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ORIGINAL STUDY

Ultrasonographic evaluation of the shoulder in asymptomatic overhead athletes

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This study aimed to evaluate the efficiency of ultrasonography (US) in the examination of soft tissue anatomical structures of the shoulder in overhead athletes. The study evaluated the shoulders of overhead elite premier league athletes involved in basketball, handball, volleyball, body building, and water polo. US examination of both shoulders was performed prospectively in 45 asymptomatic overhead athletes and 43 asymptomatic volunteers matched for age.

On US examination, subacromial-subdeltoid bursa effusion was observed in 16 of the dominant shoulders and in 2 of the non-dominant shoulders of 45 overhead athletes and in none of the asymptomatic volunteers. The mean thickness of the subacromial-subdeltoid bursa was significantly larger in the dominant and non-dominant shoulders of the overhead athletes than in the asymptomatic volunteers ($p < 0.001$, $p < 0.05$ respectively).

Ultrasonography appeared as an effective, convenient and non-invasive tool for the early diagnosis of shoulder pathologies occurring in overhead athletes, even in the asymptomatic stage.

Key words : shoulder ; ultrasonography ; subacromial impingement ; sports injury.

Overhead athletes are susceptible to injury and dysfunction because of repetitious, high-velocity mechanical stress placed on their shoulders, often at extremes of glenohumeral motion (*1,3,14*).

The rotator cuff has an essential role in overhead activities, providing dynamic glenohumeral joint stabilization (*2*). Tendinitis, impingement, instability, and rotator cuff tears are commonly seen problems in the overhead athletes (*5,8*). Although most often asymptomatic, they can be seen on ultrasound. The diagnostic accuracy of ultrasonography (US) in detecting rotator cuff tears varies according to the size of the lesion. However, a sensitivity rate of 93 to 97% and a specificity rate of 91 to 100% have been reported for the diagnosis of complete tears of the supraspinatus tendon (*5,8*). The purpose of this study was to evaluate the pathology and thickness of the supraspinatus (SS) tendon and long head of biceps (LHB) tendon, and the subacromial-subdeltoid bursa in dominant and nondominant shoulders of overhead athletes with ultrasonography and to compare these findings with those in a normal population matched for age.

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MATERIAL AND METHODS

The study evaluated the shoulders of overhead elite premier league athletes involved in basketball, handball, volleyball, body building, and water polo. The study protocol was approved by the institutional ethics committee, and informed consent was obtained from all the subjects. Ultrasonographic examination of both shoulders was performed in 45 asymptomatic overhead athletes (8 female, 37 male ; mean age: 22 years, age range : 17-40 years), and 43 asymptomatic volunteers (13 female, 30 male ; mean age : 25 years, age range: 18-33 years). Although the age distribution was within a large range, all sportsmen were playing in elite premier league and were randomly selected from the group of four overhead sports mentioned above. Forty of the 45 overhead athletes and 41 of 43 asymptomatic volunteers were right handed, while 5 overhead athletes and 2 asymptomatic volunteers were left handed. The mean duration of participation in competitions was 10.16 years (range : 1-22 years) with an average practice per week including games of 12.6 hours. The shoulders of all the overhead athletes and asymptomatic volunteers were completely asymptomatic, and the subjects had no history of previous shoulder injury, symptoms, and/or surgery. Each of the 45 players and 43 control subjects had an independent physical examination of both shoulders performed by an orthopaedic shoulder surgeon. Any current or former shoulder pain was recorded. All the shoulders were inspected for scars, atrophy, deformities and rhythm of motion. The rotator cuff was evaluated using Jobe's test and impingement was evaluated with Hawkins and Yocum's tests.

The dominant and non-dominant shoulders of the overhead athletes and asymptomatic volunteers were examined by one radiologist experienced in ultrasonographic examination of the musculoskeletal system, using 7.5 MHz high resolution linear transducer (EUB 8500, Hitachi Medical Systems, Japan)

The subjects were examined in a sitting position, the arms resting along the body with the ulnar side of the hands against the lateral side of the thighs. The radiologist assessed the muscles, periarticular bursa, and tendons of the left and right supraspinatus (SS) and long head of biceps (LHB). The thickness of the SS tendon was measured at 5mm and 10 mm from its humeral insertion, where it crosses the anterior aspect of the acromial process. In addition, any tears, calcifications, and tendinitis were recorded. The thickness of the LHB tendon was measured at the mid part of the tendon in its course through the intertubercular groove. Any effusions, tears, and subluxations were also recorded. Subacromial–subdeltoid bursa thickness between the folds of the bursa was measured. Any effusions were recorded.

