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Original Article

The high prevalence of sarcopenia and its associated outcomes following hip surgery in Taiwanese geriatric patients with a hip fracture

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KEYWORDS
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Outcome

Background: Sarcopenia, which is a common risk factor for falls and fractures, affects the functional outcome and mortality in geriatric populations. However, the prevalence of sarcopenia among geriatric Taiwanese patients with a hip fracture is unknown, nor is the effect of sarcopenia on the outcome of hip surgery.
Methods: From December 2017 to February 2019, geriatric patients who underwent surgery for a hip fracture were prospectively enrolled. Basic demographic data, responses to questionnaires for dementia screening and quality of life (QoL) and daily living activities (ADL) before the injury were analyzed to identify any association with sarcopenia. The QoL and ADL were monitored at six months after the operation to determine the difference between hip fracture patients with or without sarcopenia.

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Results: Of 139 hip fracture patients, 70 (50.36%) were diagnosed with sarcopenia. Accounting for all confounding factors in the multivariate logistic regression, lower body mass index (BMI), male gender and a weaker handgrip are the risk factors that are most strongly associated with a diagnosis of sarcopenia in geriatric patients with a hip fracture. Hip fracture patients with sarcopenia also have poor ADL and a lower QoL than patients without sarcopenia before the injury and six months after the operation.
Conclusion: A high prevalence of sarcopenia among geriatric hip fracture patients is associated with a poor mid-term outcome following hip surgery. Clinicians must recognize the risk of sarcopenia, especially for male hip fracture patients with a lower BMI and a weaker handgrip.

Introduction

The incidence of hip fracture is increasing as the population ages, which has critical implications for death rates, functional dependence and social costs.[1,2] The projected rate for hip fractures for Asia will increase from approximately 1.1 million in 2018 to 2.6 million in 2050, which will increase the direct cost of hip fractures from US$ 9.5 billion to US$ 15 billion.[3] The increase of hip fractures in Taiwan[4] means that it is estimated that the demand for post-fracture care for geriatric patients will continue to increase, so quality of care must be increased and the incidence of hip fracture must be reduced by providing robust post-fracture rehabilitation and fracture-prevention programs.

Several risk factors are associated with hip fracture, including aging, lower body weight, osteoporosis and dementia.[5,6] Sarcopenia is a condition that is characterized by loss of skeletal muscle mass and function[7] and is a predictor of all-cause mortality for older people who live in the community.[8] Geriatric patients with sarcopenia are vulnerable to both falls and hip fractures,[9,10] because they have reduced muscle strength and poor balance.[11] Sarcopenia, which reduces the mechanical loading of the skeleton and reduces adaptive bone remodeling, is associated with lower bone mineral density and osteoporosis.[12] All of these negative effects of sarcopenia are implicated in its effect on the risk of hip fracture in a geriatric population. However, more clinical evidence is required to clarify these associations.

In Taiwan, the prevalence of sarcopenia varies from 3.9% (2.5% in women and 5.4% in men) to 7.3% (6.5% in women and 8.2% in men) for elderly citizens who live in the community.[13] A higher prevalence of sarcopenia in hip fracture patients has been reported and varies from 17 to 74%, depending on population, diagnostic tools and the definition of sarcopenia.[14–18] There is also a lack of clinical evidence to show how sarcopenia affects clinical outcomes following hip fracture surgery. This study is the first to determine the prevalence of sarcopenia, its correlation with other factors and its effect on the mid-term outcome following hip fracture surgery for geriatric patients in Taiwan.

Material and methods

Study design

From December 2017 to February 2019, 139 patients who had a hip fracture and underwent surgery for the condition in Wan Fang Hospital, Taipei, Taiwan were prospectively enrolled in this observational study. Qualifying patients were men and women aged 60 years or more who had suffered a hip fracture, including intra-capsule (femoral neck) or extra-capsule (basal neck, intertrochanteric and subtrochanteric) hip fractures. Patients were excluded if they received hip surgery as a result of a condition other than a primary hip fracture, including osteoarthritis, trauma, tumor, infection and avascular necrosis of the femoral heads. Patients who failed to complete the sarcopenia assessment using dual-energy X-ray absorptiometry (DXA) were also excluded.

