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Measurements of rotator cuff tendons, acromioclavicular joint space, and subacromion-subdeltoid bursa in the adults sudanese population using ultrasonography

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ABSTRACT

Globally, musculoskeletal disorders have risen. Injuries at work are common, and workers' compensation and medical costs can be costly. The study's goal was to employ high-frequency ultrasound (US) to determine rotator cuff tendon thickness and width, acromioclavicular joint (ACJ) space, and subacromion-subdeltoid (SA-SD) bursa thickness in Sudanese. These will also be standard reference levels for early diagnosis of musculoskeletal diseases. The study comprised 286 adults aged 18 to 82 years with 35% males and 65% females.The Statistical Package for the Social Sciences (SPSS) version 16.0 for Microsoft Windows was used to analyze the data. The study found that the mean thickness and width of the long head of the biceps (LHB), subscapularis (Ssc), supraspinatus (SS), and infraspinatus (IS) tendons were 2.71±0.50 mm; 6.28 ±0.97 mm, 4.55±0.84 mm; 26.59±2.83 mm, 5.34±0.98 mm; 27.32±2.66 mm, and 2.51±0.65 mm; 26.22±3.12 mm, respectively. The average ACJ space measurement was 5.01±0.61 mm and the SA-SD bursa thickness was 1.40±0.33. This study determined the mean thickness and width of the LHB, Ssc, SS, and IS tendons, the ACJ space, and the SA-SD bursa in healthy adult Sudanese. These findings should be included in the musculoskeletal US (MSK US) interpretation checklist for shoulder joint disorders.

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Tendons; rotator cuff; ultrasonography

1. Introduction

Musculoskeletal problems have become more common throughout the world in recent decades. It is a prevalent cause of work-related disability among employees, with serious financial consequences due to workers' compensation and medical expenses (Andersson, 1999; Chang et al., 2020; Han et al., 2021). The reported prevalence statistics for shoulder problems were widely disparate. Health professionals and policymakers who estimate the amount of medical care required and associated expenditures should be aware of variations in prevalence rates and the underlying causes of these variances. For various age groups, incidence rates ranged from 0.9%–2.5%. The values for point prevalence ranged from 6.9%–26%, 18.6%–31% for one-month prevalence, 4.7%–46.7% for one-year prevalence, and 6.7%–66.7% for lifetime prevalence. Prevalence rates have declined when the case definition was narrowed, such as the length of pain or the presence of restricted movements, and increased when the area of pain was expanded (Luime et al., 2004). Shoulder disorders pose a medical, social, and economic burden on society. Shoulder disorders are common in the general population and a common reason for seeking medical attention. As a result, physicians, providers, and legislators in health care must deal with this important health issue (Van der Heijden, 1999).

Musculoskeletal US (MSK US) and magnetic resonance imaging (MRI) are the two most common methods for assessing muscles, ligaments, and tendons in patients with shoulder pain. Direct comparisons of the two methods for detecting and grading shoulder abnormalities have only been done in a few studies (EL- Melegy et al., 2017; Jacobson, 2005; Lanni et al., 2014). MSK US has expanded diagnostic US opportunities. The modality is easily accessible, inexpensive, and portable. Its real-time capability aids in clinical correlation of the location of pain and comparison with the contralateral side. Shoulder US has been the most widely used application of musculoskeletal imaging since the mid-1980s, when it was used to evaluate the rotator cuff (Cholewinski et al., 2008; Mohammed et al., 2018). In the beginning, transducers with a frequency of 7.5 MHz were used. The reported sensitivity of roughly 70% was most likely the result of this,

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paired with inadequate expertise. Advances in transducer technology with frequencies ranging from 13 to 15 MHz have greatly enhanced sensitivity and near-field resolution, providing a much-needed boost to shoulder and MSK US (Mohammed et al., 2018).

According to the authors' knowledge, the Sudanese population lacked baseline data on rotator cuff tendon thickness and width, acromioclavicular joint (ACJ) space measurements, and subacromion-subdeltoid (SA-SD) bursa thickness. Thus, the purpose of the study was to use high-frequency US to quantify the thickness and width of rotator cuff tendons, ACJ space measurements, and SA-SD bursa thickness in the Sudanese population. Furthermore, standard reference values for these will be established and proposed for early diagnosis of musculoskeletal pathology.

