



Original Article

## Reliability of musculoskeletal ultrasound imaging to measure supraspinatus tendon thickness in healthy subjects

ASHFAQ AHMAD, BSPT, TDPT, M.Phil, PT, PhD-PT (Student)<sup>1)</sup>,  
MOHAMMAD A. MOHSENI BANDPEI, BSc, PT, MSc, PT, PhD<sup>1, 2)\*</sup>,  
S. AMIR GILANI, MBBS, DMRD, MPH, PhD<sup>3)</sup>, AROOJ MUNAWAR, BSPT, PP, DPT<sup>4)</sup>,  
ISHAQ AHMED, BSPT, TDPT, MSPT<sup>4)</sup>, FAHAD TANVEER, BSPT, PPDPT, MSOMPT<sup>5)</sup>

<sup>1)</sup> University Institute of Physical Therapy, Faculty of Allied Health Sciences, The University of Lahore, Pakistan

<sup>2)</sup> Pediatric Neurorehabilitation Research Center, University of Social Welfare and Rehabilitation Sciences: Tehran, Iran

<sup>3)</sup> Faculty of Allied Health Sciences, The University of Lahore, Pakistan

<sup>4)</sup> University Institute and Clinics of Physical Therapy, The University of Lahore, Pakistan

<sup>5)</sup> University Institute of Physical Therapy, The University of Lahore, Pakistan

**Abstract.** [Purpose] The purpose of this study was to assess intra-rater and inter-rater reliability of musculoskeletal ultrasound (MSKUS) as a tool to measure supraspinatus tendon thickness in healthy subjects. [Subjects and Methods] Twenty healthy subjects were assessed in similar sitting position. Two experienced musculoskeletal ultrasound specialists measured supraspinatus tendon thickness. Tendon was measured twice in one day by each of two raters with an interval of one hour for within day reliability and was re-measured following one week for between days reliability. Data analysis was performed using the intraclass correlation coefficient (ICC) and standard error of measurement (SEM). [Results] Results reflected excellent within day intra-rater and inter-rater reliability with Mean  $\pm$  standard deviation (SD)=5.14  $\pm$  0.83 and 5.17  $\pm$  0.78, ICC (2,1)=0.89–0.93 and ICC (2,2)=0.98 (0.95–0.99) and SEM=0.18–0.18 and 0.17 while between days intra-rater and inter-rater reliability with Mean  $\pm$  SD=5.14  $\pm$  0.83 and 5.17  $\pm$  0.78, ICC(2,1)=0.88–0.90 and ICC(2,2)=0.95 (0.88–0.98), SEM=0.17–0.38 and 0.17 [Conclusion] The results of the current study indicate that MSKUS is a reliable tool for measuring supraspinatus tendon thickness in healthy subjects.

**Key words:** Musculoskeletal ultrasound, Supraspinatus tendon, Reliability

(This article was submitted Apr. 18, 2017, and was accepted May 24, 2017)

### INTRODUCTION

Shoulder pain is the most common musculoskeletal disorder. In the general population at a given time, 6.9 to 26 percent of adults experience shoulder pain, and up to 66 percent will experience pain in their lifetime<sup>1)</sup>. In Iran, point, last 6-month, last year, and lifetime prevalence of shoulder pain were found as 21.4%, 29%, 38.8%, and 41.6%, respectively<sup>2)</sup>. Rotator cuff injuries are the most common causes of painful shoulder in the elderly, accounting for up to 70% of cases and supraspinatus tendon is the most commonly involved tendon among all rotator cuff (RC) injuries. Severe supraspinatus tendon injury may affect the patient's quality of life. However, supraspinatus tendon injury can be relatively asymptomatic in some cases and may require imaging examination for diagnosis<sup>3)</sup>. Rotator cuff (RC) disorders can be diagnosed through various imaging

\*Corresponding author. Mohammad A. Mohseni Bandpei (E-mail: mohseni\_bandpei@yahoo.com)

©2017 The Society of Physical Therapy Science. Published by IPEC Inc.



