Ultrasound imaging for the rheumatologist XII. Ultrasound imaging in sports medicine

E. Filippucci[1], G. Meenagh[2], A. Delle Sedie[3], L. Riente[3], A. Iagnocco[4], S. Bombardieri[3], G. Valesini[4], W. Grassi[1]

[1]*Cattedra di Reumatologia, Università Politecnica delle Marche, Jesi, Italy;* [2]*Department of Rheumatology, Antrim Hospital, Antrim, United Kingdom;* [3]*Unità Operativa di Reumatologia, Università di Pisa;* [4]*Cattedra di Reumatologia, Sapienza - Università di Roma, Roma, Italy.*

Emilio Filippucci, MD; Gary Meenagh, MD; Andrea Delle Sedie, MD; Lucrezia Riente, MD; Annamaria Iagnocco, MD; Stefano Bombardieri, MD, Professor of Rheumatology; Guido Valesini, MD, Professor of Rheumatology; Walter Grassi, MD, Professor of Rheumatology.

Please address correspondence to: Prof. Walter Grassi, Cattedra di Reumatologia, Università Politecnica delle Marche, Ospedale "A. Murri", Via dei Colli 52, 60035 Jesi (AN), Italy. E-mail: walter.grassi@univpm.it

Received and accepted on November 27, 2007.

Clin Exp Rheumatol 2007; 25: 806-809.

Key words: Ultrasonography, sport-related pathology, tendons, muscles, ligaments.

Competing interests: none declared.

Abstract

The present review discusses the most frequent sport-related conditions which can present to rheumatologists and the available evidence base for using ultrasonography (US) in such scenarios. From a rheumatological perspective, sports-related pathology is mainly characterised by sub-acute and chronic overuse and stress-related disorders involving tendons, ligaments, muscles, joints and entheses. Major acute injuries are less frequently assessed in a standard rheumatological setting.

Longitudinal studies are required to determine the clinical importance of US findings in athletes, particularly those who are asymptomatic. US findings need to be correlated with standard references including surgical and magnetic resonance imaging assessments. Future research should also be directed at determining the usefulness of power Doppler technique in monitoring sport-related abnormalities.

Introduction

There are currently a growing number of clinical indications for using ultrasonography (US) in musculoskeletal disease (1-6). US can also accurately detect a wide spectrum of pathologies in athletes performing various types of sports activities (7-9).

Whilst basic tissue lesions are commonly identified in sports medicine, some US abnormalities can be specific to different activities. Interpretation of these US findings may be difficult due to the superimposition of acute and chronic lesions and concomitant repair process in the anatomical region under examination (7).

From a rheumatological perspective, sport-related pathology is mainly characterised by sub-acute and chronic overuse and stress-related disorders involving tendons, ligaments, muscles, joints and entheses. Major acute injuries are less frequently assessed in a standard rheumatological setting.

The present review discusses the most frequent sport-related conditions which can present to rheumatologists and the available evidence-base for using US in such scenarios.

Clinical applications

US is a valuable imaging tool for several applications in sports medicine. Apart from being less expensive and more widely accessible than magnetic resonance imaging (MRI), US has many other advantages compared with MRI in specific clinical settings.

Firstly, spatial resolution provided by the latest generation US equipment is superior to that obtained by standard MRI. This can be crucial in the evaluation of tendon integrity (10). Secondly, real time US imaging allows for a more accurate assessment of both muscle and tendon lesions. US examination during muscle contraction is very helpful in distinguishing full-thickness from partial-thickness tendon tears. Furthermore, specific movements of the subject under examination may be essential for revealing muscle herniation, tendon or nerve dislocation and impingement syndromes (7, 11). Thirdly, during US examination it is possible to obtain an exact comparison between US findings and tenderness elicited by probe compression (sono-palpation). Finally, US is a suitable imaging technique for short-term follow-up of soft tissue changes and therapy monitoring (12, 13).

In patients with acute or chronic pain syndromes potentially related to tendon involvement, US assessment should be regarded as the first line investigation.

