Table 1 Selected variable characteristics of participants at baseline by study group

Variables†	Ex + TC (n = 32)	Ex (n = 32)	TC (n = 32)	HE (n = 32)	ANOVA P-value
Age (years)	81.1 ± 3.7	79.6 ± 4.2	80.0 ± 4.0	80.2 ± 5.6	0.525
Height (cm)	145.0 ± 5.5	145.9 ± 5.8	145.6 ± 4.9	145.9 ± 5.4	0.892
Bodyweight (kg)	43.7 ± 4.1	41.5 ± 4.5	42.4 ± 5.7	42.7 ± 5.0	0.413
Percent body fat (%)	29.0 ± 3.7	28.1 ± 4.2	27.8 ± 4.8	30.3 ± 3.6	0.110
Lean body mass (kg)	30.2 ± 3.2	30.4 ± 3.6	29.9 ± 3.1	30.5 ± 2.8	0.894
Muscle mass (kg)	27.8 ± 3.0	28.0 ± 3.3	27.5 ± 2.9	28.1 ± 2.6	0.917
Legs muscle mass (kg)	10.2 ± 1.2	10.2 ± 1.3	10.2 ± 1.2	10.3 ± 1.0	0.992
Grip strength (kg)	18.5 ± 3.5	18.2 ± 4.9	16.1 ± 3.4	17.2 ± 4.0	0.078
Usual walking speed (m/sec)	1.3 ± 0.2	1.2 ± 0.3	1.2 ± 0.2	1.2 ± 0.2	0.677
Maximal walking speed (m/sec)	1.7 ± 0.3	1.6 ± 0.3	1.7 ± 0.3	1.7 ± 0.3	0.235
Timed up & go	6.61 ± 1.63	7.13 ± 1.68	7.07 ± 1.96	6.82 ± 1.21	0.597
One leg standing time with eyes open	27.1 ± 23.5	24.8 ± 21.8	32.1 ± 24.5	34.5 ± 24.4	0.375
Knee extension strength (Nm)	50.4 ± 10.7	44.5 ± 14.8	46.4 ± 9.7	47.0 ± 10.7	0.242
Exercise habit, yes (%)	48.4	40.7	37.5	19.2	0.144
Urinary incontinence, yes (%)	45.2	40.6	40.6	38.5	0.962
Frequency of outings, >once per day (%)	22.6	31.3	34.4	42.3	0.455
Fear of falling, yes (%)	71.0	84.4	68.8	73.1	0.489
Falls, yes (%)	25.8	31.3	21.9	11.5	0.347
Self-rated health, unhealthy (%)	12.9	34.4	25.0	15.4	0.163

†Data are presented as mean and standard deviation for continuous variables, and percentage for categorical variables. ANOVA (one-way analysis of variance) for continuous variables and χ^2-test for categorical variables. Ex, exercise group; HE, health education group; TC, tea catechin group.

between strength and mass is not linear. Recently, the European Working Group on Sarcopenia in Older People recommended using both low muscle mass and muscle strength or low physical performance as indicators for sarcopenia.[20] In the present study, sarcopenic women were operationally defined based on the declines in muscle strength or walking speed that accompany the loss of skeletal muscle mass or low BMI. The results of the present study showed that the combination of exercise and TC can effectively improve muscle mass and walking speed in sarcopenic elderly women; however, the present results could not confirm the efficacy of the combined intervention on both muscle mass and strength.

The benefits of resistance training in increasing muscle mass and strength for older people have been made quite clear throughout the literature.[6–8] According to a recent review, resistance exercise has been shown to increase muscle protein synthesis, and evidence suggests increases in size of both type 1 and type 2 muscle fibers, leading to overall improvement in muscle power and physical functioning.[5] However, our data did not show beneficial effects of exercise alone on measures of muscle mass or strength. This might be because of the intensity the participants in this intervention exercised at, as some studies showed that higher intensity and volume training were associated with greater strength improvements among older populations, compared with low- and moderate-intensity training.[7,21] Nevertheless, high-intensity exercise for frail elderly people is difficult and might lead to negative or adverse outcomes. Exercise at high intensities might aggravate previously mild discomforts of the lower back or knee, potentially causing mild, moderate or even severe pain. Furthermore, motivating frail elderly people to properly carry out high-intensity exercise is very challenging. Even though exercise of high intensity and volume can increase muscle mass and strength effectively, Taaffe[22] has suggested that training once or twice a week at moderate intensity is sufficient for improvement; therefore, the use of such training on frail elderly people should be reconsidered.

The role of anti-oxidants in aging has recently been a topic of interest. Studies have reported that aging skeletal muscle has been associated with decreased oxidative capacity, which might be linked to mitochondrial dysfunction.[23–25] One previous study suggested that TC might prevent decreases in muscle force production in mice.[26] Another mice study indicated that TC can effectively decrease oxidative stress, which might contribute, to a certain extent, to the maintenance of skeletal muscle mitochondrial function and energy metabolism; therefore, the concomitant intake of TC and regular exercise might suppress age-related declines in physical function.[10]

Table 2 Comparison of muscle mass and functional fitness variables among groups after 3-month interventions

Variables†	Group	Baseline	After 3-month intervention	ANOVA (G × T); *P*-value
Muscle mass (kg)	Ex + TC	28.38 ± 2.46	28.33 ± 2.69	*F* = 0.323 *(0.809)*
	Ex	29.09 ± 2.85	28.92 ± 2.98	
	TC	27.47 ± 3.02	27.28 ± 2.83	
	HE	28.23 ± 2.40	28.35 ± 2.33	
Appendicular skeletal muscle mass (kg)	Ex + TC	14.31 ± 1.30	14.18 ± 1.41	*F* = 1.280 *(0.286)*
	Ex	14.79 ± 1.45	14.45 ± 1.57	
	TC	13.66 ± 1.66	13.58 ± 1.51	
	HE	13.96 ± 1.21	14.11 ± 1.23	
Legs muscle mass (kg)	Ex + TC	10.45 ± 0.98	10.57 ± 1.08	*F* = 0.524 *(0.667)*
	Ex	10.59 ± 1.23	10.73 ± 1.22	
	TC	10.14 ± 1.29	10.12 ± 1.14	
	HE	10.30 ± 0.92	10.50 ± 0.94	
Grip strength (kg)	Ex + TC	18.63 ± 3.39	19.33 ± 4.71	*F* = 0.519 *(0.670)*
	Ex	19.11 ± 4.67	19.26 ± 4.54	
	TC	16.41 ± 3.34	17.11 ± 2.81	
	HE	17.84 ± 4.03	17.74 ± 3.59	
Timed up & go (s)	Ex + TC	8.68 ± 1.99	7.37 ± 1.64	*F* = 15.408 *(<0.001)*
	Ex	8.81 ± 1.60	7.03 ± 1.34	
	TC	8.89 ± 2.20	8.44 ± 2.15	
	HE	8.43 ± 1.70	8.88 ± 2.09	
Usual walking speed (m/s)	Ex + TC	1.25 ± 0.21	1.37 ± 0.24	*F* = 4.327 *(0.007)*
	Ex	1.26 ± 0.22	1.36 ± 0.30	
	TC	1.25 ± 0.24	1.24 ± 0.19	
	HE	1.27 ± 0.18	1.26 ± 0.20	
Maximum walking speed (m/s)	Ex + TC	1.74 ± 0.30	2.01 ± 0.39	*F* = 15.161 *(<0.001)*
	Ex	1.73 ± 0.23	2.06 ± 0.32	
	TC	1.78 ± 0.27	1.71 ± 0.23	
	HE	1.79 ± 0.33	1.71 ± 0.30	
Knee extension strength (Nm)	Ex + TC	52.81 ± 9.39	49.85 ± 8.97	*F* = 2.556 *(0.061)*
	Ex	51.39 ± 13.01	49.73 ± 13.38	
	TC	47.34 ± 9.56	39.42 ± 8.29	
	HE	47.54 ± 11.28	43.13 ± 10.93	

†Data are presented as mean and standard deviation. A post-hoc analysis was carried out using the Scheffe method. ANOVA two-way repeated-measure analysis of variance. Ex, exercise group; G, group; HE, health education group; T, time; TC, tea catechin.

Table 3 Adjusted odds ratio for changes in leg muscle mass and functional fitness after intervention according to study group

Dependent variable†	Type of intervention						
	HE	TC		Ex		Ex + TC	
	Reference	OR	95% CI	OR	95% CI	OR	95% CI
Leg muscle mass and usual walking speed	1.00	1.32	0.40–4.70	1.99	0.57–7.38	3.61	1.05–13.66
Leg muscle mass and knee extension strength	1.00	0.40	0.07–2.08	0.82	0.16–4.06	2.25	0.58–9.93

†Dependent variable; change of muscle mass and functional fitness: 1 = improve, 0 = no change or decrease. Ex, exercise; HE, health education; OR, adjusted odd ratio; TC, tea catechin.

