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Original article

The association of dynapenia with whether participants were subject to long-term care prevention or not in the Japanese long-term care insurance system: A pilot study

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ABSTRACT

Objective: The purpose of this study was to investigate the association of dynapenia, determined by lower limb muscle strength, and sarcopenia with whether participants were subject to long-term care prevention (LCP) in the Japanese long-term care insurance system.

Methods: This was a cross-sectional study. The participants were 108 older adults (78.1±7.1 years, male=20), including 45 older adults who were subject to LCP (82.8±5.4 years, male=6) and 63 healthy older adults (74.7±6.2 years, male=14). Age, sex and comorbidities were collected as basic information. Height, weight, and muscle mass were measured as body composition, and grip strength, lower limb muscle strength, and gait speed were measured as physical functions. Sarcopenia was determined according to the definition of Asian Working Group for Sarcopenia in 2019. Dynapenia was determined using lower limb muscle strength. For the statistical analysis, the analysis was divided into two groups according to whether participants were subject to LCP or not. Next, we divided the participants into two groups, sarcopenia and dynapenia, and compared their physical characteristics and classification of LCP. Lastly, we used logistic regression analysis with dynapenia and sarcopenia as independent variables; age and gender as adjustment factors, and whether to undergo LCP as the dependent variable.

Results: Dynapenia and sarcopenia were present in 17% and 26% of the participants. As a result of examining the association of dynapenia and sarcopenia with whether participants were subject to LCP or not, only dynapenia was found to be a significantly related factor (odds ratio: 4.6, P value: 0.025).

Conclusion: Dynapenia was more closely related to whether participants were subject to LCP or not than sarcopenia.

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INTRODUCTION

In Japan's super-aging society, extending healthy life expectancy has become an urgent issue. Sarcopenia has received attention as an important concept for extending healthy life expectancy in older adults. Sarcopenia has traditionally been defined as an age-related loss of muscle mass. However, because muscle strength is more associated with various adverse events such as falls, fractures, physical disability, and mortality than muscle mass, in 2018, the European Working Group on Sarcopenia in Older People[1] definition was revised to state that muscle strength is the most important parameter. In contrast, as a concept focusing on muscle strength, Clark et al.[2] proposed dynapenia in 2008, which means age-related loss of muscle strength.

Dynapenia has been attributed to both the nervous system and muscular factors. The nervous system factors include decrease in the descending excitatory upper spinal cord, decrease in alpha motor neurons, and reduction in the recruitment of motor units[3]. In contrast, the muscular factors include not only loss of muscle mass but also infiltration of fat cells into muscle fibers[4]. As loss of muscle mass is only partially related to loss of muscle strength, sarcopenia and dynapenia may be associated with different outcomes. In addition, loss of muscle strength is said to occur earlier than loss of muscle mass[5], and it is possible that the patient may already have dynapenia before presenting with sarcopenia. In validation that included sarcopenia and dynapenia, Neve et al.[6] examined the association between various risk factors in older adults and reported that sarcopenia was mainly associated with smoking and nutritional status, while dynapenia was mainly associated with hospitalization interventions. Alexandre et al.[7] and Benjumea et al.[8] examined the association of sarcopenia and dynapenia with physical and instrumental activities of daily living (IADL) disability and reported that only sarcopenia was associated with this disability.

However, in these reports, dynapenia was determined based on grip strength. Manini et al.[9] recommended using lower limb muscle strength, which is closely related to gait and physical function, to determine dynapenia. Grip strength can only explain about 40% of lower extremity muscle strength[10]; hence, grip strength may not properly indicate dynapenia.

In Japan, the long-term care insurance system has been established as a means for the entire society to support older adults who need long-term care[11]. In the long-term care insurance system, people are certified as needed support or eligible for preventive care service, as a preliminary step to determine if they require nursing care, and preventive care services and life support services are provided. Since it is believed that low muscle strength precedes muscle mass, it is possible that these people who are certified as needing support and who are eligible for nursing care prevention services have more dynapenia. Early detection of dynapenia may be more effective in preventing nursing care than in determining sarcopenia. Therefore, this study examined whether dynapenia, determined by lower limb muscle strength, or sarcopenia was more associated with the presence or absence of long-term care prevention (LCP).

