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의학석사 학위논문

Psoas muscle volume as an opportunistic diagnostic tool to assess sarcopenia in hip fracture patients

고관절 골절환자에서 근감소증의 기회적 진단 도구로써의 요근 용적의 이용

울 산 대 학 교 대 학 원

의 학 과

소 상 필

Psoas muscle volume as an opportunistic diagnostic tool to assess sarcopenia in hip fracture patients

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이 논문을 의학석사 학위 논문으로 제출함

2021 년 8 월

울 산 대 학 교 대 학 원

의 학 과

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Abstract (English)

Purpose: Sarcopenia is a progressive skeletal muscle disorder characterized by low muscle strength, quantity, or quality. We assessed the correlation between psoas muscle volume and appendicular skeletal muscle mass, measured by body composition analysis, and the correlation between psoas muscle volume and handgrip strength. We also evaluated the correlation between psoas muscle volume and variables related to postoperative short-term outcomes and preoperative physical status.

Methods: A total of 48 consecutive patients diagnosed with hip fractures who underwent surgery between April 2020 and April 2021 were enrolled. Three-dimensional pelvic computed tomography was performed with 3 mm thick slices. An expert imaging analyzer manually demarcated the margin of the psoas muscle at the inferior endplate of the L3 and L4 vertebrae. For segmentation of the psoas muscle, manual marking was performed at the margin of the psoas muscle at all axial cuts from the T12 vertebra to the lesser trochanter, and the AVIEW Modeler (Coreline Soft, Seoul, Republic of Korea) automatically calculated the cross-sectional area and volume of the psoas muscle. Body composition analysis was performed using dual-energy X-ray absorptiometry, and appendicular skeletal muscle mass was calculated. We measured handgrip strength preoperatively to assess muscle strength. Data on patient demographics, postoperative complications classified by Clavien-Dindo classification, length of stay after surgery, American Society of Anesthesiologists grade of physical status, and Koval score were also recorded.

Results: The total psoas muscle volume and adjusted values were significantly correlated with appendicular skeletal muscle mass. Total psoas muscle volume and adjusted values were significantly correlated with handgrip strength. Total psoas muscle volume did not show a correlation with postoperative complications according to the Clavien-Dindo classification, length of stay after surgery, preoperative American Society of Anesthesiologists grade of physical status, and Koval score.

Conclusion: Psoas muscle volume using pelvic computed tomography images could be a potential tool for simultaneously assessing the quantity and strength of the skeletal muscle in patients with hip fractures without additional examinations.

Level of Evidence: Retrospective cohort study; Level IV

Keywords: appendicular skeletal muscle mass, hip fracture, psoas muscle, sarcopenia

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Introduction

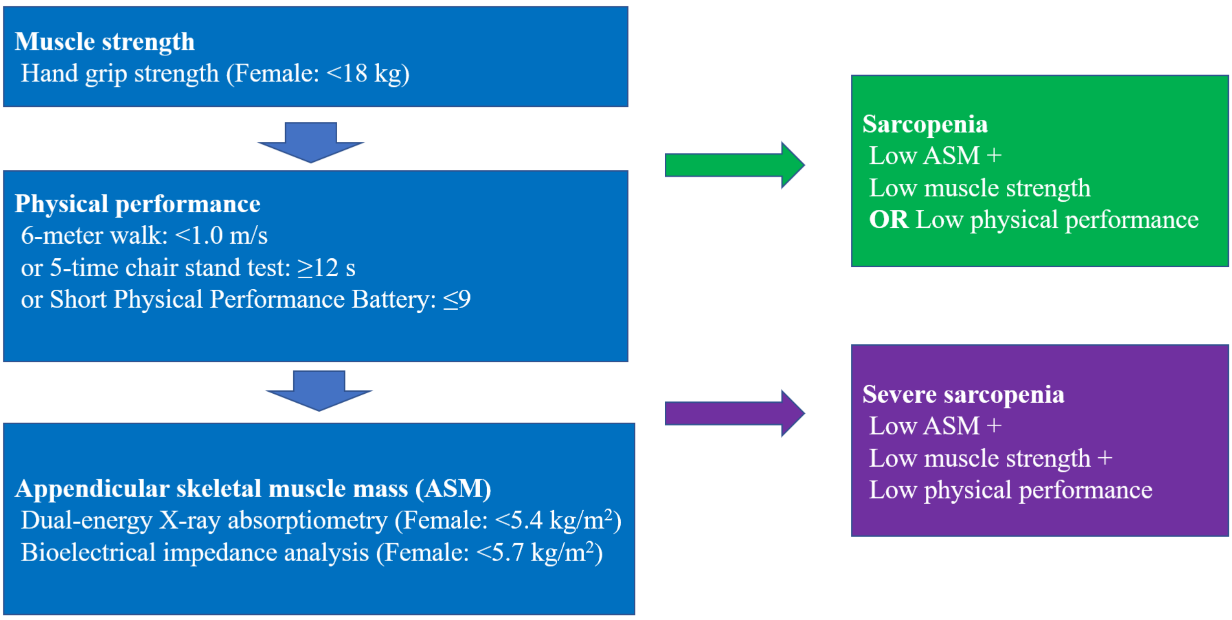
Sarcopenia is a progressive and generalized skeletal muscle disorder associated with an increased likelihood of adverse outcomes, such as falls, fractures, physical disability, and mortality.[1] In hip fracture patients, sarcopenia is a significant independent predictor of postoperative clinical outcomes, including mortality, active daily life, mobility, and quality of life.[2-8] Therefore, more prompt treatment and active rehabilitation are needed in patients with hip fractures diagnosed with sarcopenia.

