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Original Article

A Cross-Sectional Study on Metabolic Syndrome Parameters, the Nutritional Index, and Physical Status Associated with or Without the Possible Diagnosed Sarcopenia in Older Women Using A Propensity Score Matching Method

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Abstract

Objectives: To develop strategies against sarcopenia, physiological and biochemical data in older women were analyzed using propensity score matching. **Methods**: Fifty-six women aged ≥75 years with the AWGS calf circumference <33 cm were included in the sarcopenia risk group. Low muscle strength (handgrip strength <18kg) or low physical performance (five-times-sit-to-stand test ≥12s) were used the possible-sarcopenia group. Propensity score matching adjusted for age and BMI was performed between the possible-sarcopenia group with low muscle strength (or physical performance) and the sarcopenia risk group without low muscle strength (or physical performance). The comparison included nutritional index, metabolic syndrome parameters, BMD, and skeletal muscle mass index score between both groups. **Results**: The possible-sarcopenia group with low muscle strength exhibited significantly lower BMD (p=0.014) and skeletal muscle mass index score (p=0.002) compared to the sarcopenia risk group without low muscle strength. The possible-sarcopenia group with low physical performance exhibited significantly lower AST (p=0.034) compared to the sarcopenia risk group without low physical performance. **Conclusion**: These results suggest that older women with possible sarcopenia and low muscle strength may have reduced BMD and skeletal muscle mass index.

Keywords: BMD, Metabolic syndrome parameters, Sarcopenia, Skeletal muscle mass index, Women

Introduction

Sarcopenia is characterized by a decrease in skeletal muscle mass, accompanied by a loss of muscle strength and a decline in physical performance[1] It is classified into two types: primary sarcopenia (aging-related sarcopenia) for which there are no etiological factors other than aging, and secondary sarcopenia in which inactivity, various diseases, or the nutritional status decreases muscle mass[2-3]. A decreased skeletal muscle mass is associated with muscular atrophy caused by impaired muscle protein synthesis due

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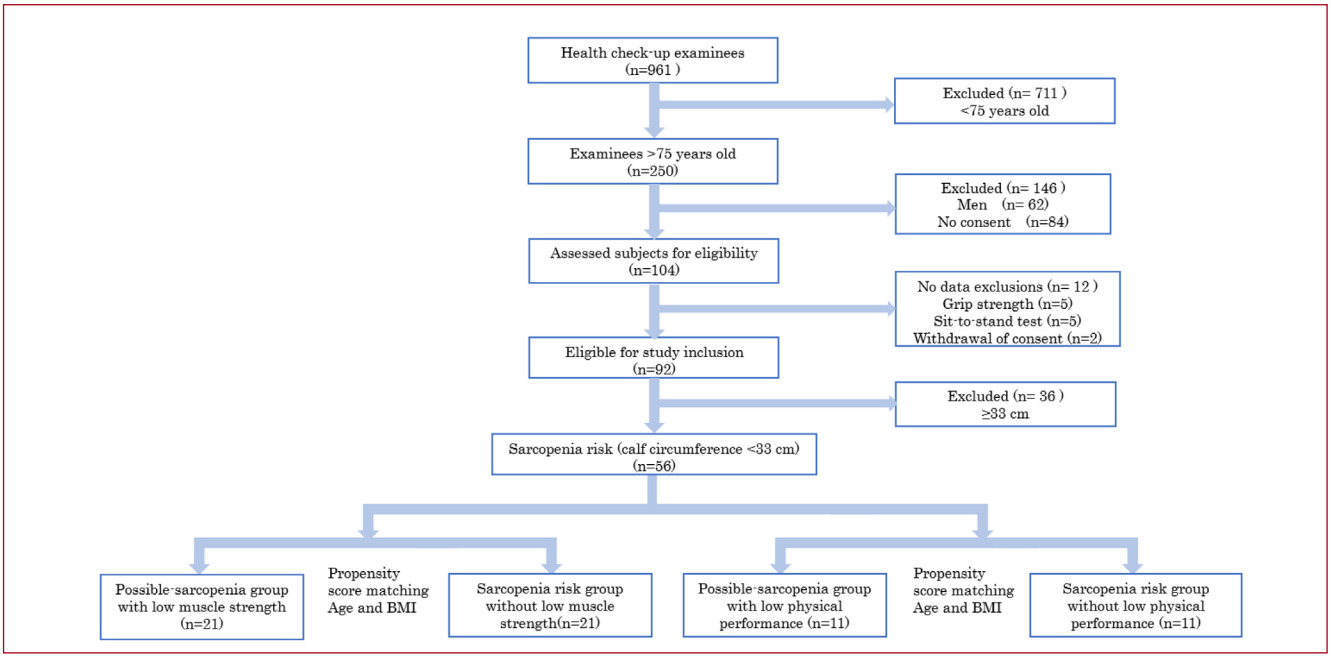

