

# Reference Values of Quadriceps Muscle Thickness Measured by Point-of-Care Ultrasound by Sex and Age Groups in Older Adults



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## ABSTRACT

Sarcopenia is an age-related skeletal muscle disorder characterized by decreased muscle mass, strength, and physical function, which increases the risk of adverse outcomes in older adults. Recently, ultrasound has emerged as a practical tool for estimating muscle thickness as a proxy for muscle quantity. However, standardized protocols, reference data, and diagnostic cut-off values for ultrasound-based muscle assessment remain lacking. This study pooled participants from three cohorts in which quadriceps muscle thickness was assessed in B-mode with a linear probe using point-of-care ultrasound (POCUS). Of 391 participants, 389 were included in the final analysis. Age was categorized into five-year groups (65-69, 70-74, 75-79, 80-85, and over 85 years old). Means and standard deviations (SD) of quadriceps thickness were calculated by sex and age group. Mean age was  $77 \pm 7$  years. Quadriceps muscle thickness followed a normal distribution with a standard deviation of 0.5 cm. Mean thickness declined with advancing age. Our pooled analysis found a mean quadriceps muscle thickness of 2.0 cm. The decline with advancing age was modest, with the lowest value observed in participants aged 85 years and older ( $1.8 \pm 0.4$ ). On average, muscle thickness decreased by approximately 0.1 cm per decade after age 65. These findings provide age- and sex-specific reference values for quadriceps muscle thickness measured by POCUS, and support its potential utility as a feasible tool for muscle assessment in older adults.

**Key words:** sarcopenia, quadriceps muscle thickness, point-of-care ultrasound (POCUS), skeletal muscle ultrasound, older adults

## INTRODUCTION

Sarcopenia is defined as an age-related skeletal muscle disorder characterized by decreased muscle mass, strength, and physical function that increases the risk of adverse outcomes in older adults.<sup>(1)</sup> Low skeletal muscle mass is one of the key diagnostic criteria for sarcopenia.<sup>(1)</sup> Muscle mass or quantity can be estimated using gold-standard imaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI), as well as more accessible methods like dual-energy X-ray absorptiometry (DXA) and bioelectrical impedance analysis (BIA).<sup>(1)</sup> Recently, ultrasound has emerged as a practical tool for estimating muscle thickness as a proxy for muscle quantity.<sup>(2)</sup> However, standardized protocols, reference data, and diagnostic cut-off values for ultrasound-based muscle assessment remain lacking.<sup>(2)</sup> Therefore, this research letter aimed to provide sex- and age group-specific mean values of muscle thickness, stratified in five-year intervals, as reference values.

## METHODS

This study pooled participants from three cohorts in which quadriceps muscle thickness was assessed in B-mode with a linear probe (7–10 MHz) using point-of-care ultrasound (POCUS; Vscan with Dual probe, GE Healthcare, IL). All participants provided written consent. The first cohort (n=150) was drawn from our previous study in community-dwelling older adults,<sup>(3)</sup> the second cohort (n=120) from another study by our group among hospitalized patients,<sup>(4)</sup> and the third cohort (n=121) from our most recent study among community-dwelling older adults.<sup>(5)</sup>

Participants were positioned in supine, knees extended at 10°-20°, with a towel roll under their knees. Quadriceps

thickness was measured at the midpoint (50%) between the greater trochanter and the lateral knee joint space with minimal pressure. Quadriceps muscle thickness was defined as the combined thickness of the Rectus femoris and Vastus intermedius muscles. Measurements were performed by BF (for the first and the third cohort) and PT (the second cohort), both trained under SA, head of the POCUS department at Vancouver General Hospital.

Of 391 participants, 389 were included in the final analysis due to missing age data. Age, sex, and quadriceps muscle thickness were extracted from the original datasets and merged into a single dataset. The normality of the age distribution was assessed using the Shapiro-Wilk test and visual inspection of histograms. Age was categorized into five-year groups (65–69, 70–74, 75–79, 80–85, and over 85 years). Means and standard deviations (SD) of quadriceps thickness were calculated by sex and age group, and the group differences were tested using Student’s *t*-test. The overall distribution of quadriceps thickness was visualized, with mean, median, and SD reported. Statistical analyses were conducted using R software (Version 2025.05.1-513; R Foundation for Statistical Computing, Vienna, Austria).<sup>(6)</sup>

The Human Subjects Committee of the University of British Columbia approved the study protocol. IRB numbers for studies: 1) H18-00577; 2) H21-03838; 3) H20-01355.

**RESULTS**

Data from 389 participants (180 males and 209 females) were included in the analysis. Mean age was 77 ± seven years. Quadriceps muscle thickness followed a normal distribution with a standard deviation of 0.5 cm (Figure 1). Mean thickness declined progressively with advancing age (Table 1). The mean quadriceps muscle thickness among older adults aged 65 years and older was ~2.0 cm. Significant sex differences were observed in the 65–69 and 80–84 year age groups.