METHODS

Study design

This cross-sectional study used part of the results of a study of older adults living in Ibaraki City, which was conducted as a collaborative project between Aino University and Ibaraki City from August 2018 to February 2019.

Participants

The participants were 133 older adults living in Ibaraki City; older adults who were subjected to LCP and healthy older adults (robust) were included. The inclusion criteria were men and women aged 65 years or older living in the community. Participants were recruited by the Ibaraki City Longevity Care Division and the Regional Comprehensive Support Center using public relations media. Exclusion criteria were as follows: participants in need of nursing care; those under 65 years; those who suffered from myocardial infarction or stroke within the last 6 months; those who suffered from angina pectoris, heart failure, or severe arrhythmia; those with a systolic blood pressure of ≥180 mmHg or a diastolic blood pressure of ≥110 mmHg; those with acute inflammatory diseases; those at risk of sudden change or deterioration in health due to exercise; those with pacemakers, artificial joints, or other devices or equipment implanted in the body; and those with severe dementia (difficulty understanding instructions). Of the 133 participants, those with missing measurements or information were excluded and 108 participants were included in the analysis (Fig 1).

In this study, consent was obtained after explaining the purpose of the study, measurement contents, protection of personal information, etc. to the participants in accordance with the Declaration of Helsinki, both verbally and in writing. This study was approved by the Research Ethics Committee of Aino University (2019-011).

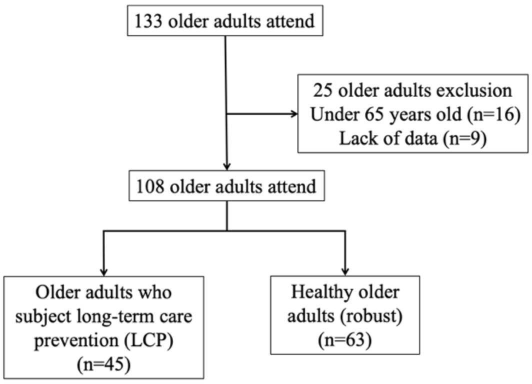

Figure 1. Participants recruitment chart

Definition of categories of participants

We defined older adults who were subject to LCP as those who were certified as needing support and those who were eligible for preventive care services.

Certification of needed support is defined as "requirement of support that is particularly conducive to reducing or preventing the deterioration of a condition that requires constant nursing care for all or part of the basic activities of daily living, such as bathing, excretion, and eating, for a period of time specified by an Ordinance of the Ministry of Health, Labour and Welfare due to physical or mental disabilities"[11]. In the long-term care insurance system, the applicant applies to the municipality for certification as requiring long-term care, and based on the results of a survey of the applicant's physical and mental condition by the municipality's certification investigator and the opinion of the applicant's doctor, a computerized primary judgment is made, followed by a secondary judgment by a specialist. The state of needing nursing care is defined as "a state in which a person is expected to require constant nursing care for all or part of basic daily activities such as bathing, toileting, and eating for a period of time specified by the Ministry of Health, Labour and Welfare Ordinance due to physical or mental disabilities"[11]. Needing support is classified into "Class 1", which requires less support, and "Class 2", which requires more support, depending on the condition of the participants. Those who require nursing care are distinguished from those who need support and are excluded from the scope of this study.

Those who are eligible for care prevention service are defined as those who are not classified as requiring support in the certification for long-term care but who are judged by the Kihon checklist to be at risk of requiring support or care. The Kihon checklist is a tool used in Japan to identify the risk of decline in the functions of older adults' daily lives at an early stage and link it to nursing care services. In total, 25 questions are included in the checklist, and its usefulness in predicting the need for nursing care has been proven[12]. The breakdown of the 25 items is as follows: No. 1 to 5 are questions about activities of daily living; No. 6 to 10, about motor functions; No. 11 and 12, about nutritional status; No. 13 to 15, about oral functions; No. 16 and 17, about confinement; No. 18 to 20, about dementia; and No. 21 to 25, about depression. The applicable criteria for persons subject to the nursing care prevention project are 10 or more items from No. 1 to 20; three or more items from No. 6 to 10; two items from No. 11 to 12; two or more items from No. 13 to 15; one item from No. 16 to 17; one or more items from No. 18 to 20; and two or more items from No. 21 to 25[13].