2. Material and methods

2.1. Design of the study and patient selection

The Institutional Review Board (IRB) and the Local Ethics Committee (LEC) of Alzaiem Alazhari University (AAU) in Khartoum, Sudan, approved this cross-sectional study (AAU, IRB, and LEC approval number: AAU; IRB & LEC 59/2016). The ethics procedures were in accordance with the 1975 Helsinki Declaration, which was amended in 2013. Prior to receiving the ultrasound (US) examination, all participants signed a written informed consent form. 286 participants took part in this study from August 2016 to December 2020.

This study was conducted at three US clinics: the Department of US at Al-Hekma Medical Center, the Prof. Abd Elsamed M. Salih US Clinic at the Affiliated Hospital of AAU, and the Khalawi Alssayim Dima for Quran US clinic in Khartoum North. Using a data collection sheet created specifically for this study, we were able to gather demographic information about the patients, including their gender, age, weight, height, and body mass index (BMI), as well as US measurements such as the thickness and width of the tendons of the long head of the biceps (LHB), subscapularis (Ssc), supraspinatus (SS), and infraspinatus (IS), as well as the thickness of the SA-SD bursa, and ACJ space measures.

2.2. Instrumentation and procedures for performing shoulder US

A KX2600 (Xuzhou Kaixin Electronic Instrument Co., Ltd, Xuzhou, Jiangsu, China), KAIXIN (Mindray DP-1100 Plus, Mindray Co., Ltd, Shenzhen, China), and Toshiba Canon Xario 200 (Toshiba America Medical Systems, Inc., Tustin, CA, USA) equipped with the same type of linear transducer with a frequency of 13 to 15 MHz were used. MSK US examinations were performed by the same sonographers who had at least ten years of general US experience and five years of MSK US experience. The MSK US scans (Figures 1, 2, 3, 4, 5 and 6) were carried out in accordance with the American Institute of Ultrasound in Medicine (AIUM) practice guideline for conducting a shoulder US exam (AIUM, 2003).

The study posed no danger to the participants in any way. Participants' privacy and confidentiality were safeguarded by removing or rejecting any personally identifiable information. It was necessary to keep all of the participant data on compact discs (CDs), personal computers (PCs), and in box files.

2.3. Statistical analysis

For statistical analysis, the Statistical Package for the Social Sciences (SPSS) Version 16 for Windows was utilized (IBM Corporation, Armonk, NY, US). The One-way ANOVA test was used to compare continuous data summarized as minimum, maximum, and standard deviation (SD). Categorical data were summarized as frequencies and percentages, and the outcomes were compared using the *t*-test, with a *p*-value ≤ 0.05 considered statistically

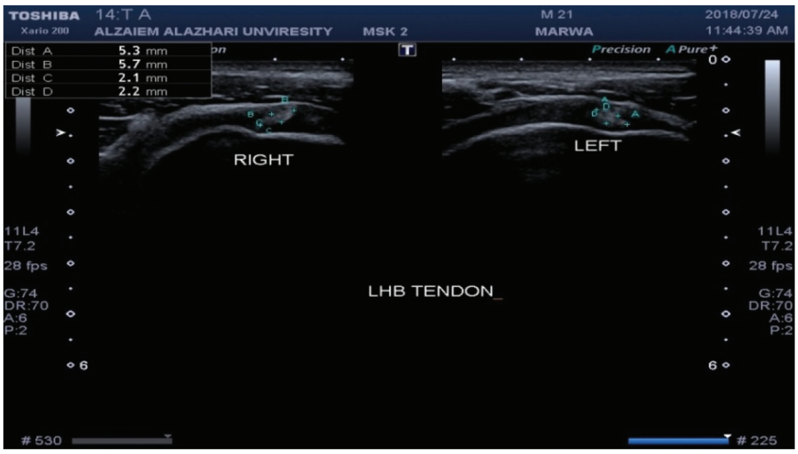

Figure 1. A 21-year-old man's US scan displays the right and left LHB tendons' thickness and width.