Basic demographic data, including age, gender, fracture type (intra-capsule or extra-capsule hip fracture), the time between the falling accident and hip surgery or DXA exam and underlying comorbidities, was collected for analysis, along with pre-operative laboratory data. Serum vitamin D (25(OH)D) level, which was not routinely surveyed in every participant (only 108 patients underwent a complete vitamin D survey), was also measured for analysis. When the participants had consented to being enrolled, interviews were conducted with the patients and their caregivers at admission for hip fracture surgery using the short portable mental status questionnaire (SPMSQ) for screening dementia, the EuroQol-5D (EQ5D) for assessing Quality of Life before the injury (QoL) and the Barthel Index (BI) for measuring Activities of Daily Living (ADL) before the injury. (See the "Instruments in questionnaire" section below for details.) During admission, all participants also underwent screening for sarcopenia to assess handgrip strength and body composition using DXA. All participants were assessed by a clinician within one week of admission. During follow-up, all eligible participants were subject to a telephone interview for BI and EQ5D scores again at 6 months following hip surgery. Mortality events were also recorded during the 6-month follow-up.

The ethical committee of Taipei Medical University approved the entire protocol and instrumentation. The ethical approval was registered as TMU-JIRB N201709053. All participants consented to the study and to the publication of data.

Instruments in questionnaire

The SPMSQ is a simple ten-item cognitive screening instrument, which includes items that test orientation to time and place, memory, knowledge of one's current situation (date, day of the week, name of current location, telephone number, date of birth, age, name of current prime minister and previous prime minister, mother's maiden name) and simple calculation (subtract three from 20 and repeat). The total number of errors, which is correlated with a clinical diagnosis of organic brain impairment or dementia, is recorded from zero to ten, with a threshold of three or more errors for a clinical or neuropsychological diagnosis.[19] The Chinese version of the SPMSQ was validated with a reported Cronbach's alpha of 0.69.[20]

The EQ5D is an international instrument for evaluating QoL.[21] This study uses the EQ-5D-3L with three states of health. The EQ-5D-3L covers the five dimensions of mobility, self-care, activities, pain/discomfort and anxiety/depression. Problems that are associated with each item are specified using three levels of severity: no problem, some problems and major problems. The Chinese version of the EQ5D that is used in this study agrees well (intraclass correlation coefficients > 0.75) and converges (Pearson's correlation coefficients > 0.95) with versions of the EQ5D from the United Kingdom, Japan and Korea.[22]

The BI has an ordinal scale with scores from zero to 100 and is used to quantify performance in basic ADL.[23] The BI is calculated using ten variables that represent ADL and mobility. A higher value is associated with a greater likelihood of being able to live at home with a degree of independence following discharge from hospital. The BI is also used to quantify functional recovery in patients who have undergone hemiarthroplasty following a femoral neck fracture.[24] The Chinese version of BI has been validated with moderate to excellent agreement among raters for individual items (kappa value range, 0.53—0.94) and total score (intraclass correlation coefficient = 0.94).[25]

Definition of sarcopenia

Participants were diagnosed with sarcopenia based on the criteria of the Asian Working Group for Sarcopenia (AWGS).[26] A diagnosis of sarcopenia requires both "low muscle mass" and "low handgrip strength".

Handgrip strength

Isometric grip strength, which is the maximum hand grip strength, was measured using a Jamar Hydraulic Dynamometer (Sammons Preston, USA) while the patient was sitting in bed or on a chair, with the elbow flexed and the wrist in the neutral position, with verbal encouragement. Patients were instructed to grip the device three times in each hand as hard as possible.[27] The same investigator made measurements for all participants and was blind to the clinical data. For each participant, the best measurement of six was used. Handgrip strength of $<$26 kg for men and $<$18 kg for women is a low handgrip strength, based on threshold values that are recommended by the AWGS.[26]

Muscle mass

Dual-energy X-ray absorptiometry (DXA) was used to calculate muscle mass based on criteria of the AWGS.[26] Body fat percentage and appendicular skeletal muscle mass (ASM) are normalized to size (total lean muscle mass in the upper and lower limbs divided by the square of the body height). The relative appendicular skeletal muscle mass index (RASM) identifies low muscle mass with a threshold of 7 kg/m^2 for men and 5.4 kg/m^2 for women, based on the consensus of the AWGS.

Statistics

All statistical analyses were conducted using IBM SPSS Statistics software version 22 (IBM Co., Armonk, New York, USA). Categorical variables are presented as a frequency (percentage) and continuous variables are presented as a mean $\pm$ standard deviation. The Chi-square test and Fisher's exact test are used to compare categorical variables, and the Wilcoxon two-sample test and Student's t-test are used to compare continuous variables.

