Ultrasound imaging for the rheumatologist XLIV. Ultrasound of the shoulder in healthy individuals

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ABSTRACT

Objective. *To investigate the prevalence of shoulder ultrasound (US) detectable abnormalities in asymptomatic individuals of various ages and to correlate the US findings with clinical data.*

Methods. *97 healthy subjects were enrolled in the present study. They were subgrouped according to their age, as follows: group I (20–29 years); group II (30–39 years); group III (40–49 years); group IV (50–59 years); group V (>60 years). A physical examination of both shoulders, based on a series of provocative maneuvers, was carried out. The US assessment was performed by using a Logiq9 machine equipped with a multi-frequency linear probe working at 12MHz and included the study of a number of structures for the evaluation of local abnormalities, as follows: the long head of biceps tendon (synovial effusion (SE), synovial hypertrophy (SH), power Doppler (PD) signal); the subacromion-subdeltoid and sub-scapularis bursae (SE, SH, PD signal); the rotator cuff tendons (tendinosis, calcifications, tears, impingement); the acromion-clavicular (ACJ) and gleno-humeral joints (SE, SH, PD signal, osteophytes, erosions, fibrocartilage calcifications, cartilage abnormalities, tophaceous deposits). In addition, deltoid, throchite and throchine enthesopathy were searched for.*

Results. *194 shoulders were studied in total. A low but variable percentage of joints of healthy individuals (3.1–13.4%) showed positive provocative maneuvers. 138 shoulders (71.1%) did not show any US abnormalities. The most frequent changes were SE of ACJ (25.5%), osteophytes of ACJ (23.3%), and supraspinatus tendinosis (20.6%). The prevalence of abnormalities progressively increased with age. Sub-clinical involvement was present in most cases, being provocative maneuvers positive only in a low percentage of joints.*

Conclusion. *The present study demonstrated the presence of a wide set of US-detectable changes in healthy subjects, that were more frequently present in elderly individuals. The absence of any clinical sign of local pathology cannot exclude the presence of local abnormalities.*

Introduction

The shoulder is a complex anatomic area. It is composed by a number of articular and peri-articular structures that, in case of local pathology, may contribute to the appearance of a wide set of symptoms in various musculoskeletal diseases (1). In healthy subjects, the presence of shoulder abnormalities might be followed by the development of local pathology and symptoms. However, joint and peri-articular changes such as osteophytes or asymptomatic tears of the rotator cuff should be regarded as part of the normal ageing process in the elderly, even though they may be less common than up to now believed (2).

Several imaging modalities, such as ultrasonography (US), magnetic resonance imaging (MRI) and arthroscopy have been applied in the evaluation of the shoulder in different musculoskeletal disorders. Particularly, over the last two decades, US has proven to be a useful and accurate tool for investigating shoulder abnormalities in patients with pain and functional impairment as well as for analysing joint and periarticular changes involving the shoulder in various rheumatic diseases (1, 3-12).

Recent data have reported the ability of US in detecting abnormalities of the

rotator cuff tendons in asymptomatic subjects (2, 13, 14). However the prevalence of shoulder changes detected by US in healthy individuals has only been analysed in a few reports and the influence of age and consequent clinical implications have been rarely discussed (2, 13, 14).

The present study was designed to investigate the prevalence of shoulder US-detected abnormalities in asymptomatic individuals of various ages and to correlate the US findings with clinical data.

Patients and methods

Ninety-seven healthy subjects were enrolled in the present study. They were subgrouped according to their age, as follows: group I (20–29 years); group II (30–39 years); group III (40–49 years); group IV (50–59 years); group V (>60 years).

The study was conducted in 4 Italian Rheumatology Units (Sapienza Università di Roma, Università Politecnica delle Marche, Università di Pisa and Università di Pavia). The presence of musculoskeletal symptoms, including painful shoulder, and a diagnosis of any rheumatic diseases as well as any other systemic pathology were exclusion criteria from the study.

Physical examination

In all subjects a physical examination was carried out by an experienced rheumatologist performing the following provocative maneuvers: Hawkins test, Jobe test, Patte test, Gerber test and Speed tests (15-19). These maneuvers were selected because they represent a core set of physical tests allowing for the assessment of the most relevant shoulder pathology in the clinical rheumatological practice (20). In addition, the presence of pain during the palpation of the acromion-clavicular joint (ACJ) was evaluated.

