

การเปรียบเทียบความหนาของกล้ามเนื้อเซอรัลด์สแอนทีเรีย
ขณะหดตัวระหว่างแขนข้างที่ถนัดและไม่ถนัดในผู้ที่มีสุขภาพดี

**A comparison of thickness of the serratus anterior muscle during contraction
between dominant and non-dominant hands in healthy individuals**

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Abstract

Background: Serratus anterior muscle is an important muscle that helps to increase stability and to control movements of the scapula. Whether there is influence of hand dominance on thickness of the serratus anterior during contraction is unknown.

Objectives: To compare thickness of the serratus anterior muscle between the dominant and non-dominant hands during muscle contraction.

Materials and methods: Twenty healthy men were recruited for the study. The thickness of the serratus anterior muscle was bilaterally measured in a wall push-up position using ultrasound imaging. Measurement of the serratus anterior thickness was performed three times using Image J software.

Results: The serratus anterior thickness on the dominant hand was significantly greater than that on the non-dominant hand ($p < 0.05$).

Conclusion: Hand dominance has an influence on the thickness of the serratus anterior muscle during contraction. This should be taken into consideration in future research when determining the serratus anterior muscle.

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Keywords: Hand dominance, serratus anterior, ultrasound imaging, muscle thickness

Introduction

The serratus anterior muscle plays an important role in scapular stability, orientation, and scapulohumeral rhythm. Its functions are to pull the scapula forward and rotate the scapula upward when the arm is raised overhead.¹ As the humerus is elevated, the serratus anterior and the trapezius muscles form an important force couple that assists in upwardly rotating and posteriorly tipping the superior scapula and produces acromial elevation.² Lack of strength or endurance in the serratus anterior muscle has been shown to be associated with cervical and shoulder disorders.^{3,4}

Morphological properties of the muscle are suggested to be associated with skeletal muscle strength.⁵ Ultrasound imaging is a promising modality to detect muscle morphological changes.⁶ It is widely used since it is safe, noninvasive and real time.⁷ Previous studies have shown that ultrasound imaging is a reliable and valid measure for assessment of muscle thickness such as the lower trapezius⁸, abdominal⁹ and tibialis anterior muscles.¹⁰ A recent study has also demonstrated that ultrasound imaging has a high intra-and inter-rater reliability in measuring the thickness of the serratus anterior muscle at rest and during contraction (intraclass correlation coefficient; ICC=0.89-0.98 and 0.90-0.91, respectively).¹¹

While ultrasound imaging has been suggested to be a valid and reliable measure, several factors including gender, age, and hand dominance can influence muscle thickness. It is generally known that muscles are larger in men than in women and in young adults compared with older adults.^{12,13} However, for hand dominance, it is not always necessary that muscle thickness on the dominant hand will be greater than the non-dominant side, especially in scapular or spinal muscles acting in a stabilizing role. A recent study by Uthairakul and coworkers¹⁴ has demonstrated that gender and dominant hand affected the thickness of lower trapezius muscle. Conversely, Springer and coworkers¹⁵ found that dominant arm did not affect the thickness of lateral abdominal muscle. As yet, there has been no research determining influence of hand dominance on the serratus anterior muscle. It has been suggested that a wall push-up position significantly activates the serratus anterior muscle¹⁶ and gender can

affect muscle thickness.^{14,17} Therefore, the purpose of this study was to investigate thickness of the serratus anterior muscle in healthy men between the dominant and non-dominant hands when performing a wall push-up. We hypothesized that the thickness of the serratus anterior muscle would be greater on the dominant side compared to the non-dominant side. The result of this study would provide valuable information for further studies when investigating the serratus anterior muscle.

Materials and methods

Participants

Twenty healthy men, aged between 18 and 25 years were included in the study. Inclusion criteria for the study were body mass index (BMI) between 18.5-22.9 kg/m² and right-handed. Exclusion criteria were a previous history of spine pain or surgery, shoulder pathology, spine/scapular abnormality (e.g. winged scapula or scoliosis) and receiving scapula-stabilizing exercises. To consider handedness, three questions were asked and two consistent answers were regarded as dominant hand:

- 1) Which hand do you write with?
- 2) Which hand do you use to throw a ball?
- 3) Which hand do you use to hold a glass?

The sample size was calculated using G*Power, with a power of 0.8, medium effect size and an alpha level of 0.05. The estimated sample size was 20.

The study was approved by Human Research Protection Unit, Faculty of Associated Medical Sciences, Chiang Mai University (Ref. no AMSEC-58EX-125). Written informed consent was obtained from each participant prior to enrollment into the study.

