Osteoporosis and Sarcopenia 5 (2019) 23–26

Contents lists available at ScienceDirect

Osteoporosis and Sarcopenia

journal homepage: http://www.elsevier.com/locate/afos

Original article

Sarcopenia and lower limb pain are additively related to motor function and a history of falls and fracture in community-dwelling elderly people

Kohei Maruya [a, *], Hiroaki Fujita [a], Tomoyuki Arai [a], Ryoma Asahi [b], Yasuhiro Morita [c], Hideaki Ishibashi [d]

[a] Department of Physical Therapy, Faculty of Health and Medical Care, Saitama Medical University, Saitama, Japan
[b] Department of Physical Therapy, Faculty of Health Science, Japan University of Health Sciences, Saitama, Japan
[c] Department of Rehabilitation, Japan Community Health-care Organization Tokyo Shinjuku Medical Center, Tokyo, Japan
[d] Department of Orthopedic Surgery, Medical Corporation Aggregate Aiyukai Ina Hospital, Saitama, Japan

ARTICLE INFO

Article history:
Received 18 January 2019
Received in revised form
27 February 2019
Accepted 8 March 2019
Available online 16 March 2019

Keywords:
Sarcopenia
Pain
Community elderly

ABSTRACT

Objectives: To clarify the prevalence and characteristics of pain associated with sarcopenia and to verify the usefulness of evaluation of pain for sarcopenia.
Methods: In total, 759 community-dwelling people (aged 65–79 years) with or without sarcopenia and lower limb pain were classified into 4 groups (NSp, nonsarcopenia; NSpP, nonsarcopenia with pain; Sp, sarcopenia; and SpP, sarcopenia with pain). Body composition, motor function, history of fractures since age 50 years, and number of falls in the past 1 year were compared between the groups.
Results: Participant proportions by group were: NSp, 53.9%; NSpP, 42.8%; Sp, 1.3%; and SpP, 2.0%. Participants with lower limb pain showed low single leg standing, walking speed, and 2-step value scores and high 25-question Geriatric Locomotive Functional Scale (GLFS-25) score after adjusting for age, sex, body mass index, and presence of sarcopenia. The SpP group showed lower functional reach test and higher GLFS-25 scores than the Sp group. Regarding the history of fractures since 50 years of age and falls in past 1 year, a high retention rate of fracture was noted in the NSpP group. They also experienced significantly more falls in the past 1 year than those in the NSp group. The SpP group noted more falls and fractures although it was insignificant.
Conclusions: The results indicate that participants with lower limb pain showed declining motor function and a high risk for falls and fractures. Sarcopenia could escalate this risk. Therefore, evaluating patients for both pain and sarcopenia may be useful for risk assessment and treatment.

1. Introduction

With the progressively aging population, the number of elderly people with multiple diseases has also increased. Sarcopenia, a condition characterized by depleting skeletal muscle mass, muscle strength, and physical ability, is one of the most important health-related problems in elderly people. The criteria for sarcopenia diagnosis vary between European and Asian countries. However, the most common criteria are low muscle mass and poor muscle strength and physical ability [1,2]. Sarcopenia is a known risk-factor for falls and frailty in community-dwelling elderly people [3,4]. In addition, sarcopenia is related to osteoporosis and poses a high risk for fractures [5].

Weakness of the knee extensor is reported to be an independent risk factor for knee osteoarthritis [6]. Lower limb impairments, including knee osteoarthritis, are one of the causes of lower limb pain, and sarcopenia, which is characterized by decreasing muscle strength and mass, makes people more susceptible to pain. Pain decreases the quality of life (QoL) of patients and is one of the chief complaints of many patients. Furthermore, pain can lead to a decrease in physical activity, which in turn increases the risk of sarcopenia. Pain generally tends to lower motor function, and pain

* Corresponding author. Department of Physical therapy, Faculty of Health and Medical Care, Saitama Medical University, 981 Kawakado, Moroyama-machi, Iruma-gun, Saitama, 350-0496, Japan.
E-mail address: maruya@saitama-med.ac.jp (K. Maruya).
Peer review under responsibility of The Korean Society of Osteoporosis.

https://doi.org/10.1016/j.afos.2019.03.002

associated with sarcopenia in particular is suspected to further lower motor function.

However, the diagnostic criteria for sarcopenia do not include evaluation for pain. In addition, the association between sarcopenia and pain has not been clearly elucidated. Clarifying the relationship between sarcopenia and pain may be of help in treatment of sarcopenia. Therefore, we sought to clarify the prevalence and characteristics of pain associated with sarcopenia and verify the usefulness of evaluation of pain for sarcopenia.