Univariate analyses were conducted on numerous risk factors that are associated with sarcopenia in patients with a hip fracture. Factors that differ significantly in hip fracture patients with or without sarcopenia (including age, body mass index (BMI), gender, dementia, white blood cell (WBC) count, SPMSQ errors, BI score, EQ-5D score, handgrip strength, total body fat and T-score; $p < 0.05$ in the univariate analysis) or which differ in terms of significance (including diabetes mellitus; $0.05 < p < 0.1$ in the univariate analysis) are included in the multivariate logistic regression model to estimate the adjusted odds ratios (AOR) with 95% confidence intervals (CI). Pearson's correlation is used with male and female groups to determine any significant relationship between RASM and hand grip strength, body mass index or T-score.

Two generalized estimation equation (GEE) models are constructed to determine the potential effect of sarcopenia on two important outcomes (ADL and QoL) for the participants. Specifically, ADL that is assessed using BI and QoL using EQ-5D at two different time points (baseline and 6-month follow-up) gives the two dependent variables for the two GEE models. The two GEE models share the same independent variable of sarcopenia and potential confounders (gender, age, BMI, T-score, and baseline score). For all tests, a value of 00P < 0.05 indicates statistical significance.

Results

A total of 139 patients (36 men and 103 women with a mean age of 80.72 years) were enrolled in this study (Table 1). Almost two-thirds were diagnosed with an intra-capsule hip fracture (n = 86; 61.87%), and 53 (38.13%) were diagnosed

Table 1 Patient demographics (n = 139).

Variables	Mean ± SD/number (percentage)
Age (years)	80.72 ± 9.66
BMI	22.64 ± 3.60
Gender	
female	103 (74.10%)
male	36 (25.90%)
Fracture type	
Intra-capsule hip fracture	86 (61.87%)
Extra-capsule hip fracture	53 (38.13%)
Delay time from falling accident	
Surgical delay (hour)	63.20 ± 76.88
DXA delay (hour)	137.04 ± 154.67
Underlying comorbidities	
Hypertension	95 (68.34%)
Diabetes mellitus	50 (35.97%)
Valvular heart disease	24 (17.27%)
Coronary heart disease	9 (6.47%)
Chronic kidney disease	10 (7.19%)
Cerebral vascular disease	11 (7.91%)
Dementia	23 (16.55%)
Affective or psychotic disorder	10 (7.19%)
Cancer history	17 (12.23%)
Pre-operative laboratory data	
Hemoglobin (g/dl)	12.08 ± 1.97
Platelet (x10^3/ul)	210.83 ± 89.32
White blood cell count (x10^3/ul)	10.41 ± 3.38
Serum creatine (mg/dl)	1.21 ± 1.42
Serum glucose (mg/dl)	173.33 ± 105.18
Serum albumin (g/dl)	3.24 ± 1.73
Serum Sodium (mmol/l)	136.73 ± 3.73
Serum Potassium (mmol/l)	3.95 ± 0.49
Serum Vitamin D (25(OH)D) level (ng/ml) (n = 108)	18.22 ± 9.64
Dementia screening	
SPMSQ errors	4 ± 3.75
Pre-injury Activities of Daily Living	
BI score	85.50 ± 23.02
Pre-injury quality of life	
EQ-5D score	0.83 ± 0.20
Muscle strength measurement	
Handgrip strength (kg)	11.85 ± 7.84
Bone mineral density	
T-score	−3.81 ± 1.11
Body composition	
Total body fat (%)	34.04 ± 7.85
Appendicular skeletal muscle mass (ASM) (kg)	14.09 ± 3.57
Diagnosis of sarcopenia[a]	
Sarcopenia	70 (50.36%)

Abbreviations: BMI = body mass index; SPMSQ = short portable mental status questionnaire; BI= Barthel index; EQ-5D = EuroQol-5D; ASM = appendicular skeletal muscle mass.
[a] Diagnosis of sarcopenia based on AWGS definition (RASM <7 kg/m^2 for men and <5.4 kg/m^2 for women, together with hand grip strength <26 kg for men and <18 kg for women).

