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REVIEW ARTICLE

THE VALUE OF MUSCULOSKELETAL ULTRASOUND IMAGING IN PHYSIOTHERAPY CLINICAL ASSESSMENT AND PRACTICE

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Abstract

Background: Diagnostic Ultrasound imaging is an established, non-invasive, real-time, dynamic technique that enables trained clinicians including physiotherapists to visualize muscles, tendons, ligaments, and joints with high resolution and accuracy with an aim to diagnose structural or functional defects. The use of musculoskeletal ultrasound imaging extends to the evaluation of common conditions facilitating targeted and effective treatment plans and aiding the progress of rehabilitation.

Purpose: This non-systematic review aims to provide a detailed overview of the application and benefits of musculoskeletal ultrasound within physiotherapy practice in musculoskeletal soft tissue and bone lesions, respiratory physiotherapy, and critical care conditions. The integration of rehabilitative musculoskeletal ultrasound imaging into clinical practice, as examined in the literature, is discussed in relation to its role in enhancing patient outcomes, informing clinical decision-making, and its potential impact on treatment quality and therapeutic efficacy. Challenges associated with the use of ultrasound scanning, including governance-related aspects such as the requirement for specialized training and the potential for operator-dependent variability, are critically examined.

Conclusions: This review explores current advancements in musculoskeletal ultrasound technology, emphasizing its growing importance and potential in physiotherapy rehabilitation, research and clinical reasoning. Through an analysis of current literature, this article highlights the substantial impact of diagnostic ultrasound on physiotherapy clinical practice and its contribution to the advancement of patient care.

Keywords: Ultrasound imaging, musculoskeletal pain, physiotherapy, assessment, clinical reasoning.

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INTRODUCTION

Ultrasound is a mechano-electrical modality with a rapidly growing list of applications in the fields of both diagnostic and therapeutic medicine. Diagnostic ultrasound is a non-invasive technique commonly used by Radiologists or Sonologists, and Sonographers and is part and parcel of the imaging armamentarium in modern hospital practice; specialist use of systems imaging by respective clinical specialists is also known.

Ultrasound comprises sound waves with frequencies above 20 kHz, which interact with bodily tissues to generate echoes; denser media produce stronger echoes due to greater acoustic reflection. However, ultrasound waves do not transmit effectively through air, which is considered a rarefied medium with low acoustic impedance. The generation of echoes relies on the acoustic impedance of tissues—a property that determines the degree of wave reflection at tissue interfaces. Each echo represents a combination of impedance and the time it takes for the wave to return, forming the fundamental basis of the ultrasound image. Musculoskeletal Ultrasound Imaging (MSK US) is a non-invasive diagnostic process that uses high-frequency sound waves (20 KHz to 20 MHA) to generate images of muscles, tendons, bones, ligaments, joints, nerves, blood vessels and bursae with high resolution. It is particularly useful for assessing acute and chronic conditions by discriminating between the differences in structure from images, detecting abnormalities, and to guide such interventions as injections, aspirations, or biopsies. US machines have also been used to debride chronic wounds such as diabetic foot and venous ulcers. Imaging may be carried out by ultrasound trained Rheumatologists, Physiotherapists or wound care specialists.

The purpose of this nonsystematic review is to examine the use of ultrasound techniques by physiotherapists and to describe the role and the value of rehabilitative musculoskeletal ultrasound imaging in physiotherapy practice and clinical reasoning. The authors also address the pros and cons of different clinical groups carrying out imaging.

Papers related to musculoskeletal ultrasound imaging and physiotherapy, were searched in PubMed, Embase and Google scholar, databases, published within the last 10 years. It outlines its anatomical clinical application areas, based on the currently available evidence of its diagnostic validity and accuracy. The article also explores potential avenues for future research in musculoskeletal ultrasound, particularly concerning the quantification of measurements and the monitoring of treatment outcomes over time.

Clinical relevance of musculoskeletal ultrasound imaging

Ultrasound probes produce high-frequency sound waves (3-17 MHz) to image soft tissues and bony structures in the body for the purposes of diagnosing pathology or guiding real-time interventional procedures.[1] Most transducers in current use operate at much higher frequencies to ensure compliance with good health and safety practice. Sound wave energy passes through the tissues until they encounter acoustic interfaces where it is reflected, and detected by the transducer to generate an ultrasound image. Bright Scan (B mode ultrasonography) is ideal for showing bone, organs and soft tissue, whereas the Doppler effect which describes the change in frequency when a sound wave is reflected in an interface in movement, is particularly useful in medicine since it gives information about the vessel blood flow, to identify occlusive or thrombotic changes and for the diagnosis of acute inflammatory conditions.[2]

