Reliability of Rehabilitative Ultrasound Imaging In Measuring Thickness of Levator Scapula Muscle in Asymptomatic Women

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Introduction: Levator Scapula Muscle (LSM) is one of the stabilizers of the scapulae. Shortening of this muscle disrupts shoulder biomechanics and results in shoulder pain. Rehabilitative Ultrasound imaging (RUSI) has been introduced as a non-invasive method to measure muscle thickness. The present study aimed to determine the intra-rater reliability of RUSI to measure thickness of LSM in a group of asymptomatic women. **Materials and method:** Images of LSM were taken using RUSI at the level of the forth cervical vertebra in sitting position in 20 asymptomatic women aged 20-36 years. Images were obtained by one examiner on two separate days and muscle thickness was measured using RUSI. Intraclass Correlation Coefficients (ICC), Standard Error of Measurement (SEM), Smallest Detectable Difference (SDD), and Bland-Altman plot were used for the assessment of reliability. **Results:** The results of ICC (0.9), SEM (0.26 mm), and SDD (0.72 mm) values revealed an excellent intra-rater reliability and accuracy of RUSI to measure LSM thickness in asymptomatic women. **Conclusion:** The method of RUSI used in the current study is recommended to measure LSM thickness. It can be used to measure thickness of LSM in patients with shoulder pain where the thickness of the muscle varies according to the level of pain and spasm.

Keywords: Levator Scapula; Ultrasonography; Muscle; Reliability; Shoulder

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Introduction

The scapula plays an important role in normal function of the shoulder and provides a stable base for the movement of the glenohumeral joint (1). This role of the scapula is highlighted especially in overhead movements of the shoulder joint. Scapular muscles control scapular position and motion. Any change in the normal position and movement pattern of the scapula can change biomechanics of the shoulder joint and leads to abnormal loads on the capsule and rotator cuff muscles (1).

The coordination between trapezius and serratus anterior muscles is vital to control scapular orientation. This coordination can be influenced by activity and extensibility of the Levator Scapulae Muscle (LSM) (2). Levator scapula controls scapular upward rotation during movements of the glenohumeral joint. Shortening of this muscle prevents scapular upward rotation, disrupts scapulohumeral rhythm, and leads to abnormal movement of the scapula and abnormal force distribution in the glenohumeral joint. In addition, shortening of this muscle can contribute to increased loads on the cervical spine during active neck and shoulder abduction movement because of attachment of this muscle to the cervical spine (3).

Evaluation of muscle size can show muscle function and strength (4, 5). Magnetic Resonance Imaging (MRI), Computed Tomographic scan (CT-scan) and Rehabilitative Ultrasound Imaging (RUSI) are common methods used to measure muscle thickness. Nevertheless, MRI and CT-scan are expensive and CT-scan entails X-ray radiation. Rehabilitative Ultrasound Imaging (RUSI) is considered as a safe and inexpensive method for assessing muscle thickness (6).

Evaluation of the reliability of instruments is significant as it can provide foundation for future studies and such studies can detect real changes. In the previous studies, reliability of RUSI was evaluated in measuring thickness of the scapular muscles

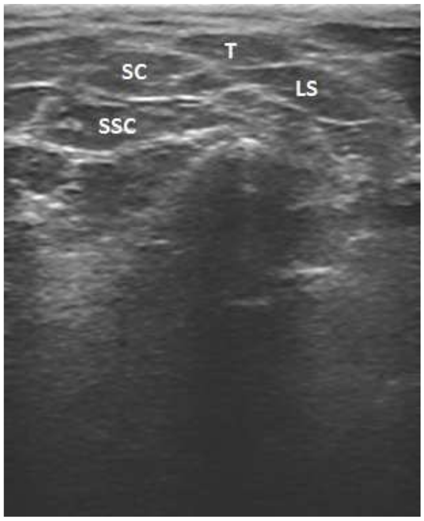

Figure 1. Ultrasonography image of levator scapula (LS:levator scapula, T:trapezius, SC:splenius capitis, SSC:semispinalis capitis)