Ultrasonographic assessment

Prior to subjects enrolment, the US examination methodology was clarified among sonographers and a consensus was obtained on scanning protocol and image interpretation. In each of the 4 units participating in the study, US examination was separately and independently performed by a single ultrasonographer who was a rheumatologist experienced in musculoskeletal US.

In all healthy individuals, US examination of both shoulders was performed according with the EULAR guidelines by either using a Logiq 9 (General Electric Medical Systems, Milwaukee, WI) or a MyLab 70 (Esaote, Genova, Italy) equipped with a multi-frequency linear probe, working at 12MHz (21).

The synovial structures of the shoulder, including the subacromial/subdeltoid bursa, the sheath of the long biceps tendon, the axillary and posterior recesses of the glenohumeral joint (GHJ) and the ACJ were examined for the presence of synovial effusions (SE) and synovial hypertrophy (SH). Power Doppler (PD) assessment of the selected local synovial sites, including the biceps sheath, the subacromial/subdeltoid bursa, and the axillary and posterior recesses, was carried out with standardised settings (pulse repetition frequency 750 Hz, Doppler frequency 7.5 MHz, low wall filters, gain at the level that avoided random noise artifacts) for assessing synovial vascularity. Rotator cuff tendons (supraspinatus, subscapularis, infraspinatus) were investigated for the presence of tendinosis, local calcifications and total or partial tears.

In addition, ACJ was analysed for the detection of osteophytes and erosions as well as of fibrocartilage calcifications. GHJ was also evaluated for the assessment of labrum calcifications, intra-cartilagineous crystal material

Table I. Results of shoulder clinical evaluation in the group of healthy subjects examined (n=97).

	Right (n=97)	Left (n=97)	Total joints (n=194)
Hawkins's test (n/%)	13/13.4	11/11.3	25/12.9
Patte's test (n/%)	6/6.2	3/3.1	9/4.6
Jobe's test (n/%)	8/8.2	5/5.1	13/6.7
Gerber's test (n/%)	3/3.1	3/3.1	6/3.1
Speed test (n/%)	6/6.2	6/6.2	12/6.2
Palpation at acromioclavicular joint (n/%)	9/9.3	8/8.2	17/8.7

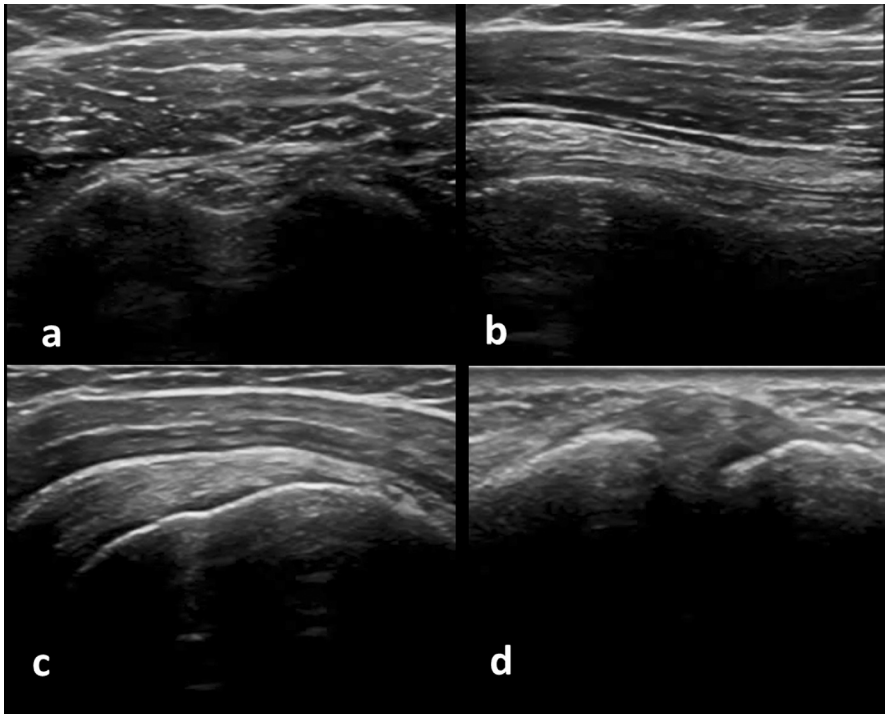

Fig. 1. Ultrasound of the shoulder in healthy individuals. Evidence of normal long head of biceps tendon both in transverse (**a**) and longitudinal scans (**b**), supraspinatus tendon (**c**) and acromiocalvicular joint (**d**).