US is accurate, non-invasive, with an axial resolution of 0,05-0,5 mm[3,4] requires little prior patient penetration and permits patients to go home without delays to recover from the appointment, except in cases of US guided intervention. Since US scanning is a real time, live the whole process, findings can be discussed with patients on soft and bone tissue pathology. Clinical findings such as edema, ligament and muscle rupture, bone erosions, inflammation and muscle atrophy, can easily and instantly be measured (diameter & cross-sectional area,) with the use of diagnostic ultrasound. Studies and systematic reviews, reported the accuracy of diagnostic US, being comparable to magnetic resonance imaging MRI, in the detection of calcifying tendonitis, full thickness rotator cuff tear and subacromial bursitis, with sensitivity and specificity ranging from 93-100%.[5,6,7,8]

Therapeutic ultrasound (US) is an acoustic energy modality with a frequency of 1.0 to 3.0 MHz and beyond, which is above the upper threshold of human hearing (16 Hz to 15 to20 000 Hz). It interacts with soft tissues but does not produce images. It is

routinely used in physiotherapy clinical practice for musculoskeletal pain in several conditions, including ligament sprains, muscle strains, tendonitis, joint inflammation, plantar fasciitis, metatarsalgia, facet irritation, impingement syndrome, bursitis, rheumatoid arthritis, osteoarthritis (OA), and scar tissue adhesions.[9] Therapeutic ultrasound is applied following on from a reliable diagnosis and causes thermal and non-thermal effects depending on the application parameters, which promote tissue repair in all stages of healing.

Ultrasound images are most commonly in 2D through 3D, including the Doppler facility permits vascular attachments to be viewed and blood flow velocity measured, this is important not only in vascular imaging but also to discriminate benign lumps from others and to visualize and quantify acute inflammation. The following sections present the main areas of musculoskeletal ultrasound imaging in physiotherapy clinical practice.

Musculoskeletal conditions and sports injuries

Musculoskeletal pain is arguably the most common complaint managed by physiotherapists. In cases of epicondylitis, or 'tennis elbow,' ultrasound imaging of the elbow joint allows for the assessment of the extent and stage of the injury. Figures 1a and 1b present longitudinal and transverse ultrasound images of the elbow, respectively. Singh (2018) reported, ultrasound to be an effective imaging tool that can be used for diagnosis of various musculoskeletal conditions, and recommended that its use by physiotherapists.[10] Kooijman et al, (2020) reported that one in six physiotherapy practices in the Netherlands used musculoskeletal ultrasound to assess mainly patients with shoulder complaints, with an emphasis on detecting tissue damage and as an aid for diagnosis.[11]

Karel et al (2017) performed a prospective cohort study of patients with shoulder subacromial impingement syndrome where they performed ultrasound scanning in 31%, in order to confirm their clinical diagnosis and detected tendinopathy, calcification, full thickness/partial thickness tears, biceps tendon rupture, biceps halo, bursitis, subacromial impingement, glenohumeral discontinuity, acromion discontinuity, labrum tear/SLAP, capsular thickening, and rotator cuff atrophycases.[12] They concluded that US led to a more specific clinical diagnosis. However, whether the effect of accurate diagnosis through US led to more efficient patient recovery cannot be supported in their study. The utility of US imaging in physiotherapy education was also described by Gaudreaulta et al, (2021), who tested the accuracy of anatomical palpation of musculoskeletal structures, as assessed through ultrasound in 24 first year physiotherapy students.[13] The results demonstrated a palpation accuracy of students ranging from 9- 64%, as evaluated by four ultrasound experts (Kappa coefficient: 1.00), depending on the anatomical structure, highlighting the ability of ultrasound in assessing the surface anatomy and palpation skills of physiotherapy students.

Musculoskeletal injuries in sport are another area where physiotherapists are involved for the assessment, treatment and functional rehabilitation. Approximately 30% of sports injuries are muscle and tendon injuries, with ultrasound (US) playing a major role in sports traumatology diagnosis as well as treatment[14]: This can be done on site i.e. on a field of play, or in a clinic, since ultrasound machines are small, battery driven and portable: in current practice images may be recorded on smartphones for transmission analysis and reporting. According to Callaghan (2012), the ability to request various forms of imaging has transformed their role in the assessment and management of sport injuries.[15] De Smet et al, (2021), underlined that US is considered the imaging technique of first choice for the diagnosis of muscle and tendon lesions[17]. (Figures 1&2)

