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Impact of edema on length of calf circumference in older adults

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Aim: Calf circumference, which is a known simple indicator of muscle mass, increases during edema. However, the extent to which edema increases calf circumference in older adults is unclear.

Methods: This retrospective cross-sectional study included patients aged ≥65 years whose nutritional status was assessed by nutrition support teams. Two different types of matching models in each sex were created according to the presence of edema on the right lower limb. All models were adjusted by age, body height, handgrip strength and performance status. Sarcopenia was diagnosed based on both reduced calf circumference and decline of handgrip strength. The prevalence of sarcopenia was estimated before and after adjustment for increment of calf circumference.

Results: In total, 2101 patients were included. Multifactor matching models showed that the mean difference in calf circumference between pairs was 1.6 cm (95% confidence interval [CI] 1.1–2.1, $P < 0.001$) for women and 2.1 cm (95% CI 1.6–2.7, $P < 0.001$) for men. The propensity score matching model similarly showed a mean difference of 1.6 cm (95% CI 1.1–2.1, $P < 0.001$) for women and 2.0 cm (95% CI 1.5–2.6, $P < 0.001$) for men. The prevalence of sarcopenia before and after adjusting for an edema-related increase in calf circumference was 42.6%/48.6% for women and 35.3%/38.5%–38.7% for men.

Conclusions: Edema in the lower limb increased the calf circumference by approximately 2 cm. When using calf circumference to assess muscle mass in patients with edema, the increase in circumference should be subtracted from the baseline circumference for an accurate assessment. **Geriatr Gerontol Int 2019; ••: ••–••.**

Keywords: anthropometry, edema, fluid collection, nutritional assessment, sarcopenia.

Introduction

Aging is associated with nutritional deterioration,[1] and malnutrition in hospitalized patients results in poor outcomes, such as extended hospital stay,[2] in-hospital complications,[3] failure to return home,[4] increased frequency of re-admission[2] and mortality.[2] Furthermore, malnutrition also leads to increased medical costs. In Singapore, the care of malnourished inpatients cost 24% more than non-malnourished inpatients,[2] and the management of disease-related malnutrition in the UK cost >£13 billion.[5] Nutritional care for inpatients is considered an effective approach for lowering healthcare costs and improving outcomes. Nutritional screening, assessment and consequent care for patients at risk of malnutrition improve the length of hospital stay, frequency of re-admission and mortality.[6] Therefore, nutritional screening and assessment to identify patients at risk of malnutrition or are malnourished would be the first vital step for nutritional care.

Evaluating muscle mass is emphasized in nutritional screening and assessment.[7] Decreased muscle mass was included in the six-item criteria for diagnosing malnutrition published by the American Society for Parenteral and Enteral Nutrition in 2009.[8] Another criteria for malnutrition proposed by the Global Leadership Initiative on Malnutrition in 2018 also included decreased muscle mass as one of the five items for diagnosing malnutrition.[9] Furthermore, sarcopenia, one of the most highlighted topics in geriatric nutrition, is suggested to occur with decreased muscle mass.[10,11] Imaging modalities, such as computed tomography, magnetic resonance imaging and dual energy X-ray absorptiometry, are considered the gold standard for evaluating muscle mass.[10] However, patients at risk of malnutrition are usually ineligible to undergo such tests, because these tests are potentially harmful. Furthermore, bioimpedance analysis is another candidate approach to measure muscle mass;[10] however, although it is less invasive and some types of bioimpedance analysis instruments are mobile, the device is also too expensive for general hospitals. Furthermore, hospitals and other healthcare facilities can only accommodate a certain number of malnourished older adults. Meanwhile, anthropometry including calf circumference is known to reflect muscle mass without being invasive, and it can be easily and quickly measured at the bedside. Calf circumference has been proven to be positively correlated to skeletal muscle mass, and might thus be a potential indicator of decreased muscle mass in clinical practice as an alternative to imaging modalities and bioimpedance analysis.[12,13] However, although calf circumference has been endorsed in as a reliable indicator for evaluating muscle mass,[8,9,14] its use remains controversial.[10]

Edema can develop from malnutrition, and renal, hepatic and cardiac diseases, and as a side-effect of medications that increase fluid accumulation in the body;[15,16] thus, edema can increase calf circumference. Despite the convenience of using calf circumference for measuring muscle mass, only a few studies have investigated the extent by which edema of the lower extremities increases calf circumference. Thus, the present study aimed to determine the difference in calf circumference between patients with and without edema of the lower extremities.

