI includes seven components (sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction); the total score ranges from 0 to 21, with higher scores indicating worse sleep quality. Poor sleep quality was indicated by a PSQI total score of >5 [16], [17].

C. Musculoskeletal Impairments and Covariates

Participants were defined as having a musculoskeletal impairment if they 1) reported that they were previously diagnosed with at least one bone or joint disease and were currently under treatment; [11], [12] or 2) did not report a prior diagnosis of musculoskeletal impairment, but described having knee or back pain, rheumatoid arthritis, osteoarthritis, spinal canal stenosis, or herniated discs. Confounding variables known to affect the association between musculoskeletal impairments and poor sleep quality [8], [9], [11], [12] were also documented: age (60-74 years or ≥75 years), sex, body mass index (BMI [<18.5 kg/m^2, ≥18.5, <25 kg/m^2, or ≥25 kg/m^2]), pre-existing comorbidities (yes/no) (hypertension, diabetes mellitus, and eye or ear problems), and lifestyle and behavioral factors (yes/no) (regular exercise, napping, smoking, alcohol consumption, and pain medication use). The 5-item Geriatric Depression Scale (GDS-5) was used to assess depressive symptoms; normal and altered moods were indicated by GDS-5 < 2 and GDS-5 ≥2, respectively [18], [19].

D. Statistical Analysis

Data were analyzed with IBM SPSS Statistics version 27 for Windows (IBM Corp., Armonk, NY, USA). The level of statistical significance was set at $P < 0.05$.

Basic characteristics including musculoskeletal impairment prevalence and sleep quality are presented descriptively for all 985 participants. A total of 872 participants were included in the main regression analysis, as those with missing information on covariates (BMI and regular exercise, n=113) were excluded. A multivariable logistic regression analysis was used to estimate the adjusted odds ratio (aOR) and 95% confidence interval (CI) of poor sleep quality in participants with musculoskeletal impairments, after adjustment for known confounding variables [4], [20] To explore potential age differences, we stratified the analyses by age (60-74 and ≥75 years).

We conducted multiple imputations of missing data for all variables among the 985 study participants for use in a sensitivity analysis and 25 imputed data sets were generated. Furthermore, because of the relatively high prevalence of poor sleep quality in both a previous study [12], and this study (>20% and >30%, respectively), we estimated the prevalence ratio (PR) and 95% CI of musculoskeletal impairments for poor sleep quality to infer the potential relative risk [15], [21]. In the supplementary analysis, Poisson regression with robust variance was used among 985 participants, with a missing data category for the variables of BMI and regular exercise (Table I).

III. Results

Participants' background characteristics and age differences are presented in Table I. Poor sleep quality and musculoskeletal impairments were reported in 34.6% and 13.9% of participants, respectively. Although the prevalence of poor sleep quality did not differ between those aged 60-74 years and ≥75 years, musculoskeletal impairments were more prevalent among those aged ≥75 years. Significant differences in sex, hypertension, eye or ear problems, and nap-taking were also observed between the 60-74 year and ≥ 75-year age groups.