The examination should be conducted within a timeframe of 2 to 48 hours following muscle trauma in order to evaluate the extent of hematoma formation and, consequently, to facilitate the grading of muscle lesions. US imaging can also be used to perform various interventions, overall making it an invaluable tool in the management of traumatic muscle sports injuries.[16,17,18,19]

Inflammatory joint disorders are common conditions which are assessed and managed by Rheumatologists and other adequately trained clinicians, including physiotherapists. Ultrasound can be used for real time diagnosis and early detection, quantification and grading of various lesions in adult and juvenile rheumatoid arthritis including, synovitis, enthesitis, bone erosion, cartilage damage, tenosynovitis and tendon damage.[20,21]

MSUS imaging is indicated for the diagnosis of some proximal

and peripheral joint diseases in the shoulder, elbow, wrist and hand, hip, knee, ankle and foot, peripheral nerves and blood vessels). Rheumatoid arthritis, gout and dactylitis are commonly detected using ultrasound imaging from the acute stages of inflammation and synovitis and the chronic phase with bone erosions and cartilage damage (Figures 3&5).[22]

A Baker's cyst, which is a fluid-filled sac that forms in the popliteal fossa, which is located on the posterior aspect of the knee, between the semimembranosus and medial head of the gastrocnemius and, is easily detected with US though also on x-ray[23] (Figure 4). However, due to its non-invasive nature, ultrasound is often the preferred diagnostic modality. It also lends itself to repeat scans without radiation exposure to patients.

The above conditions, which are frequently managed by musculoskeletal physiotherapists, can be accurately diagnosed with ultrasound and monitored throughout treatment.[13,24] MSUS education techniques should be accessible to all with interest in incorporating MSUS into their practice, including rheumatologists, radiologists, non-medical health professionals and other specialties involved in the management of rheumatologic musculoskeletal conditions worldwide (European Alliance of Associations for Rheumatology [EULAR] guidelines).[25] EULAR offers competency US training to practitioners, including physiotherapists.

Ultrasound imaging in Critical care patients

Patients admitted to intensive care unit, staying for more than 7 days, may have significant complications in the cardiorespiratory and neuromuscular systems. Peripheral muscle weakness, atrophy and heterotopic ossification are among the most prominent musculoskeletal complications.[26] In these conditions, accurate, quantitative physiotherapy assessment is valuable and arguably, important. Diagnostic ultrasound maybe used in ICU patients to quantify muscle mass atrophy, by measuring cross sectional area (mm^2) and muscle diameter (mm). It can be applied upon admission, until patient discharge to follow changes in muscle mass size with time (Figure 6).

Mechelli et al (2019), demonstrated excellent correlation (r = 0.99), between US imaging and MRI for measuring anterior thigh muscle and non-contractile tissue thickness, in twenty healthy, moderately active participants.[27] Baston et al, (2022), measured the diameter of elbow flexor, knee extensor, tibialis anterior and the cross-sectional area of rectus femoris muscles within 15 critical care patients and reported good to excellent ICC (0.87-0, 99).[28] Toledo et al (2021) measured the quadriceps muscle thickness in 74 mechanically ventilated patients and showed significant muscle wasting and greater loss of muscle thickness which was associated with poorer prognosis.[29]

Heterotopic ossification (HO) is another common complication with an incidence of 11% to 73.3% in traumatic brain and spinal cord injury[30,31] (Figure 7). Diagnostic Ultrasound has been found to be highly sensitive and reliable and significantly more sensitive, in the early detection of heterotopic deposits compared to plain x-rays[32,33,34,35] as early as one-week post-injury. Kramer et al (1979) reports HO detection, describing the sonographic pictures of an ovoid, relative echo-free mass and a center core of calcification which is described as the "zone phenomenon," the centrifugal maturation fashion of H.O.[36,37]

Ultrasound imaging in respiratory conditions – COPD

The use of diagnostic US by physiotherapists for diaphragm and lung diagnostics has also been described.[38] Patients with chronic obstructive disease frequently present with disuse weakness and loss of muscle mass with a reported frequency of up to 30% and predict mortality in COPD patients.[39] Quadriceps cross sectional area measurement has been proved to be a reliable real time assessment tool for physiotherapists involved in the recovery and rehabilitation of COPD patients (figure 6). US therefore is an additional tool to monitor patient progress, and can be correlated with muscle power and overall patient functional status.[39]