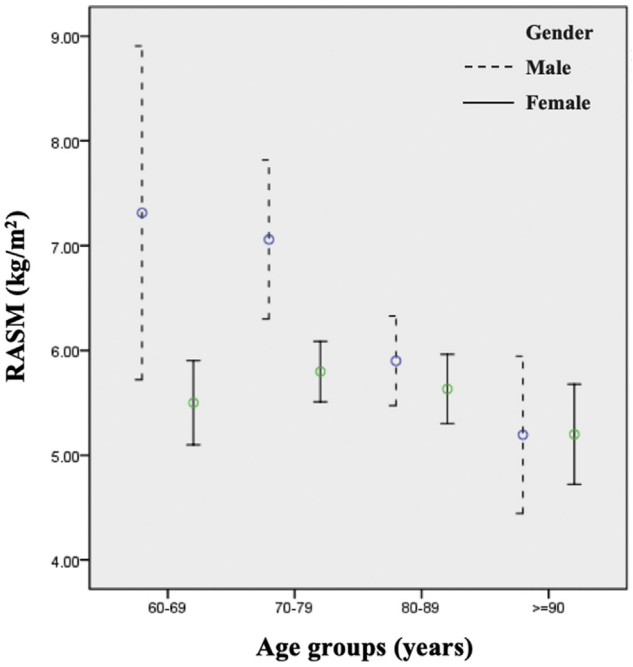

Figure 1 Relative appendicular skeletal muscle mass index (RASM) in different gender and age-group (Circles indicate means, and vertical lines indicate 95% confidence intervals).

with an extra-capsule hip fracture. The most common comorbidities for these patients are hypertension (68.34%) and diabetes mellitus (35.97%). The mean time between a falling accident and hip surgery is 63.20 h and between the falling accident and DXA assessment is 137.04 h 63.89% (69/108) of patients were deficient in serum vitamin D, based on a threshold level of 20 ng/ml,[28] and 51.1% (71/139) of patients had at least mild cognitive impairment (with more than two errors on the SPMSQ). The lowest mean T-score for the DXA assessment for geriatric patients with a hip fracture is −3.81.

The prevalence of sarcopenia in geriatric patients with hip fracture that is measured by this study is 50.36%, based on the AWGS definition. 63.89% of male and 44.66% of female patients are identified as having sarcopenia. These proportions differ significantly (p = 0.047). Fig. 1 shows that age- and sex-specific RASM. For males, the RASM declines as age increases. The difference between the RASM values for male and female patients is smaller for patients who are older than 80 years. Fig. 2 shows that the relationships between RASM and BMI, hand grip strength and T-score for both genders. RASM is positively correlated with each of these parameters and is statistically significant for male patients. In females, RASM is only positively correlated with BMI and T-score. BMI is the parameter that is most strongly correlated with RASM for both male and female patients (Pearson's r = 0.612 and 0.603, respectively).

Table 2 compares patients with and without sarcopenia. Greater age, lower BMI, higher prevalence in male patients, more dementia, lower pre-operative serum WBC counts,

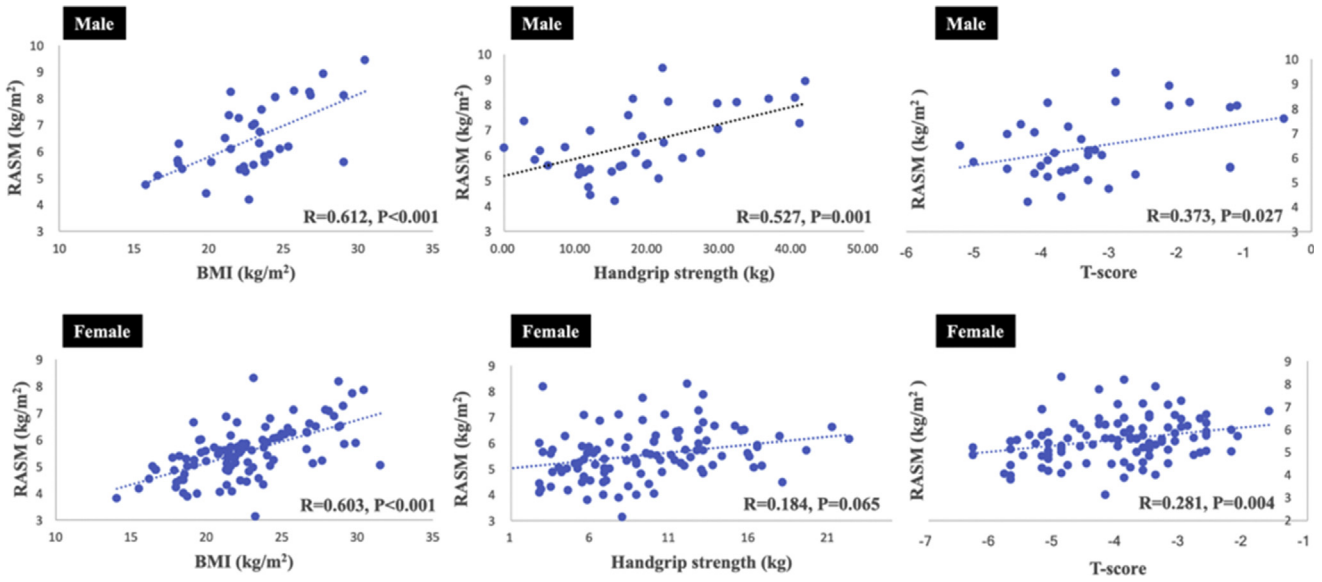

Figure 2 Correlation of relative appendicular skeletal muscle mass index (RASM) and body mass index (BMI), handgrip strength, T-score in male and female patients.