TABLE I: BACKGROUND CHARACTERISTICS OF 985 STUDY PARTICIPANTS

Variable	n (%)	Mean (SD)	Young-old 60-74 (n=673)	Old-old ≥75 (n=312)	P-value [a]
Sex					
Female	510 (51.8)		381 (56.6)	129 (41.3)	< 0.001
Male	475 (48.2)		292 (43.4)	183 (58.7)	
Body mass index [b]		22.5 (3.2)			
< 18.5	80 (8.1)		46 (6.8)	34 (10.9)	0.19
18.5-25	613 (67.2)		425 (63.2)	188 (60.3)	
≥25	218 (22.1)		150 (22.3)	68 (21.8)	
Data missing	74 (7.5)		52 (7.7)	22 (7.0)	
Sleep quality [c]					
Poor	341 (34.6)		229 (34.0)	112 (35.9)	0.31
Good	644 (65.4)		444 (66.0)	200 (64.1)	
Hypertension					
Yes	424 (43.0)		250 (37.1)	174 (55.8)	< 0.001
No	561 (57.0)		423 (62.9)	138 (44.2)	
Diabetes mellitus					
Yes	130 (13.2)		82 (12.2)	48 (15.4)	0.10
No	855 (86.8)		591 (87.8)	264 (84.6)	
Eye or ear problem					
Yes	157 (15.9)		96 (14.3)	61 (19.6)	0.02
No	828 (84.1)		577 (85.7)	251 (80.4)	
Musculoskeletal impairment					
Yes	137 (13.9)		83 (12.3)	54 (17.3)	0.02
No	848 (86.1)		590 (87.7)	258 (82.7)	
Napping					
Yes	480 (48.7)		310 (46.1)	170 (54.5)	0.01
No	505 (51.3)		363 (53.9)	142 (45.5)	
GDS-5[d]		1.0 (1.2)			
< 2 (normal)	732 (74.3)		510 (75.8)	222 (71.2)	0.07
≥2 (altered mood)	253 (25.7)		163 (24.2)	90 (28.8)	
Regular exercise [e]					
No	367 (37.3)		253 (37.6)	114 (36.5)	0.24
Yes	574 (58.3)		395 (58.7)	179 (57.4)	
Data missing	44 (4.5)		25 (3.7)	19 (6.1)	
Smoking					
Yes	59 (6.0)		44 (6.5)	15 (4.8)	0.18
No	926 (94.0)		629 (93.5)	297 (95.2)	
Alcohol consumption [f]					
Yes	225 (22.8)		155 (23.0)	70 (22.4)	0.45
No	760 (77.2)		518 (77.0)	242 (77.6)	
Pain medication use					
Yes	62 (6.3)		38 (5.6)	24 (7.7)	0.14
No	923 (93.7)		635 (94.4)	288 (92.3)	

a: Pearson's chi-squared test was used to analyze each variable. b: Overweight and underweight were defined as body mass indices more than 25 kg/m^2 and less than 18.5 kg/m^2 respectively. c: The Pittsburgh Sleep Quality Index was used to assess sleep quality. The global score (range, 0-21) was dichotomized based on the scoring instructions; scores >5.0 indicate poor sleep quality. d: The GDS-5 was used to assess symptoms of depression. Scores were dichotomized based on the scoring instructions; scores ≥2 indicate altered mood. e: Regular exercise was assessed with the following question: "do you exercise regularly?" Participants responded with "yes" or "no". f: A response of "yes" reflected a daily habit of drinking alcohol. Abbreviations: GDS-5, 5-item Geriatric Depression Scale; SD, standard deviation.

TABLE II: LOGISTIC REGRESSION ANALYSIS OF THE ASSOCIATION BETWEEN POOR SLEEP QUALITY AND ALL VARIABLES (N=872)

	Total (n)	Poor sleep quality [a], (n)	Univariable logistic regression			Multivariable logistic regression [b]		
			OR	95%CI	P-value	OR	95%CI	P-value
All participants								
Musculoskeletal impairment	121	65	2.65	1.84-3.82	< 0.001	1.87	1.16-3.00	0.010
Sex (female)	454	179	1.54	1.16-2.05	0.003	1.16	0.83-1.63	0.39
Age (≥75)	271	95	1.02	0.76-1.38	0.90	0.86	0.61-1.20	0.38
BMI (< 18.5)	75	32	1.44	0.89-2.34	0.13	1.32	0.78-2.24	0.30
Napping	430	154	1.10	0.83-1.45	0.51	1.00	0.74-1.35	0.99
GDS5 (≥2)	223	124	3.29	2.40-4.51	< 0.001	2.91	2.08-4.08	< 0.001
Hypertension	375	142	1.27	0.96-1.68	0.09	1.18	0.86-1.61	0.31
Diabetes mellitus	113	45	1.29	0.86-1.93	0.23	1.31	0.84-2.04	0.23
Eye or ear problem	131	75	3.01	2.06-4.41	< 0.001	2.91	1.94-4.36	< 0.001
No regular exercise	347	128	1.17	0.88-1.55	0.28	0.93	0.68-1.28	0.67
Smoking	55	15	0.69	0.38-1.27	0.23	0.81	0.42-1.58	0.54
Alcohol consumption	202	52	0.58	0.41-0.82	0.002	0.64	0.43-0.96	0.03
Pain medication	54	30	2.51	1.43-4.35	0.001	1.58	0.81-3.07	0.18
Age 60-74								
Musculoskeletal impairment	76	42	2.77	1.73-4.41	<0.001	2.07	1.14-3.77	0.02
Sex	344	138	1.79	1.26-2.54	0.001	1.59	1.04-2.41	0.03
BMI (< 18.5)	45	22	1.90	1.03-3.50	0.04	1.72	0.88-3.36	0.11
Napping	430	106	1.27	0.91-1.78	0.17	1.12	0.77-1.62	0.55