According to the Asian Working Group for Sarcopenia (AWGS), sarcopenia is diagnosed if a patient exhibits a combination of low muscle quantity and either low muscle strength or physical performance, while severe sarcopenia is diagnosed if the patient exhibits low muscle quantity, low muscle strength, and low physical performance (Figure 1).[9] According to the AWGS diagnostic criteria, muscle quantity is assessed by appendicular skeletal muscle mass (ASM), which is measured through dual-energy X-ray absorptiometry (DXA) or bioelectrical impedance analysis (BIA), and muscle strength is measured by assessing handgrip strength. Physical performance was assessed using the gait speed test, chair stand test, and short physical performance battery. However, in patients with acute hip fractures, BIA, gait speed test, chair stand test, and short physical performance battery are challenging to perform, and accurate measurement of muscle quantity and quality is not easy.

To assess skeletal muscle mass, ASM by DXA or BIA is widely used as a standard method; however, additional examinations should be performed to measure muscle mass by DXA or

BIA, and BIA is difficult to perform in patients with hip fractures due to its position during the examination. In patients with hip fractures, three-dimensional (3D) pelvic CT scans are commonly performed to assess the fracture pattern and plan the surgery. Pelvic CT scans can help visualize the psoas muscle, and the cross-sectional area or volume of the psoas muscle could be measured. The cross-sectional area of the lumbar muscle assessed by CT or magnetic resonance imaging (MRI) has been actively investigated as a tool to measure muscle mass. It offers advantages in that it can help objectively quantify muscle mass, and it is possible to assess fatty muscle degeneration, which predicts muscle quality simultaneously, and it can be a factor predicting prognosis in various diseases.[10-13]

Figure 1. Asian Working Group for Sarcopenia (AWGS) 2019 algorithm for sarcopenia.



In various aspects of surgeries, low muscle mass assessed by cross-sectional area and volume of the psoas muscle or lumbar muscle showed an association with poor postoperative short-term outcomes. A 2014 systematic literature review illustrated that low muscle mass assessed by the cross-sectional area of the psoas muscle or lumbar muscle was associated with increased morbidity and length of hospital stay in retrospective cohort studies on abdominal surgery.[14-16] Among patients who underwent curative resection for pancreatic adenocarcinoma, those evaluated as having low muscle mass by psoas muscle volume showed a longer length of stay and higher risk for postoperative complications as assessed using Clavien-Dindo classification.[17] Regarding preoperative physical status, there is a debate about the association between sarcopenia defined by the cross-sectional area of the psoas muscle or lumbar muscle and American Society of Anesthesiologists (ASA) grade of physical status.[18,19] There have been various reports on the correlation between sarcopenia assessed by ASM and preoperative Koval score, which represents the walking ability in patients with hip fractures; however, to the best of our knowledge, there have been no studies assessing the correlation between sarcopenia assessed by psoas muscle volume and preoperative Koval score.[20,21] Several studies have examined the cross-sectional area of the psoas muscle as a tool to diagnose sarcopenia and as a prognostic surrogate related to postoperative short-term outcomes and preoperative physical status; however, studies focusing on true psoas muscle volume are insufficient.

In this study, we hypothesized that psoas muscle volume would reflect muscle quantity better than the cross-sectional area of the psoas muscle and would be a potential opportunistic diagnostic tool to measure muscle mass and strength for the diagnosis of sarcopenia in hip fracture patients. The primary outcome was to analyze the correlation between psoas muscle volume measured by 3D pelvic CT and ASM assessed by DXA in patients with hip fractures as well as to assess the correlation between psoas muscle volume and handgrip strength. The secondary outcome was to evaluate the correlation between psoas muscle volume and variables related to postoperative short-term outcomes and preoperative physical status in patients with hip fractures.

Materials and methods

Participants

This was a single-center retrospective cohort study approved by our institutional review board. The inclusion criteria were: 1) patients diagnosed with hip fractures, defined as femoral neck fracture, intertrochanteric fracture, and subtrochanteric fracture and treated by surgery from April 2020 to April 2021; 2) patients with fractures resulting from low-energy trauma; 3) women aged 55 years or older; and 4) 3D pelvic CT scan and body composition analysis using DXA performed during hospitalization. Patients underwent one of the following surgeries: total hip replacement arthroplasty, bipolar hemiarthroplasty, intramedullary nailing for hip fracture, and multiple screw fixation for femoral neck fracture. To assess osteoporotic hip fractures, female patients and those with low-energy trauma were included. We defined low-energy trauma as a fall from a standing height or height of less than 1 m according to the general consensus.[22] Patients with fractures at more than one site, periprosthetic fractures, or metastatic pathologic fractures were excluded because these types of fractures could affect the rehabilitation protocol. Patients with insufficient data were excluded. A total of 51 patients were initially enrolled; 1 patient with fractures at more than one site, 1 patient with periprosthetic fracture and 1 patient with insufficient data were excluded. In total, 48 patients were included in the study.