Figure 1. Flow diagram of subjects.

to aging-related reductions in the secretion of IGF-1 and testosterone and insulin resistance[4-7]. Impairments in muscle protein synthesis are associated with a hypoactivity-related decrease in mechanical stimuli to skeletal muscle, an insufficient protein intake, and deficiencies in various nutrients, including vitamin D[8,9]. Insulin resistance- or hypoactivity-related decreases in muscle protein synthesis have been implicated in muscle weakness related to lifestyle-related diseases, such as diabetes mellitus[10].

Park et al.[11] examined 2,675 subjects aged 70 to 79 years and demonstrated that decreases in the limb muscle mass were significantly greater in diabetics than in non-diabetics. Park et al.[12] investigated some male non-diabetics aged ≥65 years and indicated that decreases in limb muscle mass were greater in those with high-level insulin resistance. Abe et al.[13] examined 410 dyslipidemia patients aged 40 to 76 years and reported that age- and percent body fat-corrected high-density lipoprotein (HDL) cholesterol levels were significantly lower in those with sarcopenia. On the other hand, Sanada et al.[14] investigated 932 subjects aged ≥40 years and found no significant differences in blood triglyceride (TG) or HDL-cholesterol (HDL-C) levels or the total cholesterol (TC)/HDL-C ratio between those with and without sarcopenia. Abe et al.[13] classified hypertensive patients into normal, pre-sarcopenia, and sarcopenia groups and found no significant differences in blood pressure between these groups. Castillo et al.[15] indicated that diastolic blood pressure was lower in males with than in those without sarcopenia, whereas no significant differences were observed in women. These studies investigated the above parameters with respect to sex, and most of the findings obtained were from males because of the limited number of studies conducted solely on women. Furthermore, the ages of the subjects examined varied. Aging is regarded as a contributing factor to sarcopenia, and the onset of lifestyle-related diseases is also associated with aging. Therefore, these studies may have been affected by confounding factors, such as age and sex.

In the present study, we performed matching using a propensity score analysis with respect to the age and physical status of women aged ≥75 years[16,17], and divided subjects into groups with and without possible diagnosed sarcopenia based on the results of a physical fitness test. We compared metabolic syndrome parameters, the nutritional index (blood), and the results of a bone mineral density test and body composition test between those with and without possible diagnosed sarcopenia. The present results will contribute to the development of strategies to prevent the development of sarcopenia in women.

Materials and Methods

Participants

Among 961 residents of Mihara city, Hiroshima Prefecture aged ≥75 years who underwent a basic health check-up for older adults, 250 applied to participate in the present study. The contents of this study were explained to the applicants, and 104 women, from whom written informed consent on

participation was obtained, were enrolled as subjects. Ninety-two subjects with physical fitness test data were analyzed (Figure 1). Exclusion criteria were as follows: (1) individuals with psychiatric diseases, such as depression, (2) those diagnosed with dementia, (3) those in whom participation in this study may induce a rapid change in/the deterioration of the health status due to a history of a disease with movement limitation (heart disease or brain dysfunction), (4) those who were unable to respond to questions due to difficulties with lingual communication, and (5) those in whom study-related measurements were difficult.

Measurement items

The nutritional index (blood), metabolic syndrome parameters, bone mineral density, and body composition test were measured and the results of the physical fitness test were noted.