TABLE II: LOGISTIC REGRESSION ANALYSIS OF THE ASSOCIATION BETWEEN POOR SLEEP QUALITY AND ALL VARIABLES (N=872) *(CONT)*

	Total (n)	Poor sleep quality [a], (n)	Univariable logistic regression			Multivariable logistic regression [b]		
			OR	95%CI	P-value	OR	95%CI	P-value
GDS5 (≥2)	223	83	3.61	2.45-5.33	< 0.001	3.12	2.05-4.76	< 0.001
Hypertension	375	85	1.28	0.90-1.80	0.17	1.17	0.79-1.71	0.43
Diabetes mellitus	113	27	1.18	0.71-1.97	0.52	1.19	0.68-2.09	0.55
Eye or ear problem	131	50	3.70	2.27-6.01	< 0.001	3.74	2.23-6.28	< 0.001
No regular exercise	242	89	1.17	0.83-1.65	0.36	0.89	0.61-1.31	0.55
Smoking	55	13	0.90	0.46-1.79	0.77	1.07	0.50-2.30	0.86
Alcohol consumption	202	37	0.63	0.42-0.97	0.03	0.79	0.48-1.29	0.35
Pain medication	54	19	2.37	1.19-4.71	0.01	1.22	0.54-2.78	0.63
Age ≥75								
Musculoskeletal impairment	45	23	2.45	1.35-4.44	0.003	1.59	0.70-3.64	0.27
Sex	110	41	1.18	0.71-1.95	0.53	0.68	0.36-1.27	0.23
BMI (< 18.5)	30	10	0.92	0.41-2.05	0.83	0.95	0.39-2.34	0.91
Napping	147	48	0.79	0.48-1.31	0.37	0.75	0.43-1.29	0.29
GDS5 (≥2)	79	41	2.76	1.60-4.74	< 0.001	2.82	1.56-5.08	0.001
Hypertension	152	57	1.28	0.77-2.12	0.34	1.13	0.64-1.99	0.67
Diabetes mellitus	42	18	1.48	0.76-2.89	0.25	1.58	0.74-3.36	0.24
Eye or ear problem	50	25	2.16	1.16-4.02	0.02	2.04	1.03-4.03	0.04
No regular exercise	105	39	1.16	0.70-1.93	0.57	1.01	0.57-1.78	0.97
Smoking	15	2	0.30	0.06-1.22	0.09	0.35	0.07-1.77	0.21
Alcohol consumption	65	15	0.47	0.25-0.90	0.02	0.46	0.22-0.97	0.04
Pain medication	19	11	2.75	1.07-7.09	0.04	2.35	0.72-7.65	0.16

a: Poor sleep and good sleep were dichotomized with a cutoff point of >5.0 as per the Pittsburgh Sleep Quality Index. b: Adjusted for sex, age (for the analysis of all subjects), body mass index, napping, hypertension, eye or ear problems, diabetes mellitus, Geriatric Depression Scale score, regular exercise, alcohol consumption, smoking, and pain medication use. Abbreviations: CI, confidence interval; OR, odds ratio; [a]OR, adjusted odds ratio.

TABLE III. LOGISTIC REGRESSION ANALYSIS OF THE ASSOCIATION BETWEEN POOR SLEEP QUALITY USING MULTIPLE IMPUTATION FOR MISSING DATA (N = 985)[A]