According to the literature, trained physiotherapists use musculoskeletal diagnostic ultrasound imaging in several conditions and systems. Whittaker et al, 2019, in the physical therapy context, mentions that "point-of-care US can be defined as a form of examination, using US undertaken in a clinical practice setting with the intent of clarifying uncertain clinical examination findings to enhance the quality and effectiveness of a physical therapy intervention".[40] Table 1, summarizes the applications role of diagnostic ultrasound application on different anatomical sites

and conditions for diagnostic purposes, guiding treatment, monitor recovery, and optimize rehabilitation strategies, as described above.[41]

Whitaker et al, (2019), clearly defines the role of ultrasound imaging in physical therapy practice in four specific domains: a) diagnostic, so as to detect and monitor musculoskeletal pathology, b) rehabilitative, for the real time evaluation of soft tissue function during exercise, c) interventional, in order to guide percutaneous procedures such as dry needling and d) research, for the measurement of soft tissue structure and function and healing rate before and after physiotherapy interventions.[40] According to this evidence it is well defined that musculoskeletal ultrasound in physiotherapy, is not only used for diagnostic purposes but also to guide treatment, monitor recovery, and optimize rehabilitation strategies.

Considering that musculoskeletal ultrasound imaging is a relatively new technique, and the busy work load of radiologists, the use of this technique by trained physiotherapists in a regular basis during the course of treatment, is crucial and may contribute to the improvement of assessment accuracy, clinical reasoning, monitoring of patient recovery and overall quality of physiotherapy intervention.[40] Established criteria for training, competent use and regulation, are outlined by WHO (1998) which states that: "The purchase and use of diagnostic ultrasound equipment should be restricted to those who have successfully completed an adequate training program or have achieved a proven level of competence in ultrasonography". However, its note stated how improper US use and purchase can be controlled.[42]

DISCUSSION

The purpose of this non-systematic review is to present the current perspectives of musculoskeletal ultrasound, as applied not only by radiologists and other medical professionals but also from clinicians of other disciplines. Physiotherapists, who specialize in the assessment and treatment of musculoskeletal conditions, represent one of the key professional groups involved in this field. As demonstrated in this paper, the advantages of incorporating diagnostic ultrasound into physiotherapy practice are evident; in its absence, physiotherapeutic assessment would rely solely on patient history, clinical signs and symptoms, and physical examination. These findings would need to be validated by a Radiology department or Rheumatologists which adds to their workload.

In current day the use of US imaging by trained clinicians such as physiotherapists should bring swifter assessment and management to patients.

Assessing the US, permits real time accurate objective diagnosis, which as part of the clinical reasoning process, in turn verifies or rejects the original assessment hypothesis. This could be of value in the precision of the physiotherapy assessment and the selection of the appropriate interventions.

Diagnosis, rehabilitation, intervention, research and physiotherapy education are some of the advantages presented and support this argument.[40] It is widely accepted that ultrasonography has become an invaluable first-line imaging modality for the diagnosis and treatment of diseases of the musculoskeletal system. Ultrasound is a non-invasive and atraumatic imaging modality that does not involve ionizing radiation and allows for repeated examinations with minimal patient preparation. Due to its safety and simplicity, patients are often able to drive themselves home following the procedure. Moreover, it facilitates continuous integration with clinical examination, enhancing real-time diagnostic decision-making.[43] The use of ultrasound imaging by physiotherapists has gradually evolved and although reported in the literature since the 80's, it's application in routine physiotherapy practice is not well established, with only a percentage of 18% in Australia owned a US machine themselves.[24,44]

As mentioned by Whittaker, (1996 & 2019), the value of ultrasound imaging from a rehabilitative perspective is that it allows for dynamic study (real-time images) of muscle groups as they contract.[24,40] This also applies as well to non-contractile soft tissues (tendons, ligaments, nerves, fascia) that physiotherapists are called to assess and treat. Adding US imaging, physical therapists can optimize their assessment accuracy and the effectiveness of their interventions, in order to enhance their rehabilitation and neuromuscular restoration efficacy.[24,40]

The identification of affected structures under, through ultrasound imaging, offers physiotherapists an additional advantage to verify their clinical findings, not only at the first assessment, but throughout the patient's healing process and recovery.