2. Methods

2.1. Participants

In total, 765 community-dwelling participants aged 60–79 years and living independently were recruited according to included criteria. The participants were independent and active and did not have noticeable motor and cognitive impairment. Of these, 759 participants with available body composition data were analyzed. The study was approved by the ethics board of the Faculty of Health and Medical Care of Saitama Medical University (No.114, 114-2), and all participants provided informed consent.

2.2. Evaluation

Evaluation included assessment of body composition and motor functions, including a self-reported questionnaire. Body composition, including body mass index (BMI), body fat percentage (%BF), and skeletal muscle mass of the limbs, was measured by bioelectrical impedance analysis using a multifrequency body composition analyzer (MC-190, TANITA Co., Tokyo, Japan). The skeletal muscle mass index (SMI) was calculated using the skeletal muscle mass of the limbs and height of the participants.

Motor function tests were performed to evaluate handgrip strength (HGS), duration of single-leg standing (SLS), normal and maximum walking speed (WS), functional reach test (FRT), and knee extension strength (KES). HGS was measured using a handgrip dynamometer for both hands. For the analysis, the maximum value was used. The participants attempted SLS with the left and right legs with an upper limit of 120- second after practicing. WS was measured on a 6-m long road. The FRT was conducted using a reach instrument (GB-210, OG Wellness Co Ltd., Okayama, Japan). The participants performed the FRT twice using the dominant upper limb. The maximum of the 2 values was selected for analysis. KES was measured using a hand-held dynamometer (μ-TAS F-1, ANIMA Co Ltd., Tokyo, Japan). The measured force was changed to torque by multiplying it with the length of the lower leg and was normalized by the body weight (Nm/kg). The average value for both sides was used in the analysis.

A self-reported questionnaire was used to obtain information from the participants about fractures since the age of 50 years and falls in the past 1 year. In addition, the participants were administered the 25-question Geriatric Locomotive Functional Scale (GLFS-25) questionnaire. GLFS-25 has 25 questions comprising categories evaluating pain and difficulty in performing daily activities in the past 1-month period. Each question is scored between 0 and 4 points, and a higher total score indicates lower locomotive functions [7].

2.3. Grouping of participants

Participants were judged to have pain if they scored more than 1 in the subcategories of “Lower limb pain” of the GLFS-25. The Asia working group for sarcopenia (AWGS) criteria [2] were used for evaluating sarcopenia, although the normal WS criterion was changed from less than 0.8 m/s to less than 1.0 m/s. Altogether, the participants were classified into 4 groups: nonsarcopenia (NSp), nonsarcopenia with pain (NSpP), sarcopenia (Sp), and sarcopenia with pain (SpP) using the sarcopenia and pain criteria.

2.4. Statistical analysis

Continuous variables were compared among the 4 groups using the Kruskal-Wallis test and *post hoc* multiple comparison Steel-Dwass test. Categorical variables were analyzed using the chi-square test. Analysis of covariance (ANCOVA) was used to compare motor function and body composition with or without lower limb pain adjusting for age, sex, BMI, and presence of sarcopenia. Statistical analyses were conducted using JMP ver 13.0 for Mac (SAS Institute Japan Ltd., Tokyo, Japan), and the significance level was set at less than 5%.

3. Results

Table 1 shows a comparison of the prevalence of pain between the NSp and Sp group participants. The prevalence of sarcopenia in this study was 3.3% (n = 25); the number of participants with pain was 340. In the Sp group, the proportion of participants with pain was 60.0%, which was higher than that in the NSp group (44.3%), although the difference was not significant.

After further grouping on the basis of the presence or absence of pain (Table 2), the NSp group had 409 (53.9%), the NSpP group had 325 (42.8%), the Sp group had 10 (1.3%), and the SpP group had 15 participants (2.0%). The age of the participants differed among the groups, with the age group in the Sp group being slightly high. Regarding body composition parameters (Table 2), BMI and SMI in both the NSp groups were significantly higher than those in both the Sp groups ($P < 0.001$). However, the NSpP and SpP groups had a tendency to exhibit higher %BF ($P < 0.001$).

Regarding the comparison of motor functions (Table 2), participants in the SpP group had the lowest motor function values among all categories. The NSpP group had significantly lower motor function values than that of the NSp group. There was no significant difference between the NSpP and Sp groups. Regarding participants with sarcopenia, the SpP group had significantly lower motor function than the Sp group according to the FRT ($P = 0.026$). According to the GLFS-25, the NSp and SpP groups had high scores ($P < 0.001$).