	Total (n)	Poor sleep quality [b], (n)	Univariable Logistic regression			Multivariable Logistic regression [c]		
			OR	95% CI	P-value	OR	95% CI	P-value
All participants								
Musculoskeletal impairment	121	65	2.65	1.84-3.82	< 0.001	1.92	1.22-3.02	0.005
Sex (female)	454	179	1.65	1.26-2.15	< 0.001	1.28	0.93-1.76	0.14
Age (≥75)	271	95	1.09	0.82-1.44	0.57	0.91	0.67-1.27	0.61
BMI (< 18.5 kg/m^2)	86	36	1.40	0.89-2.20	0.14	1.28	0.76-2.13	0.35
Napping	430	154	1.07	0.82-1.39	0.61	1.02	0.76-1.35	0.92
GDS5 (≥2)	223	124	3.43	2.55-4.61	< 0.001	3.00	2.19-4.12	< 0.001
Hypertension	375	142	1.23	0.94-1.60	0.13	1.16	0.86-1.56	0.33
Diabetes mellitus	113	45	1.17	0.80-1.71	0.43	1.17	0.77-1.78	0.46
Eye or ear problem	131	75	3.09	2.18-4.38	< 0.001	2.87	1.97-4.17	< 0.001
No regular exercise	384	143	1.21	0.92-1.58	0.17	1.00	0.73-1.35	0.98
Smoking	55	15	0.63	0.34-1.15	0.13	0.42	0.40-1.47	0.77
Alcohol consumption	202	52	0.59	0.42-0.82	0.002	0.70	0.48-1.03	0.07
Pain medication	54	30	2.81	1.66-4.73	< 0.001	1.71	0.91-3.23	0.10
Age 60-74								
Musculoskeletal impairment	76	42	2.77	1.73-4.41	< 0.001	1.98	1.12-3.52	0.02
Sex	344	138	1.91	1.37-2.66	< 0.001	1.74	1.17-2.60	0.007
BMI (< 18.5 kg/m^2)	51	24	1.81	1.02-3.21	0.04	1.66	0.86-3.20	0.13
Napping	430	106	1.29	0.94-1.77	0.12	1.08	0.84-1.70	0.32
GDS5 (≥2)	223	83	3.65	2.53-5.27	< 0.001	3.12	2.10-4.65	< 0.001
Hypertension	375	85	1.32	0.95-1.83	0.10	1.28	0.89-1.84	0.18
Diabetes mellitus	113	27	1.07	0.66-1.74	0.79	1.03	0.61-1.76	0.90
Eye or ear problem	131	50	3.62	2.32-5.66	< 0.001	3.50	2.17-5.64	< 0.001
No regular exercise	267	97	1.18	0.86-1.64	0.31	0.93	0.65-1.35	0.72
Smoking	55	13	0.80	0.41-1.56	0.52	0.98	0.46-2.07	0.96
Alcohol consumption	202	37	0.66	0.44-0.98	0.04	0.89	0.55-1.42	0.62
Pain medication	54	19	2.84	1.46-5.53	0.002	1.46	0.66-3.26	0.35
Age ≥75								
Musculoskeletal impairment	45	23	2.45	1.34-4.44	0.003	1.83	0.84-3.98	0.13
Sex	110	41	1.31	0.82-2.09	0.26	0.76	0.42-1.36	0.35
BMI (< 18.5 kg/m^2)	39	15	1.13	0.57-2.26	0.72	0.92	0.40-2.10	0.84
Napping	147	48	0.71	0.45-1.14	0.15	0.70	0.42-1.16	0.17
GDS5 (≥2)	79	41	3.02	1.82-5.01	< 0.001	2.97	1.72-5.14	< 0.001
Hypertension	152	57	1.03	0.65-1.64	0.90	0.92	0.54-1.54	0.74
Diabetes mellitus	42	18	1.34	0.71-2.50	0.37	1.46	0.71-2.98	0.30
Eye or ear problem	50	25	2.36	1.34-4.16	0.003	2.22	1.19-4.16	0.01
No regular exercise	122	47	1.21	0.75-1.93	0.44	1.07	0.61-1.85	0.82
Smoking	15	2	0.26	0.06-1.19	0.08	0.38	0.08-1.92	0.24
Alcohol consumption	65	15	0.45	0.24-0.83	0.01	0.46	0.23-0.95	0.03
Pain medication	19	11	2.71	1.16-6.33	0.02	2.23	0.75-6.60	0.15

a: Imputed missing values of BMI (74, 7.5%) and regular exercise (44, 4.5%) were analyzed. b: Poor sleep and good sleep were dichotomized with a cutoff point of >5.0 as per the Pittsburgh Sleep Quality Index. c: Adjusted for sex, age (for the analysis of all subjects), body mass index, napping, hypertension, eye or ear problems, diabetes mellitus, Geriatric Depression Scale score, regular exercise, alcohol consumption, smoking, and pain medication use. Abbreviations: CI, confidence interval; PR, prevalence ratio.

