



Original Research

# Muscle Thickness of Anterior Mid-Thigh in Hospitalized Patients: Comparison of Supine and Standing Postures



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## KEYWORDS

Cardiovascular diseases;  
Inpatients;  
Muscle, skeletal;  
Rehabilitation;  
Quadriceps muscle

**Abstract Objectives:** To compare the magnitude changes in muscle thickness (MTH) of the anterior mid-thigh between the supine and standing postures.

**Design:** Experimental.

**Setting:** University hospital laboratory.

**Participants:** Inpatients (N=283) between the ages of 29 and 93 years (193 men, 90 women) with cardiovascular disease who volunteered for this study.

**Interventions:** Not applicable.

**Main Outcome Measures:** MTH of the anterior mid-thigh was measured with a 10 MHz ultrasound probe while the participants stood or lay supine in a relaxed position with their arms extended and by their sides.

**Results:** Age and percentage of body fat were greater ( $P<.01$ ) in women than in men ( $74.3\pm 12.3$  vs  $67.7\pm 12.1$  y and  $32.6\pm 10.3\%$  vs  $27.4\pm 7.4\%$ , respectively), but standing height, body weight, and body mass index were greater ( $P<.01$ ) in men than in women ( $164.9\pm 6.3$  vs  $149.1\pm 7.5$  cm,  $65.4\pm 12.7$  vs  $49.5\pm 11.1$  kg, and  $23.8\pm 3.9$  vs  $22.1\pm 4.4$  kg/m<sup>2</sup>, respectively). Correlations were found between the standing posture and supine position in the anterior-mid thigh MTH for both men ( $r=0.85$ ;  $P<.01$ ) and women ( $r=0.82$ ;  $P<.01$ ). In the anterior-mid thigh for men and women, MTH was greater in the standing posture ( $3.7\pm 1.0$  vs  $2.5\pm 0.7$  cm) than in supine position ( $3.1\pm 0.8$  vs  $2.1\pm 0.7$  cm) (both  $P<.01$ ).

**Conclusions:** In this study, MTH of the anterior mid-thigh during prolonged hospitalization was approximately 16% higher in men than in women regardless of posture, and was approximately 32% higher in standing posture than in the supine position regardless of sex.

**List of abbreviations:** CSA, cross-sectional area; MTH, muscle thickness.

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Patients requiring prolonged bed rest (cardiovascular disease inpatients, etc) often experience disuse muscle atrophy in the acute and subacute phase, which increases the likelihood of a wheelchair or bedridden state in the chronic phase.<sup>1-3</sup> Consequently, the progression of muscle atrophy in lower extremity function may render a high need for medical and nursing care. In addition, a previous study reported that some patients failed to perform the chair stand test after prolonged hospitalizations (13.5% for men and 17.3% for women, respectively),<sup>4</sup> suggesting that assessment of lower extremity muscle strength is very difficult in prolonged hospitalizations. Therefore, periodic assessment of lower extremity muscle size rather than strength is important for prolonged hospitalizations to evaluate the functional status of individuals and to identify and decrease the likelihood of a wheelchair or bedridden state.

Magnetic resonance imaging-measured muscle cross-sectional area (CSA) is widely considered as the criterion standard to evaluate skeletal muscle size, but this is expensive, takes a long time, and requires a medical expert (medical doctor, radiologist, etc). On the other hand, ultrasound is a non-invasive means and is an inexpensive, fast, and tolerable imaging technique used to evaluate skeletal muscle thickness (MTH). Furthermore, MTH is strongly correlated with magnetic resonance imaging-measured muscle CSA in the lower limb.<sup>5,6</sup> Therefore, MTH measurement is widely used for a variety of reasons and subjects (eg, athletes, physical fitness test, nursing care, etc).<sup>7-9</sup> Thus, for periodic assessment, ultrasound-measured MTH is a useful tool to evaluate skeletal muscle size.

Many studies of healthy young adults have reported MTH measurement of lower limb muscles carried out using the standing posture.<sup>4,6-8</sup> However, many hospitalized patients spend most of the day in bed, and it is often difficult for them to maintain a standing posture, even for only a few minutes of measurement. Therefore, it is preferred to perform the measurement in the supine position to lessen the physical burden on the patient.

Skeletal muscle atrophy is site specific. It is reported that greater anterior mid-thigh muscle loss is found in prolonged hospitalizations.<sup>4,9</sup> Thus, the purpose of this study was to compare the magnitude of changes in MTH of the anterior mid-thigh between the supine and standing postures.