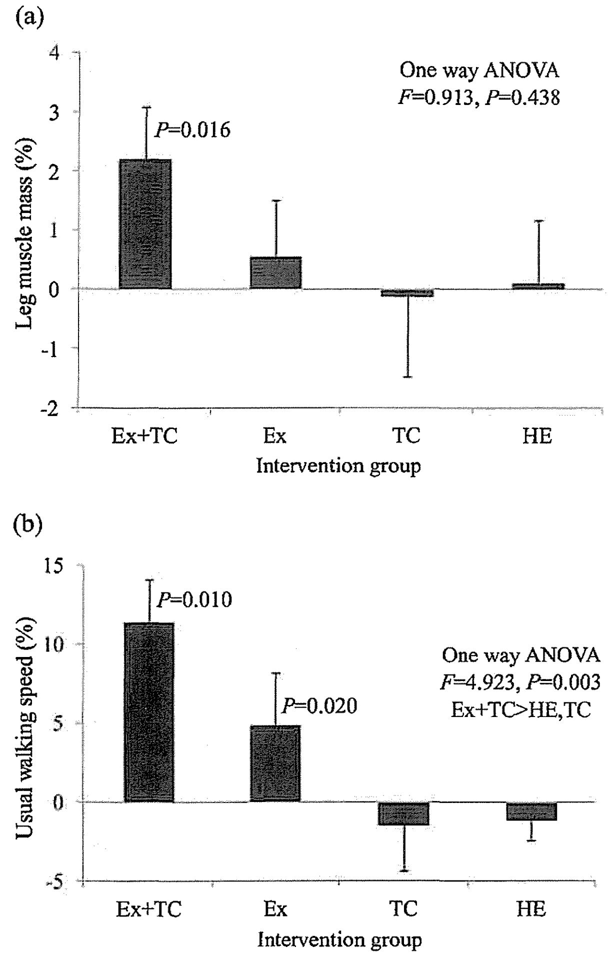

Figure 2 Mean (± SE) changes in (a) leg muscle mass and (b) usual walking speed after exercise (Ex), tea catechin supplementation (TC), usual walking speed after exercise and tea catechin supplementation (Ex + TC), or health education (HE). Bars indicate the average changes from baseline to after the 3-month interventions. A post-hoc analysis was carried out using the Scheffe method.

The data in the present study showed leg muscle mass improvements of 2.21% in the combined exercise and TC group, but the changes in muscle strength were not significant. These results are inconsistent with previous research showing strong associations between increases in muscle mass and increases in strength;[4] hence, further research is necessary.

The improvements observed in walking speed is an important finding, as studies have reported that walking speed is an indicator of vitality and a predictor of functional decline,[27] subsequent disability,[28] survival[29] and other adverse outcomes.[30] A recent statement from the Society on Sarcopenia, Cachexia and Wasting Disease stated that an improvement in gait speed of at least 0.1 m/s can be considered clinically significant.[31] The results of the current study showed that walking speed increased in the Ex group by 0.10 m/s and in the Ex + TC group by 0.12 m/s after the 3-month intervention. Exercise alone or combined exercise and TC supplementation might be effective for improving walking ability in sarcopenic women.

As sarcopenia is a multifactorial condition involving age-related declines in muscle mass, strength or function, effective treatments should target improvements in muscle mass and physical function. In the current study, the OR for muscle mass and usual walking speed improvement was more than threefold as great in the Ex + TC group compared with the HE group. Although investigation into mechanisms of the anti-oxidant capacities of TC together with exercise was beyond the scope of the present study, our results show that the combination of exercise and TC effectively enhanced muscle mass and walking ability.

The present study had several limitations. First, investigation into the mechanisms of the anti-oxidative effects of TC was not explored. Future studies should investigate TC effects on reactive oxygen species and oxidative stress markers in order to provide further understanding and insight into the treatment of sarcopenia. Second, muscle mass was measured using BIA. Other methods of measuring muscle mass, such as magnetic resonance imaging (MRI), computerized tomography and dual-energy X-ray absorptiometry, are typically considered more accurate.[32] Previous studies have reported strong correlations between MRI and BIA measurements for muscle mass in older adults.[12,33,34] Hence, the validity of the BIA measurements has little influence on the interpretation of the results in the present study. Third, 51.9% (138 sarcopenic women) were excluded from the present study based on the exclusion criteria or refused participation, and were not included in this intervention trial. Future research should consider the external validity of the populations included in randomized controlled trials, and perhaps shift the focus to community-dwelling older adults often excluded from intervention studies.

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Disclosure statement

The authors declare no conflict of interest.

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Research Article

Limited Functional Health Literacy, Health Information Sources, and Health Behavior among Community-Dwelling Older Adults in Japan

Yuko Yoshida,[1] Hajime Iwasa,[2] Shu Kumagai,[3] Takao Suzuki,[4] and Hideyo Yoshida[1]

[1] *Tokyo Metropolitan Institute of Gerontology, 35-2 Sakae-cho, Itabashi-ku, Tokyo 173-0015, Japan*
[2] *Fukushima Medical University School of Medicine, 1 Hikarigaoka, Fukushima City, Fukushima 960-1295, Japan*
[3] *University of Human Arts and Sciences, 1288 Magome, Iwatsuki-ku, Saitama City, Saitama 339-8539, Japan*
[4] *National Center for Geriatrics and Gerontology, 35 Gengo, Morioka-machi, Obu City, Aichi 474-8511, Japan*

Correspondence should be addressed to Yuko Yoshida; yossy@tmig.or.jp

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The objectives of this study were to explore how health information sources vary by functional health literacy levels and the relationship between health literacy and health behaviors among the old-old, community-dwelling adults. A cross-sectional study was used. The sample included 620 participants from a rural community in northern Japan. We used structured questionnaires to gather demographic information and assess health-related behaviors, information sources utilized, and functional health literacy. Functional health literacy scores were categorized into three groups, namely, low, middle, and high literacy. Individuals with limited health literacy were more likely to drink less alcohol, were less physically active, had less dietary variety, and had a low rate of medical check-ups. They were also less likely to use printed media, organization or medical procedure, electronic media, and accessed fewer health-related information sources. This study highlights the necessity of information tools that facilitate better access to information among older adults with limited health literacy.

1. Introduction

Limited health literacy is a barrier to adequate health care. Health literacy is defined as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" [1]. People with limited health literacy typically have a poor understanding of their medical condition and medical prescriptions, as well as poorer disease management, making it difficult for them to make good decisions regarding various aspects of their health [2].

Limited health literacy among older adults is a major concern because it has implications for their overall health. Previous research has shown a limited health literacy rate of around 24% [3–5] among community-dwelling older adults. Therefore, in the interests of community service, it is important to consider ways of providing health information to older adults who have limited health literacy.

Previous studies have shown that limited health literacy is independently associated with a poorer health status, inclusive of physical and mental health [4], as well as mortality [6–9]. Older adults with limited health literacy have a poor understanding of health-related information [10] and tend to have limited access to health care services [3, 11]. Thus, health care access may act as a mediator between limited health literacy and poor health status among older adults. Furthermore, varying health literacy levels may contribute to disparities in health status among older adults [3].

Improvements in health literacy could facilitate better healthcare decision-making and lead to better health and quality of life in later life [2]. In order to do this, better methods of providing health information to older adults with limited health literacy are needed. To devise such methods, it would be important to clarify the medical backgrounds of these older adults as well as their typical mode of accessing health information.

Older adults are often given information in written form in various contexts, including private and public health care services. Municipalities and hospitals commonly use mail, pamphlets, leaflets, and hard-copy hospital bills to provide health information to older adults—thus, this method can be considered as the typical mode of initially providing health information to older adults. However, because functional health literacy is markedly lower among older adults [12], written forms of health information may be inappropriate for this population, as they may fail to access it. As such, we saw a need to determine the extent to which older adults are able to understand this health-related information.

Thus, the purpose of this study was to assess the characteristics associated with limited health literacy and to give an indication of what health information sources are typically used by older, community-dwelling adults; furthermore, we aimed to see how health information sources differ by functional health literacy level and whether health literacy affects health behavior. Results from this study would enable the development of measures for enhancing access to health information among older adults with limited health literacy.

2. Methods

2.1. Study Setting and Participants. The target population of this study consisted of older adults living in a rural area in northern Japan. This is a predominantly agricultural region. In 2011, 969 older adults aged 74 and above were registered as residents in certain administrative district. Of these, 729 (279 men and 450 women) agreed to participate (response rate: 75.2%); of the 240 that did not participate, 207 declined participation, 22 were hospitalized, and 11 had died by the time of data collection. One hundred and nine of 729 participants gave no responses on the functional health literacy scale. Thus, the final study sample included 620 adults (244 men and 376 women; Mage = 80.7 years, SD = 4.9) who completely filled out the functional health literacy scale.