Data collection

Psoas muscle segmentation and volume measurement

A 3D pelvic CT scan (SOMATOM Definition AS, Siemens, Munich, Germany) was performed with 3 mm thick slices in the emergency room to evaluate the fracture pattern and establish a surgical plan in patients with hip fractures. Computed tomography images in the digital imaging and communications in medicine (DICOM) format were imported into a 3D modeling software program (AVIEW Modeler, Coreline Soft, Seoul, Republic of Korea) to produce 3D samplings of anatomical elements of the psoas muscle. When the expert imaging analyzer manually demarcated the margin of the psoas muscle (psoas muscle area, PA) at the level of the inferior endplate of the L3 (unadjusted PA-L3) and the inferior endplate of the L4 (unadjusted PA-L4) vertebrae, the AVIEW Modeler automatically calculated the cross-sectional area (Figure 2). For the segmentation of the psoas muscle, manual marking at the margin of the psoas muscle at all axial cuts from the T12 vertebra to the lesser trochanter was performed, and the psoas muscle volume was automatically calculated using the AVIEW Modeler (Figure 3). The cross-sectional area of each patient was adjusted for the patient's height in m^2 (PA-L3, PA-L4), which is commonly used to adjust the cross-sectional area of the psoas muscle. Because there is no established method to adjust psoas muscle volume, we used the unadjusted psoas muscle volume (total psoas volume, TPV: TPV1), and tried to adjust the psoas muscle volume for the patient's height in m (TPV2) as a fundamental unit. Considering that ASM and cross-sectional area are adjusted for the patient's height in m^2, we adjusted the psoas muscle volume for the patient's height in m^2 (TPV3). In addition, we adjusted it for the patient's height in m^3 (TPV4) because the psoas muscle volume is the measured value of the 3D structure. We used unadjusted (TPV1) and adjusted psoas muscle volumes (TPV2, TPV3, and TPV4) for the analysis.

Figure 2. Measurement of the cross-sectional area of psoas muscle at the inferior endplate of the L3

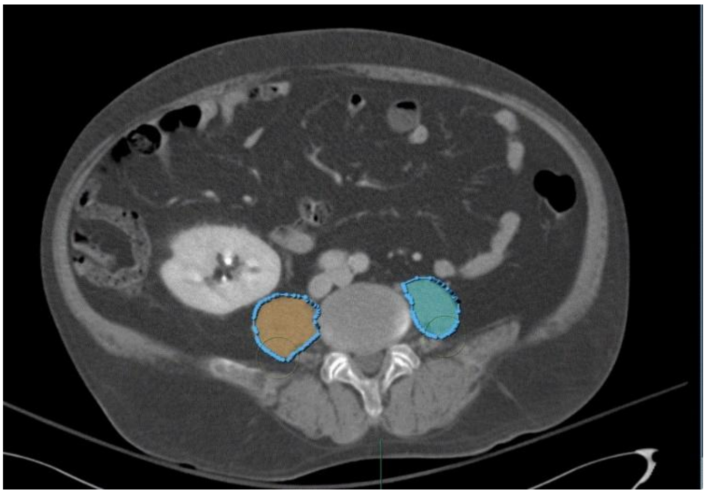
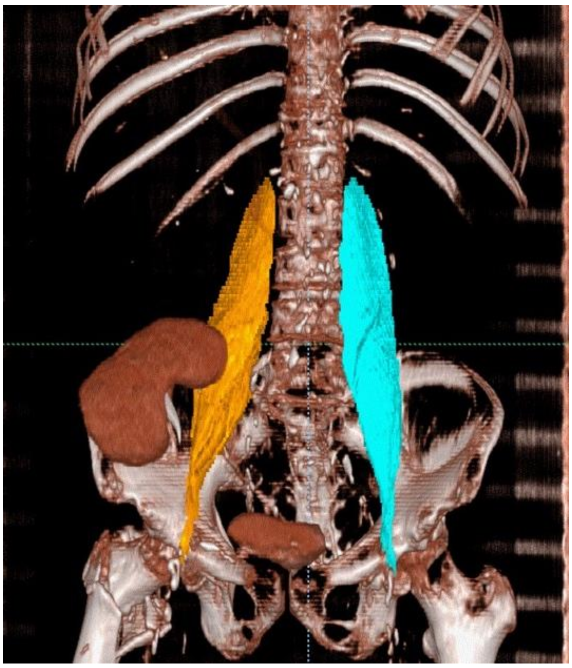