(double contour sign), tophaceous deposits and erosions (with or without local PD signal).

Finally, deltoid enthesis (at acromion attachment) for local enthesitis, and throchite and throchine region for the presence of local enthesophytes were analysed.

All abnormalities were studied according to international accepted definitions and scored according to a dichotomous assessment. In addition, calcifications were assessed for the presence of acoustic shadowing and their maximal dimension was measured (1, 22-26).

Statistical analysis

Statistical analysis was performed using SPSS statistical software, version 13.0 (SPSS, Chicago, IL, USA). Quantitative variables were given as the mean (standard deviation: SD) and range. The values of frequency were reported by percentages. Comparisons between groups were performed using contingency tables and Pearson's χ^2. Corrections were made where necessary for the sample size (Fisher's exact test). The comparisons between parametric variables were performed with the Wilcoxon's test. *p*-values <0.05 were considered statistically significant.

Results

The subgrouping of the examined individuals according to their age showed the following results: group I (20–29 years; 21 subjects, mean age 26.2±2.8years); group II (30–39 years; 19 subjects, mean age 33.6±3.3years); group III (40–49 years; 20 subjects, mean age 43.8±3.1 years); group IV (50–59 years; 19 subjects, mean age 54.5±2.7 years); group V (>60 years; 18 subjects, mean age 65.8±6.9 years).

In total, 97 healthy subjects were studied (45M/52F; mean age 44.2±14.7 years, range 20–85; mean BMI 24.5±3.04; mean HAQ 0.01±0.07).

No significant difference regarding gender mean age was identified among the subgroups (M 45.5±14.4 years, F 41.3±13.3 years; *p*=NS).

The results of the physical examination performed at shoulder level are reported in Table I. A low but variable percentage of joints of healthy individuals (3.1–13.4%) showed positive provocative maneuvers.

One hundred and thirty-eight shoulders (71.1%) did not show any US abnormalities (Fig. 1).

In Table II results of US-detected features at the level of the head long biceps tendon, subacromion-subdeltoid bursa and subscapularis bursa are reported. In particular, SE within the sheath of the biceps tendon was the most frequent finding (16.5%) and group V was the most often involved (27.8%). The prevalence of this abnormality increased progressively in subjects over 40 years (group III: 20%; group IV 23.6%). At the same level, SH was rarely detected (2.1% of total shoulders) and it was found only in group V (11.1%).

SE within the subacromion-subdeltoid bursa was present in 11.3% of the shoulders with an increasing incidence at age progression (group I:0; group II: 7.9%; group III: 15%; group IV: 15.8%; group V: 19.4%). Significant differences were registered between group II and V (*p*=0.02). Local SH was a rare finding (2.1%) and was only present in group V (11.1%). The involvement of subscapularis bursa was very rare, with the presence of SH only in 1 shoulder of group V.

The US evaluation of the rotator cuff tendons (Table III) showed that tendinosis was the most frequent abnormality and particularly the supraspinatus tendon was more often involved respect to the subscapularis and infraspinatus tendons (20.6%, 17% and 8.2% respectively). The correlations between sonographic findings and physical examination, demonstrated that the presence of US-detected tendinosis was frequently subclinical, as shown by the negative provocative maneuvers in most cases. Specifically, when considering the supraspinatus tendons, only 8/20 (40%) joints with US-detected tendinosis showed the positivity of Jobe test. This finding was even more evident at level of the subscapularis and infraspinatus tendons, where only 2/33 (6.1%) joints with US-detected subscapularis tendinosis showed the positivity of local provocative tests and only 2/16 (12.5%) joints with US-detected infraspinatus tendinosis demonstrated

Table II. US-detected features at the level of the head long biceps tendon, subacromion-subdeltoid bursa and subscapularis bursa.

Structures	All subjects							
	Right (n=97)	Left (n=97)	Total (n=194)	Group I (n=42)	Group II (n=38)	Group III (n=40)	Group IV (n=38)	Group V (n=36)
Long head of biceps tendon								
SE (n/%)	18/18.5	14/14.4	32/16.5	3/7.1	2/5.3	8/20.0	9/23.6	10/27.8
SH (n/%)	3/3.1	1/1	4/2.1	–	–	–	–	4/11.1
PD (n/%)	–	–	–	–	–	–	–	–
Subacromion-subdeltoid bursa								
SE (n/%)	13/13.4	9/9.3	22/11.3	–	3/7.9	6/15	6/15.8	7/19.4
SH (n/%)	3/3.1	1/1	4/2.1	–	–	–	–	4/11.1
PD (n/%)	–	–	–	–	–	–	–	–
Subscapularis bursa								
SE (n/%)	–	–	–	–	–	–	–	–
SH (n/%)	–	1/1	–	–	–	–	–	1/2.8
PD (n/%)	–	–	–	–	–	–	–	–

Synovial hypertrophy: SE; Synovial effusion: SH: power Doppler signal: PD.