more errors in the SPMSQ, lower pre-injury BI and EQ-5D score, lower handgrip strength, lower bone mineral density and lower total body fat percentage are significantly correlated with sarcopenia. When all of these factors and possible significant factors such as diabetes mellitus (p value = 0.08 in the univariate analysis) are included in the multivariate logistic regression for sarcopenia, only BMI, female gender and handgrip strength are significantly inversely correlated with sarcopenia (AOR = 0.756, 0.170, and 0.893, respectively) (Table 3).

Of the 139 patients, 7 patients (including 5 male and 2 female patients) died within 6 months after hip surgery (6 patients in the sarcopenia group and one patient in the non-sarcopenia group: p = 0.118). Overall 110 patients completed follow-up for BI and EQ-5D score at 6 months after hip surgery. The overall 6-month mortality rate for the geriatric hip fracture patients following hip surgery is 5.98% (7/117). At 6 months after the operation, the average BI and ADL decreases to 73.0 ± 29.0 and 0.76 ± 0.21, respectively. Only 34.55% (38/110) of hip fracture patients regain pre-injury ADL at 6 months after hip surgery. Accounting for confounders that are listed in Table 4, hip fracture patients without sarcopenia and with a higher T-score have a significantly better BI score at 6 months after surgery. For hip fracture patients without sarcopenia, a higher T-score and a higher baseline EQ-5D score has a significant positive effect on the quality of life at 6 months after hip surgery (Table 4).

Discussion

An awareness that sarcopenia in the geriatric population results in earlier mortality and poor mobility[29,30] means that clinicians must screen patients who are vulnerable to sarcopenia. Geriatric patients with a hip fracture are especially likely to have sarcopenia, but the prevalence of sarcopenia in this vulnerable population varies between studies. This study shows that the prevalence of sarcopenia for geriatric hip fracture patients in Taiwan is as high as 50%, with different values for male and female patients (64% for males and 45% for females). Accounting for all confounding factors, lower BMI, male gender and lower handgrip strength are the most relevant risk factors in predicting sarcopenia for geriatric patients with a hip fracture. Geriatric hip fracture patients with sarcopenia are also shown to have poorer pre-injury activity of daily living and quality of life than patients without sarcopenia. Hip fracture patients with sarcopenia also exhibit poor recovery at 6 months after hip surgery.

Sarcopenia is more prevalent in geriatric patients with hip fracture than in elderly people who reside in the community. Historical control data shows a 7.3% prevalence for sarcopenia among in elderly Taiwanese citizens who reside in the community,[13] but 50% of the specific hip fracture population in this study is susceptible to sarcopenia. Table 5 summarizes the results for recent studies of the prevalence of sarcopenia in geriatric patients with a hip fracture.[14–18] The reported prevalence of sarcopenia in geriatric hip fracture patients in studies,[15,17] including this one, that use DXA to define muscle mass is higher than for studies that use other tools for this purpose.[14,16] DXA is a gold standard, reliable technique for analyzing muscle mass in both a bodily region of interest and the entire body.[31] Muscle mass screening tools other than DXA can result in bias that results in muscle mass being overestimated so the prevalence of sarcopenia in geriatric hip fracture patients is underestimated.[32] This study also finds a lower prevalence of sarcopenia in geriatric hip fracture patients than studies that use DXA as a diagnostic tool for sarcopenia.[15,17,18] The shorter time between fracture accidents and DXA assessment for this study than for others may explain the difference between the prevalence rates for sarcopenia, because extended time in bed from ten days to

Table 2 Comparison of hip fracture patients with or without sarcopenia (n = 139).