This study was approved by the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology. Participants gave written informed consent to participate in the study.

2.2. Measurements. Volunteers distributed the questionnaire for completion by participants. The questionnaire contained items assessing demographic information, including sex, age, education, and living arrangements (alone, with a spouse, or living with family, such as children or relatives). Further, the questionnaire evaluated participants' health-related behavior, including their activities of daily living (ADL; i.e., the ability to walk long distances alone), smoking habits, alcohol consumption, regular physical activity, dietary variety, whether they undergo regular medical check-ups, and sources of health information.

The health information sources were also examined in more detail, and participants could provide multiple answers. Available information sources included people (family and friends), organizations/medical procedure (medical institution such as hospital or clinic, medical check-ups, complete medical check-ups, health consultation service, community organization, and community senior club), electronic media (television, radio, video/DVD, and Internet), printed media (newspapers, books/magazines, public newsletters, and circular notices), "other", and "none."

The frequency of physical activity was determined through a structured interview questionnaire. Participants were required to indicate whether they engaged in physical activity (yes or no), as well as the frequency thereof per week (5-6 days per week, 2–4 days per week, one day or less per week). During the interviews, physical activity was defined as any type of activity that increased bodily movement (e.g., calisthenics, going for walks, gate-ball, jogging, tennis, golf, hiking, dancing, swimming, and martial arts).

Dietary variety was determined through a dietary variety score [13, 14] consisting of 10 food categories (meat, fish and shellfish, eggs, milk, soybean products, potatoes, green or orange vegetables, fruits, seaweed, and fats, and oils). One point was given for consumption of an item from each food category every day throughout one week. Thus, the dietary variety score for one week for each individual ranged from 0 to 10, with a higher-end score indicating greater dietary variety.

Functional health literacy was assessed using a single five-item scale [15]. These items were adopted from a health literacy scale with three subscales: functional (5 items), communicative (5 items), and critical (4 items). The functional health literacy scale was developed to assess the level of difficulty experienced when reading instructions or leaflets from the hospital. Each of the five items was rated on a 4-point scale, from 1 (never) to 4 (often). For each participant, the scores were averaged and reversed accordingly, such that a higher average score indicated higher functional health literacy. Participants were categorized into three groups depending on the tertile (low: 1~2.2; middle; 2.3~3.0; and high: 3.1~4.0) of the health literacy score.

2.3. Statistical Analyses. We used chi-square tests to analyze categorical variables, while analysis of variance (ANOVA) was used to compare continuous variables (i.e., demographic characteristics, health information sources, and health behaviors) across the three health literacy levels (i.e., low, middle, and high).

We used IBM SPSS statistical software, Version 20.0 for Windows (SPSS, Inc., Chicago, IL) for all analyses, with statistical significance set at $P < .05$.

3. Results

The mean (SD) age was 80.3 (4.6) years for men and 80.9 (5.1) for women. The majority of the sample was female, at 60.6%, while 9.4% of all participants were living alone and 69.2% could go out alone. The mean health literacy score was significantly higher in men than women ($M = 2.9$, SD = 0.8 versus $M = 2.5$, SD = 0.9, $P < .001$).

The distribution of the response rate and the mean score for each item on the functional health literacy score is shown in Table 1. Cronbach's alpha coefficient for all five items on the

Table 1: Distribution of responses and mean scores on the functional health literacy scale (n = 620).

While reading instructions or leaflets from hospitals/pharmacies, you...	Number (%)				Means ± SD
	Never	Seldom	Sometime	Often	
Found the print too small to read	182 (29.4)	196 (31.6)	155 (25.0)	87 (14.0)	2.76 ± 1.02
Found characters and words that you did not know	112 (18.1)	185 (29.8)	235 (37.9)	88 (14.2)	2.52 ± 0.95
Found that the content was too difficult	114 (18.4)	197 (31.8)	215 (34.7)	94 (15.2)	2.53 ± 0.96
Needed a long time to read and understand	114 (18.4)	219 (35.3)	188 (30.3)	99 (16.0)	2.56 ± 0.97
Needed someone to help you read	274 (44.2)	132 (21.3)	144 (23.2)	70 (11.3)	2.98 ± 1.06
Total score on the five items					2.67 ± 0.86

functional health literacy scale was 0.94. The distribution of the total scores is shown in Figure 1.

We observed significant differences in health literacy levels by demographic characteristics. Participants with low health literacy were more likely to be female ($P < .001$) and older ($P < .01$) and have lower levels of education ($P < .001$) and lower ADL ($P < .001$); furthermore, they were more likely to live with living with family ($P < .05$).

Participants with low health literacy scores drank less alcohol ($P < .05$), were less physical active ($P < .001$), had less dietary variety ($P < .001$), and had a low rate of medical check-ups ($P < .001$; see Table 2).

The most commonly cited sources of health information for the overall sample were television (85.6%), newspapers (57.1%), doctors/health professionals (51.1%), family (40.5%), friends and acquaintances (38.8%), and medical check-ups (37.2%). Participants with low health literacy scores were less likely to use medical check-ups ($P < .01$), health consultations/health class ($P < .001$), community senior clubs ($P < .05$), several forms of electrical media (television, $P < .01$), and several forms of printed media (book/magazine, $P < .001$; newspaper, $P < .001$; public newsletter, $P < .001$).

The mean (SD) number of information sources was 3.6 (2.4) for low, 4.9 (2.8) for middle, and 5.0 (2.9) for high literacy levels, respectively ($P < .001$).

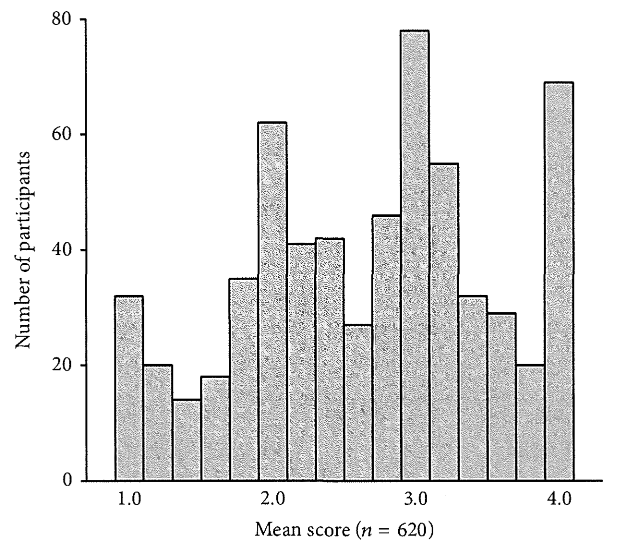

Figure 1: Distribution of functional health literacy score of all participants in this study.

4. Discussion

To address current concerns about the appropriateness of the manner in which health information is disseminated to older adults, we assessed how health information sources varied by functional health literacy level in community-dwelling older adults and examined the relationship between limited health literacy and health-related behaviors (Table 3). We observed significant differences in the type and amount of health information sources according to participants' health literacy levels. Furthermore, limited health literacy was associated with equally limited preventive health behaviors, such as less physical activity and dietary variety, as well as low frequency of medical check-ups.

Results showed that people of all health literacy levels used other people as a source, including family, friends, or doctors. In contrast, older adults with limited health literacy were less likely to use printed media, organizations, or medical procedures as information sources. Furthermore, older adults with limited health literacy had lower ADL and lived with their children or other relatives. It might be that these individuals have difficulties participating in community events, such as community gatherings. Further, they do not typically obtain information in written form voluntarily; rather they involuntarily obtain information from family members.

Previous studies have shown that the number of information sources was not significantly associated with functional health literacy scores among patients with diabetes [15]. Our findings showed that a decrease in the number of information sources was associated with a decline in functional health literacy. In addition, individuals with higher literacy levels used different types of media to access health information. Nevertheless, the difference between the results of the study by Ishikawa et al. [15] and those from the current study could be due to differences in the study samples.

Older adults with inadequate health literacy (e.g., difficulty in reading health information) may fail to gain access to important information in various contexts, such as

Table 2: Demographic and lifestyle characteristics by health literacy level.

