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Original Article

Large calf circumference indicates non-sarcopenia despite body mass

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Abstract. [Purpose] The purpose of this study is to evaluate the applicability of the calf circumference as a tool for screening sarcopenia. [Subjects and Methods] One hundred sixteen community-dwelling elderly females were enrolled. Calf circumference of the dominant leg was measured using a plastic measuring tape. Subjects were divided into 3 groups based on body mass index (BMI); subjects with the values for BMI <18.5 kg/m^2; those with BMI 18.5 to 25.0; those with BMI ≥25.0 kg/m^2. Positive predictive value and negative predictive value of sarcopenia were calculated based on the obtained cut off values of calf circumference and the diagnosis of sarcopenia in each group. [Results] Prevalence rate of sarcopenia was 9.4% (n=10). Cut off value of the calf circumference was 32.8 cm (sensitivity: 73.0%, specificity: 80.0%, AUC: 0.792). Each BMI group showed high negative predictive value of sarcopenia based on the calf circumference cut off value of 32.8 cm. [Conclusion] These results suggested that to identify non-sarcopenia by larger calf circumference is more reasonable and useful than to identify sarcopenia due to the smaller calf circumference regardless of BMI.

Key words: Sarcopenia, Calf circumferences, Negative predictive value

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INTRODUCTION

Sarcopenia is defined as a pathological condition associated with risks such as physical dysfunction, reduction in quality of life, and death that are induced by progressive reduction in muscle mass and muscle weakness[1)], and it has been attracting great interest in recent years. For the measurement of muscle mass, which is important for the diagnosis of sarcopenia, the dual energy X-ray absorptiometry method and the bioelectrical impedance analysis method are used. However, it is problematic that they need special, expensive devices. In recent years, calf circumference has been attracting attention as a surrogate marker for the diagnosis of sarcopenia[2–4)]. Calf circumference is correlated with the appendicular skeletal muscle index that was measured by dual energy X-ray absorptiometry[5)], and is also known for allowing easy measurement. Kawakami et al.[2)] reported about the relationship between calf circumference and sarcopenia by describing that calf circumference of the dominant leg that is less than 33 cm could be a surrogate marker for the diagnosis of sarcopenia. However, body builds such as body mass index (BMI) should be taken into consideration since body builds vary among individuals. The cut-off value seems to change its meaning depending on the body builds.

Therefore, the purpose of this study is to evaluate the applicability of the calf circumference as a tool for screening sarcopenia based on the relationship between calf circumference and BMI.

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SUBJECTS AND METHODS

A total of 116 community-dwelling older females (age: 65–86) who applied for a university event of physical fitness assessment were enrolled. We included only women in this study because there were only a few men who applied for this event. Subjects were recruited through the Ota-ku municipal newsletter. To be enrolled, the candidates should meet the following requirements: they should (1) be aged ≥65 and living in Ota-ku, (2) feel their physical strength is declining and want to overcome it, (3) be willing to extend their healthy life expectancy. Exclusion criteria were as follows; 1) persons who cannot come to the research site on their own. 2) persons who are restricted in exercise from their medical doctor due to severe heart disease, respiratory disease, orthopedic disease, metabolic disease, etc. 3) Persons who develop movement disorders due to diseases of the central nervous system caused by cerebrovascular diseases. 4) Persons who have been diagnosed as having dementia in the past. Written informed consent on the purpose of the study was obtained in advance from each participant.

The following measurements items were included: height, body weight, skeletal muscle index (SMI), calf circumference, grip strength, Short Physical Performance Battery test (SPPB), and Timed Up and Go test (TUG).

Body composition analysis was performed using a body composition analysis device (In Body S10, In Body Japan, Tokyo, Japan) to measure skeletal muscle mass. The muscle mass was measured using an electrode attached to the predefined position with the subjects in a supine position on a bed. The SMI was calculated using following formula: appendicular skeletal muscle mass/body height^2.

Calf circumference of the dominant leg was measured using a plastic measuring tape with the subjects in a supine position on a bed.

Grip strength of the subjects was measured in their standing position with their elbow joint bent at 90 degrees, using a hand dynamometer (Jamar Hydraulic Hand Dynamometer SH5001: Saehan Medical, Korea). Two sessions of measurement were performed for both right and left hands alternately and whichever higher value was defined as the grip strength.

SPPB[6] was measured using the following 3 kinds of tests in a random order: balance test, 4-m walking test, and sit-to-stand test.

TUG[7] was performed allowing subjects to use walking aids they usually use. They stood up from their chairs and walked to the triangular post 3 meters ahead and made a U-turn back toward their chairs with their safe and maximum effort. The time was measured twice, and we used whichever the faster speed for the analysis.