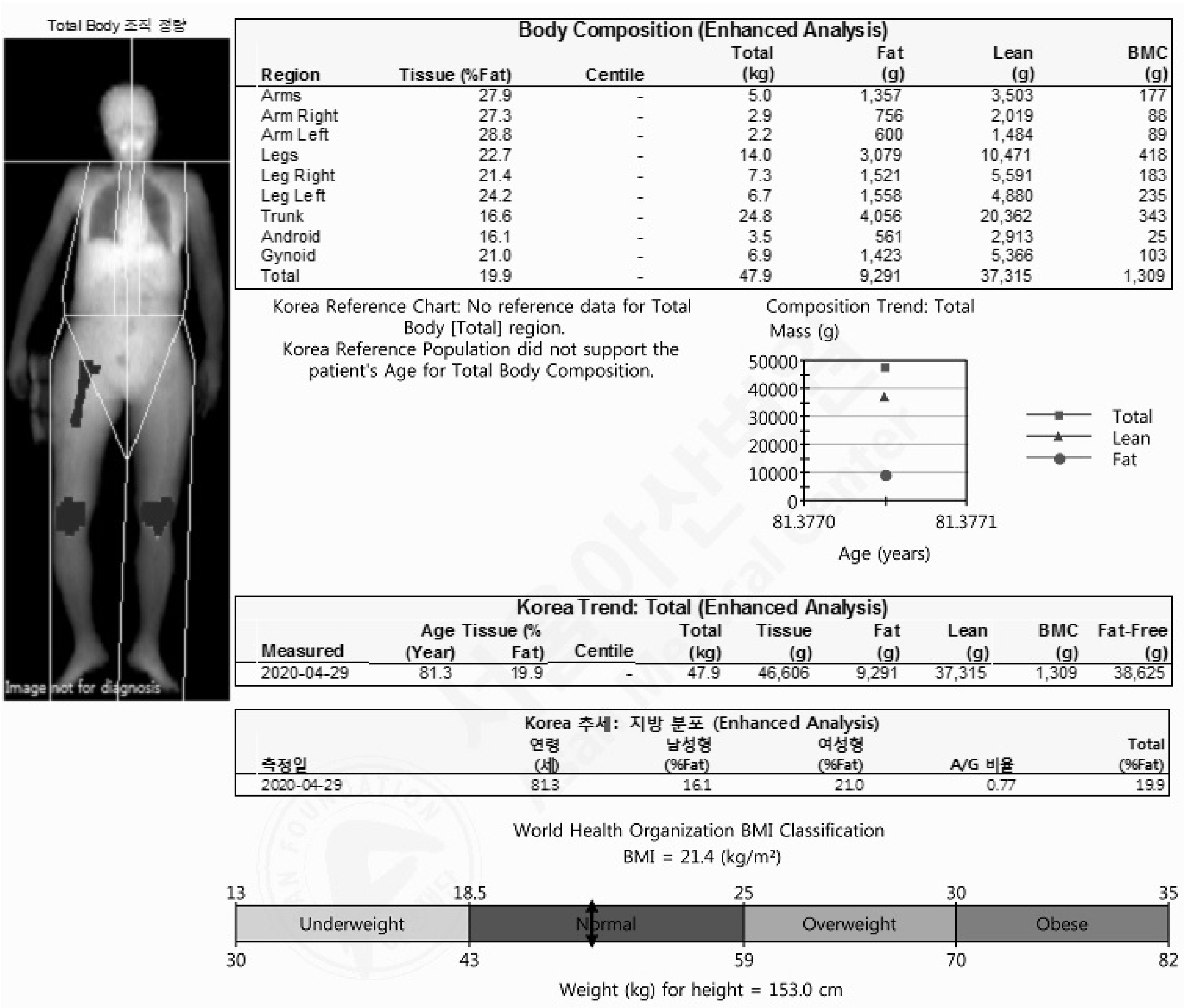
Figure 3. Segmentation of the psoas muscle and measurement of the psoas muscle volume



Primary outcomes

As a standard method to measure skeletal muscle mass, body composition analysis was performed using DXA (GE Lunar Prodigy, Siemens, Munich, Germany) during hospitalization for hip fracture surgery. Body composition analysis assessed the mass of fat, muscle, and bone mineral components of each limb and the trunk (Figure 4). Appendicular skeletal muscle mass was measured as the sum of skeletal muscle mass at both the upper and lower extremities, and it was adjusted for the patient's height in m^2. According to the AWGS, the diagnostic criteria for low skeletal muscle mass by ASM is less than 5.4 kg/m^2 in women. Handgrip strength was measured preoperatively in the supine position with shoulder adduction and 90° of elbow flexion to assess muscle strength (Figure 5). It was checked at both hands three times each with a dynamometer TKK5401 (Takei Corporation, Nigata, Japan), and the largest value was used for analysis. According to the AWGS criteria, low muscle strength was defined as grip strength less than 18 kg in women.

Figure 4. Example of body composition analysis by dual X-ray absorptiometry



Total Body 조직 정량

Image not for diagnosis

Body Composition (Enhanced Analysis)

Region	Tissue (%Fat)	Centile	Total (kg)	Fat (g)	Lean (g)	BMC (g)
Arms	27.9	-	5.0	1,357	3,503	177
Arm Right	27.3	-	2.9	756	2,019	88
Arm Left	28.8	-	2.2	600	1,484	89
Legs	22.7	-	14.0	3,079	10,471	418
Leg Right	21.4	-	7.3	1,521	5,591	183
Leg Left	24.2	-	6.7	1,558	4,880	235
Trunk	16.6	-	24.8	4,056	20,362	343
Android	16.1	-	3.5	561	2,913	25
Gynoid	21.0	-	6.9	1,423	5,366	103
Total	19.9	-	47.9	9,291	37,315	1,309

Korea Reference Chart: No reference data for Total Body [Total] region.
Korea Reference Population did not support the patient's Age for Total Body Composition.