Transferring from therapeutic to 'rehabilitative' diagnostic ultrasound imaging as a means of providing feedback to both the therapist and the patient may contribute to optimal recovery.[40,44] Whitaker et al, 2019, underlines the definition of rehabilitative US 'as a procedure used by physiotherapists to evaluate muscle and related soft tissue morphology and function during exercise and physical tasks and to assist in the application of therapeutic interventions, aimed at improving neuromuscular function'.[40] It can be repeated as often as necessary, without complications or side effects, in order to reassess and monitor recovery. Another advantage reported, is that it can be used with the patient in any position, which allows for patient movement and assessment of muscle function in positions such as lying, sitting or standing. Furthermore, considering the use of diagnostic ultrasound by trained physiotherapists, it can contribute significantly to the reduction of the heavy workload of the radiology departments. As Whitaker et al (2019) point out, 'future efforts should focus on developing international standards for self-governance of US use by physical therapists and ensuring that training and practice standards are identified, reached and maintained'.[40]

In addition to physiotherapists, other clinicians also use US for example, nurses and midwives routinely use Doppler and us imaging to better manage fetal and neonates, podiatrists use Doppler in diabetic foot management as do vascular nurses, which expands its interdisciplinary scope of practice. Clearly, adequate training and certification in US imaging is part and parcel of clinical governance in present day clinical management.

In current practice US devices are portable, and can be easily used in outpatients' departments to home visits and sporting fields for a more accurate and "on the spot" image acquisition and diagnosis. Education and training are essential for physiotherapists using US and should be encouraged by their departments in order to provide support and funding for agreed training courses by several associations such as EULAR [2019].

The present review statement aims to describe the value of diagnostic ultrasound imaging in physiotherapy practice and its role in the quality and accuracy of clinical assessment and rehabilitation of complex musculoskeletal injuries and disorders. According to Manske et al (2023), physiotherapists are equipped with the theoretical knowledge to acquire and interpret static and dynamic images and correlate these with the pathological mechanisms. Ludwig & Madenidou (2022) recognize the use of ultrasound scanning together with rheumatologists and radiologists in soft tissue and haematological conditions, since it is noninvasive, accurate and relatively inexpensive. Appropriately trained physiotherapists, on US imaging, should be qualified to use US imaging in order to correlate its findings with the clinical history, improve their intervention quality and monitor patients' progress and recovery[41]. In a review paper, patient case reports were presented, describing the use of diagnostic ultrasound in physical therapy practice[41] and in an observational cohort study it was shown that ultrasound imaging by certified USA physical therapists directly influenced patient care by informing the diagnostic process, guiding treatment, and appropriately identifying referrals.[45]

Based on current practice and evidence in the use of ultrasound imaging, there is a strong case to encourage physiotherapists and other colleagues to be educated and trained to better image systems. This would reduce workload of radiology departments while permitting more skilled radiologists to image organs, brain and other complex anatomical structures.

REFERENCES

1. Jay Smith, Jonathan T. Finnoff, Diagnostic and Interventional Musculoskeletal Ultrasound: Part 1. Fundamentals, PM&R, Volume 1, Issue 1, 2009, Pages 64-75, ISSN 1934-1482, https://doi.org/10.1016/j.pmrj.2008.09.001.
2. Catalina Poggi, Martin Palavecino, Ultrasound principles and instrumentation, Surgery pen Science, Volume 18, 2024, Pages 123-128, ISSN 2589-8450, https://doi.org/10.1016/j.sopen.2024.02.005.
3. Hadzic's Peripheral Nerve Blocks and Anatomy for Ultrasound-Guided Regional Anesthesia, 2e Ed. Admir Hadzic. The McGraw-Hill Companies, 2012, https://accessanesthesiology.mhmedical.com/content.aspx?bookid=518&sectionid=41534284
4. Ng & Swanevelder (2011) Resolution in ultrasound imaging, Continuing Education in Anaesthesia, Critical Care & Pain j Volume 11 Number 5

