Research Article

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Relation of Upper Arm and Forearm Circumferences in Identifying Sarcopenia in Hospitalized Older Patients with Hip Fractures: A Preliminary Study

Daisuke Takagi, PhD[1], Masatoshi Kageyama[2,3], Kenta Yamamoto[4], Hiroshi Matsumoto, MD[5]

[1]Department of Shizuoka Physical Therapy, Faculty of Health Science, Tokoha University; [2]Long-Term Care Health Facilities Sunrise Ohama; [3]Graduate School, Hamamatsu University School of Medicine, Cooperative Major in Medical Photonics (Doctoral Course); [4]Department of Rehabilitation, Toyoda Eisei Hospital; [5]Department of Orthopedic surgery, Toyoda Eisei Hospital

ABSTRACT

Background: A previous study has reported that calf circumference was useful in predicting sarcopenia in older adults with hip fractures. However, the relationship between sarcopenia and upper arm and forearm circumferences has not been well documented in older patients with hip fractures. This preliminary study aimed to determine whether upper arm and forearm circumferences are associated with sarcopenia in older patients with hip fractures. **Methods:** This cross-sectional study recruited 31 hospitalized older patients with hip fractures (femoral neck and trochanteric fractures). We classified patients based on the presence or absence of sarcopenia according to the criteria of the Asian working group for sarcopenia 2019. The upper arm and forearm circumferences were measured using a tape measure. **Results:** Upper arm and forearm circumferences in the non-sarcopenia group were significantly thicker than those in the sarcopenia group. Multiple logistic regression analysis revealed that upper arm and forearm circumferences were significant independent indicators of sarcopenia. We also set the cutoff values of upper arm and forearm circumferences for identifying sarcopenia. **Conclusion:** These findings suggest that upper arm and forearm circumferences could be useful methods for identifying sarcopenia in hospitalized older patients with hip fractures.

Keywords: Forearm circumference, Upper arm circumference, Sarcopenia, hip fracture, hospitalized older patients

***Correspondence to Author:**
Daisuke Takagi
Department of Shizuoka Physical Therapy, Faculty of Health Science, Tokoha University: 1-30 Mizuochi-cho, Aoi-ku, Shizuoka-City, Shizuoka 420-0831, Japan.

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Background

The World Health Organization (WHO) reported that the proportion of older adults (aged ≥60 years) will be 22% of the total global population until 2050 [1]. Femoral neck and trochanteric hip fractures are mainly caused by falls in older adults [2]. These fractures affect the mortality and gait capacity of patients aged ≥60 years [2, 3]. Hence, the number of older patients with femoral neck and trochanteric fractures is assumed to increase with aging.

In recent years, sarcopenia, characterized by low muscle mass and low muscle strength or low physical function in old age, has been reported in the aging population and increases the risk of falls, fractures, frailty, and mortality [4, 5, 6]. The prevalence of sarcopenia is approximately 7%–10% in community-dwelling older adults [7, 8] and 58.0%–63.0% (women: 44.7% and men: 81.1%) in patients with hip fractures [9, 10]. Thus, the occurrence rate of adverse health outcomes in patients with hip fractures who developed sarcopenia was higher than in those who did not develop sarcopenia. Therefore, sarcopenia should be detected in patients with hip fractures as quickly as possible.

Previous studies reported that calf circumference (CC) is useful for detecting low muscle mass and sarcopenia [11, 12]. The CC can be conveniently measured with only a tape measure. Besides, CC has been reported as a valuable method to expect sarcopenia in hospitalized older people with hip fractures [13]. Conversely, CC is easily influenced by gravity due to its location on the peripheral part of the lower limbs, and we often encounter older patients who had edema in their lower leg. Upper arm circumference (UC) and forearm circumference (FC) are also positively associated with appendicular muscle mass [14]. However, the relationship between sarcopenia and UC and FC has not been well documented in older patients with hip fracture. Clarifying the association of sarcopenia with UC and FC could help detect sarcopenia by methods with lesser effects of edema in older patients with hip fractures.