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TABLE IV: ODDS AND PREVALENCE RATIOS FOR THE ASSOCIATION BETWEEN MUSCULOSKELETAL IMPAIRMENT AND POOR SLEEP QUALITY AMONG ALL 985 PARTICIPANTS[A]

	Total (n)	Poor sleep quality (n)	Multivariable logistic regression			Multivariable Poisson regression		
			OR	95% CI	P-value	PR	95% CI	P-value
All subjects	985	341						
Musculoskeletal impairment	137	75	1.87	1.16-3.00	0.01	1.38	1.10-1.72	0.005
Sex (female)	510	204	1.16	0.83-1.63	0.39	1.15	0.95-1.39	0.16
Age (≥75)	312	112	0.86	0.61-1.20	0.38	1.05	0.88-1.25	0.63
BMI < 18.5 kg/m^2	80	33	1.32	0.78-2.24	0.30	1.13	0.86-1.48	0.39
≥ 18.5 kg/m^2	831	284	1.00			1.00		
missing	74	24	1.06	0.83-1.35	0.63	0.92	0.69-1.24	0.60
Napping	480	170	1.00	0.74-1.35	0.99	1.01	0.86-1.19	0.92
GDS5 (≥2)	253	142	2.91	2.08-4.08	< 0.001	1.82	1.54-2.15	< 0.001
Hypertension	424	158	1.18	0.86-1.61	0.31	1.09	0.92-1.29	0.32
Diabetes mellitus	130	49	1.31	0.84-2.04	0.23	1.08	0.86-1.36	0.50
Eye or ear problem	157	90	2.91	1.94-4.36	< 0.001	1.70	1.43-2.01	< 0.001
No regular exercise - yes	367	137	0.93	0.68-1.28	0.67	0.99	0.84-1.18	0.95
no	574	187	1.00			1.00		
missing	44	17	1.00	0.86-0.86	0.97	0.96	0.66-1.41	0.84
Smoking	59	15	0.81	0.42-1.58	0.54	0.85	0.57-1.27	0.42
Alcohol consumption	225	58	0.64	0.43-0.96	0.03	0.81	0.62-1.05	0.10
Pain medication	62	36	1.58	0.81-3.07	0.18	1.30	0.99-1.71	0.06
Age 60-74	673	229						
Musculoskeletal impairment	83	46	2.07	1.14-3.77	0.02	1.40	1.07-1.83	0.01
Sex (female)	381	153	1.59	1.04-2.41	0.03	1.40	1.10-1.79	0.007
BMI < 18.5 kg/m^2	46	22	1.72	0.88-3.36	0.11	1.31	0.96-1.78	0.09
≥ 18.5 kg/m^2	575	192	1.00			1.00		
missing	52	15	0.68	0.30-1.54	0.87	0.86	0.58-1.27	0.45
Napping	310	115	1.12	0.77-1.62	0.55	1.10	0.90-1.34	0.35
GDS5 (≥2)	163	93	3.12	2.05-4.76	< 0.001	1.85	1.51-2.26	< 0.001
Hypertension	250	95	1.17	0.79-1.71	0.43	1.15	0.94-1.41	0.17
Diabetes mellitus	82	29	1.19	0.68-2.09	0.55	1.03	0.77-1.37	0.85
Eye or ear problem	96	58	3.74	2.23-6.28	< 0.001	1.85	1.51-2.27	< 0.001
No regular exercise - yes	253	93	0.89	0.61-1.31	0.55	0.95	0.78-1.18	0.68
no	395	127						
missing	25	9	0.92	0.35-2.43	0.87	0.91	0.54-1.55	0.73
Smoking	44	13	1.07	0.50-2.30	0.86	1.00	0.66-1.50	0.99
Alcohol consumption	155	42	0.79	0.48-1.29	0.35	0.95	0.70-1.29	0.74
Pain medication	38	22	1.22	0.54-2.78	0.63	1.19	0.84-1.68	0.32
Age ≥75	312	112						
Musculoskeletal impairment	54	46	1.81	0.83-3.96	0.14	1.33	0.90-1.96	0.16
Sex (female)	129	51	0.77	0.43-1.37	0.37	0.84	0.61-1.16	0.29
BMI < 18.5 kg/m^2	34	11	1.05	0.53-2.08	0.88	0.92	0.55-1.54	0.76
≥ 18.5 kg/m^2	256	92	1.00			1.00		
missing	22	9	1.17	0.54-2.54	0.69	1.05	0.69-1.60	0.83
Napping	170	55	0.70	0.42-1.16	0.17	0.82	0.61-1.09	0.17
GDS5 (≥2)	90	49	2.99	1.73-5.18	< 0.001	1.81	1.37-2.40	< 0.001
Hypertension	174	63	0.91	0.54-1.53	0.73	0.95	0.71-1.28	0.73
Diabetes mellitus	48	20	1.46	0.71-2.98	0.30	1.18	0.82-1.69	0.37
Eye or ear problem	61	32	2.20	1.17-4.12	0.01	1.51	1.10-2.08	0.01
Not regularly exercise - yes	114	44	1.09	0.50-2.36	0.83	1.03	0.76-1.41	0.84
no	179	60	1.00			1.00		
missing	19	8	1.00	0.57-1.75	1.00	1.02	0.57-1.84	0.95
Smoking	15	2	0.38	0.08-1.93	0.24	0.49	0.15-1.65	0.25
Alcohol consumption	70	16	0.47	0.23-0.96	0.04	0.62	0.38-1.00	0.05
Pain medication	24	14	1.97	1.11-3.50	0.02	1.40	1.07-1.83	0.01