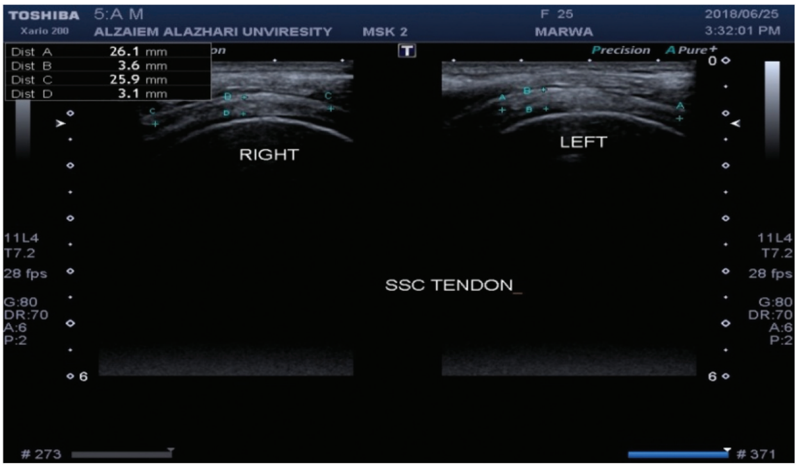

Figure 2. A 25-year-old woman's US scan shows the right and left Ssc tendons' thickness and width.

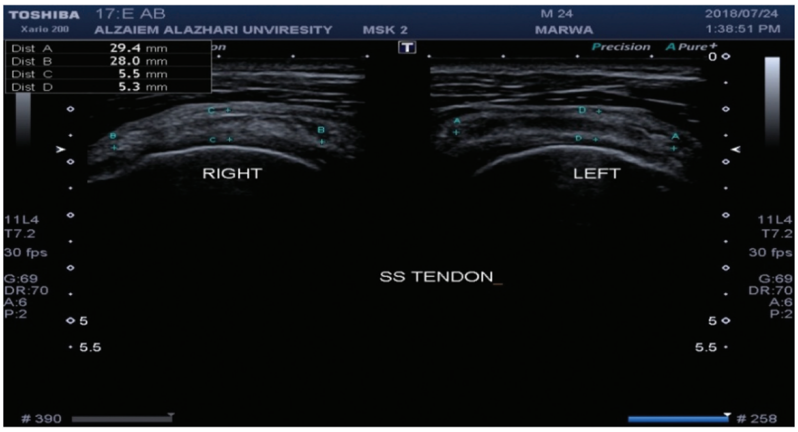

Figure 3. A 24-year-old man's US image shows the right and left SS tendons' thickness and width.

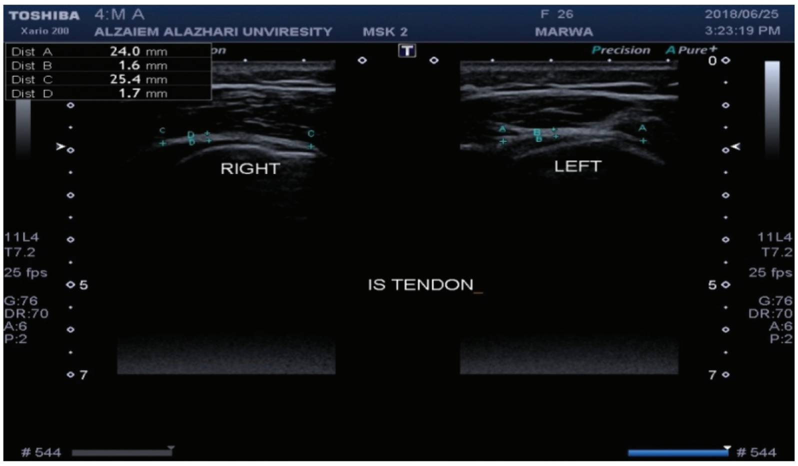

Figure 4. A 26-year-old woman's US scan reveals the right and left IS tendons' thickness and width.

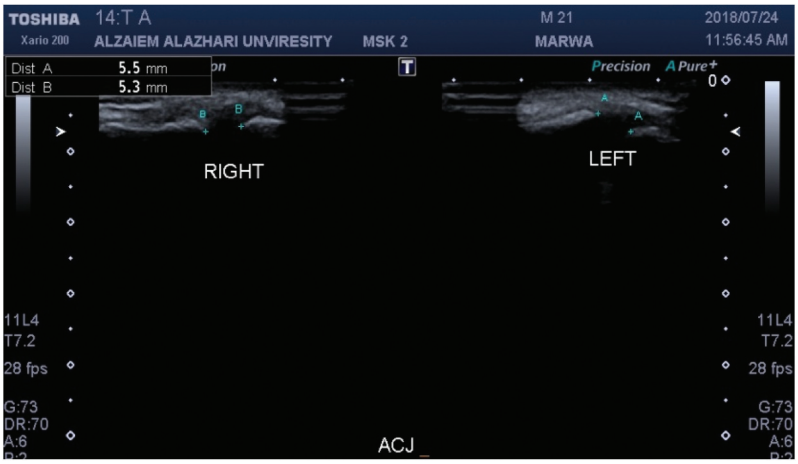

Figure 5. A 21-year-old man's US scan displays the right and left ACJ space measurements.