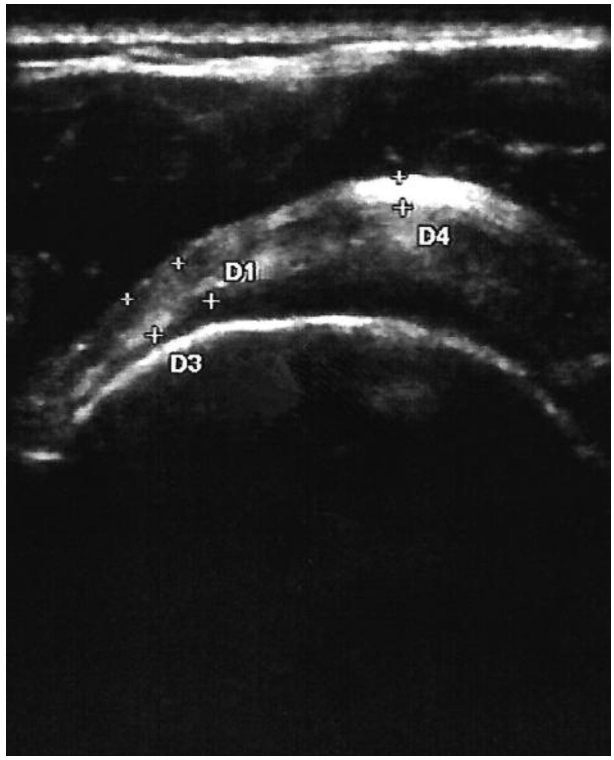

Fig. 1. — The 5mm (D3) and 10 mm (D1)thickness measurement of the tendon of supraspinatus. The thickness measurement of subacromial bursa (D4).

The results of US measurements were expressed as means ± SD(standard deviation) (table I). The values of the dominant shoulders were compared using paired t test with those of the contralateral (non-dominant) shoulders used as a control.

Student's t test was used to compare the numerical values measured in the athletes and control subjects, and Chi-Square test was used to compare categorical values. Pearson's correlation analysis was used to compare the tendon thickness with duration of the sports activity. All *p* values were two-tailed and considered significant when < 0.05.

RESULTS

The right arm was dominant in 40 (88.9%) of the 45 overhead athletes and 41 (95.3%) of the 43 nonathletic volunteers. All of them were asymptomatic before physical examination and reported no history of pain. During the physical examination, rotator cuff pain was induced by anterior flexion and external rotation in 8 dominant shoulders in the overhead athletes. Hawkins' test was mildly positive in 6 athletes, and Yocum's test was also positive in one of these 6 athletes. On US examination, subacromial-subdeltoid bursa effusion was observed in 16 (35.6%) of the dominant shoulders and in 2 (4.4%) of the non-dominant shoulders in the 45 overhead athletes and in none of the nonathletic volunteers. There was a significant correlation between the number of weekly training hours and the presence of effusion in athletes ($p < 0.05$).

The mean thickness of the subacromial-subdeltoid bursa in both the dominant and non-dominant shoulders was significantly higher in the overhead athletes than in the asymptomatic volunteers (table I). The mean thickness of the bursa was significantly higner in the dominant shoulders than in the non-dominant shoulders in overhead athletes, but not so in asymptomatic volunteers. The bursa thickness in the dominant shoulder of one athlete was 3 mm ; effusion was also detected in that shoulder. The thickness of the bursa in all the other shoulders was less than 3mm.

Various types of pathology were detected by US examination in the SS tendon of the dominant shoulders in the overhead athletes : tendinitis (decreased echogenicity and diffuse thickening of the tendon) in four subjects, calcification (hyperechoic, linear, round or oval areas interrupting the ultrasonographic wave) in two, partial tear (hypoechoic or anechoic focal defect) in six. No complete tear was noted. In addition, effusion in the subacromial-subdeltoid bursa was detected in these patients. Ten overhead athletes with pathologic US findings in the SS tendon complained of shoulder pain with forceful maneuvers in the physical examination: two of the four with tendinitis, all of the six with partial tear and two with calcifications. The SS tendon in the dominant shoulders was significantly thicker at 5mm and 10 mm from its humeral insertion in the athletes than in the asymptomatic volunteers (table I). In the non-dominant shoulders, the SS tendon was significantly thicker in the athletes than in the asymptomatic volunteers. In both the athletes and the asymptomatic volunteers, the SS tendon was significantly thicker in the dominant shoulders than in the non-dominant shoulders.