Composition Trend: Total Mass (g)

Korea Trend: Total (Enhanced Analysis)

Measured	Age (Year)	Tissue (% Fat)	Centile	Total (kg)	Tissue (g)	Fat (g)	Lean (g)	BMC (g)	Fat-Free (g)
2020-04-29	81.3	19.9	-	47.9	46,606	9,291	37,315	1,309	38,625

Korea 추세: 지방 분포 (Enhanced Analysis)

측정일	연령 (세)	남성형 (%Fat)	여성형 (%Fat)	A/G 비율	Total (%Fat)
2020-04-29	81.3	16.1	21.0	0.77	19.9

World Health Organization BMI Classification
BMI = 21.4 (kg/m²)

Weight (kg) for height = 153.0 cm

Figure 5. Measurement of handgrip strength in the supine position with shoulder adduction and 90° of elbow flexion

Secondary outcomes

We assessed postoperative complications during hospitalization and length of stay after surgery using a chart review. Postoperative complications were classified according to the Clavien-Dindo classification system (Minor: 1–2; Major: 3–5) (Table 1). The length of stay after surgery was counted in days, except for those who had transferred to the Department of Rehabilitation Medicine, or who had major postoperative complications after surgery. The Department of Rehabilitation Medicine had its own rehabilitation protocol for hip fracture, which was longer than that of the Department of Orthopedic Surgery, and major postoperative complications required extensive care with delayed discharge. To assess preoperative physical status, we reviewed the American Society of Anesthesiologists (ASA) grade of physical status and Koval score of patients. The American Society of Anesthesiologists grade of physical status represents the overall health status and is classified into five grades (Table 2). The Koval score, which describes the walking ability of patients, was scored from 1 (independent community ambulatory) to 7 (nonfunctional ambulator), preoperatively (Table 3). Variables related to secondary outcomes were analyzed not only with psoas muscle volume, but also with ASM and cross-sectional area as a previously established method to measure skeletal muscle mass. We also collected patient demographic data, including height, weight, sex, and age.

Table 1. Clavien-Dindo classification of postoperative complications

Class	Description
I	Any deviation from the normal postoperative course
II	Normal course altered
III	Complications that require intervention of various degrees
IV	Complications threatening life of patients
V	Death of a patient

Table 2. American Society of Anesthesiologists (ASA) grade of physical status

Grade	Description
1	Normally healthy patient
2	Patient with mild systemic disease
3	Patient with severe systemic disease which is not incapacitating
4	Patient with an incapacitating systemic disease that is a constant threat to life
5	Moribund patient not expected to survive for 24 h with or without operation

Table 3. Koval score and its description

Score	Description
1	Independent Community Ambulatory
2	Community Ambulatory with Cane
3	Community Ambulatory with Walker
4	Independent Household Ambulatory
5	Household Ambulatory with Cane
6	Household Ambulatory with Walker
7	Nonfunctional Ambulator

Statistical analysis

We calculated the mean and 95% confidence interval (CI) for the continuous variables and reported counts and proportions for the ordinal and nominal variables. We used the Pearson correlation test to assess correlations between continuous variables. By Pearson correlation test, the correlation between psoas muscle volume, cross-sectional area, ASM, and handgrip strength was analyzed, and correlation between psoas muscle volume, cross-sectional area, ASM, and length of stay was also assessed. We used the Spearman correlation test to check the correlation between continuous and ordinal variables, such as the correlation between psoas muscle volume, cross-sectional area, ASM, and postoperative complications, and the correlation between psoas muscle volume, cross-sectional area, ASM, and ASA grade of physical status or Koval score. We defined the degree of correlation by Pearson (r) or Spearman correlation coefficient (r_s), according to the interpretation of Dancey and Reidy

(Table 4).[23] Statistical significance was set at *P* < 0.05. Data analysis was carried out using IBM SPSS Statistics for Windows, version 21 (IBM Corp., Armonk, NY, USA).

Table 4. Degree of correlation by Pearson (r) or Spearman correlation coefficient (r_s), according to the interpretation of Dancey and Reidy

Correlation coefficient (r)	Description
$r = 1$	Perfect
$0.7 \leq r < 1$	Strong
$0.4 \leq r < 0.7$	Moderate
$0 < r < 0.4$	Weak
$r = 0$	Zero

* Description of positive correlation coefficient only.

Results

A total of 48 patients were included in this study. Detailed patient demographic data are shown in Table 5. Mean age was 79.0 years old (range, 59–93), and mean BMI was 21.8 kg/m^2 (95% CI, 20.7–22.8). By the preoperative ASA grade of physical status, 33 patients (68.8%) had grade 2 and no patients had grade 1 or 5. In case of Koval score, most patients had a score of 1 (Table 5).