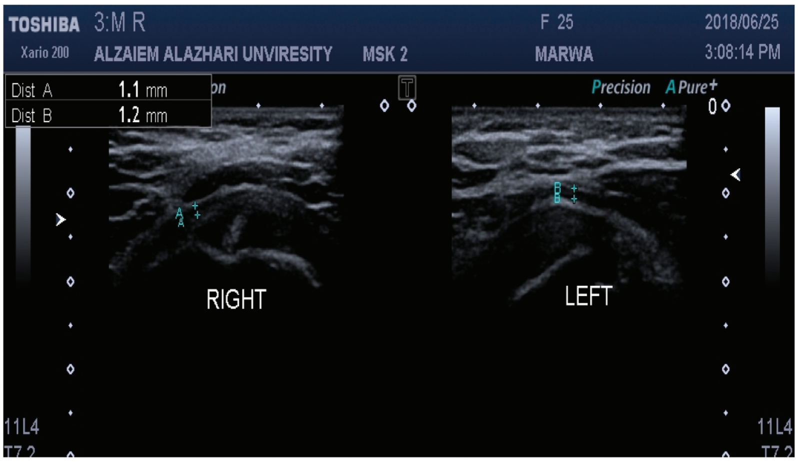

Figure 6. A 25-year-old woman's US sonogram illustrates the thickness of the SA-SD bursa on her right and left sides.

significant. Pearson's correlation was used to see if there was statistical evidence for a linear relationship between the same pairs of variables in the population.

3. Results and discussion

A total of 286 participants took part in the study, with 168 (65%) of them being female and 100 (35%) being male. Their mean age, body weight, height, and BMI were 30.02 ± 13.70 years old, 63.67 ± 12.44 kg, 163.55 ± 9.82 cm, and 23.92 ± 4.91 kg/cm^2, respectively (Table 1). Table 2 compares the mean thickness and width of the tendons of the LHB, Ssc, SS, IS, ACJ space measures, and SA-SD bursa thickness in various particpants (Figures 1–6).

This is, to the best of our knowledge, the first study to offer normative US measurements of the rotator cuff tendons, ACJ space measurements, and SA-SD bursa thickness in a healthy Sudanese adult population of variable gender and age. Our results in measuring the thickness and width of the LHB, Ssc, SS, IS, ACJ space measurements, and SA-SD bursa thickness (Table 1 and Figures 1–6) agreed with those of Abate et al. (2014), who confirmed that the SS thickness was 5.2 mm and the LHB thickness was 3.2 mm in an adult population. Part of our findings (Table 1) agreed with Manoharan et al. (2014) for SS thickness and width, however they disagreed for Ssc and IS thickness and breadth. Tsai et al. (2007) conducted a study that

Table 1. Shows the minimum, maximum, mean, and SD of an adult's age, weight, height, BMI, thickness, and width of the tendons of the LHB, Ssc, SS, IS, ACJ space measures, and SA-SD bursa thickness (n = 286).

Characteristics	Minimum	Maximum	Mean	SD
Age (years)	18	82	30.02	13.70
Weight (Kg)	36	110	63.67	12.44
Height (cm)	110	186	163.55	9.82
BMI (kg/cm^2)	12.22	49.59	23.92	4.91
LHB thickness (mm)	1.30	4.50	2.71	0.50
LHB width (mm)	4.20	8.70	6.28	0.97
Ssc thickness (mm)	2.90	7.40	4.55	0.84
Ssc width (mm)	20.00	34.40	26.59	2.83
SS thickness (mm)	3.00	8.10	5.34	0.98
SS width (mm)	20.00	35.00	27.32	2.66
IS thickness (mm)	1.00	4.20	2.51	0.65
IS width (mm)	19.40	31.60	26.22	3.12
ACJ space measures (mm)	3.20	7.50	5.01	0.61
SA-SD bursa thickness (mm)	0.70	2.00	1.40	0.33

Table 2. Compare mean of the thickness and width of the tendons of the LHB, Ssc, SS, IS, ACJ space measures, and SA-SD bursa thickness in different adults age group.

