

Sex-related Differences in Ipsilateral Hip Abductor Muscle Composition in Patients with End-stage Osteoarthritis before Total Hip Arthroplasty

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INTRODUCTION: Hip abductor muscles stabilize the pelvis, maintain the level of the contralateral pelvis, and prevent hip adduction during single-leg stance as the basis of human locomotion. Hip abductor muscles can be divided into superficial muscles that offer their effect via insertion into the iliotibial band and deeper muscles that work via insertion into the greater trochanter. While the superficial muscles contain the upper portion of the gluteus maximus and the tensor fascia lata, the deep muscles include the gluteus medius, the gluteus minimus, and the piriformis. Each muscle of hip abductors can be evaluated by computed tomography (CT). In addition to the cross-sectional area measurement, CT has been employed for accurate estimates of structural muscle composition. High-density lean tissues or lean muscle mass (LMM), low-density lean tissues (LDL), and intra-muscular fat (mFAT) are evaluated as components of muscle composition. In elderly people, the adipose tissue beneath the deep fascia of a muscle, intramuscular adipose tissue (IMAT), may cause muscle strength deficit because an altered orientation of muscle fibers by fatty infiltration into skeletal muscle can reduce the force-producing capacities. There are age-associated differences in body composition such as skeletal muscle mass and fat distribution between sexes. Females have a higher risk and prevalence rate of hip OA than males. However, no information is available about potential sex effects on hip abductor muscle composition in patients with end-stage osteoarthritis (OA) before total hip arthroplasty (THA). Therefore, this study aimed to clarify sex-related differences in ipsilateral hip abductor muscle composition in patients with end-stage OA.

METHODS: We retrospectively analyzed the data from 58 OA patients (45 females and 13 males) who underwent primary THA between 2019 and 2020 in our hospital. This study was approved by the institutional review board of our hospital. Patient consent was waived due to a general opt-out procedure using anonymized data.

Muscle composition of the operated limb was estimated by CT taken for preoperative planning within three weeks before THA. Muscle composition of the glutei medius and minimus and the gluteus maximus was evaluated on a single axial CT slice at the bottom end of the sacroiliac joint. The inferior point of the sacroiliac joint is found to be the appropriate site for the measurement of the cross-sectional area of the gluteus medius in patients with hip OA because the area at this level significantly correlates with muscle volume and muscle strength. In addition, the upper portion of the gluteus maximus was analyzed almost exclusively at this level because the upper portion arises from the posterior iliac crest whereas the lower portion originates from the inferior sacrum and upper lateral coccyx. The muscle groups were manually outlined and thereafter automatically segmented based on attenuation values: -29 to 150 Hounsfield units (HU) using CT software. The software electronically calculated the cross-sectional area in cm² of the segmented total muscle group (TM). Cross-sectional areas in cm² of LMM, LDL, and mFAT within each TM were measured electronically with the software as the areas of pixels according to the definition by attenuation values: 30 to 80 HU for LMM, 0 to 29 HU for LDL, and -190 to -30 HU for mFAT. IMAT was defined as the summation of the areas of both LDL and mFAT. The area of TM or each component was normalized for the square of the patient's height (cm²/m²). Alternatively, LMM, LDL, mFAT, and IMAT were normalized for the respective muscle's size by calculating a percentage of each measure relative to TM, designated as LMM/TM, LDL/TM, mFAT/TM, and IMAT/TM. Because alterations in the place of muscle section by hip deformity may affect cross-sectional CT analysis, this study excluded patients with hip deformity of Crowe types 2, 3, and 4.

The normality of data was evaluated by Shapiro-Wilk test. Comparisons were performed between the female and male data by t test and Mann-Whitney U test for parametric and nonparametric data, respectively. Data are shown as mean (standard deviation).

RESULTS: There was no difference in age between the female [70.4 (9.0) years] and the male [72.5 (11.4) years] patients ($P = 0.481$). Body mass index was higher in the male group [24.9 (2.7) kg/m²] compared with the female one [22.4 (3.4) kg/m²] ($P = 0.018$). TM of the glutei medius and minimus was larger in the male patients [15.2 (1.5) cm²/m²] compared with the females [12.9 (2.3) cm²/m²] ($P = 0.001$). There was no difference in other compositions of the glutei medius and minimus between the sexes. TM of the gluteus maximus were larger in the male group [10.7 (2.0) cm²/m²] than the female one [9.3 (2.2) cm²/m²] ($P = 0.046$). LMM of the gluteus maximus were also larger in the male group [5.8 (2.7) cm²/m²] than the female one [4.3 (2.3) cm²/m²] ($P = 0.045$). mFAT/TM of the gluteus maximus were higher in the female patients [14.3 (8.1) %] compared with the males [8.7 (4.9) %] ($P = 0.021$). IMAT/TM of the gluteus maximus were also higher in the female patients [52.3 (15.8) %] compared with the males [42.0 (16.5) %] ($P = 0.046$). No difference was found in other components of the gluteus maximus between the sexes.

DISCUSSION: There is increasing evidence of muscle fiber type differences and susceptibility for disuse atrophy between males and females. Compared with males, females likely depend on oxidative metabolism and have a greater content of type I muscle fibers within the same muscle. Oxidative muscle fibers are preferentially affected by disuse atrophy. Patients with hip OA demonstrate decreased volume of the gluteus maximus, the gluteus medius, and the gluteus minimus on the affected side compared with matched controls. Decreased muscle volume can be a result of functional disuse of those muscles. In addition to atrophy, muscle disuse can cause fatty infiltration. Actually, increased fatty infiltration is found in the gluteus maximus and the gluteus minimus in the hip joint with OA. This study has expanded the previous findings and is the first to suggest potential differences in preoperative muscle composition of ipsilateral hip abductors between female and male patients with hip OA. The female group showed a smaller TM of the gluteal muscles than the male one. The gluteus maximus in the female patients contained decreased LMM and increased mFAT/TM and IMAT/TM compared with that in the males. In terms of fat distribution between sexes, females likely accumulate subcutaneous fat in the lower extremities, while males tend to deposit visceral fat in the abdominal region. Like subcutaneous fat, there is a possibility that fatty infiltration may increase into the upper portion of the gluteus maximus in female patients with hip OA. In contrast to the gluteus maximus, no difference was found between the sexes in the fat infiltrate in the glutei medius and minimus. Sex-related differences in fatty infiltration into different muscles remain to be clarified. Our recent study has shown association between preoperative composition of ipsilateral hip abductors and gait function after THA [Arthroplasty 2022; 4: 23]. Effects of the sex-related differences in ipsilateral hip abductor muscle composition on postoperative outcome need to be investigated in future studies.

This study has some limitations. Measurements in axial CT images are potentially variable and may depend on the place of the section. Thus, it remains uncertain whether patients with bilateral symptomatic OA or severe deformity may demonstrate similar results.

In conclusion, this study indicates potential sex-related differences in preoperative muscle composition in ipsilateral hip abductors in patients with hip OA.

SIGNIFICANCE/CLINICAL RELEVANCE: There may be sex-related differences in preoperative muscle composition in ipsilateral hip abductors in patients with hip osteoarthritis. Preoperative muscle composition should be evaluated separately depending on the sex.

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