In the LHB tendon, tenosynovitis (effusion surrounding the tendon) was detected on US examination in one dominant shoulder among the 45 athletes. No other pathology was detected in the LHB tendons in either group of subjects. The LHB tendon of the dominant and non-dominant shoulders was thicker in the athletes than in the asymptomatic volunteers. The difference in thickness was statistically significant for the dominant shoulders, but not for the non-dominant shoulders. The LHB tendon

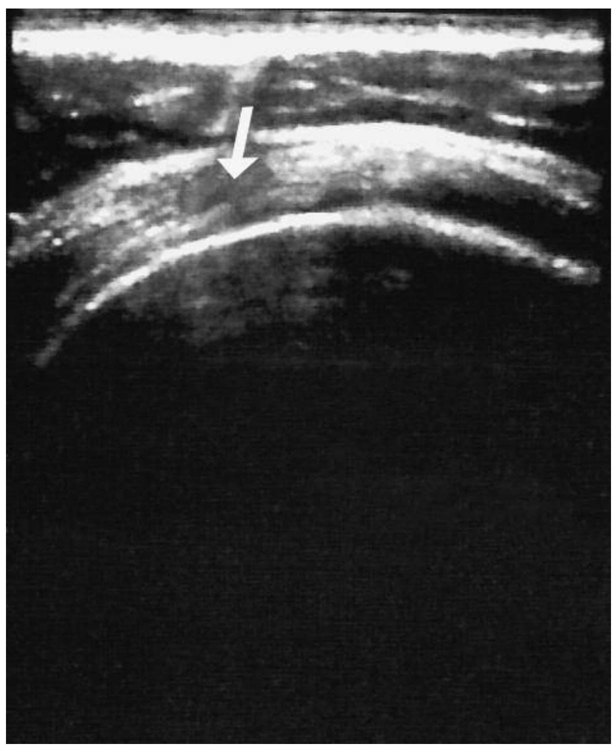

Fig. 2. — Partial rupture in supraspinatus tendon.

Table I. — Mean thickness of the supraspinatus and long head of biceps tendons and of the subacromial-subdeltoid bursa in both shoulders of the overhead athletes and healthy asymptomatic volunteers.

MEASUREMENTS	N	DOMINANT SHOULDER (mm)	NON-DOMINANT SHOULDER (mm)	P
Long Head of Biceps				
overhead athletes	45	2.684 ± 0.325	2.568 ± 0.285	$p < 0.001$
asymptomatic volunteers	43	2.503 ± 0.325	2.495 ± 0.307	$p > 0.05$
		($p < 0.05$)	($p > 0.05$)	
Supraspinatus at 5 mm				
overhead athletes	45	2.984 ± 0.451	2.728 ± 0.336	$p < 0.001$
asymptomatic volunteers	43	2.744 ± 0.303	2.574 ± 0.405	$p < 0.01$
		($p < 0.05$)	($p < 0.05$)	
Supraspinatus at 10 mm				
overhead athletes	45	3.813 ± 0.503	3.446 ± 0.416	$p < 0.001$
asymptomatic volunteers	43	3.395 ± 0.376	3.251 ± 0.356	$p < 0.01$
		($p < 0.001$)	($p < 0.05$)	
Subacromial bursa				
overhead athletes	45	1.971 ± 0.442	1.744 ± 0.317	$p < 0.01$
asymptomatic volunteers	43	1.632 ± 0.286	1.600 ± 0.232	p = NS
		($p < 0.001$)	($p < 0.05$)	

was significantly thicker in the dominant shoulders than in the non-dominant shoulders in the athletes, but not so in the asymptomatic volunteers.

DISCUSSION

Joints which are repeatedly stressed , such as throwing shoulders in overhead athletes are likely to have more structural abnormality and thus more abnormal findings (*6*). Literature reveals a few studies on US evaluation of the shoulder in overhead athletes. Moreover, few studies have compared the shoulders in overhead athletes and in a non athletic population (*5*).