The analysis included missing data for body mass index (74, 7.5%) and regular exercise (44, 4.5%). Adjustments were made for sex, age (for the analysis of all subjects), body mass index, napping, hypertension, eye or ear problems, diabetes mellitus, Geriatric Depression Scale score, regular exercise, alcohol consumption, smoking, and pain medication use. Abbreviations: OR, odds ratio; CI, confidence interval

In the multivariable logistic regression analysis of participants across all age categories (Table II), musculoskeletal impairments were associated with a higher OR for poor sleep quality compared to those without musculoskeletal impairments (aOR=1.87, 95% CI,1.16-3.00).

In the age-specific analyses (Table II), the association between musculoskeletal impairments and poor sleep quality remained significant among participants aged 60-74 years: the aORs of those aged 60-74 and ≥75 years were 2.07 (95% CI 1.14-3.77) and 1.59 (95% CI, 0.70-3.64), respectively. Other factors associated with poor sleep among participants aged 60-74 years were gender, GDS, and eye or ear problems. Among participants aged ≥ 75 years old, factors associated with poor sleep were GDS and eye or ear problems (Table II).

In the sensitivity analysis, the imputed data (Table III) supported the findings of the analysis based on the participants without missing data. A different analysis showed the PR of musculoskeletal impairments to poor sleep quality was only significant among those aged 60-74 years (PR=1.40, 95% CI 1.07-1.83) (Table IV). Therefore, the prevalence of poor sleep quality was approximately 40% greater in young-old adults with musculoskeletal impairments than in old-old adults with musculoskeletal impairments.

IV. Discussion

This study found that over one-third (34.6%) of Japanese community-dwelling older adults experience poor sleep quality, and that there was a significant association between poor sleep quality and musculoskeletal impairments. To the best of our knowledge, no prior studies have reported age-specific differences in the association between poor sleep quality and musculoskeletal impairments among community-dwelling older adults. We found that this association was most pronounced in the young-old adults aged 60-74 years. The estimated increase in the prevalence of poor sleep quality due to musculoskeletal impairments was 40%. This result was similar to that reported by a previous large-scale population-based study [8].

Our finding of an association between musculoskeletal impairments and poor sleep quality in community-dwelling older adults in Japan supports the results of some prior studies conducted in Western countries [8], [9], [11], [12]. While musculoskeletal impairments and poor sleep quality exhibit a reciprocal relationship [8], current evidence suggests that both conditions have a multifactorial etiology and are affected by common risk factors, such as mental health and chronic inflammation. Therefore, pharmaceutical interventions targeting depression and anxiety [11], [22] and markers of chronic inflammation (e.g., tumor necrosis factor-α and interleukin-6) may also be potentially used to alleviate musculoskeletal impairments and improve sleep quality [23], [24]. A large-scale epidemiological study that utilized nationally representative samples in the US found that adults with arthritis were more likely to experience sleep disturbances; this was especially evident among those who also had poor mental health and chronic inflammation [22]. Another community-based study also reported the involvement of a chronic inflammatory pathway in the etiology of both musculoskeletal impairments and poor sleep quality [25]. Potential explanations for the association between musculoskeletal impairments and poor sleep quality may also include posture changes, which are necessary for good sleep quality. Musculoskeletal impairments, such as lower back pain, have been shown to limit posture change and result in poor sleep quality [26]. These studies explain the association between musculoskeletal impairment and poor sleep quality among older adults in general but not specifically distinguished responses expressed by different age groups in older adults.