Particpants age (years)		LHB thickness (mm)	LHB width (mm)	Ssc thickness (mm)	Ssc width (mm)	SS thickness (mm)	SS width (mm)	IS thickness (mm)	IS width (mm)	ACJ space measures (mm)	SA-SD bursa thickness (mm)
18–	Mean	2.63	6.15	4.29	25.79	5.05	26.72	2.46	25.40	4.97	1.28
31	SD	0.50	1.00	0.69	2.79	0.83	2.80	0.71	3.18	0.64	0.30
32–	Mean	2.89	6.62	4.98	27.92	5.63	28.53	2.67	27.95	5.12	1.60
45	SD	0.48	0.89	0.90	2.31	0.92	1.93	0.47	2.42	0.53	0.26
46–	Mean	2.76	6.50	5.15	29.10	6.40	28.11	2.48	27.88	4.92	1.71
59	SD	0.44	0.74	0.71	1.33	0.72	1.22	0.46	1.27	0.53	0.16
60–	Mean	2.96	6.43	5.48	28.83	6.63	29.01	2.56	28.22	5.04	1.76
74	SD	0.38	0.66	0.75	0.82	0.75	1.33	0.49	1.04	0.43	0.19
75–	Mean	2.57	6.80	5.95	30.07	7.65	30.15	2.10	27.87	5.20	1.57
82	SD	0.26	0.68	0.26	1.62	0.36	0.28	0.18	1.20	0.16	0.34
Total	Mean	2.71	6.28	4.55	26.59	5.34	27.32	2.51	26.22	5.01	1.40
	SD	0.50	0.97	0.84	2.83	0.98	2.66	0.65	3.12	0.61	0.33
***p*-value**		≤ 0.01	≤ 0.01	≤ 0.01	≤ 0.01	≤ 0.01	≤ 0.01	0.018	≤ 0.01	0.16	≤ 0.01

validated our findings in SA-SD bursa thickness measurements and found that the SA-SD bursa is thinner than 2 mm by US standards.

When the LHB, Ssc, SS, IS, ACJ space measurements, and SA-SD bursa thickness were stratified by age, they exhibited a steady increase with rising age groups, which might be attributed to aging (Table 2). These findings supported the findings of a study conducted by Kim et al. (2016), who found that SS, Ssc, and SA-SD bursa thickness measurements had a tendency to rise with age and contradicted ACJ space measurements, which had a tendency to decrease with age.

Table 3 compares the mean thickness and width of the LHB, Ssc, SS, IS, ACJ space measurements, and SA-SD bursa thickness across genders in subjects. Males had higher mean thicknesses of the tendons of the Ssc, SS, ACJ space measures, and SA-SD bursa thickness, with values of 4.77 ± 0.79 mm, 5.47 ± 0.90 mm, 5.01 ± 0.56 mm, and 1.41 ± 0.02 mm, respectively. Females had thicker LHB and IS, with mean thicknesses of 2.71 ± 0.49 mm and 2.52 ± 0.64 mm. Males also had a wider mean width of the tendons of the LHB, Ssc, SS, and IS, which were 6.52 ± 0.93 mm, 27.45 ± 2.96 mm, 28.67 ± 2.27 mm, and 27.32 ± 3.12 mm, for each. Females had greater mean LHB and IS widths of 2.71 ± 0.49 mm and 2.52 ± 0.64 mm, respectively (Table 3).

Further comparisons were made between the thickness and width of the tendons of the LHB, Ssc, SS, IS, ACJ space measures, and SA-SD bursa thickness in the participants' right and left sides, with the results revealing that the thickness and width of the tendons of the LHD, Ssc, IS, and SA-SD bursa thickness were greater in the left side. Additionally, the SS thickness and width were increased on the right side. Furthermore, the ACJ space measures on both sides were equalized (Table 4).

The width and thickness of the tendons of the LHB, Ssc, SS, IS, ACJ space measures, and SA-SD bursa thickness were correlated with the participants' height, weight, and BMI. The results revealed a significant relationship between the thicknesses of the tendons of the LHB, SS, IS, ACJ joint space measures, and SA-SD bursa thickness and the participants' height. There was also a significant relationship between LHD, SS, and IS width and participants' age, weight, height, and BMI (Table 5).