Albumin (g/dL) and TC (mg/dL) levels were measured as the nutritional index (blood). Blood pressure (systolic and diastolic [mmHg]), liver function (aspartate aminotransferase [AST, GOT][IU/L], alanine aminotransferase [ALT, GPT][IU/L], and γ-GTP [IU/L]), glucose metabolism (HbA1c [%]), and lipid metabolism TG[mg/dL], HDL-C[mg/dL], and LDL-C [mg/dL]) were measured. In the bone mineral density test, an X-ray bone mineral densitometry system (ALPHYS A, Hitachi, Ltd.) was used in the bone density examination. Bone mineral density (BMD) (mg) of the left forearm was then evaluated by dual-energy X-ray absorptiometry (DXA method). Based on calibrations repeated 16 times using the same equipment during the intervention period, cv (coefficient of variation) was 0.38%, which fell within the normal ranges established by Hitachi, Ltd.. However, when left-handedness or a surgery-related metal product in the left forearm was present, the BMD (mg) of the right forearm was used. In the body composition test, skeletal muscle mass was calculated by a bioelectrical impedance analysis (BIA) with a body composition monitor (MC-780A-N, TANITA CORPORATION). The skeletal muscle mass index (SMI) score (kg/m^2) was calculated as the appendicular skeletal muscle mass divided by height squared[18]. In the physical fitness test, the circumference of the lower calf, handgrip strength, and the result of the five-times-sit-to-stand test were measured. In the assessment of the lower calf circumference, each subject was placed in a sitting position and the thickest areas of the exposed left and right lower calf were measured once each using a tape measure. In the evaluation of handgrip strength, each subject was instructed to spread the lower limbs shoulder-width apart in a standing position and place the upper limbs along the side of the body in a both-elbow extension position. In this state, each subject held a grip dynamometer, and handgrip strength was measured twice on the left side and twice on the right side. In the five-times-sit-to-stand test, each subject held the shoulders while crossing the bilateral upper limbs in a sitting position on a 40-cm stand and then stood up and sat down, which was regarded as one session. The time needed to perform 5 consecutive sessions was measured using a stopwatch.

Criteria for a possible diagnosis of sarcopenia

The Asian Working Group for Sarcopenia 2019 (AWGS 2019) diagnostic criteria were used[19]. AWGS 2019 also introduces "possible sarcopenia," defined by either low muscle strength or low physical performance only, specifically for use in primary health care or community-based health promotion. This purpose is to provide early lifestyle intervention. The basic health check-up that are the subject of this study are also intended to provide early lifestyle intervention. Therefore, the criteria of the AWGS2019 in primary health care or community-based health promotion were used in this study.

The AWGS 2019 begin by screening either calf circumference (<33 cm in women), SARC (Screening tool for sarcopenia) -F (≥4), or SARC-CalF (≥11), to facilitate earlier identification of people at risk for sarcopenia. Then there are some criteria for those at risk for sarcopenia: low muscle strength is defined as handgrip strength <18 kg for women; criteria for low physical performance are 6-min walk test <1.0 m/s, Short Physical Performance Battery score ≤9, or five-times-sit-to-stand test ≥12 seconds.

In this study, people at risk for sarcopenia was initially extracted using calf circumference <33 cm in older women. And, the "possible-sarcopenia group with low muscle strength" was defined as subjects with handgrip strength <18 kg among people at risk for sarcopenia. In addition, the "sarcopenia risk group without low muscle strength" was defined as subjects with handgrip strength ≥18 kg among those at risk for sarcopenia. Similarly, handgrip strength criteria, women with low physical performance were initially extracted from those with calf circumference <33 cm, who were considered to be at risk for sarcopenia. And, the "possible-sarcopenia group with low physical performance" was defined as subjects with five-times-sit-to-stand test ≥12 seconds among people at risk for sarcopenia. In addition, the "sarcopenia risk group without low physical performance" was defined as subjects with five-times-sit-to-stand test <12 seconds among those at risk for sarcopenia.

Thus, the AWGS2019 criteria were used to determine the risk of sarcopenia and the criteria for low muscle strength and low physical performance were used to determine the possibility of sarcopenia. After risk of sarcopenia, the presence or absence of these criteria was compared with metabolic syndrome parameters, the nutritional index, and physical status. The metabolic syndrome parameters, BMD, and SMI score were compared between the possible-sarcopenia group with low muscle strength (or physical performance) and the sarcopenia risk group without low muscle strength (or physical performance).