This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License. (CC-BY-NC-ND 4.0: <http://creativecommons.org/licenses/by-nc-nd/4.0/>)

**Table 1.** Characteristics of the subjects (N=20)

Characteristic	Mean $\pm$ SD	Range
Age (years)	37.3 $\pm$ 18.1	30–49
Gender	Male	12
	Female	8
Height (cm)	173.2 $\pm$ 11.3	162–184
Weight (kg)	72.3 $\pm$ 12.2	60–84
BMI	22.1 $\pm$ 2.4	18–25

N: total number of participants; BMI: body mass index; SD: standard deviation

tools like MSKUS which is also known as Rehabilitative Ultrasound Imaging (RUSI), Magnetic Resonance Imaging (MRI) and Magnetic Resonance Arthrography (MRA)<sup>4</sup>. For decades, ultrasound imaging has been used to assist with medical diagnosis by identifying structural tissue pathology. More recently, ultrasound imaging was introduced in rehabilitation to evaluate muscle morphology and function in persons with neuromusculoskeletal disorders such as low back pain<sup>5</sup>. In May 2006, an international panel of experts proposed a research agenda of rehabilitative ultrasound and adopted the term ‘rehabilitative ultrasound imaging’ to define the procedure of evaluating ‘muscle and related soft tissue morphology and function during exercise and physical tasks’<sup>6</sup>.

MSKUS is considered as cost-effective diagnostic modality to screen rotator cuff tears. From systematic reviews of all studies, pooled sensitivities and specificities are 0.95 & 0.96 respectively and Sensitivity figures of 0.98 are obvious when using transducer of 10 MHz or greater<sup>7, 8</sup>. MRI has high sensitivity (89%) and specificity (93%) for diagnosing full thickness tears, as noted in a systematic review of 29 studies and sensitivity for partial thickness tears identification is much lower (44%), with high specificity whereas, sensitivity for partial thickness tears identification is found to be much lower (44%), with high specificity (90%)<sup>9</sup>.

In another study, the sensitivity and specificity ranges were given as follow: 92.4% to 96% and 93% to 94.4% respectively for diagnosis of full thickness tears through MSKUS whereas from 66.7% to 84% and from 89% to 93.5% respectively for partial thickness tear from same imaging tool<sup>10</sup>. In any case, Ultrasound (US) results are strongly associated with operator’s expertise and requires careful preparing and involvement in execution and evaluation before exact analyses can be made, particularly in connection to more inconspicuous changes as regularly observed inside<sup>11</sup>. Being operator dependent, discrepancy was shown between sonographers in results of a shoulder MSKUS examination. Further research is needed to explore accuracy in diagnosis of other musculoskeletal disorders using MSKUS and to explore specific protocols for sonographers, to improve its reliability<sup>12</sup>.

The aim of this study was to assess the intra-rater and inter-rater reliability of MSKUS as a tool to measure supraspinatus tendon thickness in healthy subjects. Since, this study is the part of big project involving partial tear of supraspinatus tendon, MSKUS modality was preferred on MRI by keeping its higher sensitivity figures in view.

## SUBJECTS AND METHODS

Participants were 20 healthy subjects (12 males, 8 females), age from 30–49 years, with a mean age of 37  $\pm$  18 years, a mean height of 173  $\pm$  11 cm, and a mean body mass of 72  $\pm$  12 kg whereas all the subjects were with the BMI range from 18 and 25, the mean BMI of 22 and SD of 2 respectively (Table 1). Subjects were recruited from the employees of The University of Lahore, or, and their family members and friends at Department of Clinical Radiology, University Teaching Hospital, The University of Lahore, Pakistan. Inclusion criteria was having full active pain-free range of motion of the cervical and thoracic spine and shoulders. Exclusion criteria included neuromuscular or musculoskeletal disorders of the cervical or thoracic spine and shoulders; history of significant neck or shoulder pain, arm trauma, pain or surgery of the neck or shoulder; pregnancy, or metal implants in the upper body<sup>13</sup>.

All the subjects signed informed consent after receiving a detailed explanation of the procedure of the study. The University of Lahore’s institutional review board approved the protocol for the study.

Subjects were seated on a low wheel less stool with straight back and feet supported. The subject’s hand was positioned on his/her back with dorsum of hand in contact with lumbar spine and palm facing outwards. This rotates the shoulder medially by exposing the ligament out from underneath the acromium where it can now be pictured at ease with the help of MSKUS.

Ultrasound images were obtained by two experienced musculoskeletal ultrasound specialists having more than 10 years of experience of practice of musculoskeletal ultrasound using ultrasound machine (Toshiba Xerio, Japan, 8 to 14 MHz) with linear transducer. The tendon was examined thoroughly from all planes and final reading was taken by measuring middle and thickest part of supraspinatus tendon<sup>14</sup>.