Table 3. Compares the mean thickness and width of the tendons of the LHB, Ssc, SS, IS, ACJ space measures, and SA-SD bursa thickness in participants based on gender.

Characteristics	Gender	*n*	Mean	SD	Standard error mean (SEM)
LHB thickness (mm)	Male	200	2.70	0.51	0.03
	Female	372	2.71	0.49	0.02
LHB width (mm)	Male	200	6.52	0.93	0.06
	Female	372	6.16	0.96	0.05
Ssc thickness (mm)	Male	200	4.77	0.79	0.05
	Female	372	4.44	0.84	0.04
Ssc width (mm)	Male	200	27.45	2.96	0.20
	Female	372	26.12	2.64	0.13
SS thickness (mm)	Male	200	5.47	0.90	0.06
	Female	372	5.27	1.01	0.05
SS width (mm)	Male	200	28.67	2.27	0.16
	Female	372	26.59	2.57	0.13
IS thickness (mm)	Male	200	2.47	0.66	0.04
	Female	372	2.52	0.64	0.03
IS width (mm)	Male	200	27.32	3.12	0.22
	Female	372	25.63	2.96	0.15
ACJ space measures (mm)	Male	200	5.01	0.56	0.04
	Female	372	5.00	0.63	0.03
SA-SD bursa thickness (mm)	Male	200	1.41	0.31	0.02
	Female	372	1.39	0.34	0.01

Table 4. Compares the means of thickness and width of the tendons of the LHB, Ssc, SS, IS, ACJ space measures, and SA-SD bursa thickness on the right and left sides of the participants.

Characteristics	Side	*n*	Mean	SD	SEM
LHB thickness (mm)	Right	200	2.69	0.50	0.03
	Left	372	2.73	0.50	0.02
LHB width (mm)	Right	200	6.29	0.96	0.05
	Left	372	6.27	0.98	0.05
Ssc thickness (mm)	Right	200	4.51	0.82	0.04
	Left	372	4.60	0.86	0.05
Ssc width (mm)	Right	200	26.55	2.86	0.16
	Left	372	26.62	2.80	0.16
SS thickness (mm)	Right	200	5.36	0.97	0.05
	Left	372	5.32	1.00	0.05
SS width (mm)	Right	200	27.40	2.68	0.15
	Left	372	27.24	2.64	0.15
IS thickness (mm)	Right	200	2.47	0.67	0.03
	Left	372	2.54	0.63	0.03
IS width (mm)	Right	200	26.21	3.13	0.18
	Left	372	26.24	3.11	0.18
ACJ space measures (mm)	Right	200	5.01	0.59	0.03
	Left	372	5.01	0.63	0.03
SA-SD bursa thickness (mm)	Right	200	1.37	0.35	0.02
	Left	372	1.42	0.30	0.01

Table 5. The correlation between the mean of thickness and width of the tendons of the LHB, Ssc, SS, IS, ACJ space measures, and SA-SD bursa thickness and the participants' age, weight, height, and BMI.

Characteristics	Correlation	Age (years)	Weight (kg)	Height (cm)	BMI (Kg/cm^2)
LHB thickness (mm)	Pearson correlation	0.212**	0.182**	−0.029	0.195**
	Sig. (2-tailed)	≤ 0.01	≤ 0.01	0.488	≤ 0.01
LHB width (mm)	Pearson correlation	0.206**	0.301**	0.116**	0.221**
	Sig. (2-tailed)	≤ 0.01	≤ 0.01	0.006	≤ 0.01
Ssc thickness (mm)	Pearson correlation	0.495**	0.440**	0.112**	0.356**
	Sig. (2-tailed)	≤ 0.01	≤ 0.01	0.007	≤ 0.01
Ssc width (mm)	Pearson correlation	0.450**	0.347**	0.142**	0.263**
	Sig. (2-tailed)	≤ 0.01	≤ 0.01	0.001	≤ 0.01
SS thickness (mm)	Pearson correlation	0.520**	0.347**	0.000	0.331**
	Sig. (2-tailed)	≤ 0.01	≤ 0.01	0.991	≤ 0.01
SS width (mm)	Pearson correlation	0.361**	0.395**	0.284**	0.224**
	Sig. (2-tailed)	≤ 0.01	≤ 0.01	≤ 0.01	≤ 0.01
IS thickness (mm)	Pearson correlation	0.093*	0.157**	0.010	0.134**
	Sig. (2-tailed)	0.026	≤ 0.01	0.821	0.001
IS width (mm)	Pearson correlation	0.388**	0.390**	0.143**	0.305**
	Sig. (2-tailed)	≤ 0.01	≤ 0.01	0.001	≤ 0.01
ACJ space measures (mm)	Pearson correlation	0.059	0.098*	−0.044	0.127**
	Sig. (2-tailed)	0.160	0.019	0.290	0.002
SA-SD bursa thickness (mm)	Pearson correlation	0.473**	0.348**	0.029	0.321**
	Sig. (2-tailed)	≤ 0.01	≤ 0.01	0.492	≤ 0.01
	n (No. of shoulders scanned in total)	572	572	572	572