Robust participants were defined as those who were not certified as subject to PLC.

Measurements

Basic information, such as information on age, gender, comorbidity, and whether participants were subject to LCP or not, were obtained using a questionnaire.

For body composition information, height, weight, body fat, and muscle mass were measured. Muscle mass was measured using a high-precision body composition measuring instrument InBodyS10 (InBody Japan, Tokyo, Japan). InBodyS10 utilizes the segmental MFBIA method with six types of currents: 1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz, and 1 MkHz. The measurements were taken with the patient in the standing position, and electrodes were attached to the inner and outer ankles of both feet, middle finger, and thumb of both hands, during which the patient stood still for approximately 2 minutes. To exclude the effects of food and water intake, measurements were conducted by avoiding the time immediately after meals. No specification was made for food or water intake on the previous day. Muscle mass was calculated by summing the muscle mass of all four limbs and dividing it by the square of the height as the appendicular skeletal muscle mass (ASMM).

Grip strength was measured using a Smedley-type grip strength meter (Digital Handgrip Meter KEEP, MACROSS Inc. Tokyo, Japan). To avoid the risk of falling, the measurement posture was a seated position according to the SAGE study[14], and the measurement limb position was a drooping upper limb and elbow extension without touching the trunk.

Lower limb muscle strength was measured using the Locomoscan (ALCARE Co., Ltd., Tokyo, Japan). The Locomoscan is a recently developed instrument that mainly measures the quadriceps strength. The measurement position was a long sitting position with a slight posterior pelvic tilt (both upper limbs were placed backward to support the sitting position). The force sensor was positioned at the popliteal fossa, and the ankles of the lower limbs to be measured were fixed with a belt. The reaction force to the popliteal fossa produced when the ankle belt was kicked upward was measured. Grip strength and lower limb muscle strength were measured twice on each side, and the maximum value was taken as the measured value.

The gait speed was measured on a 6-m measuring path, with 1 m acceleration and deceleration paths before and after the 6-m measuring path. Gait was done with the instruction "as fast as usual." The number of measurements was 1, and the measured values were taken to the first decimal place. The gait speed was calculated by dividing the gait distance of 6-m by the gait time.

Definition of sarcopenia and dynapenia

Sarcopenia was defined according to the definition published by the Asian Working Group for Sarcopenia in 2019[15] as a decrease in ASMM (<7.0 kg/m2 for men and <5.7 kg/m2 for women) plus loss of muscle strength (grip strength, <28 kg for men and <18 kg for women), and/or reduced physical function (gait speed, <1.0 m/sec).

As for dynapenia, it was defined as loss of lower limb muscle strength without loss of muscle mass[9]. The cut-off value for dynapenia was defined as less than the mean lower limb muscle strength of Japanese men and women aged 20–39 years -2 SD (< 251 N for men, < 227 N for women)[16].

Statistical analysis

First, the analysis was divided into two groups according to whether participants were subject to LCP or not. Next, we divided the participants into two groups, sarcopenia and dynapenia, and compared their physical characteristics and classification of LCP. Nominal variables were analyzed using the χ-square test or Fisher's direct probability test, and continuous variables were analyzed using Student's t-test.

Lastly, we analyzed the association of dynapenia and sarcopenia with whether participants were subject to LCP or not using logistic regression analysis, dynapenia and sarcopenia as independent variables, age and gender as adjustment factors, and whether participants were subject to LCP or not as the dependent variable. The analysis was performed using two models. In Model 1, dynapenia and sarcopenia were the independent variables; in Model 2, dynapenia and sarcopenia were the independent variables with age and gender as adjustment factors. The forced entry method was used to input variables.

