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Supraspinatus tendon measurement using high frequency ultrasound in Sudanese pediatrics

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ABSTRACT

The frequency of rotator cuff diseases makes shoulder ultrasound (US) one of the most prevalent musculoskeletal ultrasound (MSK US) applications. Sudanese children's supraspinatus tendon thickness and width were measured as part of this study to help with the early detection of supraspinatus tendon disease. Between August and December 2020, researchers conducted this cross-sectional investigation. There were 114 participants in the study, ranging in age from 4 to 14 years, with 81 males (71.1%) and 33 females (28.9%) participating. Study variables were incorporated into a customized data collection sheet used to gather the information. The supraspinatus tendons were found to be 5.31 ± 0.69 mm in thickness and 26.91 ± 2.06 mm in width. While the supraspinatus tendon thickness was correlated significantly ($p < 0.01$) to age ($r = 0.280$), weight ($r = 0.254$), and height ($r = 0.335$) in terms of their p-values, it was not correlated significantly to body mass index (BMI) ($p > 0.05$). A significant correlation ($p < 0.01$) was found between the supraspinatus tendon's width and age ($r = 0.519$), weight ($r = 0.507$), height ($r = 0.489$), and BMI ($r = 0.309$). Standard reference values for supraspinatus tendon measures were found in Sudanese children. US musculoskeletal assessments of the supraspinatus tendons are proposed as a method for detecting anomalies in these tendons.

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1. Introduction

Increased use is being made in scientific and clinical contexts of ultrasound (US) imaging to analyze structure and shape (Whittaker et al., 2007). Using ultrasonography to find musculoskeletal problems could be game-changing because it can measure muscle mass as well as other properties (Whittaker et al., 2007). Furthermore, imaging of the muscular system encompasses not only the muscles but also the tendons, nerves, ligaments, and bursa. Musculoskeletal imaging also includes imaging of the joints, bones, skin, and various disease processes, as well as imaging of foreign objects and postoperative scanning (Wakefield et al., 2005).

Due to the US imaging technique's reliance on the operator, the reproducibility of muscle and perimuscular tissue measures must be examined (Wakefield et al., 2005; Whittaker et al., 2007). Muscle, tendon, ligament, and non-contractile tissue thickness can only be accurately and reliably measured with the use of the US. Monitoring changes brought on by aging or injuries may benefit from measuring muscle, tendon, and ligament characteristics over time (Agyapong-Badu et al., 2014). Magnetic resonance imaging (MRI) and US are equally effective at finding rotator cuff, tendon, nerve, and ligament anomalies because of the high prevalence of rotator cuff problems. It is possible to employ US as a targeted examination in clinical conditions to give rapid, real-time diagnosis and therapy (Gupta & Robinson, 2015; Singh, 2012). At first, scanning the shoulder can be challenging and time-consuming. However, using a protocol-driven examination, understanding relevant anatomy, tendon orientation, and being aware of imaging traps can improve an individual's overall performance (Beggs, 2011; Jacobson, 2011; Moosikasuwan et al., 2005).

In light of this, the current study will use musculoskeletal ultrasound (MSK US) to evaluate the thickness and width of the supraspinatus tendons in Sudanese children in order to develop a standard reference value for these tendons and propose it for early diagnosis of supraspinatus tendon pathology.

2. Materials and methods

2.1. Design of the study and patient selection

Between August 2018 and December 2020, a cross-sectional study was conducted. This study enrolled 114 healthy participants, including 81 (71.1%) males

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and 33 (28.9%) females ranging in age from 4 to 14 years. Participants were chosen at random, and all were enrolled in this study prospectively. As minors (aged ≤ 14 years) were involved in the study, a statement of informed consent from the parents/legally authorized representative was provided. The study was approved by the local ethics committee (LEC) of the Faculty of Radiology and Nuclear Medicine Sciences (FRNM), The National Ribat University (NRU), Khartoum, Sudan prior to its start (Ethical approval number: FRNM LEC 107/2020). The ethics procedures used were in accordance with the 1975 Helsinki Declaration, which was updated in 2013.

2.2. Instrumentation and procedures for performing shoulder US

To conduct the sonographic examinations, the team employed US equipment with an electronically focused linear array transducer operating at 7.5–10 MHz (Kaixin- KX 2600, Toshiba, Xario 200, and Mindary DP 1100 Plus). The US scan was performed in compliance with the American Institute of Ultrasound in Medicine (AIUM) practice guidelines for conducting a shoulder US exam (AIUM, 2003).

2.3. Statistical analysis

Initially, comparison tables were created to summarize all of the available data. The Statistical Package for Social Sciences (SPSS) version 16 for Windows (IBM Corporation, Armonk, NY, USA) was used to conduct the analysis. The Student's *t*-test (unpaired *t*-test) was used to compare variables. The findings' significance was assessed using the *p*-value.A $p \leq 0.05$ value was considered significant. To determine if the variances of a variable determined for two or more groups are identical, the Levene's test is utilized. The variances of populations from which various samples are obtained are assumed to be equal by several popular statistical procedures. This assumption is tested using Levene's test. By performing this measurement, whether or not the population variances are the same (homogeneity of variance or homoscedasticity) is determined. Levene's test's resultant *p*-value is less than some significance level (usually 0.05), which indicates that variations in sample variances found from random sampling from a population with equal variances are unlikely to have occurred. This means that the null hypothesis of equal variances in the population is rejected, and a discrepancy in the variances exists.