Procedures

Participants stood with their arms akimbo. An examiner palpated inferior angle of the scapula and marked it with a pen, bilaterally. The examiner drew a mid-axillary line of the trunk and the horizontal line from the inferior angle of scapula to the mid-axillary line (Figure 1).¹¹ The participants were then asked to lift their both arms to 90° of flexion measured using a goniometer with the palms flat against the wall and the elbows fully extended. During muscle contraction, the participants performed a

full protraction of the scapula by pushing against the wall with their fingers pointing up and the arms remained in the sagittal plane at 90° of flexion. The participants were instructed to hold the position and then inhale and hold their breath for 5 seconds. Ultrasound imaging of the thickness of the muscle was measured bilaterally. The side measured was randomly performed and each side was repeated three times.



Figure 1 Landmark for imaging of serratus anterior thickness.

Ultrasound Imaging

An ultrasound imaging system (Famio 8, SSA-530A; Toshiba, Japan) with a 8 MHz linear array transducer was used in the brightness-mode (b-mode) for imaging.¹⁸ The ultrasound imaging was performed by a trained examiner. The linear array transducer was placed in a vertical position on the mid-axillary line of the trunk and the superior border of the transducer was located on the horizontal line (Figure 2). The echogenic of the rib was identified and maintained as a consistent landmark. The transducer was manually adjusted in the transverse and frontal planes to obtain the sharpest image of the bone and fascia. Every effort was taken to ensure that the echogenic bone was kept in view in order to eliminate errors in the placement of the array. The images of the serratus anterior were taken during inspiration. They were recorded in freeze-frame mode on the monitor screen of the ultrasound unit.

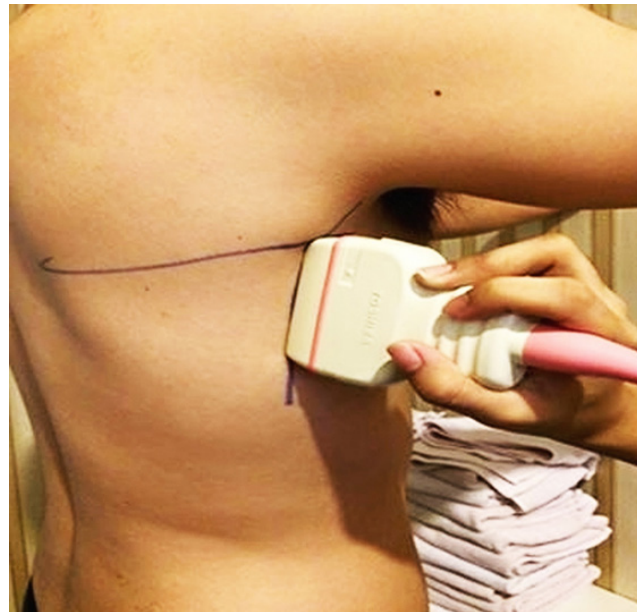


Figure 2 Position of ultrasound transducer for measuring serratus anterior thickness.

The thickness of the serratus anterior muscle was measured manually by Image J software. A perpendicular line was drawn superior to the peak convexity of the most distal rib, with cursors placed on the inside edges of the muscle borders. A linear measurement of the distance between the superior and inferior echogenic fascial lines of the serratus anterior was performed according to a study by Talbott and Witt¹⁸ (Figure 3). Measurements of each image were taken three times by a blinded examiner, and the average was used for the analysis.

Intra- and inter-rater reliability of ultrasound imaging of the serratus anterior muscle in our preliminary study was shown to be high (ICC ranged from 0.70 to 0.89).

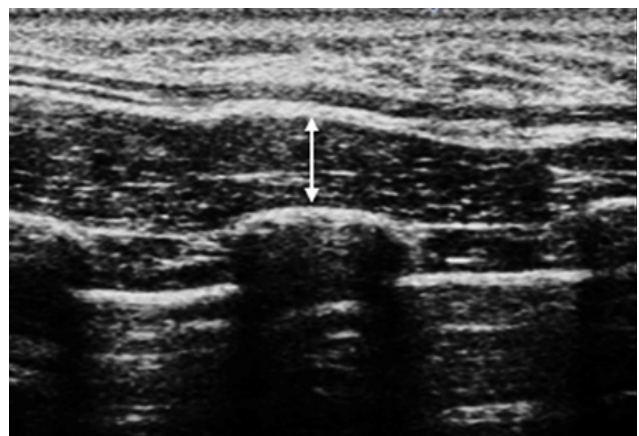


Figure 3 Ultrasound image of serratus anterior muscle. Thickness of serratus anterior was demarcated by a solid white line with arrowheads.

