Ultrasound Assessment of Adductor Muscle Size Using Muscle Thickness of the Thigh

Madoka Ogawa, Naotoshi Mitsukawa, Michael G. Bemben, and Takashi Abe

Context: Previous studies investigated the relationship between ultrasound-derived anatomical muscle thickness (MTH) and individual muscle cross-sectional area (CSA) and muscle volume in several limb and trunk muscles; however, the adductor muscle that contributes to hip adduction and pelvic stabilization, as well as balance ability, has not been studied. Objective: To examine the relationship between MTH of the lower, middle, and upper thigh measured by B-mode ultrasound and the muscle CSA and volume of adductor muscle obtained by magnetic resonance imaging (MRI) to confirm the possibility of predicting adductor muscle CSA/volume using ultrasound-derived MTH. Setting: University research laboratory. Subjects: 10 men and 10 women (20–41 y old) volunteered to participate in this study. Main Outcome Measures: A series of continuous muscle CSAs along the thigh were measured by MRI scans (1.5-T scanner, GE Signa). In each slice, the anatomical CSA of the adductors was analyzed, and the muscle volume was calculated by multiplying muscle CSA by slice thickness. Thigh MTH was measured by B-mode ultrasound (Aloka SSD-500) at 5 sites (anterior 30%, 50%, and 70% and posterior 50% and 70% of thigh length). Results: A strong correlation was observed between anterior 30% MTH and 30% adductor CSA in men (r = .845, P < .002) and women (r = .952, P < .001) and in both groups combined (r = .922, P < .001). Anterior 30% MTH was also strongly correlated to adductor muscle volume when combined with thigh length (n = 20, r = .949, P < .001). However, there were moderate or nonsignificant correlations between anterior and posterior 50% and 70% MTH and adductor muscle CSA/volume. Conclusions: The results suggest that MTH in the upper portion of anterior thigh best reflects adductor muscle CSA or muscle volume, while the lower portions of the anterior and posterior sites are least likely to predict adductor muscle size.

Keywords: B-mode ultrasonography, magnetic resonance imaging, adductor magnus, adductor longus

Three large muscle groups are located in the thigh: the quadriceps femoris muscles in the anterior compartment of the thigh, the adductor muscles in the medial compartment, and the hamstring in the posterior compartment. The quadriceps plays an important role in lateral rotation of the leg, flexion of the thigh, and extension of the leg. During the last several decades, the quadriceps muscle group has been commonly used as a marker of age-related changes in muscle size and lower limb strength. For instance, Young et al. reported a 25% and 35% reduction in the quadriceps muscle cross-sectional area (CSA) in older men and women, respectively, compared with young adults. The adductor muscles also make an important contribution to hip adduction, as well as to pelvic stabilization, during standing and walking. Previous studies reported that adductor muscle strength decreased with aging in men and women. However, changes in age-related adductor muscle size are not clearly observed. One of the reasons is that a standard method for evaluating adductor muscle size has not been established.

Ultrasound imaging of a transverse section of specific anatomical sites allows for the direct measurement of muscle thickness (MTH). Ultrasound measurement is simple, low cost, and easily applied in clinical assessment and field surveys with no health hazards. Previously, the linear relationship between anatomical MTH and individual muscle anatomical CSA or muscle volume (a strong predictor of physiological muscle CSA, as well as muscle strength and power) has been demonstrated in the quadriceps, tibialis anterior, triceps surae, triceps brachii, pectoralis major, and psoas major muscles; however, other muscle groups in the body, such as adductors, have not been studied. Whereas the muscle belly of the hamstring and quadriceps muscles is located in the middle and lower portion of the thigh, the muscle belly of the adductor muscles is observed in the upper portion of the thigh. Therefore, we hypothesized that the ultrasound MTH in the upper thigh would be closely associated with adductor muscle CSA and volume. The purpose of this study was to examine the relationship between MTH of
the lower, middle, and upper thigh measured by B-mode ultrasound and the CSA and volume of adductor muscle obtained by magnetic resonance imaging (MRI) to confirm the possibility of predicting adductor muscle CSA/volume using ultrasound-derived MTH.

Methods

Ten men (mean [SD] age 28.5 [6.8] y) and 10 women (27.1 [5.5] y) volunteered to participate in this study. Subjects had no orthopedic abnormalities (eg, surgery or trauma) in their lower extremities. The purpose, procedures, and risks of the study were explained before inclusion, and subjects signed a written informed consent to participate in the study, which was approved by the university ethics committee. Measurements of muscle size using MRI and ultrasound were carried out on the same day.

A series of continuous muscle CSAs along the right thigh were measured by MRI scans (1.5-T scanner, General Electric Signa, Milwaukee, WI). T1-weighted spin-echo axial-plane imaging was performed with a 1500-millisecond repetition time, 16.7-millisecond echo time, 1 excitation, 384 × 256 matrix, 25-cm field of view, 1.0-cm slice thickness, and 0-cm interslice gap. All MRI images were taken with subjects at rest in the supine position and the knee of the scanned leg fully extended. The length of the femur was measured on a coronal plane, and positions at 30%, 50%, and 70% of the femur length were determined. In each slice, the anatomical CSA of the adductors (adductor magnus, longus, and brevis) was digitized, and the muscle CSAs were analyzed. Muscle volume was calculated as the product of the sum of the anatomical CSAs in all slices times the MRI slice thickness. The mean difference between tests 1 and 2 for this method on 4 subjects was 1.5%.