Magnetic resonance imaging findings in the rotator cuff in overhead athletes and in a normal population as well as US findings of the rotator cuff in a normal population have been well described in literature (*9,10*). In our study, the dominant and non-dominant shoulders of the overhead athletes and asymptomatic controls were evaluated as described in literature (*8*). Several significant differences were found between the shoulders of the overhead athletes and of the asymptomatic controls.

The subacromial-subdeltoid bursa is the largest bursa in the body. The synovial fluid within the bursa attenuates the friction both between the rotator cuff and the acromion and between the rotator cuff and the deltoid muscle. The amount of fluid within the subacromial-subdeltoid bursa is also thought to be an important sign of rotator cuff tear, but this finding is non-specific and may be seen in cases of inflammatory arthropathy, trauma, and impingement. In our study, all six patients with partial supraspinatus tendon tear had accompanying subacromial-subdeltoid bursa effusion.

The percentage of the subjects having subacromial-subdeltoid bursa effusion in the dominant shoulder in our series was higher (35.6%) than reported by Brasseur *et al* (*5*) (8.7%) for a population of veteran tennis players. The presence of effusion was highly correlated with the pathology in the supraspinatus tendon in our study. There was also a significant correlation between the training time of the athletes per week and the frequency of effusion. Thickening of the subacromial-subdeltoid bursa in the dominant and non-dominant shoulders of the athletes in comparison with the control subjects can be explained by repetitive trauma causing irritation of the bursa. The latter may be irritated and thickened as a result of repetitive trauma, amyloidosis, polymyalgia rheumatica, hydroxyapatite deposition, inflammation of the synovium in sero-positive and negative rheumatoid arthritis. Furthermore, the presence of effusion can explain why the difference in thickness of the bursa between athletes and nonathletic subjects is more significant on the dominant side than on the non-dominant side.

The rotator cuff, especially the supraspinatus muscle has an essential role in overhead activities, providing dynamic glenohumeral stabilisation. Along with the rotator cuff, static stabilisers and other scapular muscles work in harmony to maintain a balance of stability and mobility of the glenohumeral joint (*2,15*). In the athlete, flexibility and laxity are required for optimal performance, but when excessive laxity becomes symptomatic, it can represent pathology. Repetitive stresses on this system may lead to tendinitis, impingement, instability, and rotator cuff tears. The athletes' age and level of performance are predisposing factors for shoulder injury (*3*). All the detected pathologies of the supraspinatus tendon were seen in the dominant shoulders of the athletes in our study, which suggests that overhead sports induce pathologic damage in this tendon. In addition, supraspinatus tendon thickness in the dominant and non-dominant shoulders was thicker in the overhead athletes than in the asymptomatic volunteers. In contrast to the findings by Mirovitz (*10*), the SS tendon was found to be thinner at 5mm from its humeral insertion in the dominant and non-dominant shoulders of the athletes and control subjects in our study (table I). Its thickness in the non-dominant shoulders of the control subjects at 10 mm from its humeral insertion was similar to that measured by Mirovitz (*10*). In our study, all measurements were made from a standard location, and in our belief, dominancy and doing overhead sports play an important role in the tendon thickness. The coracoacromial ligament has been implicated as a source of primary impingement in overhead activities (*4,7*). Burns and Whipple (*6*) examined fresh-frozen shoulders and found that when the humerus was placed in 90° forward flexion and forcibly internally rotated, the supraspinatus and biceps tendons were placed in direct contact with the coracoacromial ligament. This position corresponds to the overhead athlete's arm position in the follow-through phase of throwing.

The long head of the biceps (LHB) functions as a humeral head depressor and stabiliser (*6,11-13*). In addition, in many overhead sports, the biceps helps to accelerate and decelerate the arm. Bicipital problems in athletes usually occur in conjunction with other types of shoulder disorders, such as rotator cuff impingement and glenohumeral instability, making determination of the role and degree of biceps involvement difficult. Conditions affecting the biceps tendon in athletes can be generally classified as degeneration, instability, and disorders of the tendon origin (*11,13*).

No abnormalities were detected in the LHB tendon of overhead athletes and asymptomatic volunteers, except for one overhead athlete who had tenosynovitis of the tendon. In addition, no significant difference was noted in the LHB tendon thickness between the non-dominant shoulders of the athletes and control subjects, nor between the dominant and non-dominant shoulders of the control subjects. However, the thickness of the LHB tendon was higher in the dominant shoulders of the athletes than in their non-dominant shoulders and in the shoulders of asymptomatic volunteers. Thus, it appears that overhead activities play an important role in the LHB tendon thickness.

