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Original Article

Comparison of Muscle Strength and The Ability of Activities of Daily Living in Older Adults Requiring Care With and Without Hypertension

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Abstract

Objectives: Few studies have examined whether older adults requiring care who have hypertension have lower muscle mass, muscle strength, physical function, and activities of daily living (ADL) capacity than those without hypertension. **Methods**: This study included 163 participants aged ≥65 years who required care. The appendicular muscle mass was measured using bioelectrical impedance analysis. Handgrip and leg muscle strength (LMS) were used to assess muscle strength, and short physical performance batteries were used to assess physical function. The ADL capacity was evaluated using the Barthel Index. Participants were divided into two groups based on the absence or presence of hypertension (non-HY and HY groups, respectively). **Results**: LMS and ADL capacity were significantly lower in HY group than that in non-HY group. Multiple logistic regression analysis showed that LMS and ADL capacity were significantly associated with the absence or presence of hypertension, even after adjusting for confounding factors ($p < 0.05$). Moreover, LMS was a significant independent predictor of ADL capacity (bathing and ascending and descending stairs, $p < 0.05$). **Conclusions**: These results suggest that maintaining or improving LMS may help preserve ADL capacity in older adults requiring care who have hypertension.

Keywords: Activities of daily living, Hypertension, Leg muscle strength, Long term care, Sarcopenia

Introduction

Sarcopenia is characterized by age-related loss of muscle mass, strength, and physical function. A previous study has reported that sarcopenia affects muscle strength, physical function, and hypertension[1]. Muscle mass has been associated with arterial stiffness, whereas reduced grip strength has been implicated in the development of hypertension[2,3]. Therefore, the proportion of participants with reduced muscle mass, muscle strength, and physical function may be higher in those with hypertension than in those without. These declines can, in turn, impair the ability to perform activities of daily living (ADL)[4].

According to a report by the Cabinet Office in Japan, the population aged 65 and older accounted for 29.1% of the total population in 2023, and the number of older adults requiring support and care in daily life is expected to increase as the population ages[5,6]. Among this population, those with hypertension may have reduced muscle mass, muscle strength, physical function, and ADL capacity. Therefore, it is necessary to clarify whether the muscle mass, muscle strength, physical function, and ADL capacity of older adults requiring care for hypertension are lower than those of older adults requiring care without hypertension. Despite this, limited research has compared these parameters between older adults requiring care

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with and without hypertension. Clarifying the relationship between the absence or presence of hypertension and muscle mass, muscle strength, physical function, and ADL capacity in older adults requiring care could help in maintaining and improving ADL capacity.

This study aimed to clarify whether muscle mass, muscle strength, physical function, and ADL capacity are lower in older adults with hypertension than in those without hypertension. We hypothesized that the absence or presence of hypertension would be associated with lower values across all these parameters.

Material and Methods

Participants

This cross-sectional study screened 166 participants aged 65 years and older who required care and regularly attended one of the five adult day facilities in Japan utilizing long-term care insurance between July 2022 and December 2024. The exclusion criteria were as follows: 1) incomplete measurements; 2) inability to walk independently (except under supervision); and 3) use of a pacemaker. Participants who were unable to walk and pacemaker users were excluded as this could have impacted the data and the bioimpedance method (prohibition). Following the exclusion of three participants due to incomplete measurements (refusals during the measurement: 2, the body composition analyzer repeatedly measured but made an error: 1). The imputation method was not conducted because previous studies have shown that the impact is small if the proportion of missing is 5% or less[7]. 163 participants were included in the final analysis. Data on the absence or presence of hypertension, hyperlipidemia, and type 2 diabetes were collected from medical records. Participants usually participate in recreation and rehabilitation primarily at their facilities. Japan's long-term care insurance categorizes individuals into seven levels: support levels 1 and 2 and care levels 1 through 5, with care level 5 indicating the highest need for assistance. The required care time was determined based on the following factors: 1) direct care and assistance in daily activities (e.g., bathing), 2) indirect care and assistance in daily activities (e.g., laundry), 3) problem behaviour-related actions (e.g., wandering), 4) functional training-related actions (e.g., walking practice), and 5) medical-related actions (e.g., infusion management). Cognitive indicators were also used to determine the necessary level of care[8]. For reference, support level 1 typically requires 25–32 min of care, while care level 5 requires more than 110 min. The long-term care insurance grade distribution among participants was as follows: support level 1 (n = 10), support level 2 (n = 15), care level 1 (n = 75), care level 2 (n = 40), care level 3 (n = 15), care level 4 (n = 5), and care level 5 (n = 3). All participants were explained thorough the paper about the study and signed their written consent form.