Table III. US-detected features at the level of the rotator cuff tendons.

	Tendinosis			Calcifications							Tears		
	Right n=97	Left n=97	Total n=194	Right n=97	Left n=97	Total n=194	Acoustic shadow right n=97	Acoustic shadow left n=97	Mean±SD dimensions right (mm)	Mean±SD dimensions left (mm)	Right n=97	Left n=97	Total n=194
Supraspinatus (n/%)	24/24.7	16/16.5	40/20.6	20/20.6	15/15.5	35/18	7/7.2	3/3.1	1.4±0.8	1.5±1.4	5/5.1	2/2.1	7/3.6
Subscapularis (n/%)	20/20.6	13/13.4	33/17	17/17.5	12/12.4	29/14.9	7/7.2	2/2.1	0.9±0.4	0.9±0.2	2/2.1	2/2.1	4*/2.1
Infraspinatus (n/%)	9/9.2	7/7.2	16/8.2	10/10.3	8/8.2	18/9.3	2/2.1	1/1	1±0,2	0.8±0.2	2/2.1	2/2.1	4°/2.1

*2 complete tears (1 right, 1 left); °4 complete tears.

a positive Patte test. The presence of calcifications within the rotator cuff tendons was identified more frequently at the level of the supraspinatus tendon compared to subscapularis and infraspinatus tendons (18.0%, 14.9% and 9.3%, respectively, p=NS). The presence of calcification's acoustic shadowing was a rare finding (1–7.2%) and in most cases they were small calcifications (0.2–1.5mm).

Rotator cuff tears were also a rare US-detected abnormality and the supraspinatus tendon was more frequently involved compared to the subscapularis and the infraspinatus tendons (3.6%, 2.1% and 2.1%, respectively). However, when considering the severity of them, all tears involving the subscapularis and the infraspinatus tendons were complete. On the contrary, the tears identified at level of the supraspinatus tendon were partial-thickness lesions.

When the prevalence of US-detected modifications at level of the rotator cuff tendons was analysed by subgrouping the subjects according to their age (Table IV) all changes appeared to be more frequent in group V. Particularly, the prevalence of tendinosis of all rotator cuff tendons and local calcifications was significantly higher in subjects of group V (p<0.0001 for all comparisons). No tears were detected in groups I and III; however a similar prevalence of tears was registered in the other groups, particularly II and V.

The US evaluation of ACJ (Table V) demonstrated the frequent involvement of this joint, both in terms of inflammatory modifications and structural damage lesions. Particularly, SE was detected in 25.7% of ACJs and the presence of osteophytes in 23.7%. When considering the subgroups, a significantly higher prevalence of SE was registered in group IV and group V compared with groups I, II and III (p<0.0001 for all analysis). Moreover, a significantly higher percentage of osteophytes was detected in group IV and V with respect to group I and II (p<0.0001 for all analysis).

The GHJ (Table VI) was less frequently involved respect to the ACJ. Indeed, SE was found only in 2.6% of joints, it was detected only at the level of the posterior recess and it was present only in groups IV and V (7.9% and 5.5%, respectively). Labrum calcifications were also a rare finding (1%) and were present only in groups IV and V.

Finally, the presence of entesophytes at throchite and throchine level was detected rarely (5.1% and 4.1%, respectively) (Table VII).

The dynamic US assessment for the evaluation of impingement showed modifications totally in 6 shoulders (3.1%), with subscapularis involvement in 0.5% and supraspinatus abnormalities in 2.6% (Table VII). Groups III, IV and V were the only subgroups involved (2.5%, 10.5% and 2.7%, respectively).

Table IV. US-detected features at the level of the rotator cuff tendons subgrouping the subjects according to their age.

