

Evaluation of muscle atrophy and fat infiltration of the affected limb in women with unilateral hip osteoarthritis

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INTRODUCTION: Hip joint disease leads to a decline in each patient’s activities of daily living (ADL) due to pain and disability. To objectively quantify the decrease in ADL and to predict the recovery after hip surgery (e.g., total hip arthroplasty), previous studies have applied CT images to measure the volume and the Hounsfield Units (HU) of the muscles in the lower limb where decreases occur with atrophy and fat infiltration. Specifically, studies have quantified the amount of muscle atrophy and fat infiltration around the hip for patients with unilateral hip osteoarthritis (uHOA) and reported the affected side to present atrophy of 20-30% for the hip muscles and 10-20% for the thigh muscles. Further, it has also been reported that a decrease of 15HU is found for the hip muscles and a 5-10HU decrease for the thigh muscles.^{1,2} However, it remained uncertain if a decrease in muscle volume and HU occurred in the lower leg (i.e., below the knee) of the affected side. To this end, we aimed to clarify the muscle volume and fat infiltration of the entire lower limb and compare their amount across the regions. As previous reports that analyzed patients with unilateral knee osteoarthritis found that both muscle atrophy and fat infiltration of the affected side occur for the thigh and the lower leg,³ we hypothesized that muscle atrophy and fat infiltration could be found across the entire lower limb of the affected side for uHOA patients.

METHODS: We retrospectively identified 108 women with uHOA who underwent total hip arthroplasty and received a CT scan (region of interest: pelvis to ankle) for preoperative planning between November 2018 and April 2022 (mean age: 64.9 ± 10.0 years). From the CT images, muscles at the lower extremities were first segmented using a deep-learning model that we have previously reported.⁴ Then, each muscle was classified into three regions (hip, thigh, and lower leg) (Fig. 1). Muscle volume and HU were measured for each group and were compared between the affected and the unaffected side to calculate the muscle atrophy (%) and the degree of fat infiltration that can be quantified using the following equation.

$$\text{Amount of muscle atrophy (\%)} = \frac{\text{Muscle Volume of the Unaffected side} - \text{Muscle Volume of the Affected side}}{\text{Muscle Volume of the Unaffected side}} \times 100$$

$$\text{Degree of fat infiltration (HU)} = \frac{\text{Mean CT Value of the Unaffected side} - \text{Mean CT Value of the Affected side}}{\text{Mean CT Value of the Unaffected side}}$$

The differences in atrophy and fat infiltration across the groups were evaluated using the Mann–Whitney U test. Further, the relationship between muscle atrophy (%) and degree of fat infiltration (HU) in each group was assessed using Pearson’s correlation coefficient. All measurements and analyses were performed using MATLAB (ver9.12, The MathWorks, Natick, MA, USA), and significance was determined at a p-value < 0.05.

RESULTS: The amount of muscle atrophy on the affected side was 20.8 ± 10.5%, 18.4 ± 11.3%, and 5.2 ± 5.0% for the hip, thigh, and lower leg, respectively. The degree of fat infiltration at the affected side was 10.2 ± 5.2 HU, 3.7 ± 4.5 HU, and 2.6 ± 2.5 HU for the hip, thigh, and lower leg, respectively. (Fig. 2). When compared across the regions, muscle atrophy in the lower leg was significantly smaller than those in the hip and the thigh (both p < 0.001). For fatty infiltration, decrease of HU in the hip region was significantly larger than those for the thigh and the lower leg (both p < 0.001). When correlated, atrophy in the lower leg showed a moderate positive correlation with those in the hip (r = 0.46) and the thigh (r = 0.57) (Table 1). On the other hand, no significant correlations were found between the degree of fat infiltration in the lower leg and the other groups (Table 1).

DISCUSSION: In this study, we evaluated the muscle volume and fat infiltration of both lower limbs in uHOA patients and compared the difference between the affected and the unaffected side. We found muscle atrophy and fat infiltration on the affected side existing across the entire lower limb, which was in line with our hypothesis. On the other hand, the changes at the lower leg were smaller than those at the hip and the thigh, especially for fat infiltration. When the correlations were compared across the regions, moderate correlations were found between the lower leg and the other regions for muscle atrophy, but such correlation was not found for fat infiltration. Collectively, our findings indicate that both muscle atrophy and fat infiltration occur for the entire limb of the affected side; however, changes are likely to be different from those found for patients with unilateral knee osteoarthritis and could be the characteristics of uHOA. It would be our next step to clarify the timing of when the atrophy and fat infiltration occur in the lower leg for uHOA patients.

SIGNIFICANCE/CLINICAL RELEVANCE: In patients with uHOA, muscle atrophy and fat infiltration in the lower leg were significantly less than in the hip and the thigh. Our results indicate the importance of postoperative rehabilitation to mainly focus on the hip muscles for patients who undergo total hip arthroplasty for uHOA.

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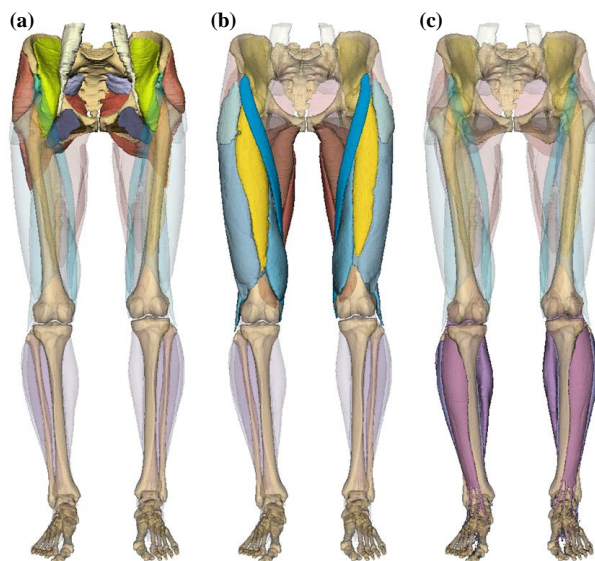


Fig. 1. Muscles segmented for the regions of hip (a), thigh (b), and lower leg (c).

Fig. 2. The boxplot of the results (** p < .01)

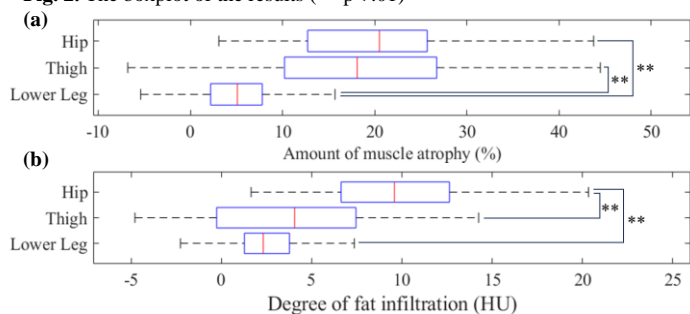


Table 1. Correlations of muscle atrophy and fat infiltration across the regions

A: Muscle atrophy		
r value (p-value)	Thigh	Lower leg
Hip	0.82 (<0.001)	0.46 (<0.001)
Thigh		0.57 (<0.001)
B: Fat infiltration		
r value (p-value)	Thigh	Lower leg
Hip	0.58 (<0.001)	0.17 (0.08)
Thigh		-0.001 (0.99)