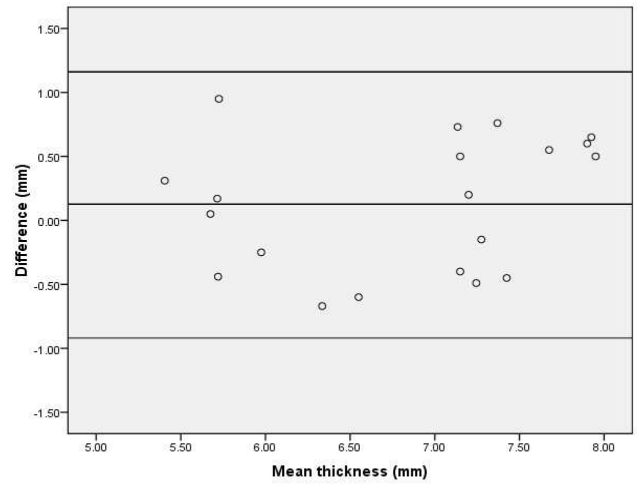

Figure 2. Bland-Altman Plot showing degree of agreement between two measurements. The difference in muscle thickness between two measurements is plotted against themean muscle thickness. The middle line represents the mean of difference in musclethickness between two measurements. Upper and lower lines show 95% limit of agreenent between two measurements.

including the lower trapezius, serratus anterior, middle trapezius, and rhomboid major (6-9), but to the best of our knowledge, no study reported the reliability of RUSI for measuring LSM thickness. Since finding a method for visualization with the imageof LSM by RUSI could improve our knowledge on the role of this muscle in movement and dysfunction of the shoulder, the present study was carried out to assess intra-rater (between-day) reliability of RUSI in measuring LSM thickness in a group of asymptomatic women.

Methods and Materials

Participants

A total of 20 female university students, aged 20-36, participated in the present reliability study. They had previously been informed about the study through printed advertisement. Inclusion criteria of the study were asymptomatic women, aged between 20-40. The exclusion criteria were history of musculoskeletal or neuromuscular diseases, neck, shoulder or upper limb pain, history of pain, traumatic injury to or surgery on the neck, thoracic, or shoulder area, full range of motion of the shoulder, and cervical spine and participation in sports activity involving the scapular muscles (7).

Procedures

Prior to the study, the aims and procedures were explained to the participants and signed informed consents were obtained. The study was approved by the Ethical Committee of Shahid Beheshti University of Medical Sciences, Tehran (SBMU.REC.1393.529, 1393/10/14). After collecting demographic information, image of LSM was taken using RUSI device (Ultrasonic scanner, HS 2100, Honda Electronic Co, Japan) using a 7-cm linear probe in the B-mode (7.5MHz) on two separate days. Image of LSM was taken by an examiner when she observed the best image on ultrasonography monitor. The examiner was a Ph.D. candidate of physiotherapy trained for a year by a musculoskeletal ultrasonography researcher.

Participants were requested to sit in the relaxed state on a chair, keep their knees and hips at 90 degrees of flexion, and maintain their head and neck in the neutral position. They were asked to keep their upper arms in resting position by their sides and forearms and hands kept on the thigh. Participant's position was checked during ultrasonography, as any change in position could change muscle thickness.

We visualized ultrasonography image of LSM at the level of the forth cervical vertebra. Then, ultrasonography probe was placed at the posterior aspect of the cervical spine and it was moved anteriorly. At this level, LSM was close to the splenius capitis and semispinalis capitis muscles (10) (Figure 1).

To obtain each image, the probe was removed and relocated at the same level. Making use of the method explained, three images of LSM were frozen and stored for future analysis. Image of LSM was taken only on the right side of the participants. All the aforementioned procedures were repeated by the same examiner on the second day. The thickness of LSM was measured using RUSI on each image by the examiner in the mornings of two separate days. We did not include facial outline for thickness measurement of LSM and placed the cursor on the inside edge of the superior fascia at the thickest portion of the muscle and drew a vertical line to the inside edge of the inferior fascia (11). The mean thickness of the three images for each day was used for the statistical analysis.

Table 1. The mean (standard deviation) of demographic characteristics of the participants (N=20)

Age (year)	**25.6 (5.51)**
Height (m)	1.63 (6.88)
Weight (kg)	58.75 (9.43)
BMI (kg /m²)	22.12 (3.69)

Table 2. Intra-rater (between- day) reliability of RUSI for measuring thickness of LSM (N=20) (mm)

Mean (SD) thickness of LSM of first day	Mean (SD) thickness of LSM of second day	ICC	95% CI of ICC	SEM	SDD
6.76 (0.83)	6.88 (0.95)	0.9	0.76-0.96	0.26	0.72

Rusi: Rehabilitative Ultrasound Imaging; *LSM:* Levator Scapula Muscle; SD, Standard Deviation; *ICC:* Intra-Class Correlation Coefficients; *CI:* Confidence Interval; SEM: Standard Error of Measurement; *SDD:* Smallest Detectable Difference

Data analysis

Intraclass Correlation Coefficient (ICC), with 95% confidence interval, the Standard Error of Measurements (SEM), and the Smallest Detectable Difference (SDD) were calculated to assess intra-rater (between-day) reliability of RUSI in measuring LSM thickness. SEM was calculated as: SD × √ (1- ICC) and SDD was computed as: SEM×1.96 × √2.