	Tendinosis	Calcifications	Tears
Group I (n=42 joints)			
Supraspinatus (n/%)	2/4.7	1/2.4	–
Subscapularis (n/%)	1/2.4	–	–
Infraspinatus (n/%)	–	–	–
Group II (n=38 joints)			
Supraspinatus (n/%)	7/18.4	4/10.5	3/7.9
Subscapularis (n/%)	6/15.8	2/5.2	1/2.6
Infraspinatus (n/%)	2/5.2	–	2/5.2
Group III (n=40 joints)			
Supraspinatus (n/%)	7/17.5	10/25.0	–
Subscapularis (n/%)	5/12.5	5/12.5	–
Infraspinatus (n/%)	–	3/7.5	–
Group IV (n=38 joints)			
Supraspinatus (n/%)	7/18.4	2/5.3	1/2.6
Subscapularis (n/%)	3/7.9	7/18.4	1/2.6
Infraspinatus (n/%)	1/ 2.6	4/10.5	–
Group V (n=36 joints)			
Supraspinatus (n/%)	17/47.2	18/50	3/8.3
Subscapularis (n/%)	18/50	15/41.6	2/5.5
Infraspinatus (n/%)	13/36.1	11/30.5	2/5.5

Table V. US-detected features at the level of the acromion-clavicular joint.

	All subjects							
	Right (n=97)	Left (n=97)	Total (n=194)	Group I (n=42 joints)	Group II (n=38 joints)	Group III (n=40 joints)	Group IV (n=38 joints)	Group V (n=36 joints)
SE (n/%)	30/30.9	20/20.6	50/25.7	3/7.1	3/7.9	7/17.5	18/47.4	19/52.8
SH (n/%)	–	–	–	–	–	–	–	–
PD (n/%)	–	–	–	–	–	–	–	–
Osteophytes (n/%)	24/24.7	22/22.7	46/23.7	1/2.4	2/ 5.2	9/22.5	14/36.8	20/55.5
Erosions (n/%)	–	–	–	–	–	–	–	–
Fibrocartilage calcifications (n/%)	3/3.1	2/2.1	5/2.6	–	–	–	1/2.6	4/11.1

Synovial hypertrophy: SE; Synovial effusion: SH; power Doppler signal: PD.

Table VI. US-detected features at level of the gleno-humeral joint.

	All subjects							
	Right (n=97)	Left (n=97)	Total (n=194)	Group I (n=42 joints)	Group II (n=38 joints)	Group III (n=40 joints)	Group IV (n=38 joints)	Group V (n=36 joints)
SE (n/%)	4/4.1*	1/1.0*	5/2.6*	–	–	–	3/7.9*	2/5.5*
SH (n/%)	–	–	–	–	–	–	–	–
PD (n/%)	–	–	–	–	–	–	–	–
Labrum calcification (n/%)	–	2/2.1	2/1.0	–			1/2.6	1 /2.6
Humeral head cartilage calcifications								
Intra-cartilagineous crystal material (n/%)	–	–	–	–	–	–	–	–
Tophaceous deposits (n/%)	–	–	–	–	–	–	–	–
Erosions (n/%)	–	–	–	–	–	–	–	–

*posterior recess.
Synovial hypertrophy: SE; Synovial effusion: SH; power Doppler signal: PD.

Table VII. US-detected features at level of other shoulder structures.

	All subjects							
	Right (n=97)	Left (n=97)	Total (n=194)	Group I (n=42 joints)	Group II (n=38 joints)	Group III (n=40 joints)	Group IV (n=38 joints)	Group V (n=36 joints)
Deltoid enthesitis (n/%)	–	–	–	–	–	–	–	–
Throchite enthesophytes (n/%)	6/6.2	4/4.1	10/5.1	–	3/7.9	5/12.5	2/5.3	–
Throchine enthesophytes (n/%)	4/4.1	4/4.1	8/4.1	–	2/5.3	4/10.0	2/5.3	–
Subscapularis impingement (n/%)	1/1.0	–	1/0.5	–	–	1/ 2.5	–	–
Supraspinatus impingement (n/%)	4/4.1	1/1.0	5/2.6	–	–	–	4/10.5	1/2.7

Discussion

The present study, aiming at evaluating the presence of US-detected abnormalities in healthy subjects, demonstrated that the majority of the shoulders (71.1%) was free from any abnormalities. However, the presence of a wide set of changes that were more frequently found in elderly individuals was shown at specific sites (ACJ, rotator cuff tendons, biceps tendon). Particularly, the prevalence of abnormalities progressively increased with age. However, although most alterations should be considered as a normal ageing process in the normal population, they may be less usual than believed (2). Interestingly, the correlations with physical tests aiming at examining the involvement of different shoulder structures, showed that subclinical involvement was present in most cases, being provocative maneuvers positive only in a low percentage of joints.