All measures were taken three times; the first and second were done in one day with an hour interval (for within day

**Table 2.** Measured values for supraspinatus tendon thickness (mm)

Subjects	Rater 1			Rater 2		
	Session 1	Session 2	Session 3	Session 1	Session 2	Session 3
1	3.9	3.7	4.3	4.1	4.2	4.5
2	5.0	4.6	4.5	4.8	5.1	5.3
3	5.6	6.0	5.3	5.3	5.6	5.7
4	5.7	5.3	5.3	5.5	5.8	5.8
5	3.3	3.8	3.5	3.5	3.2	3.1
6	4.6	5.0	5.0	4.8	4.4	4.2
7	5.3	5.9	5.7	5.5	5.2	5.0
8	4.3	4.0	3.8	4.5	4.1	4.1
9	5.1	5.5	5.4	5.2	4.9	4.9
10	6.2	6.0	6.5	6.0	5.7	5.6
11	5.8	5.4	5.4	5.6	5.3	5.2
12	6.2	6.6	6.6	6.4	6.1	6.1
13	5.3	4.8	5.7	5.5	5.3	5.1
14	5.5	5.8	5.9	5.7	5.5	5.4
15	5.8	6.1	6.2	6.0	5.7	5.7
16	4.7	4.4	4.3	4.9	4.6	5.3
17	6.3	5.9	6.7	6.5	6.3	6.3
18	5.3	5.5	5.6	5.1	5.4	5.0
19	4.3	4.1	4.8	4.1	4.4	4.5
20	4.7	4.5	4.3	4.9	4.6	4.5

reliability), and the third was performed following a one week interval (for between days reliability). The examiners were randomly assigned for measurement order. Both the examiners had equal chance to become first examiner. After taking all the measurements, the first examiner left the room and second examiner entered into the room and performed the measurements with same guidelines. Data analysis was performed using SPSS version 21. Descriptive statistics for tendon measurements were calculated using mean and standard deviations. Additionally, SEM was computed. Within day intra-rater reliability (between the first and second measurement) (ICC 2,1) was determined by comparing the two measurements by each examiner on each test session. Similarly, between days, intra-rater reliability (between the first and third measurement) (ICC 2, 1) was taken into consideration and for within day inter-rater reliability (between the first measurements of rater one and two) (ICC 2, 2) was determined by comparing the two measurements. And between days, inter-rater reliability (between the first measurement of rater one and third measurement of rater two) (ICC 2, 2) was determined.

## RESULTS

Mean thickness of supraspinatus tendon (within day and between days sessions) for rater one was found 5.14 mm and 5.19 mm and for rater two, it was 5.14 mm and 5.13 mm respectively (Table 2).

There were 20 subjects with 5.14 mm and 5.19 mm for rater one and two as mean thickness of supraspinatus tendon with non significant difference of values between males and females, hence, both are included in pooled data and a SD of 0.83–0.83 and 0.76–0.86 for within day and between days intra-rater reliability whereas within day ICC (2, 1) of 0.89–0.93 and SEM of 0.18–0.18 while between days ICC (2,1) of 0.88–0.90 and SEM of 0.17–0.38 (Table 3).

There were 20 subjects with 5.17 mm and 5.10 mm for within day and between days inter-rater reliability as mean thickness of supraspinatus tendon with non-significant difference of values between males and females, hence, both are included in pooled data and a SD of 0.78 and 0.78 for within day and between days inter-rater reliability whereas within day ICC (2, 2) of 0.95–0.99 and SEM of 0.17 while between days ICC (2,2) of 0.88–0.98 and SEM of 0.17 (Table 4).

## DISCUSSION

The main objective of this study was to assess the intra-rater and inter-rater reliability of MSKUS as a tool to measure supraspinatus tendon thickness in healthy subjects. Twenty subjects were taken with a mean age of thirty seven years, height of one seventy three centimeter, weight of seventy two kilograms and a Body mass index of twenty two. The overall results were reliable to the study objective.