## Methods

### Participants and procedure

A total of 283 inpatients aged 29 to 93 years (193 men, 90 women) with cardiovascular disease volunteered to

participate in this study and were selected according to the exclusion criteria (ie, severe orthopedic disorders, peripheral vascular disease, and cognitive dysfunction) (table 1). All participants underwent complete laboratory and hematologic evaluation, were informed of the risks associated with involvement in the study, and signed an informed consent document before participation. The experiment was conducted from February 19, 2016 to March 24, 2017.

### Ethics

The principles of the World Medical Association Declaration of Helsinki and the American College of Sports Medicine Guidelines for Use of Human Subjects were adopted in this study. The study was approved by the Ethics Committee of the Dokkyo Medical University, and informed consent was obtained from the participants.

### Measures

After thigh length measurements were made using anatomic landmarks, the measurement site was marked and the anterior mid-thigh (at 50% between the lateral condyle of the femur and the greater trochanter) muscle thickness was measured using B-mode ultrasound on the right side of the body.<sup>7,10</sup> Ultrasound evaluation of MTH was performed using a real-time linear electronic scanner with a 10.0-MHz scanning head and ultrasound probe (L4-12t-RS Probe) by using LOGIQ e ultrasound.<sup>a</sup> The scanning head was coated with a water-soluble transmission gel to provide acoustic contact without depressing the dermal surface. The subcutaneous adipose tissue-muscle interface and the muscle-bone interface were identified from the ultrasonic image. The perpendicular distance from the adipose tissue-muscle interface to the muscle-bone interface was considered to represent MTH. In each experiment time, 2 images were recorded by the same skilled investigators (physical therapists) each time and printed for analysis. Image analysis was then performed by the other investigators who were blinded to the both condition and time assignments of the participants. Two images from the same site were stored, and the mean value was used for data analysis. The measurements were carried out while the participants stood or lay in the supine position with their elbows extended and relaxed. Immediately before the MTH measurement in standing position, the investigators confirmed that the thigh muscles were fully relaxed.

### Statistical analysis

Results are presented as mean  $\pm$  SD. Correlation coefficients were automatically picked out by the JMP software.<sup>b</sup> Statistical significance was set at a *P* value of .05.

**Table 1** Physical characteristics and clinical data

Characteristics	Men (n=193)	Range	Women (n=90)	Range
Age, y	67.7±12.1*	34-90	74.3±12.3	29-93
Standing height, m	164.9±6.3*	147-180.5	149.1±7.5	134-170
Body weight, kg	65.4±12.7*	41.0-112.0	49.5±11.1	30.0-94.5
BMI, kg/m <sup>2</sup>	23.8±3.9*	15.2-38.3	22.1±4.4	14.0-38.3
% body fat	27.4±7.4*	11.3-49.0	32.6±10.3	8.0-53.6
Fat mass, kg	18.3±7.4	4.7-50.6	16.9±8.3	2.4-50.0
Systolic BP, mmHg	114±17	70-160	119±19	82-170
Diastolic BP, mmHg	65±12	40-95	66±12	40-97
CONUT score, unit	3.2±2.8	0-12	2.8±2.4	0-9
BNP, pg/mL	469±645	3-3367	451±563	32-2804
Specific diseases, n				
Cardiovascular surgery patients, n				
CABG and/or non-CABG	53	-	19	-
Aortic dissection and aneurysm	27	-	10	-
ASO	5	-	2	-
Others (VAD, VSD, etc)	2	-	2	-
TAVI	3	-	10	-
Patients with internal cardiovascular diseases				
CHF	49	-	30	-
CHD (AMI, ACS, PCI, etc)	52	-	15	-
Others (PE, etc)	2	-	2	-

NOTE. Data are given as mean ± SD or as otherwise indicated.