Methods

Study design and participants

The present retrospective cross-sectional study evaluated patients aged ≥65 years who were admitted to an academic hospital and underwent a nutrition assessment by nutrition support teams between December 2017 and August 2018. Patients with missing data on body height, handgrip strength, edema evaluation or calf circumference were excluded from the analyses. The study was approved by the ethics committee of the hospital (ID: 2018-H325), and the need for written informed consent was waived owing to the retrospective nature of the study. Participants were guaranteed the right to withdraw from the study using an opt-out procedure according to the ethics committee guidelines.

Variables

Trained nurses assessed the nutritional status of all patients on admission using the Mini Nutritional Assessment-Short Form tool.[17] The Nutritional Assessment-Short Form is a six-item tool (changes in food intake, weight loss, mobility, disease-related stress, neuropsychological problems and body mass index [BMI]) that can be used to identify older patients at risk of malnutrition. The score ranges from 0 to 14 points, with a higher score indicating a lower risk of malnutrition. In the present study, we defined a risk of malnutrition as a score of ≤11 points. The Geriatric Nutritional Risk Index, which is also an indicator of the risk of malnutrition, was calculated using the following equation:[18]

$$\text{The Geriatric Nutritional Risk Index} = (1.489 \times \text{albumin level}\,[\text{g/L}]) + 41.7 \times (\text{actual body weight}\,[\text{kg}] / \text{ideal bodyweight}\,[\text{kg}])$$

A low Geriatric Nutritional Risk Index indicates a risk of malnutrition.

The ideal bodyweight was estimated using the Lorentz equation as follows:

Men: ideal bodyweight = height [cm] – 100 – [(height [cm] – 150) / 4]

Women: ideal bodyweight = height [cm] – 100 – [(height [cm] – 150) / 2.5])

Nutritional assessment included measurement of calf circumference of the right leg, edema evaluation and measurement of handgrip strength. Calf circumference was measured with the patient in a supine position with the right leg bent at 90°, and the thickest part of the right calf was measured. The measurement of only the right-side calf circumference is a routine protocol in our hospital, Aichi Medical University Hospital, Nagakute, Japan. The presence of pitting edema in the right ankle or shin was assessed. Handgrip strength was measured using a Jamar digital handgrip gauge (MG-4800 digital hand grip gauge; CHARDER Electronic, Taichung, Taiwan). The grip strength of both the left and right hands was measured with the patient in a normal sitting position with the elbow bent at 90°, and the maximum value of the left and right hand obtained was used for analyses.

The primary cause of hospitalization was determined based on the physicians' diagnosis on admission, and coded on the medical chart of each patient according to the International Statistical Classification of Diseases and Related Health Problems version 10 (ICD-10).

Diagnosis of malnutrition

The diagnosis of malnutrition was made by the nutritional support teams based on the 2015 European Society for Clinical Nutrition and Metabolism criteria.[19] The European Society for Clinical Nutrition and Metabolism-defined malnutrition is diagnosed in two steps. The first step is screening patients at risk of malnutrition using a validated nutritional screening tool. In the present study, we applied the Nutritional Assessment-Short Form as the screening tool. Consequently, screened patients were assessed if they satisfied at least one of the following criteria: (i) BMI <18.5 kg/m^2; (ii) unintentional weight loss >5% over the past 3–6 months combined with BMI <20 kg/m^2 if age <70 years or <22.0 kg/m^2 if age ≥70 years; and (iii) unintentional weight loss combined with fat-free mass index <15.0 kg/m^2 for women or <17.0 kg/m^2 for men. The fat-free mass index was calculated by dividing the patient's estimated fat-free mass by the patient's height in meters squared (m^2).[20,21] Fat-free mass was obtained using the following formula that includes the estimated 24-h urine creatinine excretion rate (eCER): fat-free mass = 13.0 + 0.03 × eCER; eCER (mg/day) = 879.89 + 12.51 × weight (kg) − 6.19 × age (−379.42 if women).