Sarcopenia (SP)

SP was assessed according to the 2019 criteria of the Asian Working Group for Sarcopenia[9]. SP is defined as a combination of low skeletal muscle mass with either low muscle strength or low physical function, whereas severe SP is characterized by low values in all three parameters. Appendicular muscle mass was measured using bioelectrical impedance analysis (BIA; TANITA, MC-780 AN, Tokyo, Japan). Skeletal muscle mass index (SMI) was calculated by dividing appendicular muscle mass by the square of the participant's height (m^2). Low skeletal muscle mass was defined as an SMI <7.0 kg/m^2 for males and <5.7 kg/m^2 for females.

Physical function was evaluated using the Short Physical Performance Battery (SPPB)[10], which included a five-repetition chair-stand test and normal gait speed over 4 m. Gait speed was measured twice, with participants allowed to use their usual walking aids, and the faster result was used for analysis. Low physical function was defined by meeting any of the following criteria: 1) SPPB score of ≤9 points, 2) five-repetition chair-stand time of ≥12 s, or 3) gait speed of <1.0 m/s.

Handgrip strength (HS) was evaluated for muscle strength, twice on each side using a digital hand dynamometer (Grip-D, Takei, Niigata, Japan) with participants seated and elbows extended. The highest value from four attempts (two on each side) was used as the representative value for analysis. Low muscle strength was classified as a value of <28 kg for males and <18 kg for females.

Leg muscle strength (LMS)

Lower-limb muscle strength, which is more susceptible to age-related decline than upper-limb strength[11], was assessed using maximum isometric knee extensor strength measured with a handheld dynamometer (μTas F-1, Anima Co., Ltd., Tokyo, Japan). Participants sat with their hips and knees bent at 90°. Both hands were placed on the seat surface adjacent to the body. The foot being tested was elevated while the other remained flat on the floor. The sensor was positioned immediately above the malleoli and secured with a belt for stabilization. The maximum isometric knee extensor strength (N) was assessed three times per side, allowing a 30-s rest between each measurement. The lever arm length (m) was determined by measuring the distance from the lateral knee joint space to the center of the sensor. Each participant's value (Nm) was adjusted by dividing their weight (kg). Nm/kg was calculated using the average of three measurements from both sides, and the greater Nm/kg value from either side was chosen as the representative value for the analysis.

Barthel Index (BI)

The BI, which comprises 10 items, was used to evaluate ADL performance[12]. Each item is assigned a specific score.

	All (n = 163)	Non-HY Group (n = 81)	HY Group (n = 82)	*P*-values
Sex (male/female, n)	70/93	38/43	32/ 50	0.309
Age (years)	85.0 ± 6.7	84.8 ± 6.7	85.2 ± 6.8	0.676
Height (cm)	151.9 ± 10.2	153.2 ± 10.2	150.7 ± 10.2	0.115
Weight (kg)	50.5 ± 10.8	50.0 ± 11.1	50.9 ± 10.4	0.577
BMI (kg/m²)	21.6 ± 3.5	21.0 ± 3.3	22.2 ± 3.7	0.025
Hyperlipidemia (presence/absence, n)	10/153	3/78	7/75	0.199
Type 2 diabetes (presence/absence, n)	35/128	20/61	15/67	0.320
Sarcopenia (presence/absence, n)	100/63	49/32	51/31	0.824
Handgrip strength (kg)	18.6 ± 7.3	19.2 ± 8.4	18.0 ± 6.1	0.306
Normal gait speed (m/s)	0.72 ± 0.2	0.76 ± 0.3	0.69 ± 0.2	0.043
Five stand up test (s)	12.2 ± 8.3	12.7 ± 8.1	11.7 ± 8.4	0.437
SPPB (points)	7.6 ± 2.9	8.0 ± 2.8	7.2 ± 3.0	0.093
SMI (kg/m²)	5.9 ± 1.0	6.0 ± 1.0	5.9 ± 1.0	0.910
LMS (Nm/kg)	1.11 ± 0.39	1.20 ± 0.43	1.02 ± 0.33	0.004
BI (<100/=100, n)	62/101	22/59	40/42	0.004

BMI, body mass index; SMI, skeletal muscle index; SPPB, short physical performance battery; LMS, leg muscle strength; BI, barthel index.

Table 1. Characteristics of each group in this study.

Walking and moving from a wheelchair to a bed and back were scored as 0, 5, 10, or 15 points. Eating, getting on and off the toilet, ascending and descending stairs, dressing, bowel control, and bladder control were rated at 0, 5, or 10 points. Grooming activity and bathing were scored as 0 or 5 points. The total score ranged from 0 to 100, with lower scores reflecting a higher dependency on ADL assistance. BI was scored using the information provided by the facility staff and by monitoring actual behavior.