After assessing different age groups within the older adult population in Japan, we found that those in the 60-74-year-old age group were more likely to experience poor sleep quality linked to musculoskeletal impairments, compared to those in the ≥75-year-old age group. Reference [27] reported in a systematic review that musculoskeletal pain tends to increase with age until the age of 80 years. This could mean that musculoskeletal pain tends to become accepted as a natural part of life among old-old adults. As such, sleep quality among the ≥75-year-old age group may be linked to different risk factors. In our study, altered mood and vision or hearing impairments were identified as risk factors for poor sleep quality in this group, but musculoskeletal impairment was not. Also, a simple birth-cohort effect, which reflects age-specific cultural and public health backgrounds, should not be ignored [28]. Furthermore, previous studies have shown an association between poor mental health and poor sleep quality linked to musculoskeletal impairments in young-old adult populations [9], [11]. Nevertheless, we observed an age difference in the association between musculoskeletal impairments and poor sleep quality, even after controlling for depression with GDS-5. Therefore, another possible explanation may be that the perception and expression of sleep difficulties differ between young-old and old-old adults. Future studies should not only assess subjective sleep quality, but also objective sleep quality via polysomnography.

Gender differences in sleep quality and musculoskeletal impairments also should be noted. Even though, a polysomnographic evaluation showed better sleep, females report insufficient sleep than males [29]-[31]. Another research reported that decreased gonadal hormones affect sleep differently in males and females [32]. Similar to sleep disturbance, musculoskeletal impairments are also influenced by declining levels of ovarian hormones. As a result, post-menopausal females experience loss of bone density, osteoarthritis, rheumatoid arthritis, and gait disturbance more than males [33], [34]. Our female study participants reported having musculoskeletal impairment more than males (female 73% versus male 27%, $p < 0.001$). Although our results were derived from gender adjustment, a longitudinal study involving a large number of participants is warranted to confirm gender differences.

This study has some limitations. First, due to the use of a cross-sectional design, we were unable to confirm a causal relationship between musculoskeletal impairments and sleep quality. Nevertheless, many previous studies confirmed a reciprocal association between these two common disorders [8], [9], [11], [12], [22], [25]. Additionally, our estimate of a 40% increase in poor sleep quality among young-old adults was similar to that reported in a large-scale population-based study (PR, 1.5; 95% CI, 1.1-2.0) conducted among those aged 45-64 years) [12]. Therefore, our observed associations were considered to be reliable. Second, we did not assess the cognitive functions of our study participants, and there might be a potential misclassification. Nonetheless, we limited our analysis to study participants who were able to read and complete the questionnaires. In addition, the questionnaires consisted of simple, short, and easy-to-understand sets of questions and answers; thus, we could assure the cognitive function to some extent and misclassification might be less likely. Lastly, our definition of musculoskeletal impairments was only based on self-reported questionnaires, which was in line with previous studies [11], [12]. This is considered to have a lower validity than objective diagnoses of musculoskeletal impairment obtained via medial charts, imaging information [35], and medical claims data with pharmaceutical information [36]. To address these issues, we plan to collect more comprehensive data from annual health check-ups and medical claims databases in the future.

One of the strengths of this study was its sample size, which was one of the largest among prior studies investigating the association between musculoskeletal impairments and sleep quality in the Japanese population. Another strength was the use of the PSQI, which is a well-established and accurate indicator of sleep quality [16], [17].

To the best of our knowledge, this is the first study to document significant age-specific differences in poor sleep quality linked to musculoskeletal impairments among older adults.

In summary, the results of this study indicated that musculoskeletal impairments are associated with poor sleep quality, particularly among adults aged 60-74 years. Japan has the most rapidly aging demographic in the world; while adults in the 60-74-year-old age group have traditionally been considered the retired generation, their engagement in the workforce and participation in the Japanese economy has increased in the past decade [37]. Hence there is a need for the development of strategies to improve sleep quality by alleviating musculoskeletal impairments, especially among young-old adults.

ACKNOWLEDGMENT

We would like to express our sincere gratitude to all of the participants for providing us precious data and cooperation throughout the data collection process.

CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

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