3. Results and discussion

The need for detailed anatomical descriptions becomes obvious as orthopedic research improves and our understanding of the shoulder joint expands. Based on bone-to-bone measures, biomechanical investigations have provided a preliminary understanding of shoulder mechanics (Spiegl et al., 2016). Shoulder models that take into account the thickness of soft tissue structures, on the other hand, will be needed for a better understanding. This cross-sectional study examines the thickness and width of Sudanese children's supraspinatus tendons as a standard reference. Measurements should be compared with reference values to make an objective and accurate diagnosis of supraspinatus tendon pathology. Each of the 114 healthy participants in this study had their 228 shoulders scanned (Tables 1 and 2). The supraspinatus tendon thickness ranged from 3.5–6.9 mm, with a mean of 5.31 ± 0.69 mm, and its width from 20.7–30.9 mm, with a mean of 26.91 ± 2.06 mm (Tables 2 and 3).

These findings (Tables 1–3) could be compared to a retrospective study conducted on 60 healthy volunteers by Karthikeyan et al. (2014). Their findings in adults, on the other hand, could be attributed to the fact that our study only included children as a target sample. Furthermore, the mean thickness and width of the supraspinatus tendon in the 4–10 year age group were 4.82 ± 0.62 mm and 25.23 ± 2.11 mm, respectively. In the age group of 11–14 years, the mean thickness and width of the supraspinatus tendon were 5.41 ± 0.66 mm and 27.27 ± 1.87 mm, respectively (Table 3). In contrast to the findings of Kim et al. (2016), there was a significant difference in supraspinatus tendon thickness and width measures in different age groups, with a 95% confidence interval and $p < 0.05$ (Table 3). Among the 100 healthy adult volunteers investigated, there was no significant variation in supraspinatus tendon thickness and width measurements between age groups ($p < 0.003$) (Kim et al., 2016). The thickness of the supraspinatus tendon

Table 1. The frequency distribution of a child's gender and age.

Gender	Frequency	Percent	Valid percent	Cumulative percent
Males	81	71.1	71.1	71.1
Females	33	28.9	28.9	100.0
Total	114	100.0	100.0	-
Age (years)	Frequency	Percent	Valid percent	Cumulative percent
4–10	20	17.5	17.5	17.5
11–14	94	82.5	82.5	100.0
Total	114	100.0	100.0	-

Table 2. The minimum, maximum, mean and standard deviation of the children's weights, heights, and BMIs as well as the supraspinatus tendon's thickness and width.

Characteristic	*n*	Minimum	Maximum	Mean	Std. Deviation
Age (years)	228	4	17	13.01	3.16
Weight (kg)		12.0	68.0	41.16	11.80
Height (cm)		105	175	146.05	15.06
BMI		9.92	28.99	18.93	3.45
Supraspinatus tendon thickness (mm)		3.5	6.9	5.31	0.69
Supraspinatus tendon width (mm)		20.7	30.9	26.91	2.06
Valid *n* (listwise)		-	-	-	-

Table 3. Using Levene's test in children, compare the mean thickness and width of the supraspinatus tendon in different age groups (independent sample *t*-test).

Characteristic	Age group (years)	*n*	Mean	Std. Deviation	Std. Error Mean
Supraspinatus tendon thickness (mm)	4–10	40	4.82	0.62	0.09
	11–14	188	5.41	0.66	0.04
Supraspinatus tendon width (mm)	4–10	40	25.23	2.11	0.33
	11–14	188	27.27	1.87	0.13

t-test for equality of means Mean difference	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Supraspinatus tendon thickness (mm)	−5.20	226	0.00	−0.59	0.11	−0.82	−0.37
	−5.44	59.64	0.00	−0.59	0.10	−0.81	−0.37
Supraspinatus tendon width (mm)	−6.10	226	0.00	−2.03	0.33	−2.69	−1.38
	−5.65	52.84	0.00	−2.03	0.36	−2.76	−1.31

increased as the participants' average age increased in this study (Table 3). Leong et al. (2012) reported a mean supraspinatus thickness of 6.9 mm (mean age 21.4 years), whereas Michener et al. (2015) identified a mean thickness of 6 mm (mean age 45 years). Roh et al. (2000) revealed an average thickness of 3.1 mm (mean age 82 years).

During statistical analysis, all measurements in children's male subjects were higher than in females; in males, the mean thickness and width of the supraspinatus tendon were 5.44 ± 0.65 mm and 26.99 ± 2.02 mm, respectively, while in female partcipants they were 5.0 ± 0.68 mm and 26.72 ± 2.16 mm, respectively (Table 4). A statistically significant difference in thickness was found between the males and females groups in the current study with a 95% confidence interval ($p < 0.05$), but no statistically significant difference was found between males and females in supraspinatus width measurements ($p > 0.05$) (Table 4). Furthermore, measurements of the supraspinatus tendons in the right and left shoulder of both males and females revealed no statistically significant difference ($p > 0.05$) and a 95% confidence interval (Table 5).