5. Arnold MJ, Jonas CE, Carter RE. Point-of-Care Ultrasonography. Am Fam Physician. 2020 Mar 1;101(5):275-285. PMID: 32109031.
6. Ottenheijm RP, Jansen MJ, Staal JB, et al. Accuracy of diagnostic ultrasound in patients with suspected subacromial disorders [published correction appears in Arch Phys Med Rehabil. 2010;91(12):1962-1963]. Arch Phys Med Rehabil. 2010;91(10):1616-1625.
7. Ardic F, Kahraman Y, Kacar M, et al. Shoulder impingement syndrome: relationships between clinical, functional, and radiologic findings. Am J Phys Med Rehabil. 2006;85(1):53-60.
8. Nörenberg D, Ebersberger HU, Walter T, et al. Diagnosis of calcific tendonitis of the rotator cuff by using susceptibility-weighted MR imaging. Radiology. 2016;278(2):475-484
9. Papadopoulos ES, Mani R. The Role of Ultrasound Therapy in the Management of Musculoskeletal Soft Tissue Pain. Int J Low Extrem Wounds. 2020 Dec;19(4):350-358. doi: 10.1177/1534734620948343. Epub 2020 Aug 28. PMID: 32856521.
10. Singh, 2018. Role of High-Resolution Diagnostic Ultrasound in Musculoskeletal Physiotherapy, Volume 8, Issue 5, 2018 ISSN NO: 2249-2976, Pramana Research Journal
11. Kooijman, M.K., Swinkels, I.C.S., Koes, B.W. et al. One in six physiotherapy practices in primary care offer musculoskeletal ultrasound – an explorative survey. BMC Health Serv Res 20, 246 (2020). https://doi.org/10.1186/s12913-020-05119-3
12. Karel YHJM, Scholten-Peeters GGM, Thoomes-de Graaf M, Duijn E, van Broekhoven JB, Koes BW, Verhagen AP. Physiotherapy for patients with shoulder pain in primary care: a descriptive study of diagnostic- and therapeutic management. Physiotherapy. 2017 Dec;103(4):369-378. doi: 10.1016/j.physio.2016.11.003. Epub 2016 Nov 28. PMID: 28801032.
13. Gaudreaulta, N., Karina Lebelb, Sonia Bédardc, Frédériqu Daiglea, Gabriel Venned, Frédéric Balgca: Using ultrasound imaging to assess novice physiotherapy students' ability to locate musculoskeletal structures with palpation, Physiotherapy 113 (2021) 53–60
14. Peterson, L., Renstrom, P.A.F.H., & Peterson, L. (2016). Sports Injuries: Prevention, Treatment and Rehabilitation, Fourth Edition (4th ed.). Routledge. https://doi.org/10.1201/9781315382234
15. M J Callaghan (2012) A physiotherapy perspective of musculoskeletal imaging in sport, The British Journal of Radiology, 85 (2012), 1194–1197
16. Rudy C, Thompson, Bengtzen,. Ultrasonographic Findings of Acute Achilles Tendon Rupture. JETem 2019. 4(4):V14-16
17. De Smet E., Van Dyck P., Gielen J., Vanhoenacker F.M. (2021) Imaging Techniques and Procedures in Sports Injuries. In: Vanhoenacker F.M., Maas M., Gielen J.L. (eds) Imaging of Orthopedic Sports Injuries. Medical Radiology. Springer, Cham. https://doi.org/10.1007/174_2020_239
18. Ke-Vin Chang, MD, PhD, Wei-Ting Wu, MD, and Levent Özçakar, MD, Ultrasound Imaging and Rehabilitation of Muscle Disorders Part 1. Traumatic Injuries (Am J Phys Med Rehabil 2019;98:1133–1141
19. Ali Guermazi , Frank W. Roemer, Philip Robinson, Johannes L. Tol, Ravindar R. Regatte, Michel D. Crema. Imaging of Muscle Injuries in Sports Medicine: Sports Imaging Series, Radiology: Volume 282: Number 3—March 2017
20. Luca C., Luca Z. The use of support ultrasound as a working tool for the Physiotherapist a review of the literature, Journal of advanced health care (issn 2612-1344) - 2021 - volume 3 -issue ii
21. Filippucci E, Cipolletta E, Mashadi Mirza R, Carotti M, Giovagnoni A, Salaffi F, Tardella M, Di Matteo A, Di Carlo M. Ultrasound imaging in rheumatoid arthritis. Radiol Med. 2019 Nov;124(11):1087-1100. doi: 10.1007/s11547-019-01002-2. Epub 2019 Mar 9. PMID: 30852792..
22. Gohar F, Windschall D. The new role of musculoskeletal ultrasound in the treat-to-target management of juvenile idiopathic arthritis. Rheumatology (Oxford). 2021 May 14;60(5):2046-2053. doi: 10.1093/rheumatology/keab004. PMID: 33493330.
23. Leib AD, Roshan A, Foris LA, Varacallo MA. Baker's Cyst. 2023 Aug 4. In: StatPearls . Treasure Island (FL): StatPearls Publishing; 2025 Jan–. PMID: 28613525)