**Table 3.** Mean  $\pm$  SD and ICC(2,1) for within day and between days intra-rater reliability measures of supraspinatus tendon thickness

Variable	Reliability		Mean $\pm$ SD	ICC (95% CI)	SEM (deg)
Supraspinatus tendon thickness (mm)	Within day	R1	5.14 $\pm$ 0.83	0.89 (0.76–0.95)	0.18
		R2	5.14 $\pm$ 0.83	0.93 (0.85–0.97)	0.18
	Between days	R1	5.19 $\pm$ 0.86	0.90 (0.77–0.96)	0.38
		R2	5.13 $\pm$ 0.76	0.88 (0.72–0.95)	0.17

SD: standard deviation; ICC (2, 1): Intraclass Correlation Coefficient; SEM: standard error of measurement; deg: degrees; R1: Rater one; R2: Rater two; CI: confidence Interval

**Table 4.** Mean  $\pm$  SD and ICC (2,2) for within day and between days inter-rater reliability measures of supraspinatus tendon thickness

Variable	Reliability		Mean $\pm$ SD	ICC (95% CI)	SEM (deg)
Supraspinatus tendon thickness (mm)	Within day		5.17 $\pm$ 0.78	0.98 (0.95–0.99)	0.17
	Between days		5.10 $\pm$ 0.78	0.95 (0.88–0.98)	0.17

SD: standard deviation; ICC (2, 2): Intraclass Correlation Coefficient; SEM: standard error of measurement; deg: degrees; CI: confidence interval

Karthikeyan et al. proved in a study done that the mean thickness of the supraspinatus tendon was 4.9 mm in females and 5.6 mm in male which is very close to the results of the present study<sup>15</sup>.

In the study conducted by William et al., found validity and reliability of assessments extracted using RUSI for measuring supraspinatus muscle in resting and contracted stages. Readings of supraspinatus muscle thicknesses, during passive and active stages, elaborated high inter-rater and intra-rater reliability and can be differentiated easily between active and passive phases. The results showed that RUSI is reliable method in measuring thickness that is significant to see muscle function in terms of improvement and worsening<sup>13</sup>.

According to a study by Hinsley et al. who classified supraspinatus tendinopathy with the help of MSKUS in following style: Normal Tendons; Abnormal entheses / Partial-thickness tear; Single tendon full-thickness tears (0–2.5 cm); Multi-tendon full-thickness tears ( $>$ 2.5 cm) respectively which is also in accordance to our study<sup>14</sup>.

A study by Roy et al. published meta-analysis on precision of accuracy of diagnosis and ruling out RC tears with the help of RUSI. Since US is utilized for the purpose of care in different conditions, (e.g., sports drug, an auxiliary investigation surveyed precision by radiologists and non-radiologists. The results of the current study demonstrate the analytic precision of US, X-ray and MRA in the portrayal of fullthickness RC tears. Since full thickness tear constitutes a key thought for surgical repair, this is a vital trademark while choosing an imaging methodology for RC issue. While considering exactness, cost, and wellbeing, US is the best alternative option<sup>4</sup>.

Similar to the present study, Tamborrini et al. determined the inter-rater reliability in the analysis of 3D ultrasound image sets of the supraspinatus tendon between sonographer with different levels of experience. The reliability of 3D ultrasound of the supraspinatus tendon depends on the level of experience of the sonographer. Experience in 2D ultrasound does not seem to be sufficient for the analysis of 3D ultrasound imaging sets. Therefore, for a 3D ultrasound analysis new diagnostic criteria had to be established and taught even to experienced 2D sonographers to improve reproducibility<sup>16</sup>.

The first and prime strength of the study was that both the examiners were qualified musculoskeletal ultrasound specialists having more than 10 years of clinical and teaching experience and remained involved in teaching of same subject to students which may help in increasing the reliability of MSKUS for measuring supraspinatus tendon thickness. Second, maximum efforts have been put in to minimize the random errors by standardizing the procedures. This was achieved by stabilizing all the subjects to avoid movement compensation and by providing them with the same instructions before measurement. In addition to that similar environment e.g. same chair, same participant's orientation, same room, etc. was used to collect the data. Finally, on every assessment, tendon was measured within the same set sequence. The collection of the data on healthy subjects was a limitation of this study which may limit the external validity. Thus, the generalizability of the results of the current study to a patient population may be limited. Because the purpose of current study was to identify the intra-rater and inter-rater reliability of musculoskeletal ultrasound to measure the supraspinatus tendon thickness in healthy subjects, therefore, it seems that an available sample of healthy students was appropriate. The vision of this study was to prove MSKUS as a reliable, cost-effective and a non-invasive modality for assessing supraspinatus tendon thickness.

## ACKNOWLEDGEMENTS

This study was part of PhD Physical Therapy project (The effectiveness of routine physical therapy with and without low level laser therapy in the treatment of patients with partial tear of supraspinatus tendon) supported by the University Institute of Physical Therapy (UIPT) and University Physical Therapy and Rehabilitation Clinics (UPTRCs), The University of Lahore, Lahore, Punjab, Pakistan. Authors are extremely thankful to all volunteers and subjects who contributed in this study.