The supraspinatus tendon thickness correlated weakly with age and weight ($p < 0.01$, $r = 0.280$; $p < 0.01$, $r = 0.254$), and moderately with height ($p < 0.01$ and $r = 0.335$), but not with BMI ($p > 0.05$; $r = 0.121$) (Table 6). As shown in Table 6, the supraspinatus tendon width had a strong significant correlation with age and weight ($p < 0.01$, $r = 0.519$; $p < 0.01$, $r = 0.507$) and a moderate significant correlation with height and BMI ($p < 0.01$, $r = 0.489$; $p < 0.01$, $r = 0.309$). Karthikeyan et al. (2014) reported that there was no correlation between supraspinatus tendon measurements and participant height and weight in their study. Sessions et al. (2017) reported that the supraspinatus tendon for individuals measured 12.7 mm compared to the mean of 4.9 ± 2.1 mm. After taking the mean age (61 years) and BMI (26.4) into account, they concluded that the etiology of the anomaly is unknown (Sessions et al., 2017).

To put that into perspective, cross-sectional studies look at a population at a single point in time without keeping track of how they change over time. Preliminary evidence from our study will help guide a more comprehensive investigation. Our findings had limitations since we found correlations that could be difficult to interpret and because of low response and misclassification due to recall bias, the results were subject to bias. Non-response was also a problem that impacted the findings and could lead to inaccuracies in the outcome metrics.

4. Conclusion

The current study found that the average supraspinatus tendon thickness and width in Sudanese children were 5.31 ± 0.69 mm and 26.9 ± 12.06 mm, respectively. The supraspinatus tendon thickness was found to be weakly correlated with age, weight, and moderately with height, but not with BMI. Age and weight were shown to have a strong significant correlation, whilst height and BMI were found to have a moderate significant

Table 4. Using Levene's test in children, compare the mean thickness and width of the Supraspinatus tendon in both genders (independent sample *t*-test).

Group statistics Characteristic	Gender	*n*	Mean	Std. Deviation	Std. Error Mean
Supraspinatus tendon thickness (mm)	Male	162	5.44	0.65	0.05
	Female	66	5.00	0.68	0.08
Supraspinatus tendon width (mm)	Male	162	26.99	2.02	0.15
	Female	66	26.72	2.16	0.26

t-test for equality of means Mean difference	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Supraspinatus tendon thickness (mm)	4.52	226	0.00	0.44	0.09	0.24	0.63
	4.44	116.32	0.00	0.44	0.09	0.24	0.63
Supraspinatus tendon width (mm)	0.89	226	0.37	0.26	0.30	−0.32	0.86
	0.86	113.55	0.38	0.26	0.31	−0.34	0.88

Table 5. Using Levene's test, compare the mean thickness and width of the supraspinatus tendon in children on the right and left side (independent sample *t*-test).

Group statistics					
Characteristic	Side	*n*	Mean	Std. Deviation	Std. Error Mean
Supraspinatus tendon thickness (mm)	Right	114	5.36	0.79	0.07
	Left	114	5.26	0.58	0.05
Supraspinatus tendon width (mm)	Right	114	26.92	2.11	0.19
	Left	114	26.90	2.01	0.18

t-test for equality of means Mean difference	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Supraspinatus tendon thickness (mm)	1.15	226	0.25	0.10	0.09	−0.07	0.28
	1.15	207.11	0.25	0.10	0.09	−0.07	0.28
Supraspinatus tendon width (mm)	0.06	226	0.94	0.01	0.27	−0.52	0.55
	0.06	225.50	0.94	0.01	0.27	−0.52	0.55

Table 6. Pearson correlation is used to show the relationship between supraspinatus tendon thickness and width and age, weight, height, and BMI.

Characteristics	Statistical correlation	Age (years)	Weight (kg)	Height (cm)	BMI
Supraspinatus tendon thickness (mm)	Pearson correlation	0.280*	0.254*	0.335**	0.121¶
	Sig. (2-tailed)	0.000	0.000	0.000	0.069¶
Supraspinatus tendon width (mm)	Pearson correlation	0.519¶¶	0.507¶¶	0.489**	0.309**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000

*Weak significant correlation ($p < 0.01$; $r = 0.280$, $r = 0.254$)
**Moderate significant correlation ($p < 0.01$; $r = 0.335$, $r = 0.489$, $r = 0.309$)
¶No significant correlation ($p > 0.05$)
¶¶Strong significant correlation ($p < 0.01$; $r = 0.519$, $r = 0.507$)

correlation with supraspinatus tendon width.While point-of-care US has various uses for bedside assessments and clinical decision-making, we propose employing MSK US measurements of the supraspinatus tendons to identify tendon anomalies.

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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 local ethics committee.

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