Sarcopenia diagnosis

Sarcopenia was diagnosed according to the criteria of the Asian Working Group for Sarcopenia combined with low muscle strength and low muscle mass.[11] Low muscle strength was defined as handgrip strength <18 kg for women and <26 kg for men. The cut-off value for low calf circumference, the validity for which has been verified for hospitalized older adults as decreased muscle mass, was set at ≤29 cm and ≤30 cm for women and men, respectively.[22]

Statistical analysis

The influence of edema was assessed using two different types of case and control matching (multifactor matching and propensity score matching) to verify consistency of the results. The matching models were made under 1:1 matching with and without edema of the lower limb. Multifactor exact matching models were created according to age, body height, handgrip strength and Eastern Cooperative Oncology Group Performance Status score with calipers 2 years, 5 cm, 2 kg and zero, respectively, for each sex. Propensity score matching models were created by estimated probability of edema in each sex. The probability was calculated using logistic regression models with age, height, grip strength and Eastern Cooperative Oncology Group Performance Status as explanatory variables, and matching with and without edema of the lower limbs was carried out using the score under the caliper of <0.2 condition. Because we considered that nutritional parameters, such as BMI, screening score, and disease type and condition, were strongly associated with edema, we avoided using the information as matching variables.

Table 1 Balance of matched variables in crude and after matching of female patients

	Crude			After multi-factor matching			After propensity score matching		
	Edema (n = 336)	Non-edema (n = 587)	P	Edema (n = 254)	Non-edema (n = 254)	P	Edema (n = 336)	Non-edema (n = 336)	P
Age (years)	79.7 ± 6.9	79.0 ± 7.4	0.168	79.1 ± 6.7	80.0 ± 6.5	0.127	79.7 ± 6.9	79.2 ± 7.2	0.389
Body height (cm)	149.8 ± 5.5	150.1 ± 6.8	0.453	150.0 ± 5.3	149.9 ± 5.5	0.939	150.0 ± 5.5	149.9 ± 6.7	0.859
Handgrip strength (kg)	13.3 ± 5.3	14.0 ± 6.1	0.073	14.0 ± 5.1	13.9 ± 5.1	0.939	14.0 ± 5.1	13.9 ± 5.1	0.577
Performance status, n (%)			0.039			1.000			0.827
0	117 (34.8)	243 (41.4)		104 (40.9)	104 (40.9)		117 (34.8)	111 (33.0)	
1	106 (31.5)	157 (26.7)		83 (32.7)	83 (32.7)		106 (31.5)	103 (30.7)	
2	31 (9.2)	46 (7.8)		15 (5.9)	15 (5.9)		31 (9.2)	40 (11.9)	
3	66 (19.6)	93 (15.8)		45 (17.7)	45 (17.7)		66 (19.6)	68 (20.2)	
4	16 (4.8)	48 (8.2)		7 (2.8)	7 (2.8)		16 (4.8)	14 (4.2)	

Categorical variables were expressed as the number and percentage, and quantitative variables as the mean ± standard deviation. Between-group comparisons were carried out using the χ^2-test and t-test for categorical variables and quantitative variables, respectively. The prevalence of sarcopenia before and after adjusting for the increment value was analyzed by McNemar's χ^2-test. The differences in the mean calf circumference between groups and mean differences between pairs were obtained in each model, and were compared using the t-test and paired t-test, respectively. All statistical analyses were carried out using SPSS 24.0 software (IBM Japan, Tokyo, Japan), and P-values <0.05 were considered significant.

Results

Of the 2524 eligible patients identified, we excluded 423 patients because they had missing data on height (n = 2), handgrip strength (n = 44), edema evaluation (n = 40) and calf circumference (n = 337). Thus, the final cohort comprised 2101 patients. The mean patient age was 79.3 ± 7.2 years and 77.7 ± 6.8 years for women and men, respectively, and 923 (43.9%) were women. Based on the ICD-10, the primary causes of admission for women were neoplasms (26.4%), diseases of the circulatory system (16.1%), diseases of the digestive system (14.4%), diseases of the respiratory system (9.3%) and diseases of the musculoskeletal system (4.7%), whereas the primary causes of admission for men were neoplasms (27.1%), diseases of the circulatory system (18.4%), diseases of the respiratory system (13.3%), diseases of the digestive system (13.1%) and diseases of the genitourinary system (4.7%). The creation of four matching models (two models in each sex) worked well. No significant differences were seen for the factors adjusted for matching between groups (Tables 1, 2). Table 3 shows other variables between groups. In the multifactor matching models, the edema group showed heavier weight, higher fat-free mass index, and lower prevalence of malnutrition and sarcopenia than the non-edema group. Similar results were obtained for propensity score matching models.