Therefore, this preliminary study aimed to determine whether UC and FC are associated with sarcopenia in older patients with hip fractures. We hypothesized that UC and FC can be useful tools for identifying sarcopenia in older patients with hip fractures.

Materials & Methods

Participants

In this cross-sectional study, 31 hospitalized older patients with hip fractures (femoral neck fracture and trochanteric fracture) were recruited in the Toyoda Eisei Hospital [average age ± standard deviation (SD): 83.5 ± 6.9 years]. The exclusion criteria were as follows: 1) inability to obtain consent and 2) incomplete measurements. The average period from the onset of hip fracture was 22.6 ± 7.0 days. The sites of hip fracture were femoral neck fracture 64.5 % (20/31) and trochanteric fracture was 35.5 % (11/31), respectively. All participants read and signed an informed consent form. This study was also approved by the ethics committee of the Health Science University.

Sarcopenia

The presence or absence of sarcopenia was identified based on the criteria at the Asian working group for sarcopenia 2019 [15]. Low muscle mass (skeletal muscle index [SMI]; men: <7.0 kg/m^2 and women: <5.4 kg/m^2 using dual-energy x-ray absorptiometry), low muscle strength (handgrip strength [HS]; men: <28 kg and women: <18 kg), and low short physical performance battery (SPPB) score (≤9 points) were used to detect sarcopenia. Low muscle mass and low muscle strength or low SPPB score was classified as sarcopenia, and low muscle mass, low muscle strength, and low SPPB score denoted severe sarcopenia [15]. Muscle mass was estimated using the following estimation formula: men, appendicular skeletal muscle mass (ASM) = 0.287 × weight (kg) + 3.681 [R^2 = 0.685, standard error of estimate (SEE) = 1.75 kg]; women, ASM = 0.121 × height (cm) + 0.128 × weight (kg) + 0.104 × handgrip strength (kg)–13.096 (R^2 = 0.714, SEE = 1.05 kg) and SMI was calculated as ASM / height (m)^2 [16]. HS was assessed using a digital hand dynamometer (Grip-D, Takei, Niigata, Japan) twice with the left and right hands in a sitting position. The best value within a total of four times in the left and right hands was analyzed as the representative value. The SPPB consisted of standing balance (side-by-side stand, semi-tandem stand, and tandem stand), 4-m gait speed, and five-repetition chair-stand tests to evaluate physical performance [6, 17]. The score in each item (balance, 4-m gait speed, and five-repetition chair-stand tests) ranged from 0 to 4 points, and the maximum points (12 points) indicated better physical function. The 4-m gait speed was measured twice, and the higher value was used as the representative.

Upper Arm and Forearm Circumferences

UC and FC were measured at the largest points to the nearest 0.1 cm. Each circumference was measured twice using a tape measure. UC and FC were measured in a sitting position where the participant's upper limbs were placed at the side of their body with their hands in a neutral position. The higher values of each average value of both the right and left sides were used for analysis. The intraobserver reliability ranging from good to perfect (0.65–0.99) was observed in circumference measurements [18].

Barthel Index

The activities of daily living (ADL) were measured using the barthel index (BI) [19]. The BI was composed of 10 items: moving from a wheelchair to a bed and back (0, 5, 10, or 15 points); walking (0, 5, 10, or 15 points); eating (0, 5, or 10 points); getting on and off the toilet (0, 5, or 10 points); ascending and descending stairs (0, 5, or 10 points); dressing up (0, 5, or 10 points); bowel control (0, 5, or 10 points); bladder control (0, 5, or 10 points); grooming activity (0 or 5 points); and bathing (0 or 5 points). The score was categorized as independent, requiring assistance, and dependent, with the lowest score (0 points) indicating dependence and the highest score (100 points) indicating independence in performing ADL.