Muscle strength	Possible-sarcopenia (with low muscle strength) (n=21)					Sarcopenia risk (without low muscle strength) (n=21)					p value
	mean	SD	min	-	max	mean	SD	min	-	max	
Age (y)	81.0	(4.0)	75.0	-	87.0	81.1	(4.6)	75.0	-	90.0	0.944
Height (cm)	145.7	(4.8)	138.8	-	154.5	148.7	(6.3)	132.4	-	161.3	0.095
Body weight (kg)	44.4	(4.8)	35.0	-	54.7	46.5	(5.5)	36.7	-	54.2	0.207
BMI	20.9	(2.2)	16.9	-	24.6	21.0	(2.1)	17.2	-	26.0	0.908
Physical performance	**Possible-sarcopenia (with low physical performance) (n=11)**					**Sarcopenia risk (without low physical performance) (n=11)**					**p value**
	mean	SD	min	-	max	mean	SD	min	-	max	
Age (y)	82.6	(3.4)	77.0	-	87.0	82.0	(3.3)	77.0	-	87.0	0.661
Height (cm)	145.5	(4.5)	138.8	-	153.6	147.8	(7.3)	132.4	-	159.5	0.374
Body weight (kg)	47.3	(3.7)	40.8	-	52.2	47.2	(6.0)	36.7	-	58.2	0.987
BMI	22.3	(1.7)	20.1	-	25.4	21.6	(1.8)	19.5	-	25.5	0.317

Table 1. Comparison of age and physical characteristics of possible-sarcopenia and sarcopenia risk groups in older females with and without low muscle strength or low physical performance.

Statistical analysis

Regarding muscle strength and physical performance, subjects were divided into groups with and without possible sarcopenia, and age and BMI were matched using a propensity score analysis[20]. Matching of the possible-sarcopenia group with low muscle strength was done with the sarcopenia risk group without low muscle strength. Matching resulted in 21 subjects in each group for possible-sarcopenia group with low muscle strength versus the sarcopenia risk group without low muscle strength. Similarly, matching the possible-sarcopenia group with low physical performance, we conducted matching with the sarcopenia risk group without low physical performance. Matching resulted in 11 subjects in each group for possible-sarcopenia group with low physical performance versus the sarcopenia risk group without low physical performance. The sample size was selected according to diastolic blood pressure and lowest/highest serum albumin levels using G-power[21,22]. Based on the findings of studies conducted by Yamamoto M.[23] on the relationship between lowest and highest serum albumin levels, and in consideration of results showing M1 = 71 (mean score of the lowest group), SD1 = 11, M2 = 83 (mean score of the highest group), and SD2 = 12, as well as one-sided α = 0.05 and power = 90%, the sample size per group was determined to be 19. 21 subjects, the number of subjects in each group matched in the comparison of the possible-sarcopenia group with low muscle strength and the sarcopenia risk group without low muscle strength, which met the calculated sample size. However, 11 participants per group was not enough to meet the sample size for the comparison between the possible-sarcopenia group with low physical performance and the group at risk of sarcopenia without low physical performance. The normality of data obtained on metabolic syndrome parameters, the nutritional index (blood), and the results of bone mineral density/SMI score/physical fitness tests was tested using the Shapiro-Wilk normality test. The values for albumin, TC, blood pressure (systolic and diastolic), glucose metabolism (HbA1c), HDL-C, LDL-C, and BMD of the forearm, for which normality was observed, were expressed as the mean (standard deviation) (W = 0.870 – 0.988, p = 0.077 – 0.993). The values for liver function (AST [GOT], ALT [GPT], and γGTP), neutral fat and SMI score, for which normality was not observed, were expressed as the median (25%-75%). To compare results between the possible-sarcopenia and sarcopenia risk group without low muscle strength or low physical performance, items for which normality was observed were analyzed using the Student's *t*–test. Items for which normality was not observed were analyzed using the Mann-Whitney U test. SPSS version 27.0 (IBM Japan, Tokyo, Japan) was used for statistical analyses. A p-value of 0.05 was considered to be significant.

Results

The results of comparisons of physical characteristics after propensity score matching are shown in Table 1. No significant differences were observed in age, height, body weight, or BMI between the possible-sarcopenia with low muscle strength or low physical performance and sarcopenia risk group without low muscle strength or low physical performance.