Subjects were divided into the non-sarcopenia group and the sarcopenia group based on the Diagnostic Criteria of Sarcopenia for Asian Population[8]. The following values between the two groups were compared using Student's t-test: age (years), height (cm), body weight (kg), BMI (kg/m^2), SMI (kg/m^2), calf circumference of the dominant leg (cm), grip strength (kg), walking speed (m/s), TUG (s). The total sum of SPPB scores (points) was compared using a Mann-Whitney test. The area under the ROC curve was calculated to evaluate calf circumference of the dominant leg as well as the cut off value to determine the presence or absence of sarcopenia.

Then, the subjects were divided into the following 3 groups, subjects with the values for BMI <18.5 kg/m^2: those with BMI 18.5 to 25.0; those with BMI ≥25.0 kg/m^2. Analysis of variance (ANOVA) or the Kruskal-Wallis test was used to evaluate differences among the three groups. The Tukey test was used as a post hoc test, if the ANOVA was significant. Dunn's test was used as a post hoc test after the Kruskal-Wallis test.

Positive predictive value and negative predictive value were also calculated based on the obtained cut off values of calf circumference. SPSS 22.0 for Windows10 was used for statistical analysis. Statistical significance level was defined as $p<0.05$. The study protocol was approved by the Institutional Review Board of Tokyo University of Technology prior to the initiation of the study (approval No.: E15HS-025).

RESULTS

Of all the subjects, non-sarcopenia subjects and sarcopenia subjects accounted for 91.4% (n=106) and 9.4% (n=10), respectively. When each measurement was compared between both groups, significantly low values in height (cm), body weight (kg), SMI (kg/m^2), calf circumference (cm), grip strength, and significant high values in age (year) were observed in the sarcopenia group (Table 1).

The cut off value for sarcopenia that was calculated using calf circumference was 32.8 cm (sensitivity: 73.0%; specificity: 80.0%; AUC: 0.792).

Each measurement was compared between 3 groups that were categorized based on the values of BMI (Table 2). There was a significant difference in weight, BMI, SMI, calf circumference between each group.

The positive predictive value of sarcopenia was calculated based on the calf circumference cut off value of 32.8 cm in each group (Table 3). In subjects with BMI <18.5 kg/m^2, the positive predictive value of sarcopenia was 30%, and the negative predictive value was 100%. In subjects with BMI from 18.5 to 25.0 kg/m^2, the positive predictive value of sarcopenia was 20%, and the negative predictive value was 98.0%. In subjects with BMI more than 25 kg/m^2, the positive predictive value of sarcopenia was 0%, and the negative predictive value was 96.2%.

Table 1. Comparison of physical caracteristics between non-sarcopenia and sarcopenia

n=116	Non-sarcopenia	Sarcopenia
n (%)	106 (91.4)	10 (9.43)
Age, year (range)	73.1 (65–86)	75.0 (65–85)*
Height (cm)	152.1 ± 4.7	146.3 ± 5.9**
Weight (kg)	52.5 ± 7.6	44.4 ± 5.1**
BMI (kg/m^2)	22.7 ± 3.2	20.8 ± 2.9
SMI (kg/m^2)	6.0 ± 0.6	5.2 ± 0.4**
Calf circumference (cm)	34.2 ± 2.6	31.6 ± 1.9**
Grip strength (kg)	23.6 ± 4.2	15.7 ± 2.3**
Walking speed (m/s)	1.3 ± 0.2	1.2 ± 0.2
TUG (second)	6.2 ± 0.8	6.4 ± 0.5
SPPB (points)	12.0 (12–9)	12.0 (12–11)

*p<0.05 **p<0.01
BMI: Body Mass Index; SMI: Skeletal Muscle Mass Index; TUG: Timed Up and Go test; SPPB: Short Physical Perfomance Battery

Table 2. Comparison of physical caracteristics among BMI classification

n=116	BMI <18.5 kg/m^2	18.5≤ BMI <25 kg/m^2	25.0 kg/m^2≤ BMI	*ANOVA or Kruskal wallis analysis
Sarcopenia : non-sarcopenia (n)	3:10	6:70	1:26	
Age, year (range)	72.8 (65–81)	73.1 (65–85)	74.0 (65–86)	
Height (cm)	153.3 ± 3.6	151.8 ± 4.9	150.2 ± 6.0	
Weight (kg)	41.9 ± 2.3^{de}	50.2 ± 4.9^{f}	61.1 ± 7.1	**
BMI (kg/m^2)	17.8 ± 0.5^{de}	21.8 ± 1.6^{f}	27.0 ± 2.1	**
SMI (kg/m^2)	5.3 ± 0.4^{ae}	5.8 ± 0.5^{f}	6.6 ± 0.6	**
Calf circumference (cm)	30.8 ± 2.3^{de}	33.5 ± 1.9^{f}	36.7 ± 2.2	**
Grip strength (kg)	20.9 ± 3.8	23.0 ± 4.5	23.5 ± 5.4	
Walking speed (m/s)	1.3 ± 0.2	1.3 ± 0.2^{c}	1.2 ± 0.2	*
TUG (second)	5.8 ± 0.5b	6.2 ± 0.8	6.5 ± 0.8	*
SPPB (points)	11.7 (10–12)^{a}	11.9 (11–12)^{c}	11.7 (9–12)	*