Statistical Analysis

The data are reported as mean ± standard deviation. Statistical analyses were performed using the IBM SPSS Statistics version 29.0 for Mac (IBM Corp., Tokyo, Japan). First, the participants were divided into two groups, according to the absence or presence of hypertension (non-HY and HY groups), and the differences between the two groups were examined using an unpaired t-test for continuous variables and chi-square test for categorical variables. The sample size calculations were conducted using G*Power version 3.1.9.7 (two-tailed test, effect size: 0.5, α err prob: 0.05, power: 0.80), resulting in a required total of 128 participants for the t-test and 143 for the chi-square test. Second, the relationships between the absence or presence of hypertension and muscle strength and BI were assessed using multiple logistic regression analyses adjusted for sex, age, BMI, absence or presence of hyperlipidemia, and type 2 diabetes[13-16]. Additionally, previous studies indicated that the number of explanatory variables in a logistic regression analysis should not exceed the number of samples in a smaller group divided by 10[17,18]. Therefore, the number of explanatory variables used in this study was limited to eight. Furthermore, we divided the participants into two groups according to whether they were independent and non-independent in ADL items. Variables that significantly differed between the non-HY group and HY group were further investigated using multiple logistic regression, adjusting for sex, age, and BMI, which are known cofounders for ADL performance[19-21]. Statistical significance was set at $p < 0.05$.

Results

According to the medical records, 82 participants had hypertension. Characteristics of the non-HY and HY groups are presented in Table 1. No significant differences were observed in HS, SMI, or prevalence of sarcopenia between the two groups ($p > 0.05$, Table 1). In contrast, LMS and normal gait speed were significantly lower in the HY-

Variables	OR	95% CI	P value
Sex	1.007	0.491–2.067	0.984
Age	0.987	0.935–1.041	0.621
BMI	1.102	0.996–1.219	0.061
Hyperlipidemia	1.777	0.409–7.722	0.443
Type 2 diabetes	0.467	0.201–1.084	0.076
LMS	0.303	0.108–0.847	0.023

BMI, body mass index; LMS, leg muscle strength; OR, odds ratio; 95 % CI, 95 % confidence interval.

Table 2. Association between the absence or presence of hypertension and LMS in each group identified using multiple logistic regression analysis.

Variables	OR	95% CI	P value
Sex	1.289	0.647–2.568	0.471
Age	1.000	0.950–1.052	0.995
BMI	1.110	1.003–1.229	0.044
Hyperlipidemia	2.383	0.544–10.450	0.249
Type 2 diabetes	0.480	0.206–1.116	0.088
BI	2.522	1.273–4.997	0.008

BMI, body mass index; BI, Barthel Index; OR, odds ratio; 95 % CI, 95 % confidence interval.

Table 3. Association between the absence or presence of hypertension and BI in each group identified using multiple logistic regression analysis.

group than that in the non-HY group ($p < 0.05$; Table 1). Moreover, the proportion of participants with independent ADL was significantly lower in HY group than that in the non-HY group ($p < 0.05$; Table 1).

Multiple logistic regression analysis showed that LMS was significantly associated with hypertension (odds ratio [OR]: 0.303, 95% confidence interval [CI]: 0.108–0.847, $p = 0.023$, Table 2; dependent variables: HY and non-HY groups; explanatory variables: sex, age, BMI, hyperlipidemia, type 2 diabetes, and LMS). Additionally, BI was significantly associated with hypertension (OR: 2.522, 95% CI: 1.273–4.997, $p = 0.008$; Table 3; dependent variables: HY and non-HY groups; explanatory variables: sex, age, BMI, hyperlipidemia, type 2 diabetes, and BI). Normal gait speed was not an independent predictor of the absence or presence of hypertension (OR: 0.291, 95% CI: 0.071–1.201, $p = 0.088$, Table 4; dependent variables: HY and non-HY groups; explanatory variables: sex, age, BMI, hyperlipidemia, type 2 diabetes, and normal gait speed). Furthermore, the proportion of participants who required assistance using BI was mostly for bathing and ascending and descending stairs (bathing: 56/62, ascending and descending stairs 27/62, walking 5/62, bladder control 5/62, and bowel control 2/62). Logistic regression analysis was performed for the independent and non-independent groups (dependent variables) in bathing and ascending and descending stair activities. LMS was extracted as an independent factor, adjusted for sex, age, and BMI in both activities (bathing: OR, 5.06; 95% CI, 1.587–16.226; $p = 0.006$; ascending and descending stairs: OR, 7.52; 95% CI, 1.533–36.867; $p = 0.013$).