Statistical Analysis

Statistical analysis was conducted using the

Table 1. Characteristics of the hospitalized patients with hip fracture

Variables	Mean ± SD
Sex (n, men/women)	10/21
Age (years)	83.5 ± 6.9
Height (cm)	149.0 ± 8.6
Weight (kg)	46.6 ± 10.3
BMI (kg/m^2)	21.0 ± 4.0
The period from the onset (days)	22.6 ± 7.0
UC (cm)	23.9 ± 4.4
FC (cm)	20.8 ± 2.5
BI (points)	51.0 ± 15.0
HS (kg)	16.6 ± 6.4
SPPB (points)	2.9 ± 2.8
ASM (kg)	13.8 ± 3.8
SMI (kg/m^2)	6.1 ± 1.2
Sarcopenia (n, %)	13/31 (41.9%)

BMI, body mass index; UC, upper arm circumference; FC, forearm circumference; BI barthel index; HS, handgrip strength; SPPB, short physical performance battery; ASM, appendicular skeletal muscle mass; SMI, skeletal muscle index

Table 2. Comparison of characteristics between the non-SC and SC groups

Variables	Non-SC group (n = 18)	SC group (n = 13)	*P*-value
Sex (men/women)	6/12	4/9	0.88
Age (years)	82.9 ± 8.0	84.4 ± 5.4	0.56
Height (cm)	150.5 ± 7.6	146.8 ± 9.8	0.25
Weight (kg)	52.4 ± 8.8	38.6 ± 6.1	<.0001
BMI (kg/m^2)	23.2 ± 3.6	17.9 ± 1.9	<.0001
The period from the onset (days)	22.5 ± 7.5	22.7 ± 6.5	0.94
UC (cm)	25.8 ± 4.5	21.2 ± 2.6	0.002
FC (cm)	21.6 ± 2.6	19.6 ± 1.9	0.022
BI (score)	52.5 ± 17.8	48.8 ± 10.0	0.51

Non-SC, no sarcopenia; SC, sarcopenia; BMI, body mass index; UC, upper arm circumference; FC, forearm circumference; BI, barthel index

Table 3. Association of UC with sarcopenia using multiple logistic regression analysis

Model	Odds ratio	95% CI	*P*-value
Model 1			
UC	1.53	1.16–2.29	<.001
Model 2			
sex	1.08	0.17–7.19	0.93
UC	1.54	1.16–2.31	<.001
Model 3			
age	1.00	0.87–1.16	0.96
UC	1.54	1.16–2.31	<.001
Model 4			
sex	1.09	0.17–7.37	0.92
age	1.00	0.87–1.16	0.95
UC	1.54	1.16–2.34	<.001

UC, upper arm circumference Model 1: UC, Model 2: sex + UC, Model 3: age + UC, Model 4: sex + age + UC

Table 4. Association of FC with sarcopenia using multiple logistic regression analysis

Model	Odds ratio	95%CI	*P*-value
Model 1			
FC	1.49	1.07–2.28	0.017
Model 2			
sex	4.27	0.54–50.6	0.18
FC	1.79	1.16–3.27	0.006
Model 3			
age	0.99	0.87–1.11	0.81
FC	1.48	1.06–2.27	0.021
Model 4			
sex	4.27	0.52–52.4	0.18
age	1.00	0.88–1.13	0.99
FC	1.80	1.15–3.33	0.008

FC, forearm circumference; Model 1: FC, Model 2: sex + FC, Model 3: age + FC, Model 4: sex + age + FC

JMP 11 software (SAS Institute Inc., Cary, NC, USA). The values were described as mean ± SD. Patients were divided into two groups based on the presence or absence of sarcopenia (non-SC group, included patients without sarcopenia, and SC group, included patients with sarcopenia or severe sarcopenia). The characteristics between the two groups were compared using a chi-squared test and an unpaired t-test. Besides, multiple logistic regression analysis was used to evaluate the relationships between sarcopenia and UC and FC, after adjusting for sex and age. Furthermore, the cutoff UC and FC values for detecting sarcopenia were calculated using the receiver operating characteristic (ROC) curve. Minimal sample sizes were 12.7 (SC group) and 12.7 (non-SC group) with the area under the curve (AUC) of 0.80, a significant level of 0.05, power of 0.80, and kappa of 1 using the R Package "pROC" (version 1.16.2). The significant value was set at $p < 0.05$.