The mean value of ASM was 5.5 kg/m^2 (95% CI, 5.2–5.7), and the incidence of low skeletal muscle mass by ASM was 47.9% (23 patients). Appendicular skeletal mass was significantly correlated with psoas muscle volume and cross-sectional area. Appendicular skeletal mass was moderately correlated with TPV1, TPV2, TPV3, and TPV4 and weakly correlated with PA-L3 and PA-L4. TPV3 showed the strongest Pearson correlation coefficient, followed by TPV4 and TPV2, while PA-L4 showed the weakest correlation coefficient (Table 6, Figure 6). Preoperative handgrip strength was assessed in 41 patients, with a mean value of 12.1 kg (95% CI, 10.6–13.3). According to the AWGS criteria, the rate of low handgrip strength was 77.1% (37 patients). Handgrip strength was significantly correlated with psoas muscle volume and adjusted values. Of these, TPV1 and TPV2 showed moderate correlation, and TPV3 and TPV4 showed weak correlation. The cross-sectional area and ASM were not significantly correlated with handgrip strength (Table 7).

Table 5. Patient demographic data

Characteristic	Value
Mean age (year)	79.0 (range, 59–93)
BMI (kg/m^2)	21.8 (95% CI, 20.7–22.8)
ASM (kg/m^2)	5.5 (95% CI, 5.2–5.7)
TPV1 (cc)	170.7 (95% CI, 160.9–180.4)
TPV2 (cc/m)	111.1 (95% CI, 105.0–117.1)
TPV3 (cc/m^2)	72.4 (95% CI, 68.5–76.3)
TPV4 (cc/m^3)	47.3 (95% CI, 44.6–49.9)
PA-L3 (mm^2/m^2)	430.3 (95% CI, 396.2–464.3)
PA-L4 (mm^2/m^2)	540.7 (95% CI, 506.2–575.3)
Fracture type (n)	
Femoral neck fracture	16
Intertrochanteric fracture	28
Subtrochanteric fracture	4
Operation method (n)	
Total hip replacement arthroplasty	1
Bipolar hemiarthroplasty	12
Intramedullary nailing for hip fracture	32
Multiple screw fixation for hip fracture	3
Handgrip strength (kg)	12.1 (95% CI, 10.6–13.3)
ASA grade of physical status (n)	
1	0 (0%)

2	33 (68.8%)
3	13 (27.1%)
4	2 (4.2%)
5	0 (0%)
Koval score (n)	
1	28 (58.3%)
2	3 (6.3%)
3	3 (6.3%)
4	4 (8.3%)
5	3 (6.3%)
6	6 (12.5%)
7	1 (2.1%)

Table 6. Pearson correlation test between psoas muscle volume, cross-sectional area and ASM

		Correlation coefficient	P-value
Standard method	ASM		
Psoas muscle volume	TPV1	0.401	<0.01
	TPV2	0.429	<0.01
	TPV3	0.439	<0.01
	TPV4	0.431	<0.01
Psoas muscle area	PA-L3	0.323	0.03
	PA-L4	0.307	0.03

Figure 6. Scatter plot depicting the correlation of psoas muscle volume and its adjusted values with ASM

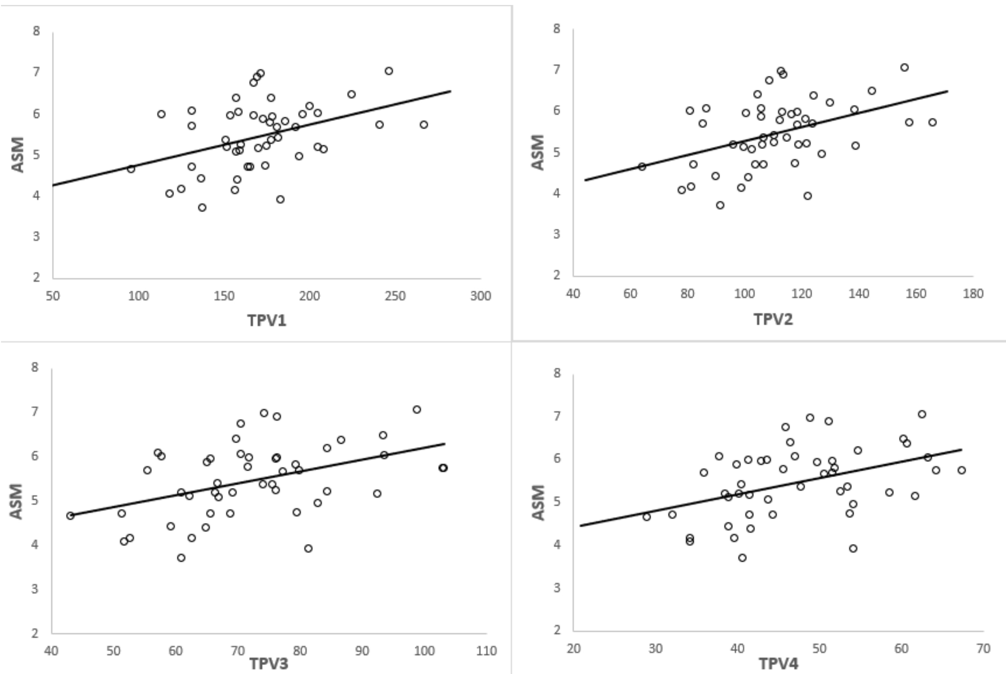


Table 7. Pearson correlation test between psoas muscle volume, cross-sectional area, ASM and handgrip strength