As shown in Table 2, differences in the means of the nutritional index, blood pressure, liver function, glucose metabolism, lipid metabolism, BMD, and SMI score were

		Muscle strength					Physical performance				
		Possible-sarcopenia (with low muscle strength) (n=21)		Sarcopenia risk (without low muscle strength) (n=21)		p-value	Possible-sarcopenia (with low physical performance) (n=11)		Sarcopenia risk (without low physical performance) (n=11)		p-value
		mean	(SD)	mean	(SD)		mean	(SD)	mean	(SD)	
Nutritional index	Albumin (g/dL)	4.25	(0.26)	4.36	(0.26)	0.180	4.22	(0.22)	4.33	(0.23)	0.270
	TC (mg/dL)	200.7	(32.5)	208.3	(34.0)	0.462	190.8	(31.2)	198.3	(23.2)	0.532
Blood pressure	Systolic (mmHg)	132.2	(19.5)	139.2	(16.9)	0.224	129.5	(24.0)	145.7	(20.8)	0.105
	Diastolic (mmHg)	70.0	(13.2)	77.5	(10.5)	0.051	70.4	(15.1)	75.2	(10.1)	0.391
Liver function	AST(GOT) (IU/L)*	15.0	(12.0-20.0)	17.0	(15.0-20.0)	0.245	21.0	(20.5-24.5)	25.0	(23.0-30.0)	0.034
	ALT(GPT) (IU/L)*	10.0	(7.0-15.0)	10.0	(7.0-15.0)	0.495	17.0	(15.0-19.0)	16.0	(14.0-21.5)	0.791
	γ-GTP (IU/L)*	17.0	(16.0-23.0)	20.0	(17.0-25.0)	0.250	18.0	(16.0-24.5)	21.0	(18.5-24.0)	0.576
Glucose metabolism	HbA1c(%)	5.70	(0.44)	5.67	(0.42)	0.832	5.82	(0.33)	5.85	(0.51)	0.846
Lipid metabolism	TG(mg/dl) *	76.0	(61.0-108.0)	71.0	(61.0-108.0)	0.850	83.0	(59.5-99.0)	68.0	(60.0-103.0)	0.948
	HDL-C(mg/dl)	67.3	(16.6)	77.9	(20.8)	0.075	59.6	(11.1)	72.5	(18.3)	0.062
	LDL-C(mg/dl)	117.1	(28.6)	115.2	(24.0)	0.812	115.3	(28.1)	108.6	(15.0)	0.498
Bone mineral density	left forearm (mg)	435.4	(61.5)	484.0	(60.6)	0.014	451.0	(66.4)	426.1	(56.9)	0.356
Skeletal muscle mass index score	(kg/m^2)*	5.78	(5.46-5.98)	6.20	(5.96-6.50)	0.002	6.18	(5.43-6.38)	6.16	(5.99-6.32)	0.599

*Student's t-test: mean (standard deviation). *: Mann-Whitney U test: median (25-75%).*

Table 2. Comparison of the nutritional index, blood pressure, liver function, glucose metabolism, lipid metabolism, bone mineral density, and skeletal muscle mass index of possible-sarcopenia and sarcopenia risk groups in older females with and without low muscle strength or low physical performance.

examined. BMD (p=0.014) and SMI score (p=0.002) were significantly lower in the possible-sarcopenia group with low muscle strength than in the sarcopenia risk group without low muscle strength. Diastolic blood pressure (p=0.051) and HDL-C levels (p=0.075) were slightly lower in the possible-sarcopenia group, although diastolic blood pressure and HDL-C levels did not reach statistical significance. In addition, the correlation between handgrip strength and BMD was calculated for the possible-sarcopenia group with low muscle strength (n=21), the sarcopenia risk group without low muscle strength (n=21), and the all subjects in both groups (n=42). The correlation between handgrip strength and BMD was r=0.087, p=0.707 for subjects with the sarcopenia risk group without low muscle strength, r=0.378, p=0.091 for those with the possible-sarcopenia group with low muscle strength, and r=0.427, p=0.005 for all subjects in both groups. Furthermore, AST (GOT) levels (p=0.034) were significantly lower in the possible-sarcopenia group with low physical performance than in the sarcopenia risk group without low physical performance. HDL-C levels (p=0.062) was also lower in the possible-sarcopenia group, although HDL-C levels did not reach statistical significance. There were no significant differences in BMD and SMI score between the possible-sarcopenia group with low physical performance and the sarcopenia risk group without low physical performance.