Results

The patient characteristics are described in Table 1. The prevalence of sarcopenia was 41.9% (n = 13/31; sarcopenia [1/31] and severe sarcopenia [12/31]) in this study. UC and FC in the non-SC group were significantly thicker than those in the SC group ($p < 0.05$, Table 2). In Pearson's product-moment correlation coefficient, positive correlations of ASM, UC and FC were observed (UC: $r = 0.42$, $p = 0.02$; FC: $r = 0.70$, $p < 0.01$). Besides, SMI was positively associated with UC and FC (UC: $r = 0.44$, $p = 0.013$; FC: $r = 0.78$ $p < 0.01$).

In multiple logistic regression analysis adjusted for sex and age, UC and FC were significant independent indicators of sarcopenia in this study ($p < 0.05$, Tables 3 and 4). Moreover, the cutoff UC and FC values for the presence or absence of sarcopenia were 22.5 cm (AUC 0.81, sensitivity 85%, specificity 72%) and 21.7 cm (AUC 0.74, sensitivity 100%, specificity 44%) using the ROC curve, respectively.

Discussion

In this preliminary study, UC and FC were found to be associated with sarcopenia in hospitalized older patients with hip fractures. These findings suggest that UC and FC could be useful methods for identifying sarcopenia in hospitalized older patients with hip fractures (femoral neck and trochanteric fractures).

The prevalence of sarcopenia was lower in this study than that of previous studies (41.9% vs. 58.0%–63.0%, respectively [women: 44.7% and men: 81.1%]) [9, 10]. This result might under or overestimate the amount of ASM due to the calculation using the estimation formula. Moreover, no significant difference in the BI score was observed between the non-SC and SC groups in this study. The onset of sarcopenia results in an increased risk of frailty [4, 20]. Conversely, another study has reported that sarcopenia was not related to ADL [21]. Therefore, the association of sarcopenia with ADL should be clarified in future studies.

This study found that UC and FC were significantly related to sarcopenia. We also calculated the cutoff UC and FC values (UC: 22.5 cm and FC: 21.7 cm) for identifying sarcopenia, despite the small sample size. The average body mass index (BMI) in Japanese people ranged from 80 to 84 years was 20.94 kg/m^2 for men and 20.49 kg/m^2 for women [22]. As our patient's BMI (the average age, 83.5 years) was 21.0 kg/m^2, we relatively recruited Japanese people of normal physiques. Moreover, a moderate and high accuracy in AUC values was from 0.7 to 0.9 and from 0.9 to 1.0, respectively [23]. The AUC values of UC and FC were 0.81 and 0.74, respectively, which were classified as moderate accuracy. However, those values were calculated on a small sample size in this study. The specificity value of FC was also lower than that of UC. The low specificity induces a higher probability to judge patients without sarcopenia than patients with sarcopenia (high false-positive rate). We should recruit more number of patients and reanalyze the cutoff values, AUC, sensitivity, and specificity of UC and FC for identifying sarcopenia using the ROC curve in future studies.

Our study has the following limitations: 1) The sample size was small. 2) For UC and FC were significant independent indicators after adjusting sex and age in multiple logistic regression analysis, the cutoff UC and FC values were calculated regardless of sex for identifying sarcopenia; 3) Multiple logistic regression analysis was adjusted for only sex and age. 4) Calculation of ASM was carried out by the estimation formula, 5) Our patients included Japanese people only. In future studies, more number of patients and different races should be recruited. ASM should also be evaluated using dual-energy x-ray absorptiometry or bioelectrical impedance analysis. Furthermore, we need to recalculate the cutoff UC and FC values by sex and reconsider other confounding factors affecting sarcopenia.

Abbreviations:

ADL, Activities of daily living

ASM, Appendicular skeletal muscle mass

AUC, Area under the curve

BI, Barthel index

BMI, Body mass index

CC, Calf circumference

CI, Confidence interval

FC, Forearm circumference

HS, Handgrip strength

OR, Odds ratio

ROC, Receiver operating characteristic

SD, Standard deviation

SEE, Standard error of estimate

SMI, Skeletal muscle index

SPPB, Short physical performance battery

UC, Upper arm circumference

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