Table 4 shows the comparison of calf circumference between the edema and non-edema group. In the multifactor matching models, the mean difference of calf circumference between pairs was 1.6 cm (95% confidence interval [CI] 1.1–2.1, P < 0.001) for women and 2.1 cm (95% CI 1.6–2.7, P < 0.001) for men. In the propensity score matching models, the mean difference in calf circumference between pairs was 1.6 cm (95% CI 1.1–2.1, P < 0.001) for women and 2.0 cm (95% CI 1.5–2.6, P < 0.001) for men.

Table 5 shows the prevalence of sarcopenia of all participants before and after adjusting for the increase in calf circumference in decreased muscle mass. After correcting for the effect of edema, the prevalence of sarcopenia increased by 6.0 points for women and by 3.2–3.4 points for men.

Discussion

The present study investigated the extent by which lower extremity edema increases calf circumference in older patients. Primarily, we found that the calf circumference of male and female patients with lower extremity edema increased by 1.6 cm and 2.0–2.1 cm, respectively, than their counterparts without edema. Second, the prevalence of sarcopenia in patients with edema was overestimated by approximately 10% if the influence of edema was not considered.

The differences in calf circumference were determined using two types of matching models in each sex, with adjustment for age, body height, handgrip strength and performance status between patients with and without pitting edema in the lower extremity. The mean differences of matched pairs of different two models were similar in women, and were 0.1 cm in men. Shi *et al.* reported that subcutaneous posterior soft-tissue

Table 2 Balance of matched variables in crude and after matching of male patients

	Crude			After multi-factor matching			After propensity score matching		
	Edema (n = 266)	Non-edema (n = 912)	P	Edema (n = 198)	Non-edema (n = 198)	P	Edema (n = 264)	Non-edema (n = 264)	P
Age (years)	78.6 ± 6.8	77.3 ± 6.8	0.009	79.1 ± 6.7	80.0 ± 6.5	0.166	78.5 ± 6.8	78.8 ± 6.8	0.598
Body height (cm)	163.8 ± 6.7	164.0 ± 6.4	0.632	150.0 ± 5.3	149.9 ± 5.5	0.730	163.8 ± 6.8	163.5 ± 6.7	0.674
Handgrip strength (kg)	21.8 ± 8.8	6.0 ± 0.7	<0.001	14.0 ± 5.1	13.9 ± 5.1	0.975	21.9 ± 8.7	22.1 ± 5.1	0.829
Performance status, n (%)			<0.001			1.000			0.972
0	87 (32.7)	391 (42.9)		104 (40.9)	104 (40.9)		87 (33.0)	82 (31.1)	
1	61 (22.9)	232 (25.4)		83 (32.7)	83 (32.7)		61 (23.1)	66 (25.0)	
2	39 (14.7)	97 (10.6)		15 (5.9)	15 (5.9)		39 (14.8)	40 (15.2)	
3	55 (20.7)	143 (15.7)		45 (17.7)	45 (17.7)		55 (20.8)	52 (19.7)	
4	24 (9.0)	49 (5.4)		7 (2.8)	7 (2.8)		22 (8.3)	24 (9.1)	