We also calculated the effect size using a post hoc test. To compare the two groups, LCP and Robust, and dynapenia and sarcopenia, Cohen's *d* was calculated for analysis using the Student's t-test, and Cramer's *V* was calculated for analysis using the χ-square test or Fisher's direct probability test. We considered small, medium, and large effect sizes to be indicated by *d* or *V* values of 0.1, 0.3, and 0.5, respectively. In addition, the Hosmer-Lemeshow test and calculation of the percentage of correct classifications were conducted to examine the goodness of fit of the regression model for logistic regression analysis. The calculation of Cohen's *d* and Cramer's *V* and Hosmer-Lemeshow test were all performed using a statistical software. All statistical analyses were performed using SPSS version 27 for Windows (IBM Japan Corporation, Tokyo, Japan). The level of statistical significance was set at $p<0.05$.

RESULTS

The determination percentages of dynapenia and sarcopenia were 17% and 26% for all participants, 24% and 40% for older adults

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Table1. Participants' characteristics

	Total (n=108)	Older adults who subject LCP (n=45)	Robust (n=63)	*P* value*	effect size**
Men. n	20 (19)	6 (13)	14 (22)	0.317	0.11[a]
Age. years	78.6 (7.1)	82.8 (5.4)	74.7 (6.2)	<0.001	1.37[b]
Hight. m	1.54 (0.07)	1.52 (0.08)	1.55 (0.07)	0.050	0.39[b]
Weight. kg	55.4 (9.6)	54.3 (10.6)	56.2 (8.8)	0.314	0.58[b]
Comorbidity					
musculoskeletal disease. n	30 (28)	17 (38)	13 (21)	0.080	0.19[a]
cardiovascular disease. n	56 (52)	29 (64)	27 (43)	0.033	0.21[a]
respiratory system diseases. n	4 (4)	1 (2)	3 (5)	0.639	0.07[a]
digestive system diseases. n	11 (10)	7 (16)	4 (6)	0.195	0.15[a]
endocrine, nutritional and metabolic diseases. n	27 (25)	8 (18)	19 (30)	0.179	0.14[a]
urogenital diseases. n	8 (7)	6 (13)	2 (3)	0.065	0.19[a]
neoplasm. n	7 (6)	1 (2)	6 (10)	0.235	0.15[a]
Number of comorbidities. n	1.3 (1.0)	1.5 (1.1)	1.2 (0.9)	0.067	0.36[b]
Physical function					
grip strength. kg	22.4 (7.1)	18.7 (4.3)	25.0 (7.0)	<0.001	0.98[b]
lower limb muscle strength. N	292 (138)	248 (111)	324 (148)	0.004	0.57[b]
gait speed. m/seconds	1.12 (0.34)	0.88 (0.26)	1.29 (0.28)	<0.001	1.53[b]
Appendicular skeletal muscle mass. kg/m^2	6.3 (1.0)	6.2 (1.0)	6.4 (1.0)	0.332	0.19[b]
Dynapenia. n	18 (17)	11 (24)	7 (11)	0.114	0.18[a]
Sarcopenia. n	28 (26)	18 (40)	10 (16)	0.007	0.27[a]
Classification of LCP					
eligible for care prevention service. n	11 (10)		-	-	-
needing support "class 1". n	21 (19)		-	-	-
needing support "class 2". n	13 (12)		-	-	-

Nominal variable, n (%); continous variable, mean (SD); LCP, long-term care prevention; Robust, healthy older adults. *Nominal variables were analyzed using the χ-square test or Fisher's direct probability test, and continuous variables were analyzed using the Student's t-test. ** Effect size between groups was calculated as Cramer's V using the χ-square test or Fisher's direct probability test and as Cohen's d using the Student's t-test. a, Cramer's V; b, Cohen's d.