Table I. Specific sports-related injuries detectable by US.

Sport-related injury	Sport
Finger pulley rupture (14-15)	Rock climbing
Chronic patellar tendinosis (Jumper's knee) (16)	Basketball, volleyball
Chronic tendinopathy of the common extensor tendons at the lateral epicondyle of the elbow also called "tennis elbow" (17, 18)	Tennis
Chronic tendinopathy of the common extensor tendons at the medial epicondyle of the elbow also called "golfer's elbow" (18)	Golf
Osgood-Schlatter disease (19)	Basketball, volleyball
Overuse insertional tendinopathy of the pectoralis minor muscle (20)	Weightlifting
Rectus abdominis muscle strain (21)	Tennis
Rupture of the distal musculotendinous junction of the medial head of the gastrocnemius also called "tennis leg" (22)	Tennis
Injury ulnar collateral ligament of the elbow (23)	Baseball (baseball pitchers)

Power Doppler assessment has a key role in the detection of even minimal inflammatory involvement at any level of the affected area. An initial rapid assessment of tissue perfusion may be very useful to detect specific areas of interest that should be carefully assessed by high-frequency greyscale US to evaluate morpho-structural changes.
Since most tendons are superficially located, high-frequency linear probes (not less than 13 MHz) should be used to obtain the best sensitivity/specificity ratio. In general a Doppler frequency higher than 7 MHz is recommended for Doppler assessment.
Advances in technology have made portable US systems suitable for providing both high quality greyscale and power Doppler imaging for use at sports grounds allowing immediate assessment.
US can also prove invaluable in the assessment of fitness to perform in specific sports activities, especially in amateur athletes.
Table I lists the most frequent sport-specific injuries which can be evaluated by rheumatologists.
The main drawbacks to US imaging include restriction of the available acoustic window and operator dependency. The first limitation cannot be modified and hinders the assessment of anatomical structures that can be involved especially after trauma (*i.e.* at knee level, meniscal tears and/or cruciate ligaments lesions). Operator experience is essential for ensuring accuracy both in diagnosis and monitoring sport-related abnormalities.

Sonographic findings

It is vital to consider the coexistence of both sport-induced injuries and pre-existing pathology when interpreting US imagery in sport-related cases. This is particularly pertinent in amateur athletes and in older subjects.

Tendons with synovial sheath

The pattern of involvement of tendons with a synovial sheath in sport-related pathology is similar to that seen in work related pathology. Exudative tenosynovitis is the most characteristic feature of acute and chronic stress and strain pathology with a distribution correlated to the specific movements of the athletes and the use of specific sports equipment.
Tendon assessment is directed at evaluating the morphostructural features of the sheath content and identification of any indications to perform a sonographic-guided injection.
Particular attention must be paid to the identification of minimal interruption of the tendon fibrils which may precede larger partial-thickness or full-thickness tears. This is especially important in all sports activities which overload tendons (*i.e.* weight lifting, tennis, volleyball, football). The most common tendons involved in sports trauma include: tibialis posterior tendon (football), long head of biceps tendon (baseball), finger flexor tendons (archery) and peroneals (skiing and running).

Tendons without synovial sheath

Tendons without a synovial sheath are a frequent target in sport-related injury mainly because some originate from the most powerful muscles in the human body (quadriceps, triceps). The Achilles tendon is the most frequently involved tendon in several sports activities. It can be relatively easily assessed by US because of its superficial location and its axis parallel to the skin surface. It is advisable to perform scheduled US examinations of the Achilles tendon in all athletes who expose it to overload.
Comprehensive US examination of the Achilles tendon consists of multiplanar scanning from the musculo-tendinous junction to the distal insertion into the calcaneum. This allows the detection of even minimal changes that can justify immediate preventive (partial or complete suspension of the sports activity) or therapeutic (physiotherapy, pharmacological, surgical) intervention (6). Correlation between US changes and clinical findings is more complex in sport-related injuries than in other musculoskeletal disorders. In long distance runners, chronic tendinopathy with diffuse intra-tendineous and pre-insertional power Doppler signal may be completely asymptomatic. Other tendons devoid of synovial sheaths frequently involved in sport-related injury include: supraspinatus tendon, common extensor and flexor tendons at the elbow, quadriceps tendon and patellar tendon (Fig. 1A-B).