## REFERENCES

- 1) Luime JJ, Koes BW, Hendriksen IJ, et al.: Prevalence and incidence of shoulder pain in the general population; a systematic review. *Scand J Rheumatol*, 2004, 33: 73–81. [[Medline](#)] [[CrossRef](#)]
- 2) Mohseni-Bandpei MA, Keshavarz R, Minoonejhad H, et al.: Shoulder pain in Iranian elite athletes: the prevalence and risk factors. *J Manipulative Physiol Ther*, 2012, 35: 541–548. [[Medline](#)] [[CrossRef](#)]
- 3) Keener JD, Steger-May K, Stobbs G, et al.: Asymptomatic rotator cuff tears: patient demographics and baseline shoulder function. *J Shoulder Elbow Surg*, 2010, 19: 1191–1198. [[Medline](#)] [[CrossRef](#)]
- 4) Roy JS, Braën C, Leblond J, et al.: Diagnostic accuracy of ultrasonography, MRI and MR arthrography in the characterisation of rotator cuff disorders: a systematic review and meta-analysis. *Br J Sports Med*, 2015, 49: 1316–1328. [[Medline](#)] [[CrossRef](#)]
- 5) Teyhen DS: Rehabilitative ultrasound imaging: the roadmap ahead. Alexandria: JOSPT, 2007.
- 6) Teyhen D: Abstracts from the Rehabilitative Ultrasound Imaging Symposium. May 8–10, 2006. San Antonio, Texas, USA. *J Orthop Sports Phys Ther*, 2006, 36: A1–A17. [[Medline](#)] [[CrossRef](#)]
- 7) Ottenheijm RP, Jansen MJ, Staal JB, et al.: Accuracy of diagnostic ultrasound in patients with suspected subacromial disorders: a systematic review and meta-analysis. *Arch Phys Med Rehabil*, 2010, 91: 1616–1625. [[Medline](#)] [[CrossRef](#)]
- 8) Smith TO, Back T, Toms AP, et al.: Diagnostic accuracy of ultrasound for rotator cuff tears in adults: a systematic review and meta-analysis. *Clin Radiol*, 2011, 66: 1036–1048. [[Medline](#)] [[CrossRef](#)]
- 9) Dinnes J, Loveman E, McIntyre L, et al.: The effectiveness of diagnostic tests for the assessment of shoulder pain due to soft tissue disorders: a systematic review. *Health Technol Assess*, 2003, 7: iii, 1–166. [[Medline](#)] [[CrossRef](#)]
- 10) de Jesus JO, Parker L, Frangos AJ, et al.: Accuracy of MRI, MR arthrography, and ultrasound in the diagnosis of rotator cuff tears: a meta-analysis. *AJR Am J Roentgenol*, 2009, 192: 1701–1707. [[Medline](#)] [[CrossRef](#)]
- 11) Naredo E, Möller I, Moragues C, et al. EULAR Working Group for Musculoskeletal Ultrasound: Interobserver reliability in musculoskeletal ultrasonography: results from a “Teach the Teachers” rheumatologist course. *Ann Rheum Dis*, 2006, 65: 14–19. [[Medline](#)] [[CrossRef](#)]
- 12) Johnson L: Comparison of accuracy between MRI and musculoskeletal ultrasound in diagnosis of a rotator cuff tear. Azusa Pacific University, Student Thesis, 2016.
- 13) Temes WC, Temes Clifton A, Hilton V, et al.: Reliability and validity of thickness measurements of the supraspinatus muscle of the shoulder: an ultrasonography study. *J Sport Rehabil*, 2014, Technical Notes: 2013–0023. [[Medline](#)]
- 14) Hinsley H, Nicholls A, Daines M, et al.: Classification of rotator cuff tendinopathy using high definition ultrasound. *Muscles Ligaments Tendons J*, 2014, 4: 391–397. [[Medline](#)]
- 15) Karthikeyan S, Rai SB, Parsons H, et al.: Ultrasound dimensions of the rotator cuff in young healthy adults. *J Shoulder Elbow Surg*, 2014, 23: 1107–1112. [[Medline](#)] [[CrossRef](#)]
- 16) Tamborrini G, Marx C, Micheroli R: Inter-rater reliability in the classification of supraspinatus tendon tears using 3D ultrasound—a question of experience? *J Ultrason*, 2016, 16: 252–259. [[Medline](#)] [[CrossRef](#)]