Characteristic	Overall (n = 620)	Functional health literacy			
		Low; 1~2.2 (n = 222)	Middle; 2.3~3.0 (n = 193)	High; 3.1~4.0 (n = 205)	
Gender (women; %)	376 (60.6)	159 (71.6)	111 (57.5)	106 (51.7)	* * *
Age (mean ± SD)	80.7 ± 4.9	81.6 ± 5.3	80.1 ± 4.5	80.1 ± 4.6	* *
Education (≥high school; %)	114 (19.2)	21 (10)	38 (20.5)	55 (27.8)	* * *
Living arrangements (%)					*
Alone	57 (9.4)	22 (10.2)	18 (9.4)	17 (8.4)	
Spouse	99 (16.3)	22 (10.2)	32 (16.8)	45 (22.3)	
Living with family	453 (74.4)	172 (79.6)	141 (73.8)	140 (69.3)	
Total ADL (going out alone; %)	420 (69.2)	107 (48.9)	183 (75.9)	130 (88.4)	* * *
Drinking habits (current; %)	163 (26.5)	44 (19.9)	61 (31.9)	58 (28.4)	*
Smoking habits (current; %)	27 (4.4)	10 (4.5)	10 (5.2)	7 (3.4)	ns
Physical activity (active; %)	231 (37.7)	60 (27.1)	73 (38.4)	98 (48.5)	* * *
Dietary variety score (≥5; %)	230 (39)	65 (30.7)	64 (35.2)	101 (51.5)	* * *
Medical check-up (attended; %)	360 (58.1)	96 (43.2)	120 (62.2)	144 (70.2)	* * *

Note. Data are n (%) or means ± SD. $^{*}P < .05$, $^{**}P < .01$, $^{***}P < .001$. There are missing values on some items.
ADL: activities of daily living.
χ^2 was used for categorical variables and one-way analysis of variance was used for continuous variables.

Table 3: Health information sources and number thereof by health literacy level.

	Overall (n = 620)	Functional health literacy			
		Low; 1~2.2 (n = 222)	Middle; 2.3~3.0 (n = 193)	High; 3.1~4.0 (n = 205)	
People					
Family	250 (40.5)	102 (46.2)	68 (35.2)	80 (39.2)	ns
Friend	240 (38.8)	89 (40.3)	77 (39.9)	74 (36.3)	ns
Organization/medical procedure					
Medical institution	316 (51.1)	105 (47.5)	111 (57.5)	100 (49.0)	ns
Medical check-up#	230 (37.2)	62 (28.1)	84 (43.5)	84 (41.2)	* *
Complete medical check-up#	23 (3.7)	3 (1.4)	9 (4.7)	11 (5.4)	—
Health consultation service	108 (17.5)	20 (9.0)	46 (23.8)	42 (20.6)	* * *
Community society	30 (4.9)	6 (2.7)	12 (6.2)	12 (5.9)	ns
Community senior club	111 (18.0)	27 (12.2)	41 (21.2)	43 (21.1)	*
Electronic media					
Television	529 (85.6)	180 (81.4)	161 (83.4)	188 (92.2)	* *
Radio	76 (12.3)	23 (10.4)	27 (14.0)	26 (12.7)	ns
Video/DVD	5 (0.8)	0 (0.0)	1 (0.5)	4 (2.0)	—
Internet	6 (1.0)	0 (0.0)	4 (2.1)	2 (1.0)	—
Printed media					
Book/magazine	168 (27.2)	23 (10.4)	59 (30.6)	86 (42.2)	* * *
Newspaper	353 (57.1)	83 (37.6)	123 (63.7)	147 (72.1)	* * *
Public newsletter	168 (27.2)	39 (17.6)	61 (31.6)	68 (33.3)	* * *
Circular notice	151 (24.4)	43 (19.5)	52 (26.9)	56 (27.5)	ns
Other	5 (0.8)	1 (0.5)	1 (0.5)	3 (1.5)	—
None	10 (1.6)	10 (4.5)	0 (0.0)	0 (0.0)	—
Number of sources	4.7 ± 2.8	3.6 ± 2.4	4.9 ± 2.8	5.0 ± 2.9	* * *

Data are n (%) or means ± SD. There are missing values on some items. $^{*}P < .05$, $^{**}P < .01$, $^{***}P < .001$.
χ^2 was used for categorical variables, while analysis of variance (ANOVA) was used for continuous variables.
The number of sources was calculated using the ANOVA with the post hoc least significant difference test. The low functional health literacy group used less information sources than the middle ($P < .001$) and high ($P < .001$) functional health literacy groups.
—Not examined due to too few responses.
A "medical check-up" refers to health-care services typically provided by a health insurance organization (in public health service), while a "complete medical check-up" is provided by private hospitals that operate in private practice.

interacting with health care service providers [3, 11]. However, the results from the current study showed that older adults with limited health literacy do not typically obtain health information from printed media. Thus, these individuals could fail to access health information provided in written form. Although written information is a predominant mode of information communication for older adults in public health care settings, older adults with limited health literacy would have difficulty in accessing relevant information. This is compounded by the fact that these individuals used fewer information sources than did those with adequate health literacy. Therefore, there is a need to develop more ways of disseminating health-related information to the target population in a suitable manner.

Previous studies have shown that limited health literacy among individuals is associated with less frequent participation in physical activities [16] and lower likelihood of performing frequent, vigorous physical activity [7]. In line with this, our findings showed that low levels of functional health literacy were associated with less physical activity. Limited health literacy was also associated with less dietary variety; similarly, previous studies have shown that limited health literacy was associated with lower fruit and vegetable consumption [17].

The above findings suggest that individuals with low health literacy would find it difficult to engage in appropriate health care management. Healthier lifestyles choices such as regular physical activity and comprehensive dietary habits are important factors in the maintenance of health status in old age. Some studies have also shown that physical activity is inversely associated with all-cause mortality in older men and women and that there are benefits from even low levels of activity [18]. Diet quality was also significantly associated with all-cause mortality in older adults aged 65 and over [19]. Furthermore, the cited study showed that combinations of diet and lifestyle factors, including physical activity, were associated with all-cause and cause-specific mortality in older adults [20] and that physical activity and the intake of fruits and vegetables are independently and jointly related to longevity in older women [21]. Therefore, individuals with limited health literacy tend to lead poorer lifestyles, which could induce functional and mental decline.

Previous studies have shown that limited health literacy is associated with poor access to health care, inclusive of primary care, preventive services, and medication [3]. Another study showed that inadequate health literacy is independently associated with lower use of preventive health care services among individuals enrolled in Medicare, who are aged between 65 and 79 years old [11]. The current study supported this finding, as it showed that limited health literacy among older adults coincided with less frequent medical check-ups. It is common to receive a notice for a medical check-up in written form in Japan; this information would be inaccessible to older adults with limited health literacy.

Many studies have shown that education plays a considerable role in literacy levels; however, nearly all of the participants in this study had undergone mandatory education, which facilitates basic literacy levels. Therefore, the limited health literacy levels were due to reasons other than simply being unable to read the information on the most basic level.

In sum, limited health literacy may hamper older adults' ability to benefit from information relating to health care. In turn, this could result in poorer health outcomes among such individuals.

5. Limitations

Several limitations were identified in the current study. First, this study used a cross-sectional design, which does not allude to any causal relationship between health literacy and preventive health behavior. In addition, previous studies have shown that general cognitive performance affects health literacy [5]. The current study did not include any analysis of the participants' cognitive functioning. In addition, the study excluded disabled older adults, inclusive of those suffering from cognitive decline, or those requiring nursing care. There is a need for further research on the long-term effects of health literacy on health behavior; these could further be explored in relation to cognitive functioning.

6. Conclusion

We explored how health information sources differed by functional health literacy levels and sought to determine the relationship between limited health literacy and health behavior among rural, community-dwelling older adults. Older adults with limited health literacy were less likely to use printed media and accessed fewer health information sources. Furthermore, limited health literacy was associated with less engagement in preventive health behavior.

Older adults with limited health literacy need to modify their lifestyles to ensure better health outcomes. It is evident that the dissemination of health information in written form is unsuitable for many people, particularly older adults with low functional literacy. Thus, better information tools are necessary to enable older adults with limited health literacy to access health information.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Prevalence of knee pain, lumbar pain and its coexistence in Japanese men and women: The Longitudinal Cohorts of Motor System Organ (LOCOMO) study

Noriko Yoshimura, Toru Akune, Saeko Fujiwara, Yoko Shimizu, Hideyo Yoshida, Go Omori, Akihiro Sudo, Yuji Nishiwaki, Munehito Yoshida, et