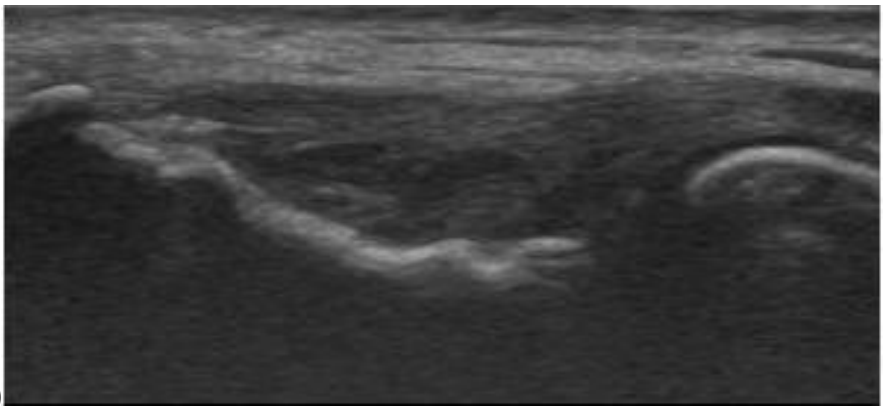
24. Whittaker J.L., Current Perspectives: The Clinical Application of Ultrasound Imaging by Physical Therapists, The Journal of Manual & Manipulative Therapy Vol. 14 No. 2 (2006)
25. Möller I, Janta J, Backhaus, M (2017) The 2017 EULAR standardised procedures for ultrasound imaging in rheumatology. Ann Rheum Dis 2017; 0:1–6. doi:10.1136/annrheumdis-2017-211585
26. Toledo DO, Freitas BJ, Dib R, Pfeilsticker FJDA, Santos DMD, Gomes BC, Silva-Jr JM. Peripheral muscular ultrasound as outcome assessment tool in critically ill patients on mechanical ventilation: An observational cohort study. Clin Nutr ESPEN. 2021 Jun; 43:408-414. doi: 10.1016/j.clnesp.2021.03.015. Epub 2021 Apr 6. PMID: 34024548.
27. Machelli et al (2019) Validity of Ultrasound Imaging Versus Magnetic Resonance Imaging for Measuring Anterior Thigh Muscle, Subcutaneous Fat, and Fascia Thickness, Methods Protoc. 2019, 2, 58; doi:10.3390/mps2030058
28. Baston M.D.,Alfred C. Gellhorn M.D.,Catherine L. et al, (2022) Inter-Rater Reliability of Quantitative Ultrasound Measures of Muscle in Critically ill Patients https://doi.org/10.1002/pmrj.12758
29. Toledo DO, Freitas BJ, Dib R, Pfeilsticker FJDA, Santos DMD, Gomes BC, Silva-Jr JM. Peripheral muscular ultrasound as outcome assessment tool in critically ill patients on mechanical ventilation: An observational cohort study. Clin Nutr ESPEN. 2021 Jun; 43:408-414. doi: 10.1016/j.clnesp.2021.03.015. Epub 2021 Apr 6. PMID: 34024548.
30. Meyers C, Lisiecki J, Miller S, Levin A, Fayad L, Ding C, Sono T, McCarthy E, Levi B, James AW. Heterotopic Ossification: A Comprehensive Review. JBMR Plus. 2019 Feb 27;3(4):e10172. doi: 10.1002/jbm4.10172. PMID: 31044187; PMCID: PMC6478587.
31. Christakou, A., Alimatiri, M., Patsaki, E., Kouvarakos, A., Papadopoulos, E., Efstathiou, F., Sidiras, G., & Nanas, S. (2019). Symptomatic heterotopic ossification: incidence and risk factors of a musculoskeletal complication in a general Intensive Care Unit. Health & Research Journal, 5(2), 66–76.https://doi.org/10.12681/healthresj.20876
32. Rosteius, T., Suero, E., Grasmücke, D. et al. The sensitivity of ultrasound screening examination in detecting heterotopic ossification following spinal cord injury. Spinal Cord 55, 71–73 (2017). https://doi.org/10.1038/sc.2016.93
33. Ranganathan K, Hong X, Cholok D. (2018) High-frequency spectral ultrasound imaging (SUSI) visualizes early posttraumatic heterotopic ossification (HO) in a mouse model, Bone 109 (2018) 49–55, https://doi.org/10.1016/j.bone.2018.01.034 8756-3282/© 2018 Elsevier Inc
34. Wang Q, Zhang P, Li P, Song X, Hu H, Li X, Chen W, Wang X. Ultrasonography Monitoring of Trauma-Induced Heterotopic Ossification: Guidance for Rehabilitation Procedures. Front Neurol. 2018 Sep 13; 9:771. doi: 10.3389/fneur.2018.00771. PMID: 30271377; PMCID: PMC6149315.
35. Stefanidis, K Brindley, P, Ramnarine, R. (2017) Bedside Ultrasound to Facilitate Early Diagnosis and Ease of Follow-Up in Neurogenic Heterotopic Ossification: A Pilot Study From the Intensive Care Unit, Journal of Head Trauma Rehabilitation: November/December 2017 - Volume 32 - Issue 6 - p E54-E58doi: 10.1097/HTR.0000000000000293
36. Kramer FL, Kurtz AB, Rubin C, et al. Ultrasound appearance of myositis ossifications. Skeletal Radiol 1979; 4:19e20.
37. Thomas EA, Cassar-Pullicino VN, McCall IW. The role of ultrasound in the early diagnosis and management of heterotopic bone formation. Clin Radiol 1991;43:190e6
38. Hayward SA, Janssen J. Use of thoracic ultrasound by physiotherapists: a scoping review of the literature. Physiotherapy. 2018 Dec;104(4):367-375. doi: 10.1016/j.physio.2018.01.001. Epub 2018 Feb 2. PMID: 29958691.
39. Seymour JM, Ward K, Sidhu PS, Puthucheary Z, Steier J, Jolley CJ, Rafferty G, Polkey MI, Moxham J. Ultrasound measurement of rectus femoris cross-sectional area and the relationship with quadriceps strength in COPD. Thorax. 2009 May;64(5):418-23. doi: 10.1136/thx.2008.103986. Epub 2009 Jan 21. PMID: 19158125.