**DISCUSSION**

Our pooled analysis, based on a relatively large sample of older adults, showed a mean quadriceps muscle thickness of 2.0 cm. The decline with advancing age was modest, with the lowest value observed in participants over 85 years (1.8±0.4). On average, muscle thickness decreased by

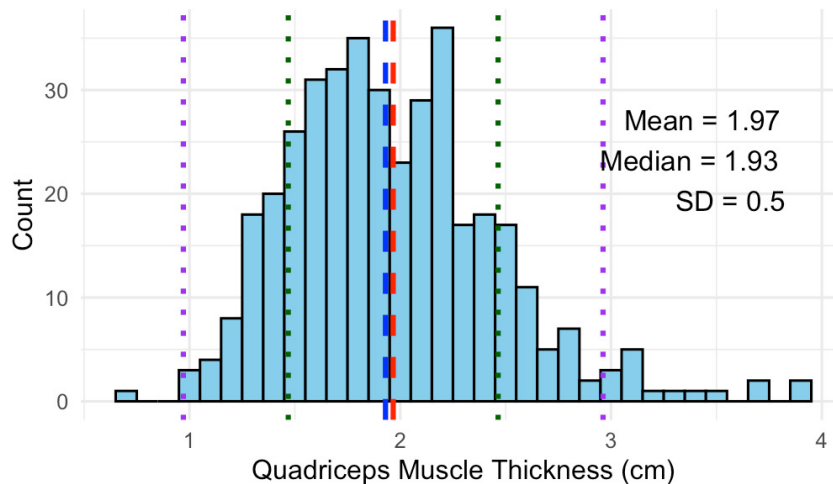


FIGURE 1. Histogram of quadriceps muscle thickness by sex (with mean, median, ±1 SD and ±2 SD)

TABLE 1. Quadriceps muscle thickness by age group

| Age group        | Total |             | Females (209) |             | Males (180) |             | p value |
|------------------|-------|-------------|---------------|-------------|-------------|-------------|---------|
|                  | n     | Mean ± SD   | n             | Mean ± SD   | n           | Mean ± SD   |         |
| All participants | 389   | 1.97 ± 0.5  | 209           | 1.89 ± 0.46 | 180         | 2.05 ± 0.52 | .001    |
| 65–69 yrs        | 70    | 2.16 ± 0.4  | 40            | 2.03 ± 0.35 | 30          | 2.34 ± 0.41 | .001    |
| 70–74 yrs        | 75    | 2.1 ± 0.52  | 37            | 2.08 ± 0.57 | 38          | 2.11 ± 0.47 | .795    |
| 75–79 yrs        | 91    | 1.95 ± 0.52 | 51            | 1.92 ± 0.49 | 40          | 1.98 ± 0.57 | .624    |
| 80–84 yrs        | 91    | 1.86 ± 0.48 | 49            | 1.73 ± 0.37 | 42          | 2.01 ± 0.55 | .006    |
| 85 and older     | 62    | 1.77 ± 0.44 | 32            | 1.7 ± 0.4   | 30          | 1.85 ± 0.47 | .168    |

approximately 0.1 cm per decade after age 65, beginning at 2.1 cm at that age.

In the Spanish ECOSARC-2 cohort of 424 community-dwelling older adults aged 70 years and older, the mean quadriceps thickness was nearly double that observed in our study (females: 4.25 cm; males: 4.02 cm), with a mean participant age of 81.5±6.2.<sup>(7)</sup> In a cohort of 95 older adults attending a sarcopenia clinic in Greece, the mean quadriceps muscle thickness (rectus femoris and vastus intermedius) was 2.98 cm—approximately 1 cm greater than that observed in our study.<sup>(8)</sup> In healthy Japanese older adults, the reported means were comparable to our findings (females: 2.07±0.48 cm; males: 2.59±0.57 cm).<sup>(9)</sup> However, in that study, quadriceps muscle thickness was measured in a sitting position with a knee flexed at 60°. Another Japanese study involving 204 older adults reported values closer to ours (females: 2.53±4.4 cm; males: 2.91±0.5 cm), but in this case, measurements were taken while participants were seated with the knee flexed at 90°. The discrepancies may be partly due to measurement positions; however, the significantly higher values in the Spanish and Greece cohort, also measured in the supine position, suggest that population-related factors, such as body composition, nutrition, ethnicity, or lifestyle, may be contributing to the differences.

A key strength of this study is the relatively large sample of older adults, with a well-represented distribution across all age groups. However, several limitations should be noted. The cross-sectional design prevents the conclusion of longitudinal changes in the muscle thickness over time, and differences in ethnicity, lifestyle, or other population characteristics may limit the generalizability of the findings. We were unable to include anthropometric factors, such as body composition and physical characteristics, because data were missing for one of the cohorts.

## CONCLUSION

Our study provides reference values for quadriceps muscle thickness in older adults, showing a modest decline with age. These findings may help guide clinical assessment of muscle health and support early identification of muscle loss.

## ACKNOWLEDGEMENTS

Not applicable.

## CONFLICT OF INTEREST DISCLOSURES

We have read and understood the *Canadian Geriatrics Journal's* policy on conflicts of interest disclosure and declare that we have none.

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