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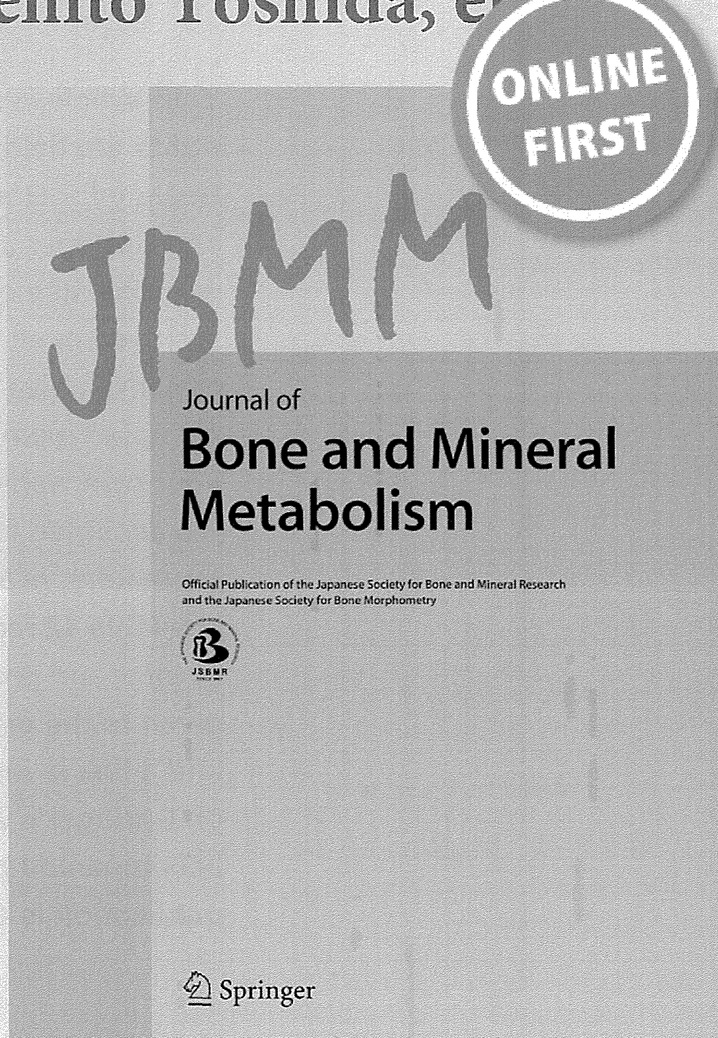

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ORIGINAL ARTICLE

Prevalence of knee pain, lumbar pain and its coexistence in Japanese men and women: The Longitudinal Cohorts of Motor System Organ (LOCOMO) study

Noriko Yoshimura · Toru Akune · Saeko Fujiwara · Yoko Shimizu · Hideyo Yoshida · Go Omori · Akihiro Sudo · Yuji Nishiwaki · Munehito Yoshida · Hiroshi Shimokata · Takao Suzuki · Shigeyuki Muraki · Hiroyuki Oka · Kozo Nakamura

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Abstract The Longitudinal Cohorts of Motor System Organ (LOCOMO) study was initiated in 2008 through a grant from the Ministry of Health, Labour, and Welfare of Japan to integrate information from several cohorts established for the prevention of musculoskeletal diseases. We integrated the information of 12,019 participants (3,959 men and 8,060 women) in the cohorts comprising nine communities located in Tokyo (two regions: Tokyo-1 and Tokyo-2), Wakayama [two regions: Wakayama-1 (mountainous region) and Wakayama-2 (seaside region)], Hiroshima, Niigata, Mie, Akita, and Gunma prefectures. The baseline examination of the LOCOMO study consisted of an interviewer-administered questionnaire, anthropometric measurements, medical information recording, X-ray radiography, and bone mineral density measurement. The prevalence of knee pain was 32.7 % (men 27.9 %; women 35.1 %) and that of lumbar pain was 37.7 % (men 34.2 %; women 39.4 %). Among the 9,046 individuals who were surveyed on both knee pain and lumbar pain at the baseline examination in each cohort, we noted that the prevalence of both knee pain and lumbar pain was 12.2 % (men 10.9 %; women 12.8 %). Logistic regression analysis showed that higher age, female sex, higher body mass index (BMI), living in a rural area, and the presence of lumbar pain significantly influenced the presence of knee pain. Similarly, higher age, female sex, higher BMI, living in a rural area, and the presence of knee pain significantly influenced the presence of lumbar pain. Thus, by using the data of the

N. Yoshimura (✉) · H. Oka
Department of Joint Disease Research, 22nd Century Medical and Research Center, Graduate School of Medicine, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8655, Japan
e-mail: yoshimuran-ort@h.u-tokyo.ac.jp

T. Akune · S. Muraki
Department of Clinical Motor System Medicine, 22nd Century Medical and Research Center, Graduate School of Medicine, University of Tokyo, Tokyo, Japan

S. Fujiwara
Hiroshima Atomic Bomb Casualty Council, Hiroshima, Japan

Y. Shimizu · H. Yoshida
Tokyo Metropolitan Institute of Gerontology, Tokyo, Japan

G. Omori
Center for Transdisciplinary Research, Institute for Research Promotion, Niigata University, Niigata, Japan

A. Sudo
Department of Orthopaedic Surgery, Mie University Graduate School of Medicine, Mie, Japan

Y. Nishiwaki
Department of Environmental and Occupational Health, School of Medicine, Toho University, Tokyo, Japan

M. Yoshida
Department of Orthopedic Surgery, School of Medicine, Wakayama Medical University, Wakayama, Japan

H. Shimokata
Graduate School of Nutritional Sciences, Nagoya University of Arts and Sciences, Aichi, Japan

T. Suzuki
National Center for Geriatrics and Gerontology, Aichi, Japan

K. Nakamura
National Rehabilitation Center for Persons with Disabilities, Saitama, Japan

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LOCOMO study, we clarified the prevalence of knee pain and lumbar pain, their coexistence, and their associated factors.

Keywords Nation-wide population-based cohort study · Epidemiology · Prevalence · Knee pain · Lumbar pain

Introduction

Musculoskeletal diseases, including osteoarthritis (OA) and osteoporosis (OP), are major public health problems among the elderly; these diseases can affect activities of daily living (ADL) and quality of life (QOL), and can lead to increased morbidity and mortality. According to the recent National Livelihood Survey by the Ministry of Health, Labour, and Welfare in Japan, OA is ranked fourth among diseases that cause disabilities and subsequently require support for ADL, whereas falls and osteoporotic fractures are ranked fifth [1]. Studies have reported increased mortality after osteoporotic fractures at the hip and other sites [2]. An estimated 47,000,000 individuals (21,000,000 men and 26,000,000 women) aged ≥40 years will eventually be affected by either OA or OP [3].

Considering that the population of Japan is aging rapidly, a comprehensive and evidence-based prevention strategy for musculoskeletal diseases is urgently needed. However, only a few prospective, longitudinal studies designed to develop such a strategy have been conducted. Therefore, little information is available regarding the incidence of disability and the prevalence and incidence of musculoskeletal disorders, including knee pain, and lumbar pain, and their associated factors in Japan. The absence of such epidemiological data hampers the rational design of clinical and public health approaches for the diagnosis, evaluation, and prevention of musculoskeletal diseases.

Several cohorts have focused on the prevention of OP, knee OA (KOA), lumbar spondylosis (LS) or disability caused by musculoskeletal diseases. However, since the prevalence of the musculoskeletal diseases has been reported to be high [3], the extent of the population at risk after excluding those who had the target disease at the baseline seems to be small. To identify epidemiological indices, especially the incidence of musculoskeletal diseases and/or disability, a large number of subjects is required. In addition, to determine the regional differences in epidemiological indices, we need a survey of cohorts across Japan.

The Longitudinal Cohorts of Motor System Organ (LOCOMO) study was initiated in 2008 by the members of the committee for 'the prevention of knee and back pain and bone fractures in a large cohort of regionally representative residents from across Japan,' through a grant from the Ministry of Health, Labour, and Welfare of Japan (Director, Noriko Yoshimura). This study aimed to integrate the information of several cohorts established for the prevention of musculoskeletal diseases from 2000 onwards, and to initiate a follow-up examination using the unified questionnaire from 2006 onwards in Japan.

In the present paper, by using the integrated information at the baseline of the LOCOMO study, we tried to confirm the prevalence of clinical symptoms of musculoskeletal diseases, such as knee pain and lumbar pain and their characteristics.

Materials and methods

Participants

Participants in the cohorts were residents of nine communities located in Tokyo (two regions: Tokyo-1, principle investigators (PIs): Shigeyuki Muraki, Toru Akune, Noriko Yoshimura, Kozo Nakamura; Tokyo-2, PIs: Yoko Shimizu, Hideyo Yoshida, Takao Suzuki), Wakayama [two regions: Wakayama-1 (mountainous region) and Wakayama-2 (seaside region); PIs: Noriko Yoshimura, Munehito Yoshida], Hiroshima (PI: Saeko Fujiwara), Niigata (PI: Go Omori), Mie (PI: Akihiro Sudo), Akita (PI: Hideyo Yoshida), and Gunma (PI: Yuji Nishiwaki) prefectures [4]. Figure 1 shows the location of each cohort in Japan, and Fig. 2 provides the timeline of the LOCOMO study. Residents of the nine regions were recruited from resident registration lists in the relevant region. Data for the 12,019 participants were collected and registered as an integrated cohort. Numbers of participants in the LOCOMO study classified by regions of each cohort are shown in Table 1. The smallest cohort consisted of 826 individuals in Wakayama-2, and the largest consisted of 2,613 individuals in Hiroshima.