Thigh MTH was measured by B-mode ultrasound (SSD-500, Aloka, Tokyo, Japan) with a linear-array probe (5.0-MHz wave frequency) at 3 sites (anterior [30%, 50%, and 70% of thigh length] and posterior [50% and 70% of thigh length]). Thigh length was measured by using anatomical landmarks (the distance between the lateral condyle of the femur and greater trochanter), and the measurement sites were marked by a marker pen. The measurements were carried out while subjects stood with their weight evenly distributed on both legs. The probe was placed on the medial anterior aspect of the thigh, and cross-sections of thigh muscles were imaged (Figure 1). Three images from each site were printed (Sony UP-897MD, Tokyo, Japan), and mean values of each site were used for data analysis. The distance from the adipose-tissue–muscle interface and muscle–bone interface at the middle of the image was accepted as muscle thickness. We previously reported that the coefficient of variation for this method was 0.8% (intraclass correlation coefficients .97). The same investigator (T.A.) made all the ultrasound measurements.

Results

Standing height and body mass were 1.71 (0.08) m and 65.2 (8.7) kg, respectively, for men and 1.61 (0.06) m and 54.2 (5.4) kg, respectively, for women. Body-mass index was similar between men (22.2 [1.8] kg/m²) and women (20.9 [1.9] kg/m²).

A strong correlation was observed between anterior 30% MTH and 30% adductor muscle CSA in men

Figure 1 — Typical ultrasound images showing transverse scan on the anterior thigh at (a) 30%, (b) 50%, and (c) 70% of thigh length. MTH, muscle thickness.
(n = 10, \( r = .845, P < .002 \)) and women (n = 10, \( r = .952, P < .001 \)) and in both groups combined (n = 20, \( r = .922, P < .001 \); Figure 2). The correlation coefficients between 50% and 70% anterior and posterior MTH and adductor muscle CSA were relatively low compared with the anterior 30% MTH (Table 1). There was also a significant strong correlation between anterior 30% MTH and adductor muscle volume (n = 20, \( r = .841, P < .001 \); Table 1). When using a set of MTH and limb length (MTH × thigh length) as an independent variable for predicting muscle volume, the correlation coefficient between anterior 30% MTH × thigh length and adductor muscle volume was higher (n = 20, \( r = .949, P < .001 \)) than the anterior 30% MTH alone. The simple regression equation obtained in the current sample was adductor muscle volume (cm\(^3\)) = 5.51 \times \text{anterior 30\% MTH} \times \text{thigh length} – 434.9, where MTH and thigh length are in centimeters.

![Figure 2](image-url) — Relationship between anterior 30\% muscle thickness and 30\% adductor muscle cross-sectional area (CSA) in men and women.

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<th>Table 1 Correlation Coefficients Between Adductor Muscle Cross-Sectional Area (CSA) and Volume and Anterior and Posterior Thigh Muscle Thickness (MTH)</th>
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<tr>
<td><strong>Adductor Muscle CSA</strong></td>
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<td>Adductor muscle volume</td>
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<td>Anterior</td>
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<td>30%</td>
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\*P < .05, \**P < .01, \***P < .001.
Discussion
In the current study, the anterior MTH of the upper thigh (at 30% of thigh length) was strongly correlated with adductor muscle CSA at 30%, as well as with adductor muscle volume. The regression lines between anterior 30% MTH and adductor muscle CSA/volume are similar in men and women and in both groups combined. On the other hand, posterior MTH did not demonstrate a strong correlation coefficient with adductor muscle CSA/volume. The current results indicated that the MTH determined at 30% of thigh length reflects the whole volume of the adductors, as well as adductor muscle CSA at 30%. Thus, our findings imply that the ultrasound-derived anterior 30% MTH is useful for estimating the total volume of the adductors as an alternative approach to MRI multiple scans.

In the current study, the muscle volume of 3 major adductors (adductor magnus, longus, and brevis) was measured using MRI. The adductor longus and brevis are located in the anterior medial compartment of the thigh, while the adductor magnus is located in the posterior medial compartment, and the peak anatomical muscle CSA of these adductors is observed in the upper portion of the thigh. Based on these anatomical considerations, we had hypothesized that the ultrasound MTH from the upper thigh (30% anterior) would be the best predictor for evaluating adductor muscle size. The reason there was no posterior anatomical site at 30% of the thigh obtained is that the gluteus muscles do not allow for this site to be assessed.

It has been demonstrated that ultrasound MTH is strongly correlated with MRI-measured muscle CSA in the quadriceps (r = .91),10 tibialis anterior (r = .90),12 and pectoralis major (r = .92) muscles. However, Miyatani et al13 reported that there was a weak correlation between midthigh MTH and quadriceps muscle volume (r = .47, P < .05) in young men even if the relationship was statistically significant. They also reported that when combined with limb length, midthigh MTH was a good predictor for quadriceps muscle volume. In the current study, our result was consistent with the study of Miyatani et al13 in that a relatively strong correlation was observed between adductor muscle volume and the combined variables of MTH and thigh length (r = .949) compared with MTH alone (r = .869).

Several limitations of this study should be mentioned. First, because our subjects were healthy young adult men and women, we cannot infer similar results for other age groups such as children and elderly populations. Second, since the ultrasound measurements were carried out while subjects stood, it is uncertain whether the same results would be obtained if the testing were performed in a different posture such as supine/prone. Finally, since we did not include a validation or cross-validation group in the research design, additional research is needed to establish these relationships.

In conclusion, our results suggest that MTH in the upper portion of the anterior thigh (at 30% of thigh length) best reflects adductor muscle CSA or muscle volume, while the anterior and posterior 50% or 70% MTH sites are least likely to predict adductor muscle CSA/volume.

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References