Table 3 Other variables between groups

	Crude			After multi-factor matching			After propensity score matching		
	Edema	Non-edema	*P*	Edema	Non-edema	*P*	Edema	Non-edema	*P*
Women									
Calf circumference (cm)	30.1 ± 3.4	28.6 ± 3.2	<0.001	30.3 ± 3.5	28.7 ± 3.0	<0.001	30.1 ± 3.4	28.5 ± 3.2	<0.001
Bodyweight (kg)	48.4 ± 8.3	44.7 ± 7.9	<0.001	48.4 ± 8.3	44.5 ± 7.6	<0.001	48.4 ± 8.3	44.6 ± 7.7	<0.001
FFMI (kg/m^2)	14.0 ± 1.5	13.4 ± 1.4	<0.001	14.0 ± 1.4	13.3 ± 1.3	<0.001	14.0 ± 1.5	13.4 ± 1.4	<0.001
GNRI	89.2 ± 11.2	88.8 ± 11.5	0.573	89.6 ± 11.3	87.8 ± 11.3	0.071	89.2 ± 11.2	88.5 ± 10.6	0.415
ESPEN-d fined malnutrition, *n* (%)	69(20.5)	229(39.0)	<0.001	52(20.5)	109(42.9)	<0.001	69(20.5)	129(38.4)	<0.001
Sarcopenia, *n* (%)	115 (34.2)	278 (47.4)	<0.001	81 (31.9)	122 (48.0)	<0.001	115 (34.2)	165 (49.1)	<0.001
Men									
Calf circumference (cm)	31.8 ± 4.1	30.4 ± 3.3	<0.001	32.2 ± 3.7	30.1 ± 3.0	<0.001	31.9 ± 4.1	29.9 ± 3.4	<0.001
Bodyweight (kg)	58.6 ± 11.4	55.3 ± 9.3	<0.001	58.6 ± 10.6	54.4 ± 9.2	<0.001	58.8 ± 11.4	54.8 ± 9.4	<0.001
FFMI (kg/m^2)	17.5 ± 1.6	17.1 ± 1.4	<0.001	17.5 ± 1.4	16.9 ± 1.3	<0.001	17.5 ± 1.5	17.0 ± 1.4	<0.001
GNRI	86.1 ± 12.9	87.9 ± 11.8	0.039	86.2 ± 12.4	87.2 ± 12.4	0.409	86.2 ± 12.9	87.2 ± 11.9	0.359
ESPEN-defined malnutrition, *n* (%)	56 (21.1)	253 (27.7)	0.032	34 (17.2)	61 (30.8)	<0.001	54 (20.5)	73 (27.7)	<0.001
Sarcopenia, *n* (%)	83(31.2)	333(36.5)	0.126	53(26.8)	83(41.9)	0.002	81(30.7)	121(45.8)	<0.001

ESPEN, European Society of Clinical Nutrition and Metabolism; FFMI, fat-free mass index; GNRI, Geriatric Nutritional Risk Index.

edema on the back was associated with increasing bodyweight.[23] The results of the current study demonstrating that the bodyweight of patients with edema was greater than that of patients without edema show that the matching methods were successful. Mittermayr *et al.* reported that long-term sitting position caused edema in the lower extremities and increased the leg volume.[24] Furthermore, Olsen *et al.* reported that sitting for 3 h on a flight increased the calf circumference by 0.5 cm.[25] Although these reports show that edema in the lower extremities could increase calf circumference, participants in these studies were younger and healthier than those in the current study. One study reported that ankle joint angle is concordant with calf circumference in assessing for muscle mass, with a standardized error of 0.5–0.6 cm.[26] Considering the size, the measurement error of calf circumference would be assumed to be <1.0 cm. The increase in calf circumference in the current study is much greater than the measurement error; therefore, the increase might be considered to have been induced by edema. Because the study included older adult inpatients, the results appear to be more reflective of and applicable to hospitalized patients rather than community-dwelling individuals.

When the measured calf circumference was subtracted from the baseline value in patients with edema, the proportion of sarcopenia patients increased up to 48.4% for women and 38.5–38.7% for men, which corresponded to an increment of 6.0 points and 3.2–3.4 points for women and men, respectively. This indicates that 10% of the participants with sarcopenia in the present study were misdiagnosed to have no sarcopenia when the presence of edema was not factored in. Edema would result in an overestimation of muscle mass. Therefore, determining the prevalence of sarcopenia might be relatively accurate when measurement of muscle mass is adjusted for the influence of edema. Halil *et al.* studied older adults in nursing homes, and reported that the diagnosis of sarcopenia using only calf circumference underestimated the prevalence of sarcopenia defined by lower muscle strength.[27] Their result might indicate that edema and edema-related increase in bodyweight lower the frequency of decreased muscle mass. Because calf circumference includes several kinds of tissues, such as the skin, subcutaneous fat, muscle, vessels and bone, some of which certainly thicken in the presence of edema, muscle mass as assessed using calf circumference without adjusting for edema is likely to be overestimated. However, calf circumference is the most reliable parameter of anthropometry to evaluate muscle mass, even in older adults.[28] It is widely used in clinical practice, because it can be obtained at the bedside, and is economical, convenient and non-invasive. Patients with edema are possibly malnourished, and assessment of the presence of lower extremity edema and measurement of calf circumference for nutritional assessment are usually carried out concurrently.[8] Calf circumference is expected to be used for muscle mass evaluation in nutritional assessment and sarcopenia diagnosis effectively in both edema and non-edema cases. However, for a more accurate assessment, we recommend that in older patients with edema, the calf circumference should be subtracted against the measured calf circumference. The procedure might generalize muscle mass value with adjusting for influence of edema.