Table2. Comparison of the characteristics of sarcopenia and dynapenia

	Sarcopenia (n=28)	Dynapenia (n=18)	*P* value*	effect size**
Men. n	5 (18)	5 (28)	0.480	0.12[a]
Age. years	82.5 (6.9)	78.6 (6.6)	0.061	0.58[b]
Number of comorbidities. n	1.4 (1.0)	1.7 (1.4)	0.298	0.32[b]
Physical function				
grip strength. kg	18.1 (4.6)	20.8 (6.9)	0.127	0.47[b]
lower limb muscle strength. N	228 (121)	162 (39)	0.031	0.67[b]
gait speed. m/seconds	0.90 (0.27)	0.97 (0.34)	0.478	0.22[b]
Appendicular skeletal muscle mass. kg/m^2	5.5 (0.7)	6.9 (1.1)	<0.001	1.76[b]
Older adults who subject LCP. n	18 (64)	11 (61)	1.000	0.13[a]
Classification of LCP				
eligible for preventive care service. n	6 (21)	2 (11)	0.453	0.13[a]
needing support "class 1". n	5 (18)	7 (39)	0.170	0.23[a]
needing support "class 2". n	7 (25)	2 (11)	0.448	0.17[a]

Nominal variable, n (%); continous variable, mean (SD); LCP, long-term care prevention; Robust, healthy older adults. *Nominal variables were analyzed using the χ-square test or Fisher's direct probability test, and continuous variables were analyzed using the Student's t-test. ** Effect size between groups was calculated as Cramer's V using the χ-square test or Fisher's direct probability test and as Cohen's d using the Student's t-test. a, Cramer's V; b, Cohen's d.

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Table3. Association of dynapenia and sarcopenia with whether participants were subjects LCP or not

	Crude model			Model 1			Model 2		
	odds ratio	95%CI	*P* value	odds ratio	95%CI	*P* value	odds ratio	95%CI	*P* value
Dynapenia	2.6	0.9~7.3	0.07	4.5	1.5~13.6	0.007	4.6	1.2~17.7	0.025
Sarcopenia	3.5	1.4~8.7	0.006	5.2	2.0~13.5	0.001	2.3	0.7~7.3	0.163

Model 1, the independent variables are dynapenia and sarcopenia; Model 2, the independent variables are dynapenia and sarcopenia and the adjustment factors are age and gender. The Hosmer-Lemeshow test p value and percentage of correct classifications were p=1.00 and 69.4%, respectively, for Model 1 and p=0.254 and 81.5%, respectively, for Model 2.

who were subject to LCP, and 11% and 16% for robust participants, respectively (Table 1). As a result of comparing older adults who were subjected to LCP with robust participants, there were significant differences in age, cardiovascular disease, grip strength, lower limb muscle strength, gait speed, and sarcopenia. Next, we compared the physical characteristics of sarcopenia and dynapenia with the number of LCP subjects. As a result, we found significant differences in lower limb muscle strength and ASMM, but no significant differences in the others. As a result of examining the association of dynapenia and sarcopenia with whether participants were subject to LCP or not, in model 1, both dynapenia and sarcopenia were extracted as significantly associated factors (odds ratio; 4.5, 5.2, respectively). In model 2, only dynapenia was extracted as a significantly associated factor (odds ratio, 4.6; Hosmer-Lemeshow test p value and percentage of correct classifications were p=0.254, 81.5%) (Table 3).

DISCUSSION

In this study, we examined the association of dynapenia and sarcopenia with whether participants were subject to LCP or not in 108 older adults in the community. This study showed that dynapenia was significantly associated with whether participants were subject to LCP or not.

Sarcopenia has been reported to be associated with various adverse events in systematic reviews[17-19] and is reported to be a significant factor in mortality, disability, falls, and fractures. However, there is no systematic review on the association between dynapenia and adverse events.

In a report examining the occurrence of adverse events, including sarcopenia and dynapenia, the SABE study[7] followed 478 subjects for 4 years and found that only sarcopenia was the factor associated with the occurrence of disability. Additionally, Benjumea et al.[8] reported that sarcopenia was a factor associated with IADL disability in a study of 534 older adult patients who visited a fall and fracture clinic. However the study results showed that dynapenia relationship functional disability in community-dwelling older adults at an earlier stage than sarcopenia, suggesting the importance of determining dynapenia separately from sarcopenia.