Muscles

The spectrum of US findings due to muscle involvement includes contusion, strain, partial and complete tears, fascial tear, muscle herniation, haematoma, scar tissue, intramuscular calcification and intramuscular cyst formation (Fig. 1C) (11). Muscle healing can be normal, with the return to the previous muscle echotexture or abnormal, with hyperechoic scars and/or intramuscular cysts (5).
Hematomas US appearance evolves from hyperechoic, soon after its formation, to hypoechoic after only very few hours. At follow-up US examinations, hematomas show an anechoic fluid collection surrounded by a hypoechoic reparative tissue (24, 25).

Ligaments

Ligaments are frequently involved by post-traumatic macro and micro lesions.

In healthy subjects, they normally appear hyperechoic with a homogeneous fibrillar echotexture. Partial tears are characterised by focal loss of the normal echotexture and hypoechoic thickening of the ligament with or without surrounding hypoechoic or anechoic fluid collection (7, 9).

Literature review

Tendons

Tendinopathies of the rotator cuff, long head of the biceps brachii tendon and of the tendon pectoralis major muscle are frequent causes of shoulder pain in athletes. However, morpho-structural and perfusional abnormalities can be detected by US also in asymptomatic athletes. The rotator cuff may show relevant echo-textural changes, such as complete tears or calcifications of the supraspinatus tendon, in asymptomatic tennis or baseball players (26, 27). In these subjects, subdeltoid bursitis is almost always associated with shoulder pain (27).

Similar discrepancy between clinical and US findings has been reported for chronic tendinopathy of the Achilles or patellar tendons affecting asymptomatic athletes in sports such as soccer and basketball (28-30).

Power Doppler findings seem to have a higher correlation with symptoms than greyscale findings (31, 32). However, the intra-tendineous colour Doppler signal may, in part, be a physiological response to sports activity as suggested in a recent study performed in elite badmington players at the Achilles tendon level (33).

Muscles

Minor lesions, such as contusions and strains, can be difficult to identify, being comparison with contralateral muscle echotexture and sonopalpation very important for increasing accuracy (11). Major lesions, including partial and complete tears, can be easier identified by US which has a role also in detecting possible associated lesions like hematomas, guiding their aspiration and monitoring their evolution.

Some muscle findings are highly specific to certain sports activity *e.g.* asymmetrical hypertrophy of the rectus abdominis muscle sometimes seen in elite tennis players. The muscle belly on the side opposite the dominant arm, is overused, becomes hypertrophied and exposed to a higher risk of muscle tears at its deepest fibres below the umbilicus (22).

US monitoring of muscle lesions provides useful information to improve both therapy tailoring and sports activity resumption planning.

In experienced hands, US has shown to provide an accurate diagnosis of muscle injuries. In a recent study, MRI and US yielded an exact agreement of 87.6% in 81 football players examined for assessing site, type and extent of traumatic muscle injuries of the lower limbs (34). Thus, US should be considered as the first-line technique for assessing muscle injuries (35).

Ligaments

Ligament injuries are very frequent in almost every sports activity, even if their detection by US is not always easy due to the acoustic barriers. A correct approach for assessing ligaments requires practical skills and experience in visualising their pathology. Rheumatologists should pay attention to possible findings of chronic involvement. Acute pathology is generally assessed in orthopaedic and sports medicine settings. One of the most common injuries in skiers is a tear of the ulnar collateral ligament of the metacarpophalangeal joint of the thumb. A rapid assessment with US can identify a need for surgical intervention to prevent chronic functional instability of the joint. Studies have evaluated the ability of US to detect this injury ranging from 74 to 86% using surgical exploration as gold standard (36-40). There is, however, conflicting evidence on the effectiveness of US to differentiate between displaced and non-displaced tears of this ligament (36, 41, 42).