Statistical Analysis

All statistical analyses were performed using SPSS 17.0 software. A paired t-test was used to analyze the serratus anterior muscle thickness between the dominant and non-dominant sides. Statistical significance was set at $p < 0.05$.

Results

All participants had no history of spine pain, shoulder pathology, spine/scapular abnormality. All participants were right-handed. Participants' characteristics are shown in Table 1.

Table 1 Baseline characteristics of participants.

Characteristics	Mean	Standard deviation
Age (yr)	20.65	1.18
Weight (kg)	61.03	5.42
Height (cm)	172.01	0.06
BMI (kg/m ²)	20.71	0.06

The mean and standard deviation of the serratus anterior thickness on the dominant and non-dominant sides are shown in Table 2. The serratus anterior thickness was significantly greater on the dominant side than the non-dominant side ($p < 0.05$)

Table 2 Thickness of serratus anterior muscle between dominant and non-dominant sides.

	Wall push-up	
	Dominant arm (right)	non-dominant arm (left)
Thickness of the serratus anterior muscle (mm)	10.37±3.62	9.64±3.73*

Values are means±SD, * $p < 0.05$

Discussion

The result of this study demonstrated that the thickness of the serratus anterior muscle was influenced by hand dominance. The thickness of the serratus anterior on the dominant hand was greater than that on the non-dominant hand. This supports the notion that muscle thickness is generally larger on the dominant side.

The result of this study supports the study hypothesis and is consistent with a previous study of Uthairakul et al.¹⁴ suggesting the influence of hand dominance on the lower trapezius thickness both at rest and during contraction. Greater lower trapezius muscle thickness was found on the dominant side compared with the non-dominant side. It has been suggested that a wall push-up with full scapular protraction activates the serratus anterior.¹⁶ According to biomechanics, the serratus anterior and lower trapezius muscles form an important force couple that produces upward rotation of the scapular for stabilizing scapular during arm activities.¹⁹ Yoshizaki et al.²⁰ examined shoulder muscle activities between dominant and non-dominant hands during elevation and lowering the arm using electromyography (EMG). They found that EMG activities for the serratus anterior showed a significant difference in the initial phase of elevation. They suggested that the differences in EMG activity of muscle between the dominant and non-dominant shoulders would occur in more complicated tasks or with the addition of an external load on the arms. Everyday activities are usually performed utilizing the dominant arm first e.g. writing, cutting or catching and throwing a ball. This may be a reason for the greater thickness of the serratus anterior muscle on the dominant side. Furthermore, the previous study showed that the repeated contraction of muscles would create more motor recruitment and larger muscle fibers.²¹ Therefore, the result of this study may imply that the serratus anterior muscle on the dominant hand has greater muscle recruitment.

However, the results of this study are inconsistent with other previous studies. Springer et al.¹⁵ found no significant side-to-side differences in thickness of the transversus abdominis muscle using ultrasound imaging in asymptomatic subjects. McCreesh and Egan²² also did not find the effect of leg dominance on the thickness of anterior tibial muscle group in the healthy controls but

football players. The discrepancy between the previous and the current studies may be related to the functions or roles of the muscles. The main role of transverse abdominis muscle is to maintain the stability of the lumbar spine against the effects of gravity during daily physical activities.²³ In healthy persons, it is likely that the transversus abdominis muscle of both sides is required to work equally to stabilize the spine. In contrast, the serratus anterior activity is likely to be associated with the dominant hand use. Thus thickness of skeletal muscles may depend on several factors other than hand dominance including physical activity, muscle mass and muscle function.

Dysfunction of the serratus anterior muscle has been shown to be associated with cervical and shoulder disorders.^{3, 4} The result of this study is relevant for clinicians in terms of assessing dysfunction and gauging recovery in rehabilitation. However, this should be considered with cautions. Although there was statistically significant difference between the dominant and the non-dominant hand, a clinically significant finding is not

determined in this study. Further research in this area is still required. Scapular muscle thickness may also be confounded by scapular dyskinesis.²⁴ Assessment of scapular dyskinesis was not measured in this study however the participants with observable abnormalities of the scapula were excluded. In addition, we could not measure the thickness of the serratus anterior muscles on both sides at the same time. Muscle force or strength during contraction was not assessed in this study. Further studies should address muscle force during contraction and the relationship between muscle force and muscle thickness of the serratus anterior muscle.

Conclusions

This study demonstrated the influence of hand dominance on the thickness of the serratus anterior muscle in a wall push-up position. This factor should be considered in further studies when evaluating the serratus anterior muscle.

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