Table 3 shows the results of the ANCOVA analysis. Participants with lower limb pain showed higher BMI (22.1 kg/m^2; $P < 0.001$) and GLFS-25 score (10.5 point; $P < 0.001$), lower SLS (39.0 seconds; $P = 0.041$), normal WS (1.30 m/s; $P = 0.002$), maximum WS of 1.77 m/s ($P < 0.001$), and 2-step value of 1.32 m/m ($P < 0.001$).

Table 4 shows the results of assessment of the history of fractures since age 50 years and falls in the past 1 year. Regarding fractures since age 50 years, high retention rates were noted in the SpP group (NSp, 10.0%; NSpP, 16.6%; Sp, 20.0%; SpP, 26.7%; $P = 0.026$). Participants in the NSpP and SpP groups had experienced more falls than those in the other groups (NSpP, 15.4%; SpP, 20.0% vs. NSp, 8.3%; Sp, 10.0%; $P = 0.021$).

Table 1
The prevalence of pain in sarcopenia or nonsarcopenia groups.

Pain	Nonsarcopenia	Sarcopenia
Total	734 (96.7)	25 (3.3)
Pain (+)	325 (44.3)	15 (60.0)
Pain (−)	409 (55.7)	10 (40.0)

Values are presented as number (%).
$P = 0.121$, chi-square test.

Table 2
Comparison of characteristics and motor functions in the 4 groups.

Characteristic	NSp (n = 409)	NSpP (n = 325)	Sp (n = 10)	SpP (n = 15)	P-value	P-value		
						NSp vs. NSpP; Sp; SpP	NSpP vs. Sp; SpP	Sp vs. SpP
Age, yr	69.3 ± 5.2	70.0 ± 5.4	73.5 ± 4.1	71.3 ± 5.7	0.018	ns; ns; ns	ns; ns	ns
Women[a]	199 (48.7)	198 (60.9)	5 (50.0)	8 (53.3)	0.011	0.001; ns; ns	ns; ns	ns
BMI, kg/m^2	22.5 ± 2.7	23.4 ± 3.3	20.0 ± 2.3	20.7 ± 2.2	<0.001	<0.001; 0.040; ns	0.002; 0.003	ns
%BF, %	24.1 ± 7.4	27.2 ± 8.6	21.2 ± 7.7	24.9 ± 7.9	<0.001	<0.001; ns; ns	ns; ns	ns
SMI, kg/m^2	6.92 ± 1.06	6.93 ± 1.04	5.92 ± 0.63	6.06 ± 0.50	<0.001	ns; 0.016; 0.011	0.010; 0.005	ns
HGS, kg	29.6 ± 8.0	27.6 ± 8.4	22.1 ± 4.1	19.7 ± 6.6	<0.001	0.002; 0.023; <0.001	ns; 0.002	ns
SLS, s	54.2 ± 40.8	44.6 ± 38.3	46.6 ± 40.0	21.2 ± 28.7	<0.001	0.005; ns; <0.001	ns; 0.014	ns
FRT, cm	37.4 ± 5.2	36.3 ± 5.7	38.0 ± 4.7	31.0 ± 6.2	<0.001	0.030; ns; <0.001	ns; 0.003	0.026
Normal WS, m/s	1.43 ± 0.22	1.37 ± 0.23	1.31 ± 0.42	1.19 ± 0.19	<0.001	0.004; ns; <0.001	ns; 0.010	ns
Maximum WS, m/s	1.91 ± 0.28	1.81 ± 0.28	1.82 ± 0.47	1.61 ± 0.23	<0.001	<0.001; ns; <0.001	ns; 0.023	ns
2-Step value, m/m	1.42 ± 0.15	1.35 ± 0.16	1.32 ± 0.21	1.26 ± 0.16	<0.001	<0.001; ns; 0.002	ns; ns	ns
KES, Nm/kg	1.78 ± 0.55	1.61 ± 0.53	1.57 ± 0.35	1.43 ± 0.38	<0.001	<0.001; ns; ns	ns; ns	ns
GLFS-25, point	2.5 ± 2.9	8.7 ± 7.5	4.6 ± 5.9	14.1 ± 10.9	<0.001	<0.001; ns; <0.001	0.038; ns	0.025

Values are presented as mean ± standard deviation or number (%).
NSp, nonsarcopenia; NSpP, nonsarcopenia with pain; Sp, sarcopenia; SpP, sarcopenia with pain; BMI, body mass index; %BF, body fat percentage; SMI, skeletal muscle mass index; HGS, handgrip strength; SLS, single leg standing; FRT, functional reach test; WS, walking speed; KES, knee extension strength; GLFS-25, 25-question geriatric locomotive function scale; ns, no significance.
Kruskal-Wallis test and *post hoc* Steel-Dwass test.
[a] Chi-square test and post hoc Residual analysis.