The major difference between sarcopenia and dynapenia is that in sarcopenia, the loss of muscle strength is conceptualized around the muscles, whereas dynapenia has been broadly classified into muscular and nervous system factors in its pathogenesis, and loss of muscle mass is only partially responsible for the loss of muscle strength. A study analyzed changes in thigh muscle mass and lower limb strength in older adults aged 70–79 years for 5 years and found that loss of muscle strength was 2–5 times greater than loss of muscle mass and that loss of muscle strength occurred even in subjects with increased muscle mass[5]. Moreover, Clark et al.[20,21] reported that muscle strength and muscle mass decreased significantly by 15% and 9%, respectively, after 4 weeks of disuse, and that the decrease in muscle strength was 50% due to neural factors and 40% due to muscular factors. In contrast, muscle mass plays an important role in metabolic resistance to withstand adverse events, such as to determine the prognosis in cancer surgery[22,23]. In addition, grip strength can only explain approximately 40% of lower limb muscle strength, and lower limb muscle strength is more related to gait and physical function than grip strength[10]. Therefore, it is necessary to use lower limb muscle strength to determine dynapenia to detect physical function decline at an earlier stage.

There is no doubt that the loss of both muscle mass and muscle strength is closely associated with various adverse events when both are present, but as long as loss of muscle strength and loss of muscle mass occur by different mechanisms and at different times, it is necessary to change the approach depending on the background of the participants and the intended outcome. Therefore, it is important to evaluate not only the results of the determination of muscle mass and muscle strength combined, but also those of muscle strength alone. While only sarcopenia was identified as an associated factor for adverse events in the previous study[6,7], only dynapenia was identified as a significant factor associated with adverse events in this study. The reason for this may be largely due to differences in outcomes and target groups. According to a previous study[24] comparing the characteristics of healthy older adults and those who were certified as needed support, those who were certified as needed support had less independence in "gait" and "bathing." On the other hand, a study has reported no difference in "gait" and "knee extension muscle strength" between those who were certified as needed support and those requiring light nursing care[25]. This suggests that there is a functional boundary in terms of physical function in the process of changing from healthy older adults to those who were certified as needed support. Since the decline in gait ability, which is one of the characteristics of those certified as requiring support, is closely related to a decline in lower limb muscle strength, dynapenia determined by lower limb muscle strength was also believed to be closely related to whether participants were subject to LCP or not.

However, in this study, no significant difference was found in the number of subjects with LCP in sarcopenia and dynapenia, but each LCP category showed a different distribution, suggesting that the participants may have different characteristics depending on the category in which they were certified. Therefore, it is necessary to increase the number of participants in the future and further examine the differences by certification category.

The first limitation of this study was the small sample size and the specificity of the participants. The recruitment of older adults who were subject to LCP from among older adults living in the community was not done randomly but through Ibaraki City and the community comprehensive support center. Therefore, the results of this study cannot be directly applied to the general older adult population. The elderly patients who were eligible for preventive health care services were assessed using a Kihon checklist, but not all the participants in this study underwent the Kihon checklist. Therefore, it is possible that there were potential targets for care prevention among the older adults who were considered healthy in this study, and the results of this study are limited to those who have been certified as requiring support under Japan's long-term care insurance system and who are eligible for long-term care prevention. In addition, because we did not know the content of the subjects' answers to the Kihon checklist in this study, we could not verify the relationship between answers and the status of motor function in the Kihon checklist, and thus, there may be potential confounding bias. The second limitation would be that since this study focused on comparing dynapenia and sarcopenia, it was not possible to analyze other health-related confounding factors, such as educational history, lifestyle, and number of medications. Finally, this study is tentative with regard to the determination of dynapenia, and the validity of the determination based on the method of correction of muscle strength and the equipment used needs to be further verified.

Conclusion

In this study, we examined the association of dynapenia and sarcopenia with whether participants were subject to LCP or not in 108 older adults in the community. Only dynapenia was identified as a significantly associated factor. The results suggest that it is important to determine dynapenia in terms of lower limb muscle strength, rather than sarcopenia alone, for participants subjected to long-term care prevention.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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