There are some limitations to note in the present study. First, the data of many patients were lost due to a 1:1 matching model, and this might limit the generalizability of the results. Second, the study did not evaluate the degree of edema that probably influenced calf circumference. However, no reliable method to evaluate the degree of edema has been established. The impact of the degree of edema will be a future research topic. Finally, eCER was developed using data from a non-Asian population, whereas the current study mostly included Asian patients. There might be differences in eCER according to ethnicity, and this might lead to underestimations of nutritional status.

Table 4 Comparison of calf circumference between the edema and the non-edema group

	Mean calf circumference (cm)	Difference between means of groups (cm)	Mean difference between pairs, cm [95% CI]	*P*-value
Women				
Multifactor matching				
Edema	30.3 ± 3.5	1.6	1.6 [1.1–2.1]	<0.001
Non-edema	28.7 ± 3.0			
Propensity score matching				
Edema	30.1 ± 3.4	1.6	1.6 [1.1–2.1]	<0.001
Non-edema	28.5 ± 3.2			
Men				
Multi-factor matching				
Edema	32.2 ± 3.7	2.1	2.1 [1.6–2.7]	<0.001
Non-edema	30.1 ± 3.0			
Propensity score matching				
Edema	31.9 ± 4.1	2.0	2.0 [1.5–2.6]	<0.001
Non-edema	29.9 ± 3.4			

CI, confidence interval.

Table 5 Prevalence of sarcopenia before and after adjusting for increase in calf circumference

	Before	After	*P*-value
Women, *n* (%)			
1.6-cm adjustment	393 (42.6)	449 (48.6)	<0.001
Men, *n* (%)			
2.0-cm adjustment	416 (35.3)	454 (38.5)	<0.001
2.1-cm adjustment	416 (35.3)	456 (38.7)	<0.001

In conclusion, the present study found that edema of the lower extremity increased calf circumference by an average of 1.6 cm and 2.0 cm for women and men, respectively. When using calf circumference to assess the muscle mass of patients with edema, the measured value should be subtracted from the baseline calf circumference to determine the correct muscle mass.

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Disclosure statement

The authors declare no conflict of interest.