Table 3
Comparison of motor functions and body compositions by presence of sarcopenia.

Variable	Lower limb pain		p-value
	With	Without	
BMI[a], kg/m^2	22.1 ± 0.3	21.1 ± 0.3	<0.001
%BF, %	26.3 ± 0.3	26.2 ± 0.4	ns
SMI, kg/m^2	6.75 ± 0.05	6.73 ± 0.05	ns
HGS, kg	25.5 ± 0.5	26.0 ± 0.5	ns
SLS, s	39.0 ± 3.9	44.4 ± 3.9	0.041
FRT, cm	35.3 ± 0.6	36.1 ± 0.6	ns
Normal WS, m/s	1.30 ± 0.02	1.35 ± 0.02	0.002
Maximum WS, m/s	1.77 ± 0.03	1.84 ± 0.03	<0.001
2-Step value, m/m	1.32 ± 0.02	1.37 ± 0.02	<0.001
KES, Nm/kg	1.55 ± 0.05	1.61 ± 0.05	ns
GLFS-25, point	10.5 ± 0.6	4.7 ± 0.6	<0.001

Values are presented as adjusted mean ± standard deviation.
BMI, body mass index; %BF, body fat percentage; SMI, skeletal muscle mass index; HGS, handgrip strength; SLS, single leg standing; FRT, functional reach test; WS, walking speed; KES, knee extension strength; GLFS-25, 25-question geriatric locomotive function scale; ns, no significance.
Covariance analysis adjusted by age, sex, BMI, and presence of sarcopenia.
[a] Adjusted by age, sex and presence of sarcopenia.

4. Discussion

Sarcopenia is known to be a frailty-associated condition in elderly individuals. Therefore, several patients with sarcopenia potentially experience pain; however, this has not been clearly elucidated. According to the results of this study, participants with pain had lower motor function. Moreover, when lower limb pain was present in addition to sarcopenia, the motor function further declined.

Previous research has reported the prevalence of sarcopenia to be from 7.5% to 8.2% in community-dwelling elderly people [8], although in this study it was 3.3%. The normal WS of participants in this study was 1.19–1.31 m/s, which was faster than 0.8 m/s in the AWGS criteria and 1.0 m/s in the frailty criteria, even though we included participants with sarcopenia. Thus, it may be inferred that more healthy participants were enrolled in this study. However, 340 participants (44.8%) had lower limb pain. Especially, the sarcopenia groups had a higher tendency toward retention than did the non-sarcopenia groups, although there was no significant difference.

It was reported that participants with osteoarthritis had a higher BMI [9,10]. In this study, the NSpP group participants had higher BMI and %BF, whereas in the SpP group, %BF was high, although the difference was not significant, and BMI was low. In addition, the groups with pain had significantly lower motor functions and a higher GLFS-25 score than the groups without pain. Hirano et al. [11] reported that low back and knee pain were associated with declining motor function and QoL. The present study had similar results to those of the previous report. The GLFS-25 has a cutoff of over 7 points at stage 1 and over 16 points at stage 2, wherein stage 1 refers to the beginning of decline in locomotive functions and stage 2 refers to a progressive decline in locomotive functions [12]. The participants in the NSpP group had a mean GLFS-25 score of 8.7 points, which is close to the cutoff point for stage 1. In addition, in the SpP group, the GLFS-25 score was 14.1 points, which was close to the stage 2 cutoff point. Iizuka reported that low back pain, shoulder pain, and knee pain were associated with the screening results for locomotive dysfunction by the GLFS-25 [13]. The results of this study corroborate this observation. In terms of the body composition, participants with sarcopenia had lower SMI and BMI, although %BF was higher in participants with pain.

The ANCOVA analysis participants with lower limb pain showed significantly low SLS, normal and maximum WS, and 2-step value scores. Their BMI and GLFS-25 score were high. This result showed

Table 4
Comparison of experience of fracture and falls.