In the present study, the involvement of the rotator cuff tendons was one of the most striking finding, with a number of abnormalities which were particularly evident in the group of elderly subjects. This finding is in line with those report-

ed in previous studies which showed a higher prevalence of asymptomatic rotator cuff involvement in subjects older than 50 years (13, 14). In particular, the study by Schibany *et al*. demonstrated the presence of rotator cuff tears, mostly the supraspinatus tendon, in 6% of subjects from 56 to 83 years of age who had no functional deficit, pain or decrease in activities of daily living. In addition, the prevalence of rotator cuff tears in asymptomatic subjects has been suggested in other US or MRI studies and the influence of age as well as the resulting clinical implications have been previously discussed (27-32). However, only a few reports analysed the presence of abnormalities involving other articular and peri-articular structures such as the long head of biceps tendon, the local bursae, the ACJ and the GHJ (33). Moreover, the evaluation of age-related rotator cuff abnormalities in healthy subjects has been mainly focused on the analysis of tears, so far, without paying much attention to other changes such as tendinosis and calcifications (13, 14, 33). In the study by Girish *et al*. asymptomatic shoulder abnormalities were demonstrated in 96% of healthy individuals from 40 to 70 years old and the most common findings were subacromial-subdeltoid bursitis, ACJ osteoarthritis, and supraspinatus tendinosis. In the present study, SE within the biceps tendon sheath and the subacromion-subdeltoid bursa were frequent findings, which could be suggestive of local inflammatory abnormalities. Indeed, the presence of rotator cuff tears, which could be one of the causes of local SE within those synovial structures, was rarely found. The US evidence of tendinosis was a frequent finding that could also be considered as an age-related abnormality, being its prevalence progressively higher in the groups of older subjects.

The involvement of the ACJ was complex, with the evidence of a wide set of abnormalities that were both related to inflammation and structural damage lesions. This is not an unexpected finding, being the ACJ an articular site where shoulder motion and local attrition may markedly influence the appearance of local pathology since the youth and may progressively increase with advance of age. Surprisingly, the GHJ was rarely involved and this finding could be partially related to the fact that this is a difficult-to-scan joint, where, for the lack of acoustic windows, the structures located in inner part of the joint cannot be visualised by US scanning. Therefore, abnormalities involving the hyaline cartilage as well as the labrum and the bony cortex may be underestimated by US assessment.

Finally, US-detected features at the level of other periarticular structures, such as the deltoid enthesis, the throchine and thochine areas and the supraspinatus and subscapularis tendons for local impingement, were uncommon findings, showing that these structures may have a minor role in the appearance of abnormalities at shoulder level.

US is a useful imaging modality for the assessment of a wide set of soft-tissue and joint pathological changes in patients with shoulder pain and local dysfunction (1, 34). It has demonstrated to be of value in the assessment of various rotator cuff disorders such as tendinosis, tendon tear, and bursitis (35). Data published in the literature demonstrated equal sensitivity and specificity of US and MRI in the assessment of the rotator cuff lesions (36, 37). A recent systematic review reported the high sensitivity of MR arthrography in the detection of full- and partial-thickness rotator cuff tears (38). However, US is characterised by several advantages over MRI, such as the wide availability, the high cost-effectiveness, the higher patient acceptance, the dynamic imaging assessment and the feasibility (39). The accuracy in the diagnosis of rotator cuff tears can reach 100% for full thickness tears and 91% for partial thickness tears (37-40). On the other hand, the experience of the operator performing the US examination could markedly influence the accuracy of the sonographic evaluation in the shoulder pathology as well as in case of involvement of other joint sites (41-47).

However, our study demonstrated that even in healthy individuals, sonography is able to detect a number of abnormalities which may involve both the ACJ and GHJ articular structures and the complex and variegate periarticular structures that model the shoulder girdle. Physical examination and plain radiographs are less sensitive than US in the differentiation between the various pathological findings that may be present at shoulder level and that may lead to similar clinical features, even though these aspects can be influenced by the experience of the examiner (1, 7). The present study demonstrated that these findings can also be extended to healthy subjects in which the absence of any clinical sign of local pathology cannot exclude the presence of local abnormalities.

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