Variables	Mean ± SD/number (percentage)		P value
	With Sarcopenia	Without Sarcopenia	
Age (years)	83.49 ± 9.77	77.99 ± 8.80	0.000
BMI	20.94 ± 3.27	24.34 ± 3.09	0.000
Gender			
female	46 (44.66%)	57 (55.34%)	0.047
male	23 (63.89%)	13 (36.11%)	
Fracture type			
Intra-capsule hip fracture	*46(66.67%)*	*57(81.43%)*	0.809
Extra-capsule hip fracture	*23(33.33%)*	*13(18.57%)*	
Delay time from falling accident			
Surgical delay (hour)	53.46 ± 62.24	72.30 ± 88.39	0.383
DXA delay (hour)	134.75 ± 186.91	139.30 ± 115.77	0.430
Underlying comorbidities			
Hypertension	44 (63.77%)	51 (72.86%)	0.249
Diabetes mellitus	20 (28.99%)	30 (42.86%)	0.088
Valvular heart disease	15 (21.74%)	9 (12.86%)	0.166
Coronary heart disease	6 (8.70%)	3 (4.29%)	0.291
Chronic kidney disease	6 (8.70%)	4 (5.71%)	0.496
Cerebral vascular disease	6 (8.70%)	5 (7.14%)	0.735
Dementia	16 (16.19%)	7 (10.00%)	0.036
Affective or psychotic disorder	7 (10.14%)	3 (4.29%)	0.181
Cancer history	7 (10.14%)	10 (14.29%)	0.456
Pre-operative laboratory data			
Hemoglobin (g/dl)	11.95 ± 1.92	12.22 ± 2.03	0.403
Platelet ($x10^3$/ul)	207.99 ± 98.00	213.63 ± 80.48	0.322
White blood cell count ($x10^3$/ul)	9.72 ± 2.94	11.10 ± 3.66	0.016
Serum creatine (mg/dl)	1.12 ± 1.05	1.30 ± 1.72	0.686
Serum glucose (mg/dl)	158.59 ± 79.69	187.40 ± 123.76	0.218
Serum albumin (g/dl)	3.35 ± 2.44	3.14 ± 0.43	0.155
Serum Sodium (mmol/l)	136.81 ± 4.03	136.66 ± 3.45	0.629
Serum Potassium (mmol/l)	3.93 ± 0.43	3.98 ± 0.54	0.891
Serum Vitamin D (25(OH)D) level (ng/ml) (n = 108)	18.69 ± 9.95	17.80 ± 9.41	0.578
Dementia screening			
SPMSQ errors	4.64 ± 3.87	2.66 ± 3.38	0.001
Pre-injury activities of daily living			
BI score	80.65 ± 25.26	90.29 ± 19.60	0.001
Pre-injury quality of life			
EQ-5D score	0.78 ± 0.21	0.88 ± 0.18	0.000
Muscle strength measurement			
Handgrip strength (kg)	9.84 ± 5.41	13.84 ± 9.27	0.007
Bone mineral density			
T-score	−4.12 ± 1.07	−3.51 ± 1.08	0.001
Body Fat composition			
Total body fat (%)	31.52 ± 8.43	36.52 ± 6.36	0.000

Abbreviations: BMI = body mass index; SPMSQ = short portable mental status questionnaire; BI= Barthel index; EQ-5D = EuroQol-5D.

2 months after a fracture can significantly reduce total body mass and lean mass.[33] This study accurately demonstrates the prevalence of sarcopenia in geriatric hip fracture patients by minimizing the effect of muscle loss as a result of prolonged waiting for DXA.

To date, there is little evidence that sarcopenia is associated with clinical outcomes following hip fracture surgery in a geriatric population, although a high prevalence of sarcopenia has been reported for these specific populations. Yoo et al. reported that hip fracture patients aged 60 years or older with osteosarcopenia have a 1.8 times higher one-year mortality rate than patients without osteosarcopenia.[34] It was also proven that hip fracture patients with sarcopenia have lower mobility at one-year after surgery in a prospective, multicenter observational study.[35] To the best of the authors' knowledge, this study is the first to demonstrate that sarcopenia may be an independent predictor of poor functional recovery and a decrease in life quality for geriatric hip fracture patients at 6-months after surgery. Although no statistical significance

Table 3 Multivariate logistic regression analysis for hip fracture patients with sarcopenia.