The Bland-Altman plot was also conducted to show the degree of agreement between two measurements (9). Data was analyzed using SPSS (Version 16).

Results

Demographic characteristics of the participants are given in Table 1. The results for the intra-rater (between-day) reliability of RUSI for thickness measurement of LSM are given in Table 2. The value obtained for ICC was 0.9, ranging from 0.76 to 0.96. The SEM and SDD values were 0.26 mm and 0.72 mm, respectively. Figure 2 illustrates Bland-Altman plot. This plot represents the degree of agreement between two measurements. In this plot, the difference in muscle thickness between the two measurements (mm) is plotted against the mean muscle thickness (mm). The mean of the difference in muscle thickness between the two measurements is shown in the middle line. The mean and standard deviation of difference in muscle thickness between the two measurements were observed to be 0.12 mm and 0.52 mm, respectively. In this plot, the upper and lower lines represent 95% limits of agreement between the two measurements (mean ± 2SD, 0.12±1.04 mm) and the limits of agreement between the two measurements were-0.92 to 1.16 mm.

Discussion

In the current study, we assessed the intra-rater (between-day) reliability of RUSI for measuring thickness of LSM because LSM is one of the stabilizers of the scapulae. Shortening or over-activity of this muscle can result in scapular downward rotation syndrome. This syndrome is one of the abnormal positions and movement patterns of the scapula and is related to shoulder and neck pain (3).

In the present study, ICC and Bland-Altman plot were computed because these statistical methods have been considered as the statistical methods of choice in assessment of reliability (8). The ICC value in our study showed excellent reliability (11) and according to the Bland-Altman plot, there is good agreement between the two measurements. We also computed SEM value to measure absolute reliability as the previous studies considered SEM as the most important index in reliability studies (12). SEM represents variability of scores between measurements and it indicates measurement error. The smaller the SEM, the higher the degree of reliability (12). SEM value can be even more useful if it is accompanied by SDD value because SDD value can exclude measurement error (12) and SDD can demonstrate real changes after interventions. The SEM value in our study was 0.26 mm. This value was nearly 4% of the mean of muscle thickness. This small value suggests that our method had small measurement error (8). Also, the SDD value was observed to be 0.72 mm indicating that changes in LSM thickness greater than 0.72mm can be considered as actual changes in an intervention.

In comparison with the previous studies evaluating the intra-rater reliability of RUSI for thickness measurement of the scapular muscles, the results of the present study were similar to those reported in O'Sullivan et al. They reported ICC values between 0.89 and 0.91 and SEM values between 0.24-0.27 mm for intra-rater (between-day) reliability for thickness measurement of lower trapezius (8), while the results of Bentman et al.'s study demonstrated that the ICC value was 0.61 and SEM value was 2 mm for thickness measurement of middle trapezius (7), and Talbott et al. reported an ICC value of 0.67 and SEM value of 1 mm for measuring thickness of serratus anterior (9). In contrast, Jeong *et al.* reported a better intra-rater reliability index for thickness measurement of rhomboid major. They reported ICC values between 0.93-0.97 and SEM values between 0.019-0.029 mm (6).

In the present study, we considered Bland-Altman plot because there may be poor agreement in repeated measurements in spite of the high correlation coefficient. We calculated the mean of the difference in muscle thickness between two measurements to be close to zero (0.12 mm) and Bland-Altman plot revealed that our method had good agreement between the two measurements.

It should also be mentioned that the current study has some limitations that should be taken into account before generalizing the findings. Our study assessed only intra-rater (between-day) reliability of RUSI for thickness measurement of LSM in women. More studies are required to assess inter-rater reliability of RUSI for thickness measurement of LSM both in both women and men. The present study was conducted only on asymptomatic women; we also suggest evaluation of the reliability of RUSI for LSM thickness measurement in patients groups (e.g. in patients with shoulder pain), as well. Future studies may also be necessary to provide normal values for LSM thickness using RUSI in wider population.

Conclusion

The results of the current study showed that our method was a reliable method for measuring thickness of LSM using RUSI in asymptomatic women. The present study can be fundamental to compare LSM thickness between participants with and without shoulder pain to shed light on our knowledge about the role of this muscle in shoulder pain and evaluate treatment methods for shoulder pain.

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