Radiographic Measurements of Thigh Muscle are a Simple and Reliable Tool to Predict Sarcopenia

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INTRODUCTION:

Sarcopenia is a skeletal muscle disorder characterized by low muscle mass and poor muscle function that is associated with falls, fractures, postoperative complications, prosthetic joint infection and dislocation, and early mortality. The European Working Group on Sarcopenia in Older People (EWGSOP) diagnostic criteria includes both low muscle quantity (frequently measured using cross-sectional imaging) and low muscle strength (measured using functional physical exam tests). Using cross-sectional imaging with CT or MRI for screening is costly, time-consuming, and can impart a significant radiation exposure. Therefore, the authors believe there is a need for reliable, inexpensive, and widely available screening tests to facilitate the early diagnosis and treatment of sarcopenia in orthopaedic surgery patients. The purpose of this study was to determine whether thigh muscle size could be reliably measured from plain radiographs of the distal femur, and whether these radiographic measures could reliably predict psoas muscle area and the presence of sarcopenia on CT scans.

METHODS:

Patients ≥18 years old who had both a femur radiograph and CT scan of the abdomen and pelvis performed on the same day were retrospectively identified. Measurements of the thigh musculature were made on the AP view 15cm proximal to the adductor tubercle and lateral view 15cm proximal to the distal terminus of Blumensaat's line. Measurements of psoas muscle area were made from CT scans at the inferior endplate of the L3 and L4 vertebral bodies. Sarcopenia was defined using sex-specific cut-offs of CT psoas area indexed to the patient's height. The correlation between thigh muscle size and psoas muscle area was determined, and multivariable models were optimized using backward stepwise regression to identify predictors of psoas muscle area and sarcopenia.

RESULTS:

Four-hundred-fourteen patients (252 male, 162 female) met final inclusion criteria. The intraclass correlation coefficients were >0.8 for all measurements of thigh muscle and >0.9 for all CT psoas measurements. Sarcopenia based on L4 psoas muscle area was found in 76 (18.4%) patients (44 male, 32 female, $p=0.72$). Patients with sarcopenia on abdominal CT had significantly smaller thigh muscle measurements on all radiographic views. The psoas muscle attenuation in the sarcopenia group was also lower.

Lateral quadriceps width was identified as a strong independent predictor for both psoas muscle area and sarcopenia. For the linear model predicting L4 psoas muscle area, all variables were significant $p<0.001$ and the model r-squared was 0.66. For the model predicting sarcopenia at L4, each additional centimeter of lateral quadriceps width was associated with 0.94 times lower odds of sarcopenia ($p=0.015$).

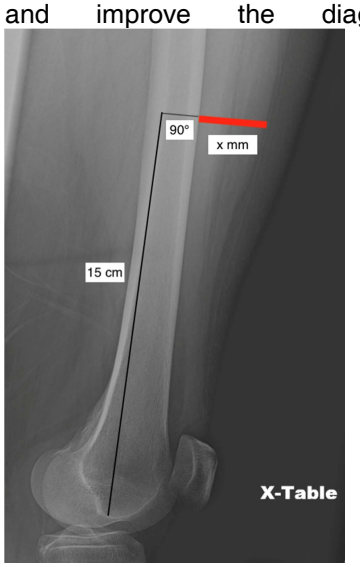
DISCUSSION AND CONCLUSION:

In this study, we demonstrated that thigh muscle could be reliably measured from plain radiographs of the distal femur, and that these measures were independent predictors of psoas muscle area and sarcopenia on CT. The interobserver reliability of the thigh muscle measurements was good to excellent. We also established the mean and standard deviation of the thigh muscle measurements in adults aged 18-40 without sarcopenia, which can be used as reference ranges in future studies. After multivariable model optimization, lateral quadriceps width was identified as a strong independent predictor of psoas muscle are and sarcopenia across all models.

Sarcopenia is emerging as a powerful predictor of patient outcomes in patients undergoing both elective and urgent orthopaedic surgery. Sarcopenia based on CT scan has been shown to be associated with 4.6 times greater odds of prosthetic joint infection, higher rates of total hip arthroplasty dislocation, and higher hospital costs and readmissions. While current studies in the orthopaedic literature have used cross-sectional abdominal imaging to predict adverse outcomes from sarcopenia, the vast majority of patients undergoing elective or urgent orthopaedic surgery do not undergo cross-sectional abdominal imaging. Therefore, more widely available, cost-effective screening tests are needed. Radiographic measurement of thigh muscle may fill this need. Thigh muscle size is an excellent proxy for whole body skeletal muscle, and the quadriceps is disproportionately involved early in the development of sarcopenia. Using radiographic measurements of thigh muscle to screen for sarcopenia would also facilitate the use of radiographic studies that are already obtained as part of routine clinical care for patients with traumatic or degenerative conditions of the hip and knee.

In 2019, the European Working Group on Sarcopenia in Older People issued a call to action for physicians "to take actions that will promote early detection and treatment" of sarcopenia. Orthopaedic surgeons who care for elderly patients

with degenerative or traumatic conditions routinely encounter patients at risk for sarcopenia, and are uniquely trained to scrutinize the radiographic studies that could be the first step in making the diagnosis. This study demonstrates that radiographs of the distal femur are a reliable and accessible tool to help orthopaedic surgeons answer that call to action and improve the diagnosis and treatment of sarcopenia in the orthopaedic population.



Sarcopenia at L4 to No Sarcopenia					
	No Sarcopenia (N = 337)		Sarcopenia (N = 76)		MW P Value
	Mean ± SD	Range	Mean ± SD	Range	
Age (Years)	46.33 ± 19.81	75	68.22 ± 18.2	78	*P<.001*
Height (m)	1.72 ± 0.1	0.53	1.69 ± 0.11	0.53	*0.049*
Weight (kg)	83.49 ± 21.83	133.3	70.19 ± 16.4	79.6	*P<.001*
BMI (kg/m²)	28.2 ± 6.56	38.6	24.51 ± 5.16	24.2	*P<.001*
AP Thigh Width (mm)	172.99 ± 30.66	172.4	149.23 ±25.91	143.3	*P<.001*
AP Muscle Width (mm)	131.05 ± 20.36	118.5	111.03 ±19.09	86	*P<.001*
Lateral Thigh Width (mm)	166.83 ±31.08	185.7	142.74 ± 26.68	162.2	*P<.001*
Lateral Muscle Width (mm)	118.46 ± 22.12	135.9	99.16 ±16.34	89	*P<.001*
Lateral Quad Width (mm)	25.67 ± 8.98	48.9	16.56 ± 7.26	37.8	*P<.001*
CT Bilateral Psoas Muscle Average Attenuation at L3 (HU)	46.22 ± 11.62	74.43	34.08 ±12.29	67.18	*P<.001*
CT Bilateral Psoas Muscle Average Attenuation at L4 (HU)	47.08 ± 10.06	69.8	35.81 ± 12.49	51.85	*P<.001*
Psoas L3 Bilateral Muscle Index (cm²/m²)	7.73 ±2.17	11	4.69 ± 1.3	5.75	*P<.001*
Psoas L4 Bilateral Muscle Index (cm²/m²)	9.49 ± 2.38	69.8	5.44 ±1.3	51.85	*P<.001*