Variables	AOR	95% CI		P value
		Lower limit	Upper limit	
Age	1.304	0.980	1.092	0.223
BMI	0.756	0.618	0.924	0.006
Gender (Female vs Male)	0.170	0.043	0.680	0.012
Diabetes mellitus (Yes vs No)	0.571	0.237	1.379	0.213
Dementia (Yes vs No)	1.006	0.222	4.563	0.994
White blood cell count	0.925	0.816	1.048	0.222
SPMSQ errors	0.999	0.847	1.178	0.987
BI score	0.995	0.967	1.024	0.724
EQ-5D score	0.483	0.025	9.406	0.631
Handgrip strength	0.893	0.809	0.986	0.025
Total body fat	1.023	0.937	1.116	0.617
T-score	0.982	0.629	1.534	0.937

Abbreviations: BMI = body mass index; SPMSQ = short portable mental status questionnaire; BI=Barthel index; EQ-5D = EuroQol-5D.

is demonstrated, this study also shows that there is a greater chance of mortality within 6 months after surgery for geriatric hip fracture patients with sarcopenia than those without sarcopenia. A greater understanding of the negative effects of sarcopenia on the outcomes following hip fracture surgery for geriatric populations might allow the early detection of sarcopenia, especially for male hip fracture patients with lower BMI and lower handgrip strength. This would allow early intervention for sarcopenia treatment to reverse these poor outcomes.

This study demonstrates that hip fracture patients with sarcopenia have poor mid-term outcomes after hip surgery and poor baseline general conditions. In terms of the population of geriatric patients with hip fracture for this study, greater age, lower BMI, more dementia, lower pre-operative serum WBC counts, a tendency for cognitive impairment, lower pre-injury activity of daily living and life quality and lower bone mineral density are significantly correlated with sarcopenia in the univariate analysis. Sarcopenia is a process that is related to aging,[36] so all of these changes could develop with direct or indirect connections with sarcopenia as patients age. By definition, sarcopenia is a condition that is characterized by loss of skeletal muscle mass and function,[7] which may be why the pre-injury activity of daily living and life quality is poor for the sarcopenia group. Various risk factors are reportedly associated with sarcopenia, including older age, lower BMI, poor nutrition, frailty and cognitive impairment,[14,37,38] which agrees with the results of the univariate analysis. Although there is evidence that patients with sarcopenia have higher serum WBC counts than non-sarcopenic patients due to chronic inflammation,[39] the univariate analysis for this study shows an inverse correlation between baseline serum WBC counts for hip fracture patients with and without sarcopenia. The pre-operative serum WBC counts were measured during admission in this study, so the WBC counts represent the ability of inflammatory reaction to trauma, instead of the baseline inflammatory status for geriatric hip fracture patients. Aging can also impair the inflammatory response to trauma.[40] Therefore, hip fracture patients in this study with sarcopenia who are older than those in the non-sarcopenic group, may have a lower inflammatory reaction to hip fracture and lower pre-operative serum WBC counts. Further investigation is necessary to verify the association between sarcopenia and serum WBC counts, especially in specific regard to geriatric patients with a hip fracture.

There is a large difference in several variables at the baseline between hip fracture patients with or without sarcopenia when the confounding effects of these variables are controlled in a multivariate analysis for logistic regression, but only lower BMI, male gender and lower handgrip strength are significant relevant risk factors for sarcopenia in geriatric hip fracture patients. Geriatric hip fracture patients with sarcopenia are older than non-sarcopenic patients in this study, multiple variables may be directly or indirectly correlated with each other. Dementia, osteoporosis and poor mobility could be associated with aging, so the univariate analysis could provide different results for sarcopenic and non-sarcopenic groups in this study. Using the multivariate analysis for all possible associated factors, the results of this study are consistent

Table 4 Impacts of sarcopenia on activity of daily living (ADL) and quality of life (QoL) at the 6 months following hip surgery.

Parameter	6 months following hip surgery			
	ADL: Barthel index		QoL: EuroQoL-5D	
	B(SE)	P value	B(SE)	P value
Gender (reference: male)	−4.477(4.705)	0.341	−0.038(0.029)	0.190
Age	0.222(0.171)	0.195	−0.001(0.002)	0.426
Body mass index	−0.055(0.710)	0.939	−0.005(0.004)	0.202
T-score	5.306(1.744)	0.002	0.047(0.012)	0.000
Sarcopenia (reference: no)	16.242(4.988)	0.001	0.075(0.030)	0.013
Baseline score	−1.767(3.604)	0.624	0.071(0.025)	0.004

Note: Analyses were done using generalized estimating equations with Barthel index and EuroQoL-5D assessing in two time points (baseline and 6-month follow-up).

Table 5 Comparison of current studies on the prevalence of sarcopenia in hip fracture patients.