Discussion

In this study, LMS and ADL abilities in the HY group were significantly lower than those in the non-HY group. In addition, LMS and ADL abilities were significant independent explanatory factors for the absence or presence of hypertension, even after adjusting for sex, age, BMI, hyperlipidemia, and type 2 diabetes in the multiple logistic

Variables	OR	95% CI	P value
Sex	1.411	0.711–2.804	0.325
Age	0.999	0.948–1.051	0.958
BMI	1.118	1.012–1.235	0.029
Hyperlipidemia	1.774	0.402–7.839	0.449
Type 2 diabetes	0.497	0.217–1.140	0.099
Normal gait speed	0.291	0.071–1.201	0.088

BMI, body mass index; OR, odds ratio; 95 % CI, 95 % confidence interval.

Table 4. Association between the absence or presence of hypertension and normal gait speed in each group identified using multiple logistic regression analysis.

regression analysis. LMS was significantly associated with ADL (bathing and ascending and descending stairs) after adjusting for sex, age, and BMI. These results suggest that maintaining or improving LMS may preserve ADL capacity in older adults requiring care for hypertension.

No significant differences in SMI or HS were observed between the groups. A previous study reported that sarcopenia impact on hypertension[1] and muscle mass was related to arterial stiffness[1,2]. Grip strength is also associated with the development of hypertension[3]. The required sample size was calculated in this study; however, the sample size was smaller than that in previous studies. Additionally, muscle mass may have been influenced by nutrition status[22], as indicated by higher BMI[23] observed in the HY group than that in the non-HY group in this study. Low BMI is a risk factor for sarcopenia in older adults[24]. Grip strength is an indicator of overall muscle strength and reflects upper-limb strength[25]. However, lower-limb muscle strength tends to decline more substantially with age than upper-limb muscle strength[11]. A previous study found no significant association between HS and hypertension[1]. This may explain why only LMS was lower in older adults with hypertension in the present study. Moreover, LMS was a significant explanatory factor for ADL (bathing and ascending and descending stairs) in this study. Previous research has shown that quadriceps strength predicts ADL performance in nursing home residents[26]. Hence, LMS may have been associated with ADL (bathing and ascending and descending stairs) in this study.

No associations were found between the five stand-up test times and SPPB scores for physical function with the absence or presence of hypertension. The SPPB assesses physical performance through a series of tests, including balance evaluations (side-by-side, semi-tandem, and tandem stances), 4-m gait speed test, and a five-time sit-to-stand test[10]. The total balance evaluation scores (0–4 points) did not significantly different between the non-HY and HY groups based on the Mann–Whitney U test ($p = 0.116$). Total SPPB scores may have been offset between groups. In addition, normal gait speed was not a significant independent predictor of the absence or presence of hypertension in the multiple logistic regression analysis; however, a trend of association was observed ($p = 0.088$). Normal gait speed in the HY group was significantly lower than that in the non-HY group according to the unpaired t-test ($p < 0.05$). These results suggest that the HY group may have a decreased ability to perform applied movements, such as those involving mobility (e.g., gait and ADL movements).

Our study had several limitations. The sample size was relatively small, consisting solely of Japanese participants, which restricts the generalizability of the results. As this is a cross-sectional study, causal relationships are unknown. Additionally, this study included participants with varying severity levels and disease. Future research should ensure a better alignment of participant severity levels and disease for more accurate results. Moreover, no nutritional status indicators were measured; therefore, it was not possible to examine the impact of nutritional status on muscle condition. As the number of participants was small in this study, only the association between bathing and ascending and descending stairs and LMS was examined. We should examine the association between other ADL abilities and LMS in future studies. We also assessed the participants' ADL capacity using the BI. However, alternative tools such as the Functional Independence Measure, which consists of 18 items rated on a 7-point scale[27], might offer a more detailed evaluation, particularly in terms of assistive device usage and the required level of support.

Conclusions

The LMS and ADL abilities in the HY group were significantly lower than those in the non-HY group. In addition, LMS and ADL ability were significant independent explanatory factors for the absence or presence of

hypertension, even after adjusting for confounding factors in the multiple logistic regression analysis. LMS was also significantly associated with ADL (bathing and ascending and descending stairs) after adjusting for sex, age, and BMI. These results suggest that maintaining or improving leg muscle strength may help maintain ADL in older adults requiring care for hypertension.

Ethics approval

The study was approved by the Ethics Committee of the Health Science University, Japan (Approval No: R2-004).

Consent to participate

Written informed consent was obtained from all participants.

Authors' contributions

Daisuke Takagi: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Visualization, Writing-original draft, Writing-review & editing, Supervision, Project administration, Funding acquisition. Masatoshi Kageyama: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Visualization, Writing-original draft, Writing-review & editing. All authors read and approved the final version of the manuscript.

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