Variable	NSp (n = 409)	NSpP (n = 325)	Sp (n = 10)	SpP (n = 15)	P-value	P-value		
						NSp vs. NSpP; Sp; SpP	NSpP vs. Sp; SpP	Sp vs. SpP
Fractures since the age of 50 years	41 (10.0)	54 (16.6)	2 (20.0)	4 (26.7)	0.026	0.009; ns; ns	ns; ns	ns
Falling in the past 1 year	34 (8.3)	50 (15.4)	1 (10.0)	3 (20.0)	0.021	0.003; ns; ns	ns; ns	ns

Values are presented as number (%).
Fisher exact test and post hoc Residual analysis.
NSp, nonsarcopenia; NSpP, nonsarcopenia with pain; Sp, sarcopenia; SpP, sarcopenia with pain; ns, no significance.

that lower limb pain was related to decline in motor function with or without sarcopenia.

The participants with sarcopenia and lower limb pain were significantly older and had lower motor function compared to participants experiencing lower limb pain without sarcopenia. Furthermore, motor function values further declined when pain was present in addition to sarcopenia. The FRT was lower in the SpP group than in the Sp group. In addition, the mean SLS time in the SpP group was the lowest, at 21.1 s. Sakamoto et al. [14] reported that it is necessary for elderly people older than 70 years to have an SLS time of over 30 s to avoid falling. In this study, the participants were approximately 70 years old. Only the SpP group participants had a mean SLS time under 30 s and they were speculated to be at high risk for falling. The SpP group showed the highest GLFS-25 score. This could be because the SpP group was not only dealing with pain but also possibly difficulty performing activities of daily living, although subitems of GLFS-25 were not analyzed in this study. In brief, participants with sarcopenia and pain experienced more difficulties in daily activities than participants in other groups.

In addition, the SpP group had a higher history of fractures since age 50 years and falls in the past 1 year, although there was no statistical significance. Falling in the past 1 year was a major factor determining falling risk, and it was reported to be the strongest associated risk factor for multiple falls in a previous 5-year longitudinal study [15]. The history of fractures since age 50 years is thought to be associated with osteoporosis. Hip fractures are also associated with osteoporosis, and the prevalence of hip fractures progressively increases with age over 50 years [16]. Hagino et al. [17] reported that in comparison with the general population, women $\geq$65 years of age who sustained an initial hip fracture, were four times more likely to sustain an additional hip fracture. Sarcopenia was also reported to be associated with osteoporosis [5]. Thus, it was speculated that participants of the SPp group showed a higher risk of falls and fractures compared to other groups. However, the symptomatic period of pain, fracture, and falls was not researched. Therefore, these results cannot explain more in detail the relationship between pain and fracture.

In this study, participants with pain had lower motor function than did those without pain. Furthermore, the NSpP group had a higher incidence of falls and fractures than did the NSp group, and the motor function of the NSpP group was similar to that of the Sp group. Thus, evaluating pain might become an effective screening criterion for low motor function. Furthermore, our results indicate that declining motor function and risk of falls and fractures will also increase with the presence and extent of sarcopenia. Therefore, we speculate that evaluating lower limb pain could be useful in community-dwelling elderly people with or without sarcopenia.

This study has some limitations. The prevalence of sarcopenia was low because the participants were mostly healthy, leading one to believe there might be a bias. Moreover, the evaluation of pain was done using self-reported questionnaires; hence, some amount of bias was unavoidable. In addition, the cause of pain and sarcopenia, symptomatic period, and details of location of pain were unclear. Therefore, our study could not explain the causal relationship between pain and other outcomes.

5. Conclusion

Altogether, in this study, body composition, motor function, and the incidence of falls and fractures were compared among four groups (NSp, NSpP, Sp, and SpP) of community-dwelling people between 65 and 79 years of age. Our results indicated that the participants with pain had a higher percentage of BF and lower motor function and that sarcopenia further decreased motor function. Furthermore, participants with lower limb pain had more histories of fractures since the age of 50 and more falls in the past 1 year. Therefore, evaluating pain as well as sarcopenia in community-dwelling elderly people may be useful for risk assessment of motor dysfunction.

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

Acknowledgments

The research described in this paper was funded by a grant to MEXT KAKENHI Grant-in-Aid for Young Scientists B (No. 25870680), Japan Foundation for Aging and Health and Japanese Society for Musculoskeletal Medicine. **ORCID**. Maruya Kohei: 0000-0001-5386-8450. Fujita Hiroaki: 0000-0002-7469-1372. Arai Tomoyuki: 0000-0001-5138-601X. Asahi Ryoma: 0000-0002-7475-795X. Morita Yasuhiro: 0000-0002-4934-9188. Ishibashi Hideaki: 0000-0001-7769-9751.

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