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

The independent sample *t*-test was performed to compare means in males and females, and it was found that there was no significant difference in LHB and IS thickness, ACJ space measures, and SA-SD bursa thickness ($p \leq 0.05$) with a 95% confidence interval of difference (Table 5). These findings contradicted Kim et al. (2016)'s findings, which indicated that the SA-SD bursa measures differed considerably. However, with a 95% confidence interval of difference, there was a significant difference (Table 5) in LHB width, thickness and width of Ssc and SS, and IS width in both genders ($p \leq 0.01$). Furthermore, these findings support the findings of Karthikeyan et al. (2014), who discovered that males have larger rotator cuff tendons than females. Kim et al. (2016) confirmed that the SS, IS, Ssc, and SA-SD bursa thickness thicknesses differed considerably between males and females. The Ahmad et al. (2017) study, on the other hand, revealed that there was no significant difference in values between males and females.

The *t*-test for equality of means on both sides reveals that the means for LHB, Ssc, IS, and SA-SD bursa thickness and width are slightly higher on the left side than on the right side. The ACJ space measures, on the other hand, appear on both sides equally. As a result, the differences in shoulder measurements on both sides are not significant enough to indicate the existence of a side effect in shoulder morphology (Tables 4 and Tables 5). In addition, we looked at anthropometric parameters that can influence shoulder morphology, such as weight, height, and BMI, as indicated in the figure (Table 5). These results (Table 5) contradict those of Alasaarela et al. (1997), who found that the ACJ space measures decreased with age. Furthermore, we disagree with the findings of the Kim et al. (2016) study, which found that ACJ space measures tend to decrease with age. Despite the fact that the SA-SD thickness bursa showed a somewhat significant connection with age, weight, and BMI but not with height (Table 5).

The demographic variability in this study may alter the exactness of our results and diminish the intensity of our conclusions due to the randomized selection approach. Another disadvantage of this study is that the US is prone to perceptual problems with transducer placement. As imaging modalities improve, future research will most likely rely more on MRI to determine shoulder tendon measurements. Although direct comparisons between studies that differed in location and technique (US vs. structure) are impossible, a general tendency can be seen. It also underlines the significance of offering training to US practitioners in order to improve their expertise in employing MSK US in radiology departments. However, to the best of our knowledge, this is the first large cohort study that uses ultrasonography to characterize shoulder structures in the adult Sudanese population, emphasizing the importance of this research.

4. Conclusion

Standard reference values have been created and recommended for the early diagnosis of musculoskeletal pathology. When detecting rotator cuff pathology, particularly rotator cuff tear or tendinopathy, measurement data should be compared to reference values. This study provides Sudanese adults with normative data on the thickness of their SA-SD bursa and rotator cuff tendons, as well as measurements of their ACJ space and SA-SD bursa. Furthermore, it established baseline measurements for the LHB, Ssc, SS, and IS tendons thickness and width, ACJ space measurements, and SA-SD bursa thickness in the healthy adult Sudanese population. These baseline measurements should be included in the checklist when interpreting an MSK US in cases with shoulder joint dysfunction. Furthermore, we demonstrated that the shoulder joint US evaluation can be used to help clinicians manage shoulder joint problems.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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Informed consemt statement

All participants' rights were protected and a written informed consent was obtained from each participant before the procedures were carried out according to the 1975 Helsinki Declaration, which was updated in 2013.

Ethical approval

Prior to its start, the study was approved by the Institutional Review Board (IRB) and the Local Ethics Committee (LEC) of Alzaiem Alazhari University (AAU) (AAU, IRB, and LEC approval number: AAU; IRB & LEC 59/2016) in Khartoum, Sudan.

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