References

1 Kagansky N, Berner Y, Koren-Morag N, Perelman L, Knobler H, Levy S. Poor nutritional habits are predictors of poor outcome in very old hospitalized patients. *Am J Clin Nutr* 2005; **82**: 784–791.
2 Lim SL, Ong KC, Chan YH, Loke WC, Ferguson M, Daniels L. Malnutrition and its impact on cost of hospitalization, length of stay, readmission and 3-year mortality. *Clin Nutr* 2002; **31**: 345–350.
3 Velasco C, Garcia E, Rodriguez V *et al*. Comparison of four nutritional screening tools to detect nutritional risk in hospitalized patients: a multicentre study. *Eur J Clin Nutr* 2011; **65**: 269–274.
4 Maeda K, Koga T, Akagi J. Nutritional variables predict chances of returning home and activities of daily living in post-acute geriatric care. *Clin Interv Aging* 2018; **13**: 151–157.
5 Elia M, Russell CA, Stratton RJ. Malnutrition in the UK: policies to address the problem. *Proc Nutr Soc* 2010; **69**: 470–476.
6 Jensen GL, Compher C, Sullivan DH, Mullin GE. Recognizing malnutrition in adults: definitions and characteristics, screening, assessment, and team approach. *J Parenter Enteral Nutr* 2013; **37**: 802–807.
7 Reijnierse EM, Trappenburg MC, Leter MJ *et al*. The association between parameters of malnutrition and diagnostic measures of sarcopenia in geriatric outpatients. *PLoS One* 2015; **10**: e0135933.
8 White JV, Guenter P, Jensen G *et al*. Consensus statement: Academy of Nutrition and Dietetics and American Society for Parenteral and Enteral Nutrition: characteristics recommended for the identification and documentation of adult malnutrition (undernutrition). *J Parenter Enteral Nutr* 2012; **36**: 275–283.
9 Jensen GL, Cederholm T, Correia M *et al*. GLIM criteria for the diagnosis of malnutrition: a consensus report from the global clinical nutrition community. *J Parenter Enteral Nutr* 2019; **43**: 32–40.
10 Cruz-Jentoft AJ, Baeyens JP, Bauer JM *et al*. Sarcopenia: European consensus on definition and diagnosis: report of the European Working Group on Sarcopenia in Older People. *Age Ageing* 2010; **39**: 412–423.
11 Chen LK, Liu LK, Woo J *et al*. Sarcopenia in Asia: consensus report of the Asian Working Group for Sarcopenia. *J Am Med Dir Assoc* 2014; **15**: 95–101.
12 Perez-Zepeda MU, Gutierrez-Robledo LM. Calf circumference predicts mobility disability: a secondary analysis of the Mexican health and ageing study. *Eur Geriatr Med* 2016; **7**: 262–266.
13 Kawakami R, Murakami H, Sanada K *et al*. Calf circumference as a surrogate marker of muscle mass for diagnosing sarcopenia in Japanese men and women. *Geriatr Gerontol Int* 2015; **15**: 969–976.
14 Fujishima I, Fujiu-Kurachi M, Arai H *et al*. Sarcopenia and dysphagia: position paper by four professional organizations. *Geriatr Gerontol Int* 2019; **19**: 91–97.
15 Trayes KP, Studdiford JS, Pickle S, Tully AS. Edema: diagnosis and management. *Am Fam Physician* 2013; **88**: 102–110.
16 Ely JW, Osheroff JA, Chambliss ML, Ebell MH. Approach to leg edema of unclear etiology. *J Am Board Fam Med* 2006; **19**: 148–160.
17 Rubenstein LZ, Harker JO, Salva A, Guigoz Y, Vellas B. Screening for undernutrition in geriatric practice: developing the short-form mini-nutritional assessment (MNA-SF). *J Gerontol A Biol Sci Med Sci* 2001; **56**: M366–M372.
18 Bouillanne O, Morineau G, Dupont C *et al*. Geriatric Nutritional Risk Index: a new index for evaluating at-risk elderly medical patients. *Am J Clin Nutr* 2005; **82**: 777–783.
19 Cederholm T, Bosaeus I, Barazzoni R *et al*. Diagnostic criteria for malnutrition - an ESPEN Consensus Statement. *Clin Nutr* 2015; **34**: 335–340.
20 Jassal SK, Wassel CL, Laughlin GA, Barrett-Connor E, Rifkin DE, Ix JH. Urine creatinine-based estimates of fat-free mass in community-dwelling older persons: the Rancho Bernardo study. *J Ren Nutr* 2015; **25**: 97–102.
21 Ix JH, Wassel CL, Stevens LA *et al*. Equations to estimate creatinine excretion rate: the CKD epidemiology collaboration. *Clin J Am Soc Nephrol* 2011; **6**: 184–191.
22 Maeda K, Koga T, Nasu T, Takaki M, Akagi J. Predictive accuracy of calf circumference measurements to detect decreased skeletal muscle mass and European Society for Clinical Nutrition and Metabolism-defined malnutrition in hospitalized older patients. *Ann Nutr Metab* 2017; **71**: 10–15.
23 Shi H, Schweitzer ME, Carrino JA, Parker L. MR imaging of the lumbar spine: relation of posterior soft-tissue edema-like signal and body weight. *Am J Roentgenol* 2003; **180**: 81–86.
24 Mittermayr M, Fries D, Innerhofer P *et al*. Formation of edema and fluid shifts during a long-haul flight. *J Travel Med* 2003; **10**: 334–339.
25 Olsen JHH, Oberg S, Rosenberg J. The effect of compression stocking on leg edema and discomfort during a 3-hour flight: a randomized controlled trial. *Eur J Intern Med* 2019; **62**: 54–57.

26 Carmont MR, Silbernagel KG, Mathy A, Mulji Y, Karlsson J, Maffulli N. Reliability of Achilles tendon resting angle and calf circumference measurement techniques. *Foot Ankle Surg* 2013; **19**: 245–249.
27 Halil M, Ulger Z, Varli M *et al*. Sarcopenia assessment project in the nursing homes in Turkey. *Eur J Clin Nutr* 2014; **68**: 690–694.
28 Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* 1995; **854**: 1–452.

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