	Di Monaco et al.,[18] 2012	Hida et al.,[17] 2013	Gonzalez-Montalvo et al.,[16] 2015	Ho et al.,[15] 2016	Steihaug et al.,[14] 2017	Present study, 2019
Population	Italian	Japanese	Spanish	Hong Kong Chinese	Norwegian	Taiwanese
Mean age	79.7	82.3	85.3	82	79.1	80.7
Prevalence	95% (M), 64% (F)	44.7% (M), 81.1% (F)	12.4% (M), 18.3% (F)	73.6% (M), 67.7% (F)	42% (M), 34.9% (F)	63.9% (M), 44.7% (F)
Criteria	New Mexico Elder Health Survey	Japanese criterion	EWGS definition	AWGS definition	EWGS definition	AWGS definition
Screening tool for muscle mass	DXA	DXA	Electrical bioimpedance	DXA	Anthropometry	DXA
DXA delay time (day)	20.9	Immediately after fracture and before surgery	N/A	14.2	N/A	5.7

Abbreviations: AWGS = Asian Working Group for Sarcopenia; EWGS = European Working Group for Sarcopenia; DXA = dual-energy X-ray absorptiometry; F = female; M = male; N/A = not applicable.

with the results of other studies[16,18] and this study identifies more reliable predictors, including lower BMI, male gender and lower handgrip strength, which could be used to screen geriatric patients at risk of sarcopenia, who are proven to have poor mid-term outcomes following hip surgery.

Relative appendicular skeletal muscle mass index (RASM), which is an important index of muscle mass, decreases with the age in both male and female patients in this study (Fig. 1). However, the rate of decline of RASM differs for the genders, with a significant decrease in muscle mass in male patients who are older than 80 years. This result is confirmed by a previous study on age- and gender-related variations of muscle mass and strength in community-dwellers.[41] Although the GASM remains comparable between genders after the age of 80 years in this study, male patients who are older than 80 years are more likely to be diagnosed with sarcopenia than female patients, because males have a more restricted threshold for RASM for a diagnosis of sarcopenia than females (a threshold of 7 kg/m^2 for men and 5.4 kg/m^2 for women).[26] Among the participants in this study, all (18/18) male patients who are older than 80 years fulfill the diagnosis for sarcopenia, but only 51.5% (34/66) of the female patients after the age of 80 years are diagnosed with sarcopenia. Men have already been determined to have a poorer prognosis after hip fracture than women, with a 4.6-fold vs. 2.8-fold increase in mortality.[42] This study has more mortality events for male patients (5 male versus 2 female) within 6 months after hip fracture surgery. Of the 5 male patients who died, 4 patients were in the sarcopenia group and were older than 80 years, so a difference between genders in the rate of decline of muscle mass may be critically associated with a higher mortality rate after hip fracture, especially in vulnerable male patients who are older than 80 years. Further studies are warranted to determine relevant correlations. Bone mineral density, handgrip strength and BMI have all been proven to be positively associated with RASM,[12,15] and this relationship acts in concert with that shown in Fig. 2. BMI is the best predictor of RASM in both male and female patients with hip fracture in this study.

This study has limitations. Only 139 participants were enrolled in this study, and they may not be representative of the overall geriatric population with a hip fracture in Taiwan. Although the waiting time from fracture to DXA assessments is only one week for this study, potential muscle wasting as a result of immobilization following hip fracture might produce a bias in the muscle mass assessment. However, since the time to DXA is neither associated with a diagnosis of sarcopenia nor correlated with RASM ($R = -0.019$, $p = 0.824$), its effect on muscle wasting is not substantial. Finally, this study only determines the difference in mid-term outcomes after hip surgery between geriatric hip fracture patients with and without sarcopenia. Further study and long-term follow-up is required to verify the natural course and clinical relevance, especially for the specific hip fracture population with sarcopenia.

Conclusion

This study is the first to report on the prevalence of sarcopenia and associated risk factors for geriatric patients with a hip fracture in Taiwan. It shows a prevalence of sarcopenia in geriatric patients with hip fracture of 50% with poor functional outcomes and life quality at 6 months after hip surgery. Male hip fracture patients with lower BMI and lower handgrip strength are especially vulnerable to sarcopenia. A robust screening and treatment program for sarcopenia is necessary, in order to improve functional outcomes and reduce mortality after hip fracture.

Declaration of Competing Interest

The authors have no conflicts of interest relevant to this article.

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Abbreviation

ADL	activities of daily living
ASM	appendicular skeletal muscle mass
AWGS	Asian Working Group for Sarcopenia
BI	Barthel index
BMI	body mass index
DXA	dual-energy X-ray absorptiometry
EQ-5D	EuroQol-5D
EWGS	European Working Group for Sarcopenia
QoL	quality of life
RASM	relative appendicular skeletal muscle mass index
SPMSQ	short portable mental status questionnaire
WBC	white blood cell

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jfma.2020.02.004.

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