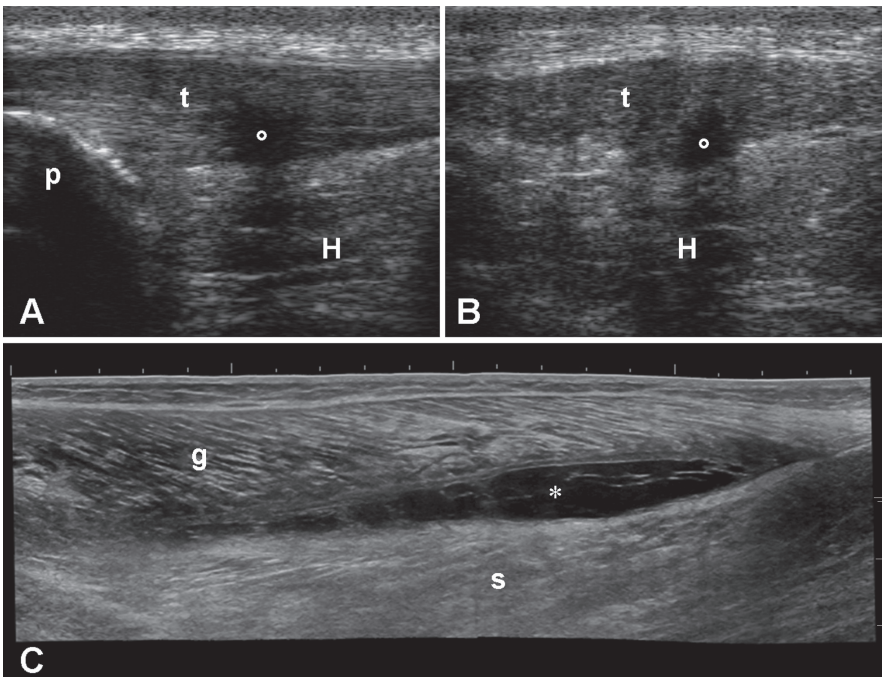

Fig. 1. A-B. Jumper's knee. Longitudinal (A) and transverse (B) views of the proximal patellar tendon (**t**) showing a focal anechoic area (°) due to degenerative tendinopathy. **C.** Partial tear of the medial head of the gastrocnemius (**g**) and concomitant hematoma (*). **p** = lower pole of the patella; **H** = Hoffa fat pad; **s** = soleus.

For further ultrasound images, please go to www.clinexprheumatol.org

Research agenda

Longitudinal studies are required to determine the clinical importance of US findings in athletes particularly those who are asymptomatic (24). US findings need to be correlated with standard references including surgical and MRI assessments.

Future research should also be directed at determining the usefulness of power Doppler technique in monitoring sport-related abnormalities.