		Handgrip strength (n = 41)	
		Correlation coefficient	P-value
Standard method	ASM	0.233	0.14
Psoas muscle volume	TPV1	0.422	<0.01
	TPV2	0.419	<0.01
	TPV3	0.396	0.01
	TPV4	0.357	0.02
Psoas muscle area	PA-L3	0.063	0.69
	PA-L4	0.254	0.11

According to the Clavien-Dindo classification of postoperative complications, 10 patients had grade 2, seven patients had grade 3, and one patient had grade 5 complications, and the mean length of stay after surgery was 6 days (95% CI, 5.3–6.6). Psoas muscle volume, cross-sectional area, and ASM were not significantly correlated with postoperative complications or length of stay (Table 8). In addition, psoas muscle volume, cross-sectional area, and ASM did not correlate significantly with ASA grade of physical status and Koval score (Table 9).

Table 8. Spearman correlation test between psoas muscle volume, cross-sectional area, ASM and grade of complication according to the Clavien-Dindo classification and Pearson correlation test between psoas muscle volume, cross-sectional area, ASM and length of stay

		Grade of complication (n = 48)		Length of stay (n = 36)	
		Correlation coefficient	P-value	Correlation coefficient	P-value
Standard method	ASM	-0.002	0.99	0.026	0.88
Psoas muscle volume	TPV1	-0.203	0.17	-0.035	0.84
	TPV2	-0.195	0.19	-0.05	0.77
	TPV3	-0.169	0.25	-0.066	0.7
	TPV4	-0.21	0.15	-0.079	0.65
Psoas muscle area	L3-PA	-0.164	0.26	0.113	0.51
	L4-PA	-0.153	0.3	0.092	0.59

Table 9. Spearman correlation test between psoas muscle volume, cross-sectional area, ASM and ASA grade of physical status and between psoas muscle volume, cross-sectional area, ASM and Koval score

		ASA grade (n = 48)		Koval score (n = 48)	
		Correlation coefficient	P-value	Correlation coefficient	P-value
Standard method	ASM	-0.014	0.92	-0.036	0.81
Psoas muscle volume	TPV1	-0.182	0.22	0.021	0.88
	TPV2	-0.182	0.22	0.029	0.84
	TPV3	-0.149	0.31	0.049	0.74
	TPV4	-0.145	0.32	0.06	0.68
Psoas muscle area	PA-L3	-0.014	0.92	-0.049	0.74
	PA-L4	0.061	0.68	-0.049	0.74

Discussion

This study demonstrated that psoas muscle volume and its adjusted values were significantly correlated with ASM, and psoas muscle volume showed a higher correlation coefficient than cross-sectional area. In addition, psoas muscle volume was significantly correlated with handgrip strength, while ASM and cross-sectional area were not significantly correlated with handgrip strength. These findings suggest that psoas muscle volume measured by 3D pelvic CT could be used as a potential opportunistic screening tool to measure muscle mass and strength for the diagnosis of sarcopenia.

Appendicular skeletal muscle mass predicted by DXA or BIA and total skeletal muscle mass (TSM) predicted by BIA have been used as a standard method to measure the quantity of skeletal muscle. However, DXA and BIA have inconsistent results for different instrument brands, and BIA can be influenced by the hydration status of the patient.[24-28] Also, additional examinations are needed to measure muscle mass by DXA and BIA in hip fracture patients. In particular, BIA is hard to be performed in hip fracture patients due to its position during the exam. In contrast, we could measure the volume and cross-sectional area of the psoas muscle without additional examinations in hip fracture patients by 3D pelvic CT. Amini et al. suggested that psoas muscle volume may be better in defining sarcopenia than a single axial image and revealed its association with both short-term and long-term outcomes following resection of pancreatic cancer.[17] Because the psoas muscle is a 3D structure and the cross-sectional area lacks the standard axial level for measurement, we assumed that psoas muscle volume would have a stronger correlation with ASM than the cross-sectional area. In addition, we assumed that adjusted psoas muscle volume would have a stronger correlation with ASM than the unadjusted one because we used the adjusted value of ASM for the patient's height in m^2. Results were consistent with our assumption. The total psoas muscle volume showed a stronger correlation with ASM than the cross-sectional area, and of these, adjusted psoas muscle volumes (TPV2, TPV3, TPV4) showed a higher correlation coefficient than the unadjusted one (TPV1). Overall, the results suggest that we could consider using adjusted total psoas muscle volume (TPV2, TPV3, TPV4) rather than the cross-sectional area to measure skeletal muscle quantity in hip fracture patients without additional examinations.

Handgrip strength has been widely used to assess muscle strength.[29,30] Pawel et al. reported an association between cross-sectional area of the psoas muscle and handgrip strength.[31] In this study, unadjusted total psoas muscle volume and adjusted psoas muscle volumes showed a significant correlation with handgrip strength, while ASM and cross-sectional area of the psoas muscle did not significantly correlate with it. In addition, unadjusted total psoas muscle volume (TPV1) and psoas muscle volume adjusted by m (TPV2) showed moderate correlation, while psoas muscle volumes adjusted by m^2 (TPV3) or m^3 (TPV4) showed weak correlation. This suggests that we could consider using TPV1 and TPV2 to measure muscle strength in hip fracture patients without additional examinations and in patients with a hand disability. Considering the degree of correlation with both ASM and handgrip strength, we propose psoas muscle volume adjusted by m (TPV2) as the most meaningful parameter to simultaneously assess skeletal muscle mass and muscle strength.