There are some limitations in our study. One limitation is that US examination is user- dependent, but radiologists in our study were experienced in musculoskeletal ultrasonography. Another limitation is that the US findings could not be verified. Ideally ultrasonographic findings would be confirmed by MRI and optimally by surgery, but none of the athletes and control subjects volunteered for MRI examination and/or arthroscopic evaluation.

Overhead activities were found to affect the supraspinatus tendon, subacromial-subdeltoid bursa and biceps tendon, but dominancy appeared to affect only the supraspinatus tendon and subacromial-subdeltoid bursa. Weekly training time was highly correlated with the presence of subacromial-subdeltoid bursa effusion. Presence of bursa effusion was found to be highly correlated with supraspinatus tendon pathology. Therefore, in a patient with subacromial-subdeltoid bursa effusion, the supraspinatus tendon should be comprehensively evaluated for any pathology. Moreover, periodical evaluation of the overhead athlete with US examination may prevent serious problems such as tendon rupture.

This study has shown that shoulder pathologies such as bursitis, impingement syndrome and rotator cuff lesions can be evaluated with US. US can especially be used in the asymptomatic period, to evaluate overhead athletes' shoulder pathologies due to overuse. It can be used as a noninvasive and convenient method to prevent injuries and can periodically be used as a screening method .

REFERENCES

1. **Altchek DW, Dines DM.** Shoulder injuries in the throwing athlete. *J Am Acad Orthop Surg* 1995 ; 3 : 159-165.
2. **Atalar H, Yilmaz C, Polat O *et al.*** Restricted scapular mobility during arm abduction : implications for impingement syndrome. *Acta Orthop Belg* 2009 ; 75 : 19-24.
3. **Arroyo JS, Hershon SJ, Bigliani LU.** Special considerations in the athletic throwing shoulder. *Orthop Clin North Am* 1997 ; 28 : 69-78.
4. **Bigliani LU, Rodosky MW, Newton PD *et al.*** Arthroscopic coracoacromial ligament resection for impingement in the overhead athlete. *J Shoulder Elbow Surg* 1995 ; 4 : S54.
5. **Brasseur JL, Lucidarme O, Tardieu M *et al.*** Ultrasonographic rotator-cuff changes in veteran tennis players : the effect of hand dominance and comparison with clinical findings. *Eur Radiology* 2004 ; 14 : 857-864.
6. **Burns WC, Whipple TL.** Anatomic relationships in the shoulder impingement syndrome. *Clin Orthop Relat Res* 1993 ; 294 : 96-102.
7. **Jobe CM, Coen MJ, Screnar P.** Evaluation of impingement syndromes in the overhead-throwing athlete. *J Athl Train* 2000 ; 35 : 293-299.
8. **Jost B, Zumstein M, Pfirrmann CW, Zanetti M, Gerber C.** MR findings in throwing shoulders. *Clin Orthop Relat Res* 2005 ; 434 : 130-137.
9. **Miniaci A, Mascia AT,Salonen DC, Becker EJ.** Magnetic resonance imaging of the shoulder in asymptomatic professional baseball pitchers. *Am J Sports Med* 2002 ; 30 : 66-73.
10. **Mirowitz SA.** Normal rotator cuff : MR imaging with conventional and fat-suppression techniques. *Radiology* 1991 ; 180 : 735-740.
11. **Neer CS.** Impingement lesions. *Clin Orthop Relat Res* 1983 ; 173 : 70-77.
12. **Neer, CS.** Anterior acromioplasty for the chronic impingement syndrome in the shoulder. A preliminary report. *J Bone Joint Surg* 1972 ; 54-A : 41-50.
13. **Paulson MM, Watnik NF, Dines DM.** Coracoid impingement syndrome, rotator interval reconstruction, and biceps tenodesis in the overhead athlete. *Orthop Clin North Am* 2001 ; 32 : 485-493.
14. **Wasserlauf BL, Paletta GA.** Shoulder disorders in the skeletally immature throwing athlete. *Orthop Clin North Am* 2003 : 34 : 427-437.
15. **Yildiz Y, Aydin T, Sekir U *et al.*** Shoulder terminal range eccentric antagonist/concentric agonist strength ratios in overhead athletes. *Scand J Med Sci Sports* 2006 ; 16 : 174-180.