All participants provided written informed consent, and the study was conducted with the approval of the ethics committees of the University of Tokyo (nos. 1264 and 1326), the Tokyo Metropolitan Institute of Gerontology (no. 5), Wakayama (no. 373), The Radiation Effects Research Foundation (RP03-89), Niigata University (no. 446), Mie University (no. 837 and no. 139), Keio University (no. 16–20), and National Center for Geriatrics and Gerontology (no. 249). Safety of the participants was ensured during the examination and during all other study procedures.

Data collection

The baseline examination of the LOCOMO study consisted of the following: an interviewer-administered questionnaire,

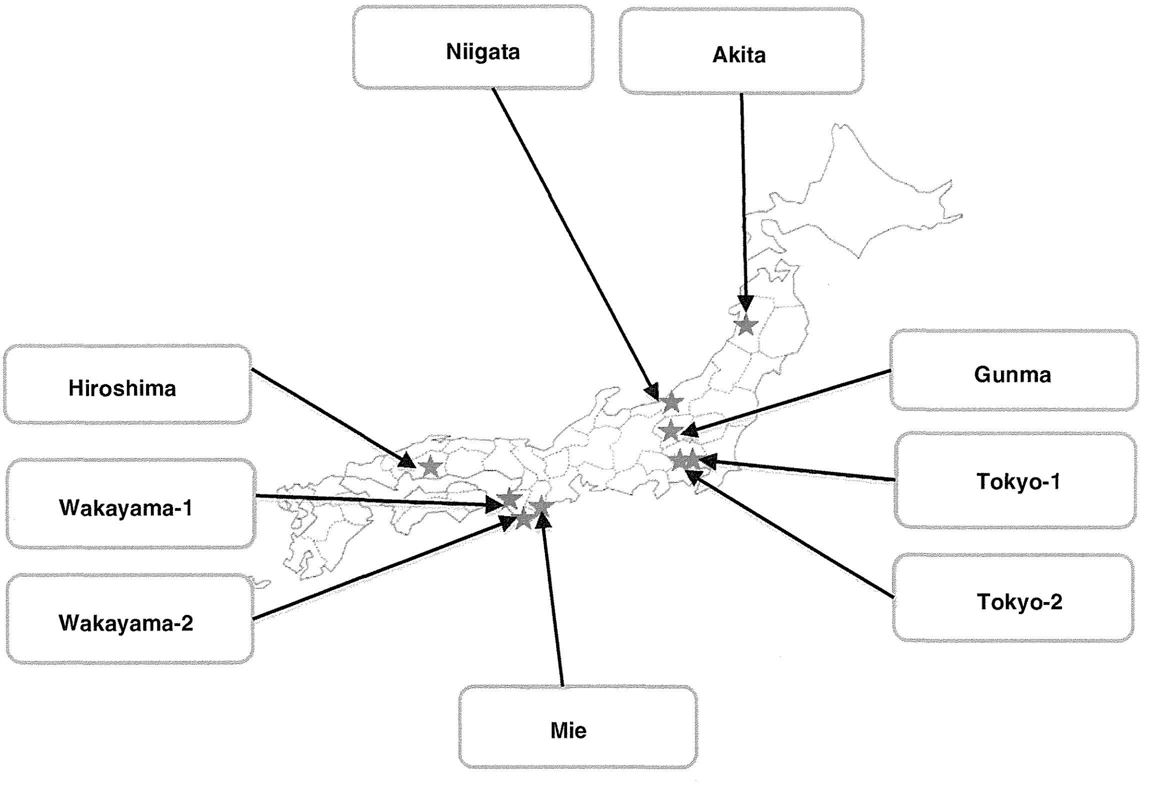

Fig. 1 Locations of the nine different regions from which the study cohorts were derived

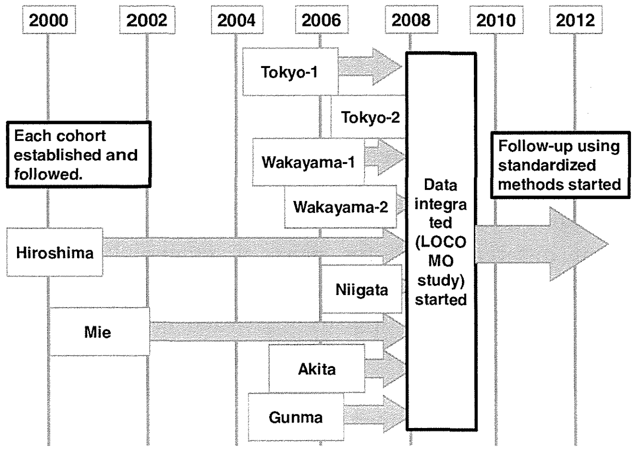

Fig. 2 Timeline of the LOCOMO study

Table 1 Numbers of participants in the LOCOMO study classified by regions of each cohort

Regions of each cohort	Start year	Total	Men	Women
Tokyo-1	2005	1,350	465	885
Tokyo-2	2008	1,453	59	1,394
Wakayama-1 (mountainous)	2005	864	319	545
Wakayama-2 (seaside)	2006	826	277	549
Hiroshima	2000	2,613	794	1,819
Niigata	2007	1,474	628	846
Mie	2001	1,175	423	752
Akita	2006	852	366	486
Gunma	2005	1,412	628	784
Total		12,019	3,959	8,060

anthropometric measurements, medical information recording, radiography, and bone mineral density (BMD) measurement.

Interviewer-administered questionnaire

A questionnaire was prepared by modifying the questionnaire used in the Osteoporotic Fractures in Men Study (MrOS) [5], and some new items were added to the modified questionnaire. Knee symptoms were evaluated using the Western Ontario and McMaster University Osteoarthritis Index (WOMAC) [6]. Health-related QOL was evaluated using the European QOL-5 dimensions instrument (EuroQOL EQ5D) [7] and the Medical Outcomes Study 8-item Short Form (SF-8) [8]. The study staff recorded all the medications administered and their doses.

Anthropometric measurements

Anthropometric factors were measured by well-trained medical nurses. Body mass index [BMI; weight in kilograms/(height in meters)^2] was calculated on the basis of the current height and weight. Hand grip strength was measured using a Toei Light handgrip dynamometer (Toei Light Co., Ltd., Saitama, Japan). Both hands were tested, and the higher value was used to characterise the maximum muscle strength of the subject. Walking speed was determined by recording the time taken by a subject to walk a determined distance, such as 5 or 6 m, at his/her usual speed. The ability to rise from a chair without using the arms (chair stand) and the ability to perform 5 chair stands was evaluated. The time required to complete the tasks was recorded.

Medical information

Medical information was obtained by experienced medical doctors in each cohort. All participants were questioned about pain in both knees by asking the following questions: 'Have you experienced right knee pain on most days (and continuously on at least one day) in the past month, in addition to the current pain?' and 'Have you experienced left knee pain on most days (and continuously on at least one day) in the past month, in addition to the current pain?' Subjects who answered 'yes' were considered to have knee pain. Lumbar pain was determined by asking the following question: 'Have you experienced lumbar pain on most days (and continuously on at least one day) in the past month, in addition to the current pain?' Subjects who answered 'yes' were considered to have lumbar pain.

In some cohorts (Tokyo-1, Wakayama-1, and Wakayama-2), the participants completed the modified Mini-Mental Status Examination-Japanese version [9] for evaluating cognitive function. Physicians explained any unclear sections of this questionnaire to the participants and assessed the cognitive status on the basis of the completed questionnaire.

Radiography and radiographic assessment

In several cohorts (Tokyo-1, Wakayama-1, Wakayama-2, Hiroshima, Niigata, and Mie), the radiographic examination of knees and/or spine was performed to evaluate the OA or fractures. Plain radiographs were obtained for both knees in the antero-posterior view with weight-bearing and foot map positioning and for the spine in the antero-posterior and lateral views.

The severity of OA was radiographically determined according to the Kellgren-Lawrence (KL) grading system as follows [10]: KL0, normal joint; KL1, slight osteophytes; KL2, definite osteophytes; KL3, narrowing of joint cartilage, and large osteophytes; and KL4, bone sclerosis, narrowing of joint cartilage, and large osteophytes. In the LOCOMO study, joints exhibiting disc-space narrowing alone and no large osteophytes were graded as KL3. In each cohort, radiographs were examined by a single, experienced orthopaedic surgeon who was masked to the clinical status of the participants. If at least one knee joint was graded as KL2 or higher, the participant was diagnosed with radiographic KOA. Similarly, if at least one intervertebral joint of the lumbar spine was graded as KL2 or higher, the participant was diagnosed with radiographic LS.