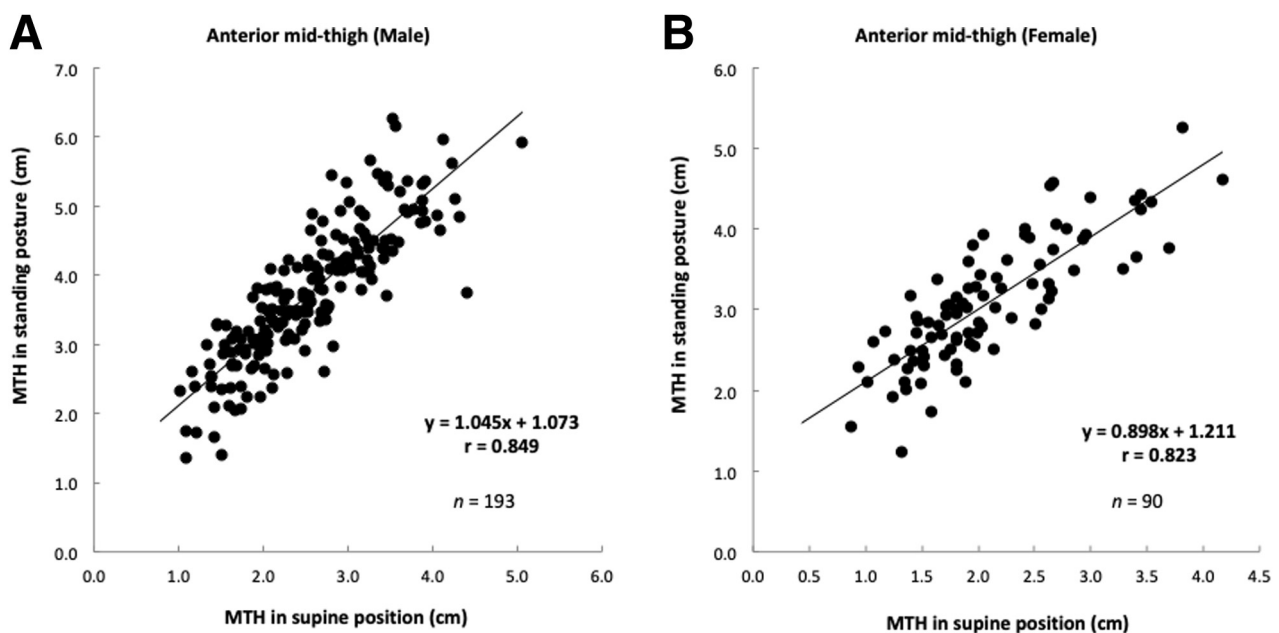
Abbreviations: ACS, acute coronary syndrome; AMI, acute myocardial infarction; ASO, arteriosclerosis obliterans; BMI, body mass index; BNP, brain natriuretic peptide; BP, blood pressure; CABG, coronary artery bypass grafting; CHD, coronary heart disease; CHF, congestive heart failure; CONUT, controlling nutrition status; non-CABG, heart valve replacement and repair; PCI, percutaneous coronary intervention; PE, pulmonary embolism; TAVI, transcatheter aortic valve implantation; VAD, ventricular assist device; VSD, ventricular septal defect

\*  $P < .01$ , men versus women.

## Results

Age and percentage of body fat were greater ( $P < .01$ ) in women than in men, but standing height, body weight, and

body mass index were greater ( $P < .01$ ) in men than in women (see [table 1](#)). There were correlations between standing posture and supine position in the anterior-mid thigh MTH for both men ( $r = 0.85$ ;  $P < .01$ ) and women



**Fig 1** Relationships between anterior mid-MTH in the supine position and standing posture of in men (A) and women (B).

( $r=0.82$ ;  $P<.01$ ) (fig 1). In the anterior-mid thigh for men and women, MTH was greater in the standing posture ( $3.7\pm1.0$  and  $3.1\pm0.8$  cm, respectively) than in the supine position ( $2.5\pm0.7$  and  $2.1\pm0.7$  cm, respectively) (both  $P<.01$ ) (fig 2A). There was no difference in the ratio of MTH in the supine position to MTH in the standing posture between men and women (both 0.68) (fig 2B).

## Discussion

Periodic assessment of lower extremity muscle size is important for prolonged hospitalizations to evaluate the functional status of individuals and to identify and reduce the risk of the patient being in a wheelchair or bedridden state. In addition, many hospitalized patients spend most of the day in bed, and it is often difficult for them to maintain a standing posture, even for only a few minutes during measurement. Therefore, we compared the magnitude changes in MTH of the anterior mid-thigh between the supine and standing postures because medical staff can conduct ultrasound measurement regardless of the patient's posture.