Discussion

In this study, the effects of confounding factors were suppressed by performing a data analysis of older female residents alone using propensity score matching. The present results revealed significant differences in BMD and SMI score. Mitsutake et al. adjusted for differences in the characteristics of patients with and without early rehabilitation service using propensity score matching[24]. Fisher et al. obtained showed that the risk of care needs was low in those receiving early rehabilitation service[25], and that it was possible to perform

a data analysis while minimizing the effects of confounding factors on disease control[24]. In the present study, a confounding factor (age and BMI)-suppressed analysis may also have been performed.

Regarding muscle strength, significant differences were noted in BMD and SMI score between the possible-sarcopenia and the sarcopenia risk groups. Bone formation is activated by mechanical stress from muscles. Inoue et al.[26] examined 495 patients (mean age: 76.5±7.2 years) and indicated that changes in BMD were associated with skeletal muscle mass. In a previous study, we found that the number of sit-ups was a preventive factor against reduction in BMD of the lumbar spine, and ante flexion in a sitting position was a preventive factor against reduction in BMD of the femoral neck. In other words, it can be inferred that muscle strength around the bone affects the BMD of the bone[27]. Rittweger et al. reported an increase in bone cross-sectional area after increasing muscle cross-sectional area through muscle strengthening[28]. These reports suggest the following process: mechanical load → increase in muscle strength → maintenance of BMD. In the present study, BMD was measured in the forearm of the possible-sarcopenia group with decreased handgrip strength, and a significant difference in forearm BMD may have been observed. In addition, SMI score was low in the possible-sarcopenia group with low muscle strength. Taniguchi et al. investigated 265 older female residents, and found that skeletal muscle mass was correlated with muscle strength, and strongly correlated with handgrip strength[29]. Chan et al. observed a statistically significant correlation between handgrip strength and upper and lower muscle mass in older women[30]. These studies support the finding of significantly lower SMI score in the possible-sarcopenia group with decreased handgrip strength in this study. On the other hand, there were no significant difference in BMD between the possible-sarcopenia group with low physical performance and the sarcopenia risk group without low physical performance. Hughes et al. examined the relationship between long-term changes in body composition and physical performance in older men and women[31]. The study results report that there was no decrease in BMD or skeletal muscle mass that would have affected physical performance decline. Instead, they suggest that the effects of weight change and physical activity are more important[31]. Therefore, the results of these studies of sarcopenia risk subjects support the findings of this study. Results of the correlation between handgrip strength and BMD, all subjects showed significant correlations, but no significant correlations were found the possible-sarcopenia group with muscle strength and the sarcopenia risk group without low muscle strength. In the possible-sarcopenia group with low muscle strength, there was a trend toward a positive, although not significant, correlation between handgrip strength and BMD. In older women at risk for sarcopenia, the association between grip strength and BMD differs with and without low muscle strength. In addition, in the possible-sarcopenia group with low muscle strength, reduced BMD, and reduced SMI score are suspected. The results of this study as a decrease in skeletal muscle mass indicated that falls may occur[32], and the fractures that occur during these falls may be due to a decrease in BMD[33]. Regarding blood pressure, Abe et al.[13] classified patients into normal, pre-sarcopenia, and sarcopenia groups and found no significant differences in blood pressure between these groups. And Castillo et al.[15] also indicated that diastolic blood pressure was lower in males with than in those without sarcopenia, whereas no significant differences were observed in females. On the other hand, Du et al.[34] reported that the risk of sarcopenia was lower in patients with a higher blood pressure, but concluded that this may reflect the relationship between hypertension and obesity. In the present study, blood pressure was low in the possible-sarcopenia group with low muscle strength.