BMD measurement

In the Wakayama-1, Wakayama-2, and Hiroshima cohorts, BMD of the lumbar spine and proximal femur was measured using dual energy X-ray absorptiometry (DXA) (Hologic Discovery; Hologic, Waltham, MA, USA) during the baseline examination.

OP was defined on the basis of the World Health Organization (WHO) criteria. Specifically, OP was diagnosed when the BMD T scores were lower than the mean lumbar peak bone mass—2.5 SDs [11]. In Japan, the mean BMD of the L2–L4 vertebrae among both young male and female adults has been measured using Hologic DXA [12]. In the present study, lumbar spine BMD < 0.714 g/cm^2 (for both men and women) and femoral neck BMD < 0.546 g/cm^2 (men) or <0.515 g/cm^2 (women) were considered to indicate OP.

Statistical analysis

All statistical analyses were performed using STATA statistical software (STATA Corp., College Station, TX, USA). Differences in proportions were compared using the Chi square test. Differences in continuous variables were tested for significance using analysis of variance for comparisons among multiple groups or Scheffe's least significant difference test for pairs of groups. To test the association between the interaction between the knee pain and lumbar pain, a logistic regression model was used. First, the presence of knee pain was used as an objective variable (0: absence, 1: presence) and age (+1 year), gender (men vs. women), BMI (+1 kg/m^2), regional differences (0: rural areas including Wakayama-1, Wakayama-2, Niigata, Mie, Akita, and Gunma vs. 1: urban areas including Tokyo-1, Tokyo-2, and Hiroshima), and lumbar pain (0: no, 1: yes) were used as explanatory variables. Then, lumbar pain was used as an objective variable, and knee pain was used as an explanatory variable in the identical model. All p values and 95 % confidence intervals (CI) of two-sided analysis are presented.

Results

Table 2 shows the number of participants classified by age and gender. Most participants were aged ≥60 years, and

Table 2 Numbers of participants in the LOCOMO study classified by age and gender

Age strata (years)	Total (%)	Men (%)	Women (%)
≤39	125 (1.0)	49 (1.2)	76 (0.9)
40–49	483 (4.0)	183 (4.6)	300 (3.7)
50–59	963 (8.0)	320 (8.1)	643 (8.0)
60–69	3,170 (26.3)	1,161 (29.3)	2,009 (24.9)
70–79	5,041 (41.9)	1,573 (39.7)	3,468 (43.0)
80–89	2,111 (17.6)	627 (15.8)	1,484 (18.4)
≥90	126 (1.1)	46 (1.2)	80 (1.0)
Total	12,019 (100.0)	3,959 (100.0)	8,060 (100.0)

99.0 % of the participants were aged ≥40 years. Two-thirds of the participants were women, and their mean age was 1 year greater than that of the male participants.

Selected characteristics of the study populations, including age, height, weight, BMI, and proportions of participants who smoked and consumed alcohol are shown in Table 3. The participants were considered as smokers and alcohol consumers if they answered 'yes' to the question 'Are you currently smoking/drinking?' in the self-administered questionnaire. The mean values of age and BMI were significantly higher in women than in men ($p < 0.01$). The proportions of both current smokers and alcohol consumers were significantly higher among men than among women ($p < 0.001$).

Table 3 Baseline characteristics of participants in the LOCOMO study classified by age and gender

Variables	Men	Women	*p* Value (men vs. women)
Age (years)	70.0 (10.6)	71.0 (10.3)	<0.001
Height (cm)	161.1 (6.8)	148.5 (6.4)	<0.001
Weight (kg)	59.3 (9.5)	50.8 (8.6)	<0.001
BMI (kg/m^2)	22.8 (3.0)	23.0 (3.5)	0.007
Smoking (%)	34.0	4.8	<0.001
Drinking (%)	52.4	21.1	<0.001

Values are represented as mean (standard deviation)

BMI body mass index

By analysing the data at the baseline examination, we determined the prevalence of knee pain and lumbar pain. Figure 3 shows the age-sex distribution of the prevalence of knee pain and lumbar pain. Overall, the prevalence of knee pain was 32.7 % (27.9 % in men and 35.1 % in women) and that of lumbar pain was 37.7 % (34.2 % in men and 39.4 % in women). The prevalence of pain in both the knee and lumbar region were significantly higher in women than in men ($p < 0.001$). On the basis of the total age and sex distributions derived from the Japanese census in 2010 [13], our results estimate that 18,000,000 people (7,100,000 men and 10,900,000 women) aged ≥40 years would be affected by knee pain and that 27,700,000 people (12,100,000 men and 15,600,000 women) aged ≥40 years would be affected by lumbar pain.

Further, among 9,046 individuals who were surveyed on both knee pain and lumbar pain at the baseline examination in each cohort, the prevalence of both knee pain and lumbar pain was 12.2 % (10.9 % in men and 12.8 % in women). The prevalence of the coexistence of knee and lumbar pain in the participants aged <40, 40–49, 50–59, 60–69, 70–79, and ≥80 years was 4.0, 4.8, 7.4, 13.0, 13.3, and 11.7 %, respectively, (6.1, 5.3, 6.0, 10.0, 11.5, and 13.2 %, respectively, in men and 2.6, 4.6, 8.1, 14.8, 14.2, and 11.0 %, respectively, in women). The prevalence of both knee pain and lumbar pain increased with age in men, whereas that in women reached a plateau at 60–69 and 70–79 years and then declined. On the basis of the total age and sex distributions derived from the Japanese census in 2010 [13], our results estimate that 6,800,000 people

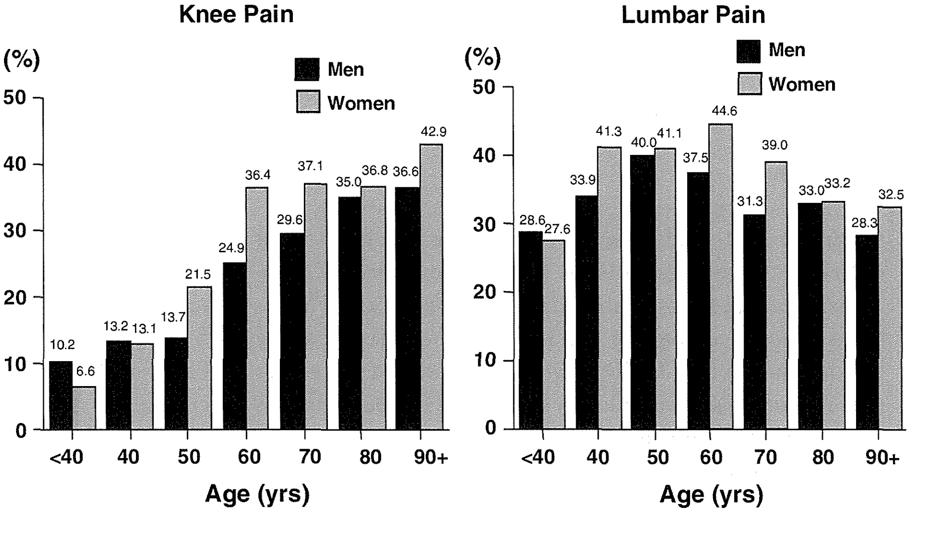

Fig. 3 Prevalence of knee pain and lumbar pain according to age and gender

Table 4 Odds ratios (OR) of potentially associated factors for the presence of knee pain/lumbar pain vs. absence of pain

Explanatory variables	Reference	OR	95% confident interval	p
Knee pain (presence vs. absence)				
Age (years)	+1 year	1.045	1.039–1.051	<0.001***
Gender	0: men, 1: women	1.602	1.441–1.780	<0.001***
Region	0: urban area, 1: rural area	2.419	2.152–2.720	<0.001***
BMI (kg/m^2)	+1 kg/m^2	1.141	1.124–1.158	<0.001***
Lumbar pain	0: absence, 1: presence	1.373	1.243–1.515	<0.001***
Lumbar pain (presence vs. absence)				
Age (years)	+1 year	1.018	1.013–1.023	<0.001***
Gender	0: men, 1: women	1.130	1.023–1.248	0.016*
Region	0: urban area, 1: rural area	2.016	1.801–2.256	<0.001***
BMI (kg/m^2)	+1 kg/m^2	1.020	1.003–1.031	0.021*
Knee pain	0: absence, 1: presence	1.375	1.246–1.518	<0.001***

BMI body mass index

* $p < 0.05$, *** $p < 0.001$

(2,800,000 men and 4,000,000 women) aged ≥40 years would be affected by both knee pain and lumbar pain.