The impact of sarcopenia on clinical outcomes has been investigated continuously, and sarcopenia is a well-known predictor of adverse outcomes in patients with hip fractures. In hip fracture patients after surgery, Landi et al. showed an association between sarcopenia and ADL at discharge from a rehabilitation hospital and after 3 months, and Byun et al. reported an association between sarcopenia in women and one-year mortality.[2,6] In this study, psoas muscle volume and adjusted values were not significantly correlated with postoperative short-term outcomes, including the grade of postoperative complications and length of stay after surgery. Because postoperative complications and length of stay after surgery are affected by various factors, the psoas muscle volume itself might not be enough to affect them as a single factor. A relatively small population group analyzed in this study might have resulted in no obvious correlation between them. In addition, as the length of stay after surgery is usually determined by hospital policy, minor complications between patients might not have provoked a significant statistical difference. Considering that psoas muscle volume has a stronger correlation with ASM than cross-sectional area, there is a possibility of a meaningful correlation between psoas muscle volume and postoperative outcomes; therefore, further studies with larger sample sizes and long-term follow-up are needed. In addition, there was no correlation between the psoas muscle volume and preoperative physical status in this study. We could consider that preoperative physical status is affected by various factors, and psoas muscle volume itself might not be associated with preoperative general physical status.

This study has several limitations. First, it was a retrospective study with relatively small sample size. To establish the reference value of low muscle mass and low muscle strength with psoas muscle volume, studies with larger populations are needed for each sex. Second, we did not consider the long-term outcomes after surgery. Third, although the measurement of volume and cross-sectional area was performed by an expert imaging analyzer, assessment only by a single person can reduce the reliability of the measured values. Nonetheless, this study has several strengths. To the best of our knowledge, this study is the first to propose psoas muscle volume as a tool for simultaneously assessing the strength and quantity of muscle without additional examinations in patients with hip fractures, which could be easily implemented in clinical settings. In addition, the values of variables related to the patients are reliable because a single surgeon has a consistent surgical technique and postoperative care. Furthermore, this study dealt with various aspects of patient data, ranging from preoperative patient status to postoperative complications and length of stay after surgery.

Conclusion

Psoas muscle volume using pelvic CT images could be a potential tool for simultaneously assessing the quantity and strength of the skeletal muscle in patients with hip fractures without additional examinations.

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요 약 (국 문)

목적: 근감소증은 진행하는 골격근의 질환으로 낮은 근육 강도, 근육량, 근육의 질로 정의된다. 본 연구에서는 요근의 용적과 체성분 분석을 통해 측정된 사지골격근량과의 상관관계와 요근의 용적과 악력관의 상관관계를 확인하고, 요근의 용적과 수술 후 단기 결과 및 수술 전 환자 상태와의 상관관계를 평가하였다.

대상 및 방법: 2020 년 4 월부터 2021 년 4 월까지, 고관절 골절로 진단 후 수술을 받은 48 명이 연구에 포함되었다. 삼차원 골반컴퓨터단층촬영은 3 mm 의 간격으로 시행되었다. 숙련된 연구원이 요추 3 번과 4 번의 하부 종판에서 요근의 경계를 따라서 직접 표시하였다. 또한, 흉추 12 번에서 소전자까지 각각의 축면영상에서 요근의 경계에 표시를 함으로써 요근의 분절화를 시행하였고, AVIEW Modeler (Coreline Soft, 서울, 한국)를 통해 요근의 단면적 및 용적을 자동으로 계산하였다. 사지골격근량은 이중에너지 방사선 흡수계측법을 통해 체성분분석을 시행하여 계산되었다. 근육 강도를 측정하기 위해 수술 전 악력을 측정하였다. 환자의 인구학적 정보, 클라비엔-딘도 (Clavien-Dindo) 분류에 따른 수술 후 합병증, 수술 후 입원 기간, 미국 마취과 학회의 신체 상태 등급, 코발(Koval) 점수에 대한 정보 또한 수집하였다.

결과: 요근의 용적과 보정된 값들은 사지골격근량과 의미 있는 상관관계를 보여주었다. 요근의 용적 및 보정된 값들은 악력과 유의미한 상관관계를 보여주었다. 요근의 용적은 클라비엔-딘도 분류에 따른 수술 후 합병증, 수술 후 입원기간 수술 전 미국 마취과 학회에 따른 신체 상태 등급, 코발 점수와 유의미한 상관관계를 보여주지 못했다.

결론: 골반컴퓨터단층촬영에서 측정한 요근의 용적은 고관절 골절 환자에게 추가적인 검사 없이 골격근의 양과 근력을 동시에 평가하는 잠재적인 도구로써 사용될 수 있을 것으로 생각된다.

근거 수준: 후향적 코호트 연구; Level of evidence IV

중심 단어: 사지골격근량, 고관절 골절, 요근, 근감소증