The findings of this study suggest that the MTH of the anterior mid-thigh in hospitalized patients was higher in the standing posture than in the supine position regardless of sex (see fig 2). This conclusion is in agreement with that of another study conducted in healthy young adults.<sup>5</sup> Notably, the ratio of MTH in the supine position to MTH in the standing posture was similar in the current study (0.68 for

men and 0.68 for women) and in that of Abe et al (0.72 for mixed-sex).<sup>5</sup> Therefore, in the anterior-mid thigh, the MTH measurement requires paying attention to the subject's posture and being aware that the supine position is approximately 30% lower than the standing posture regardless of age and sex. This difference in anterior-mid thigh MTH was similar to that in a previously reported study in healthy young men.<sup>10</sup> The reasons for this are not well known, but local fluid shift and pressure on muscles owing to gravity may cause the transformation.<sup>11</sup> A previous study reported age-related changes in muscle stiffness and MTH,<sup>12</sup> but there have been no studies investigating the similarity of the ratio of MTH in the supine position to MTH in the standing posture between young adults and individuals with prolonged hospitalizations. Taken together, this difference in MTH may lead to an underestimation of the anterior-mid thigh MTH when measured in the supine position. On the other hand, the ratio of MTH in the supine position to MTH in the standing posture for the external oblique, internal oblique, and transversus abdominis show non-uniform results, suggesting that these structures differ greatly from the anterior-mid thigh MTH.<sup>13</sup> Thus, the tendency of the value of MTH owing to the difference in posture differs specific to the site. Further study is needed to understand the relationship between the subject's posture and MTH using ultrasound.

## Study limitations

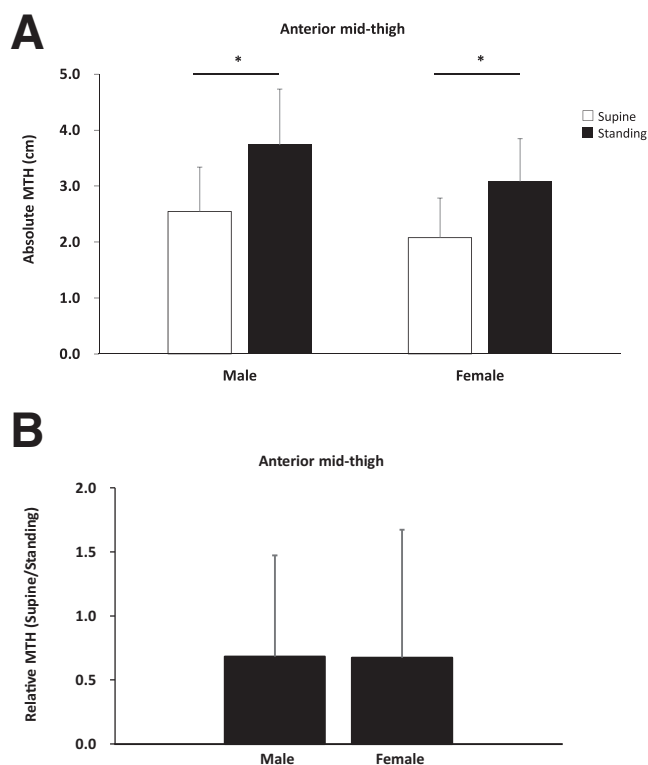
Some limitations of this study should be discussed. First, as the subjects were cardiovascular disease inpatients, the age distribution and physical characteristics were limited. Second, data of healthy adults and outpatients were not obtained, because target values are needed for inpatients to achieve independent living. Third, we instructed the participants not to contract their thigh muscle as much as possible, but there may have been some muscle contraction to maintain their body balance in a standing position. Additional research is needed to address these issues.

## Implications for the future

A large number of anterior mid-thigh MTH data concerning both the supine and standing postures of outpatients, healthy adults, and inpatients will make it possible to determine the amount of muscle mass required to improve or maintain, helping the patient avoid a wheelchair or bedridden state. These data may also contribute to the reduction of medical expenses and nursing care expenses.

## Conclusions

Our results indicated that MTH of the anterior mid-thigh during prolonged hospitalizations was approximately 16% higher in men than in women regardless of posture. We also found that it was approximately 32% higher in the standing posture than in the supine position regardless of sex.



**Fig 2** (A) Absolute MTH of the anterior mid-thigh. Values are mean and SD. \* $P<.01$ , supine versus standing. (B) Relative MTH of the anterior mid-thigh. Values are mean and SD.

## Suppliers

- a. LOGIQ e ultrasound; GE Healthcare.
- b. JMP, version 12.0.1; SAS Institute Inc.

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