Link

For further ultrasound images, go to www.clinexprheumatol.org/ultrasound

References

1. DELLE SEDIE A, RIENTE L, IAGNOCCO A *et al.*: Ultrasound imaging for the rheumatologist X. Ultrasound imaging in crystal-related arthropathies. *Clin Exp Rheumatol* 2007; 25: 513-7.
2. RIENTE L, DELLE SEDIE A, FILIPPUCCI E *et al.*: Ultrasound imaging for the rheumatologist IX. Ultrasound imaging in spondyloarthritis. *Clin Exp Rheumatol* 2007; 25: 349-53.
3. MEENAGH G, FILIPPUCCI E, IAGNOCCO A *et al.*: Ultrasound imaging for the rheumatologist VIII. Ultrasound imaging in osteoarthritis. *Clin Exp Rheumatol* 2007; 25: 172-5.
4. FILIPPUCCI E, IAGNOCCO A, MEENAGH G *et al.*: Ultrasound imaging for the rheumatologist VII. Ultrasound imaging in rheumatoid arthritis. *Clin Exp Rheumatol* 2007; 25: 5-10.
5. IAGNOCCO A, FILIPPUCCI E, MEENAGH G *et al.*: Ultrasound imaging for the rheumatologist. I. Ultrasonography of the shoulder. *Clin Exp Rheumatol* 2006; 24: 6-11.
6. FILIPPUCCI E, IAGNOCCO A, MEENAGH G *et al.*: Ultrasound imaging for the rheumatologist. *Clin Exp Rheumatol* 2006; 24: 1-5.
7. JACOBSON JA: Ultrasound in sports medicine. *Radiol Clin North Am* 2002; 40: 363-86.
8. GIBBON WW: Diagnostic ultrasound in sports medicine *Br J Sports Med* 1998; 32: 3.
9. KIJOWSKI R, DE SMET AA: The role of ultrasound in the evaluation of sports medicine injuries of the upper extremity. *Clin Sports Med* 2006: 25; 569–90.
10. GRASSI W, FILIPPUCCI E, FARINA A, CERVINI C: Sonographic imaging of tendons. *Arthritis Rheum* 2000: 43; 969-76.
11. ROMAGNOLI C, CHHEM RK, CARDINAL E: Muscle and fascia. *In* CHHEM RK, CARDINAL E (Eds.) *Guidelines and Gamuts in musculoskeletal ultrasound*. New York, Wiley-Liss 1999: 247-79.
12. REES JD, WILSON AM, WOLMAN RL: Current concepts in the management of tendon disorders. *Rheumatology* 2006; 45: 508-21.
13. ÖHBERG L, LORENTZON R, ALFREDSON H: Eccentric training in patients with chronic Achilles tendinosis: normalised tendon structure and decreased thickness at follow up. *Br J Sports Med* 2004; 38: 8-11.
14. MARTINOLI C, BIANCHI S, NEBIOLO M, DERCHI LE, GARCIA JF: Sonographic evaluation of digital annular pulley tears. *Skeletal Radiol* 2000; 29: 387-91.
15. KLAUSER A, FRAUSCHER F, BODNER G *et al.*: Finger pulley injuries in extreme rock climbers: depiction with dynamic US. *Radiology* 2002; 222: 755-61.
16. GISSLÉN K, ALFREDSON H: Neovascularisation and pain in jumper's knee: a prospective clinical and sonographic study in elite junior volleyball players. *Br J Sports Med* 2005; 39: 423-8.
17. LEVIN D, NAZARIAN LN, MILLER TT *et al.*: Lateral epicondylitis of the elbow: US findings. *Radiology* 2005; 237: 230-4.
18. JACOBSON JA, MILLER BS, MORAG Y: Golf and racquet sports injuries. *Semin Musculoskelet Radiol* 2005; 9: 346-59.
19. BLANKSTEIN A, COHEN I, HEIM M *et al.*: Ultrasonography as a diagnostic modality in Osgood-Schlatter disease. A clinical study and review of the literature. *Arch Orthop Trauma Surg* 2001; 121: 536-9.
20. BHATIA DN, DE BEER JF, VAN ROOYEN KS, LAM F, DU TOIT DF: The "bench-presser's shoulder": an overuse insertional tendinopathy of the pectoralis minor muscle. *Br J Sports Med* 2007; 41: e11.
21. CONNELL D, ALI K, JAVID M, BELL P, BATT M, KEMP S: Sonography and MRI of rectus abdominis muscle strain in elite tennis players. *Am J Roentgenol* 2006; 187: 1457-61.