Regarding physical performance, AST (GOT) levels were low in the possible-sarcopenia group with low physical performance. AST (GOT) produces amino acids by decomposing proteins. Since AST (GOT) levels are generally high in the liver, cardiac muscle, and skeletal muscle, these organs are more strongly affected by elevations in AST (GOT). Physical performance refers to motor function, and the muscle load may be greater in individuals with higher motor function. A previous study showed that increases in transaminase levels were commonly detected in the initial phase of diseases in the field of internal medicine, and also that abnormalities in AST (GOT) levels were more frequent than those in ALT (GPT) levels[35]. The present results suggest the potential of AST (GOT) and ALT (GPT) levels as indices for evaluating sarcopenia with low physical performance, which is novel. Based on these findings, daily exercise may have resulted in a greater skeletal muscle load in the sarcopenia risk group without low physical performance in the present study, thereby increasing the levels of inflammation parameters and AST (GOT) levels.

In the present study, HDL-C levels were low in the possible-sarcopenia group with low muscle strength or low physical performance. Changes in HDL-C levels may be associated with physical activity-induced increases in lipoprotein lipase (LPL) activity or a reduction in hepatic triglyceride lipase (HTGL) activity[36,37]; therefore, HDL-C levels may be elevated in individuals with higher physical performance, namely, motor function[38]. Lee et al. cross-sectionally examined metabolic syndrome indices associated with grip strength in women and found that HDL-C levels, fasting glucose, HbA1c, and log high sensitive CRP showed significant associations[39] These studies suggested that physical activity improved muscle strength and endurance increased HDL-C levels in older women.

The physical constitution of the present subjects was similar to that of subjects of the same age in another survey conducted in Japan[40]. Accordingly, the results of the present study, at least from the viewpoint of physical constitution,

are considered to be valid to represent older women in Japan.

As a limitation of the present study, subjects were voluntary participants in a health survey and not patients at medical institutions or individuals admitted to facilities; therefore, subjects may have been biased towards those with a good health condition or high-level health consciousness. The health survey for which the subjects were recruited for this study will be conducted at a community hall or other location. The subjects whose were able to come to this location and to drive a car were targeted. The subjects in this study are health conscious and can walk independently. Therefore, it is assumed that the number of subjects with possible sarcopenia in this study was smaller than the number of subjects diagnosed with sarcopenia in the AWGS 2019. In addition, the effects of confounding factors were minimized by matching with a propensity score analysis[14,15,41]. However, this was a cross-sectional study and no individual dietary survey was conducted; therefore, we cannot deny the heterogeneity of lifestyles. Since the number of subjects in the possible-sarcopenia group with low physical performance was small, we also cannot deny the possibility of a deviation in the results obtained. These issues need to be considered in further studies. Nevertheless, significant differences were noted in BMD and SMI score in the possible-sarcopenia group with low muscle strength, which is a novel result.

Conclusions

In the present study, women over 75 years of age with a calf circumference of less than 33 cm on AWGS were included in the sarcopenia risk group. Then, low muscle strength (handgrip strength <18kg) or low physical performance (five-times-sit-to-stand test ≥12s) were used the possible-sarcopenia group. Propensity score matching adjusted for age and BMI was performed between the possible-sarcopenia group with low muscle strength (or physical performance) and the sarcopenia risk group without low muscle strength (or physical performance). Results of metabolic syndrome parameters, nutritional indices (blood), BMD and SMI score were compared between groups. In the results, the possible-sarcopenia group with low muscle strength exhibited significantly lower BMD and SMI score compared to the sarcopenia risk group without low muscle strength. And, the possible-sarcopenia group with low physical performance exhibited significantly lower AST (GOT) levels compared to the sarcopenia risk group without low physical performance.

The present study suggests a decrease in BMD and skeletal muscle mass index in older women with possible sarcopenia associated with low muscle strength.

Ethics approval

The present study obtained ethical approval from the Ethics Committee of the Prefectural University of Hiroshima (approval no. 2OMH017).

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Authors' contributions

Study conception and design: TI, YK. Acquisition of data: SA, YK, YO, MN, MK. Analysis and interpretation of data: TI, MK, YO, MN, KA. Drafting of manuscript: TI, MK, YO. Critical revision of manuscript: TI, SA, MK. All authors read and approved the final version of the mansucript

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Possible-sarcopenia (with low muscle strength) (n=21)		Sarcopenia risk (without low muscle strength) (n=21)		All subjects in both groups (n=42)	
r	p	r	p	r	p
0.378	0.091	0.087	0.707	0.427	0.005

Supplemental Table 1. Correlation between handgrip strength and BMD in the possible-sarcopenia with low muscle strength and sarcopenia risk without low muscle strength groups.