*p<0.05 **p<0.01
BMI: Body Mass Index; SMI: Skeletal Muscle Mass Index; TUG: Timed Up and Go test; SPPB: Short Physical Perfor-mance Battery
a: BMI <18.5 kg/m^2 vs. 18.5≤ BMI <25 kg/m^2 p<0.05
b: BMI <18.5 kg/m^2 vs. 25.0 kg/m^2≤ BMI p<0.05
c: 18.5≤ BMI <25 kg/m^2 vs. 25.0 kg/m^2≤ BMI p<0.05
d: BMI <18.5 kg/m^2 vs. 18.5≤ BMI <25 kg/m^2 p<0.01
e: BMI <18.5 kg/m^2 vs. 25.0 kg/m^2≤ BMI p<0.01
f: 18.5≤ BMI <25 kg/m^2 vs. 25.0 kg/m^2≤ BMI p<0.01

Table 3. Positive predictive value and negative predictive value of sarcopenia based on cut off value of 32.8 in calf circumference based on BMI classification

BMI	Sarcopenia	Calf circumference		Positive predictive value	Negative predictive value
		<32.8cm	≥32.8cm		
<BMI18.5	(+)	n=3	n=0	30.0%	100%
	(−)	n=7	n=3		
18.5≤ BMI <25	(+)	n=5	n=1	20.0%	98.0%
	(−)	n=20	n=50		
25≤ BMI	(+)	n=0	n=1	0%	96.2%
	(−)	n=1	n=25		

BMI: Body mass index

DISCUSSION

Kawakami et al.[2] focused on calf circumference of the dominant leg as a surrogate marker of sarcopenia diagnosis, and reported that calf circumference ≤33 cm could be a surrogate marker of sarcopenia diagnosis for community-dwelling

women. Ishii et al.[4] reported that the presence or absence of sarcopenia was associated with age, grip strength, and calf circumference of the dominant leg, and additionally reported that calf circumferences of the dominant leg in the non-sarcopenia women and the sarcopenia women were 34.5 ± 2.7 cm and 32.1 ± 2.1 cm on average, respectively. Our results also showed that calf circumferences of the dominant leg in the non-sarcopenia women and the sarcopenia women were 34 cm and 32 cm on average, respectively (Table 1), and that the cut off value of calf circumference of the dominant leg was 32.8 cm. This was line with the observations of Ishii et al.[4] and Kawakami et al[2].

However, body build varies among individuals. The positive predictive value of sarcopenia in subjects with BMI <18.5 kg/m^2 calculated using a cut-off value of calf circumference were 30%. In addition, the positive predictive value of sarcopenia in subjects with BMI from 18.5 to 25.0 kg/m^2 was only 20.0%. These results indicate that thin individuals and normal weight individuals are not always sarcopenia even if the calf circumference value is low. In other words, relying only on calf circumference values may lead to misdiagnosis for most of the thin individuals even if their calf circumference is less than the cut off value.

On the other hand, the negative predictive values in each subject group were very high. This implies that it is not sarcopenia in most cases if the calf circumference value is more than 32.8 cm regardless of BMI. When sarcopenia is screened using the calf circumference, to identify non-sarcopenia by larger calf circumference is more reasonable and useful than to identify sarcopenia due to the smaller calf circumference. The diagnosis of sarcopenia requires documentation of low muscle mass plus documentation of either low muscle strength (grip strength) or low physical performance (walking speed)[1, 8]. A small calf circumference means a decrease in muscle mass which is essential for diagnosis of sarcopenia. On the other hand, muscle strength or walking speed do not depend solely on muscle mass[9]. This is considered to be a factor with the low positive predictive values of sarcopenia based on the calf circumference cut off value of 32.8 cm in all subject groups.

There were some limitations in this study. First, the number of subjects was relatively small. Secondly, data were collected from only a part of Tokyo. Thirdly, subjects were all females. To verify the results of this study, further studies using more subjects including men in several areas are required.

Conflict of interest

No potential conflicts of interest.

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