22. DELGADO GJ, CHUNG CB, LEKTRAKUL N *et al.*: Tennis leg: clinical US study of 141 patients and anatomic investigation of four cadavers with MR imaging and US. *Radiology* 2002; 224: 112-9.
23. NAZARIAN LN, MCSHANE JM, CICCOTTI MG, O'KANE PL, HARWOOD MI: Dynamic US of the anterior band of the ulnar collateral ligament of the elbow in asymptomatic major league baseball pitchers. *Radiology* 2003; 227: 149-54.
24. WANG HK, LIN JJ, PAN SL, WANG TG: Sonographic evaluations in elite college baseball athletes. *Scand J Med Sci Sports* 2005; 15: 29-35.
25. 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 Radiol* 2004; 14: 857-64.
26. FREDBERG U, BOLVIG L: Significance of ultrasonographically detected asymptomatic tendinosis in the patellar and achilles tendons of elite soccer players. *Am J Sports Med* 2002; 30: 488-91.
27. COOK JL, KHAN KM, HARCOURT PR *et al.*: Patellar tendon ultrasonography in asymptomatic active athletes reveals hypoechoic regions: A study of 320 tendons. *Clin J Sport Med* 1998; 8: 73-7.
28. COOK JL, KHAN KM, KISS ZS *et al.*: Patellar tendinopathy in junior basketball players: A controlled clinical and ultrasonographic study of 268 patellar tendons in players aged 14-18 years. *Scand J Med Sci Sports* 2000; 10: 216-20.
29. TERSLEV L, QVISTGAARD E, TORP-PEDERSEN S, LAETGAARD J, DANNESKIOLD-SAMSØE B, BLIDDAL H: Ultrasound and Power Doppler findings in jumper's knee - preliminary observations. *Eur J Ultrasound* 2001; 13: 183-9.
30. GISSLÉN K, ALFREDSON H: Neovascularisation and pain in jumper's knee: a prospective clinical and sonographic study in elite junior volleyball players. *Br J Sports Med* 2005; 39: 423-8.
31. BOESEN MI, BOESEN A, KOENIG MJ, BLIDDAL H, TORP-PEDERSEN S: Ultrasonographic investigation of the Achilles tendon in elite badminton players using color Doppler. *Am J Sports Med* 2006; 34: 2013-21.
32. PEETRONS P: Ultrasound of muscles. *Eur Radiol* 2002; 12: 35-43.
33. VAN HOLSBEECK MT, INTROCASO JH: Musculoskeletal ultrasound, 2nd edition, Mosby, 2001.
34. MEGLIOLA A, EUTROPI F, SCORZELLI A *et al.*: Ultrasound and magnetic resonance imaging in sports-related muscle injuries. *Radiol Med* 2006; 111: 836-45.
35. CONNELL DA, SCHNEIDER-KOLSKY ME, HOVING JL *et al.*: Longitudinal study comparing sonographic and MRI assessments of acute and healing hamstring injuries. *Am J Roentgenol* 2004; 183: 975-84.
36. NOSZIAN IM, DINKHAUSER LM, ORTHNER E, STRAUB GM, CSANADY M: Ulnar collateral ligament: differentiation of displaced and nondisplaced tears with US. *Radiology* 1995; 194: 61-3.
37. SCHNUR DP, DELONE FX, MCCLELLAN RM, BONAVITA J, WITHAM RS: Ultrasound: a powerful tool in the diagnosis of ulnar collateral ligament injuries of the thumb. *Ann Plast Surg* 2002; 49: 19-22.
38. HAHN P, SCHMITT R, KALL S: Stener lesion yes or no? Diagnosis by ultrasound. *Handchir Mikrochir Plast Chir* 2001; 33: 46-8.
39. HÖGLUND M, TORDAI P, MUREN C: Diagnosis by ultrasound of dislocated ulnar collateral ligament of the thumb. *Acta Radiol* 1995; 36: 620-5.
40. HERGAN K, MITTLER C, OSER W: Pitfalls in sonography of the Gamekeeper's thumb. *Eur Radiol* 1997; 7: 65-9.
41. HERGAN K, MITTLER C, OSER W: Ulnar collateral ligament: differentiation of displaced and nondisplaced tears with US and MR imaging. *Radiology* 1995;194:65-71.
42. SUSIC D, HANSEN BR, HANSEN TB: Ultrasonography may be misleading in the diagnosis of ruptured and dislocated ulnar collateral ligaments of the thumb. *Scand J Plast Reconstr Surg Hand Surg* 1999; 33: 319-20.