To test the association between the knee pain and lumbar pain, the presence of knee pain was first used as an objective variable (0: absence, 1: presence) and age (+1 year), gender (men vs. women), BMI (+1 kg/m^2), regional differences (0: rural areas including Wakayama-1, Wakayama-2, Niigata, Mie, Akita, and Gunma vs. 1: urban areas including Tokyo-1, Tokyo-2, and Hiroshima), and lumbar pain (0: no, 1: yes) were used as explanatory variables. Then, the presence of lumbar pain was used as an objective variable (0: absence, 1: presence) and age (+1 year), gender (men vs. women), BMI (+1 kg/m^2), regional differences (0: rural areas including Wakayama-1, Wakayama-2, Niigata, Mie, Akita, and Gunma vs. 1: urban areas including Tokyo-1, Tokyo-2, and Hiroshima), and knee pain (0: no, 1: yes) were used as explanatory variables. Table 4 shows the result of the logistic regression analysis. Higher age, female sex, higher BMI, living in a rural area, and the presence of lumbar pain significantly influenced the presence of knee pain. Similarly, higher age, female sex, higher BMI, living in a rural area, and the presence of knee pain significantly influenced the presence of lumbar pain.

Discussion

In the present study, we integrated the information of individual cohorts established for the prevention of musculoskeletal diseases, and created the nationwide large-scale cohorts comprising the LOCOMO study. By using the data of the LOCOMO study, we found that the prevalence of knee pain was 32.7 % and that of lumbar pain was 37.7 %. Both knee pain and lumbar pain were prevalent in 12.2 % of the total population. In the present study, we also clarified that the factors associated with knee or lumbar pain were age, sex, body build, and residential characteristics. In addition, the presence of knee pain affected the lumbar pain, and vice versa. This association remained even after the adjustment for the above-mentioned associated factors. To our knowledge, this is the first study to report the frequency of the knee pain and lumbar pain and to estimate the total number of prevalent subjects, by using a large-scale population-based cohort study in Japan.

With regard to musculoskeletal pain, several population-based epidemiological studies have demonstrated that chronic pain is a highly prevalent condition. Soni et al. [14] reported that the prevalence rates of self-reported knee pain using the baseline data in 1,003 participants from the Chingford Women's Study were 22.97 % in the left knee and 24.80 % in the right knee. The definition of the presence of the knee pain (based on the following two questions: 'Have you had any knee pain in either knee in the last month?' and 'How many days of pain have you experienced in the last month?') was similar but not identical to our definition used in the LOCOMO study, and the subjects' age was younger in the Chinford study than in the LOCOMO study. Therefore, we could not compare the prevalence between the Chinford and LOCOMO studies directly. However, at a glance, the prevalence seems to be higher in the Japanese population. This may be due to the fact that the prevalence of KOA (KL grades ≥2) was higher in the Japanese population than that in the Caucasian population [15]. Verhaak et al. [16] reviewed epidemiological studies on chronic benign pain among adults, including subjects aged between 18 and 75 years, and reported that the prevalence ranged between 2 and 40 % of the population. Coggon et al. did not perform a population-based study, but instead conducted a cross-sectional survey comparing the prevalence of disabling low back pain and disabling wrist/hand pain among groups of workers carrying out similar physical activities in different cultural environments in 18 countries including Japan. They reported that the 1-month prevalence of disabling low back pain in nurses ranged from 9.6 to 42.6 %, and that of disabling wrist/hand pain in office workers ranged from 2.2 to 31.6 % [17]. We could not compare our results to those of Coggon's results directly because of the difference in the characteristics of the targeted population. However, previous reviews and reports demonstrated that the prevalence of the chronic pain varied in the population surveyed, and therefore, estimating the prevalence and number of patients in pain would require a study that comprises various regions with a large number of subjects. Our LOCOMO study contains 12,019 participants from the cohorts consisting of nine communities in different locations in Japan. Therefore, we believe that our estimation of the prevalence of knee pain and lumbar pain is appropriate, and the number of patients was sufficient.

With regard to the characteristics of subjects with chronic pain, Soni et al. [14] reported that among subjects who could be followed up for 12 years, a higher BMI was predictive of persistent knee pain (odds ratio = 1.14) and incident knee pain (odds ratio = 1.10). Verhaak et al. [16] demonstrated that chronic pain generally increased with age, with some studies reporting a peak prevalence between the ages of 45 and 65 years. These results were not consistent with our results. Moreover, we noted that living in a rural area was associated with the presence of knee pain and lumbar pain, which may be due to the difference of the primary occupation in that area. Muraki et al. [18] reported that the presence of KOA and LS was influenced by the primary occupation of the participants. According to their report, the prevalence of higher K/L grades of KOA and LS was significantly higher among agricultural, forestry, and fishery workers than among clerical workers and technical experts [18]. For occupational activities, sitting on a chair had a significant inverse association with K/L grades ≥ 2 for KOA and LS, whereas standing, walking, climbing and heavy lifting were associated with higher K/L grades for KOA [18]. An association between occupational activities and KOA was also observed in several studies [19–21]. Agricultural, forestry, and fishery workers seemed to be more common in rural areas than in urban areas. In addition, occupational activities, such as sitting on a chair, might be observed more commonly in clerical workers than in agricultural, forestry, and fishery workers. These findings might support the regional differences of pain that were observed in the present study. The main focus of the present study was pain, and not OA; however, the most probable diagnosis underlying knee pain among older people was reported to be OA [22].

There are also several reports regarding the coexistence of pain. The above-mentioned Coggon's investigation indicated that the rates of disabling pain at 2 anatomical sites—the lumbar spine and wrist/hand—covaried ($r = 0.76$) [17]. In their cross-sectional study, Smith et al., examined the presence and sites of chronic pain in 11,797 women. The presence of chronic pain was noted in 38 % of women; among them, the percentage of women experiencing chronic pain at 1, 2, 3, 4, and ≥ 5 sites was 23.2, 24.4, 20.0, 14.3, and 18.2 %, respectively [23]. These results showed that chronic pain coexists at other anatomical sites. In the present study, the prevalence of both knee pain and lumbar pain was 12.2 % (10.9 % in men and 12.8 % in women) among the general population. However, among the subjects with lumbar pain, 37.3 % also had knee pain (39.0 % in men and 36.6 % in women). Unfortunately, in the LOCOMO study, we were unable to collect the data regarding pain at anatomical sites other than knee pain and lumbar pain. Nevertheless, the coexistence of pain was commonly noted, which is inconsistent with previous reports.

There were several limitations in the present study. First, the current subjects do not truly represent the entire Japanese population. We should carefully consider this limitation, especially when determining the generalisability of the results. However, the LOCOMO study is the first large-scale population-based prospective study with more than 12,000 participants. Although it does not comprise the whole population of Japan, the number of participants in the cohorts established for the prevention of the musculoskeletal diseases appears to be biggest worldwide. Second, all the items of our survey in the baseline examination were not recorded in all cohorts. For example, radiographic examination of knees was performed only in Tokyo-1, Wakayama-1, Wakayama-2, Niigata, and Mie prefectures and radiographic examination of the lumbar spine was performed only in Tokyo-1, Wakayama-1, Wakayama-2, Hiroshima, and Mie prefectures. Third, the radiographic findings for OA assessment using KL scales have not been integrated yet, because of the delay in the standardisation of reading methods of the observers. Radiographs should be assessed by a single observer to omit the inter-observer variability, and if this is impossible, then the inter-observer variability among observers should be tested using the standardised criteria. Therefore, in the present study, we could not evaluate the severity of knee/spinal OA or vertebral fractures for assessing knee pain and lumbar pain. After suitable evaluation of intra-observer and inter-observer variability in the assessment of radiography findings and integration of this information, we hope to re-analyse the factors associated with the presence of chronic pain. Moreover, not only OA and fractures, but also rheumatoid arthritis and spondyloarthritis should be considered as parameters for assessing knee pain and lumbar pain. Although collection of the information on the diagnosis may be difficult on a large scale due to the associated cost, it may be possible to obtain this information in at least two cohorts.

In addition, our study has several strengths. First, as mentioned above, the large number of the integrated subjects included in the LOCOMO study is the biggest strength of this study. Moreover, we collected data from nine cohorts across Japan. By using the data of the LOCOMO study, we could compare the regional differences of specific clinical symptoms such as knee pain or lumbar pain, or particular diseases, such as KOA, LS, or OP, as well as its prognosis, such as the incidence of disability or mortality. In particular, we identified regional differences in the prevalences of knee pain and lumbar pain. In addition, we collected a substantial amount of information, via an interviewer-administered questionnaire, dietary assessment, anthropometric measurements, neuromuscular function assessment, biochemical measurements, medical history recording, radiographic assessment, and BMD measurement. However, all items were not recorded in all cohorts and the regional selection bias in each examination should be considered when interpreting the results.

In summary, by using the data of the LOCOMO study, we clarified the prevalence of knee pain and lumbar pain, their coexistence, and their associated factors.

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