40. Whittaker JL, Ellis R., Hodgeset P, al. Imaging with ultrasound in physical therapy: What is the PT's scope of practice? A competency-based educational model and training recommendations J Sports Med 2019; 53:1447–1453. doi:10.1136/bjsports-2018-100193
41. Manske, R., Podoll, K., Markowski, A., Watkins, M., Hayward, L., & Maitland, M. (2023). Physical Therapists Use of Diagnostic Ultrasound Imaging in Clinical Practice: A Review of Case Reports. International Journal of Sports Physical Therapy, 18(1), 215-227
42. Minimum education & training requirements for ultrasound practitioners. Australas J Ultrasound Med. 2017 Aug 23;20(3):132-135. doi: 10.1002/ajum.12061. PMID: 34760485; PMCID: PMC8409892.
43. Michel Court-Payen A guide to musculoskeletal Ultrasound. Examination techniques and ultrasonography of normal structures and pathology, http://analogicultrasound.com/applications/msk
44. McKiernan S., Chiarelli P., Warren-Forward H.: A survey of diagnostic ultrasound within the physiotherapy profession for the design of future training tools, Radiography 17 (2011) 121e125
45. Markowski, A. M., Watkins, M. K., Maitland, M. E., Manske, R. C., Podoll, K. R., & Hayward, L. M. (2022). Exploring the integration of diagnostic musculoskeletal ultrasound imaging into clinical practice by physical therapists. Physiotherapy Theory and Practice, 1-12.

ANNEX

FIGURE 1. Lateral elbow epicondylitis with bone irregularities a) longitudinal view, and b) transverse view.

a)



b)

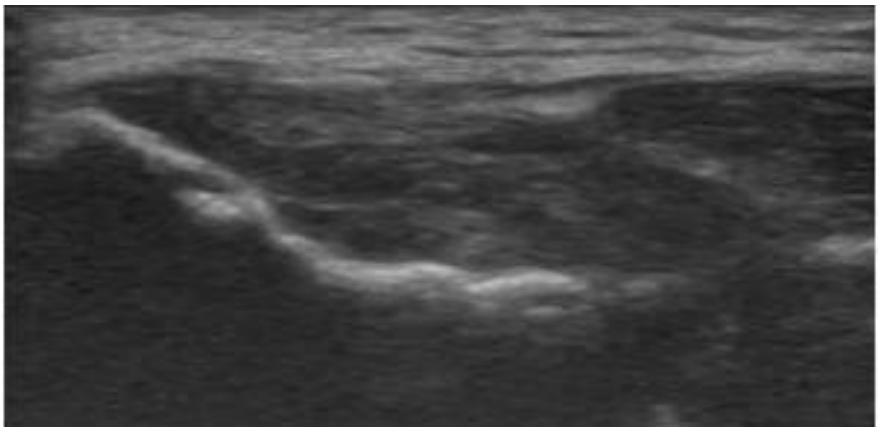


FIGURE 2. Achilles tendon complete rupture visualized as loss of continuity in the hypoechoic area (Arrow) (Reproduced with permission from Rudy et al, 2019)

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FIGURE 3. Patient with Elbow Rheumatoid arthritis, a) longitudinal view, b) transverse view. Blood flow imaging is achieved using the Doppler facility. (Reproduced with permission by J. Raftakis)

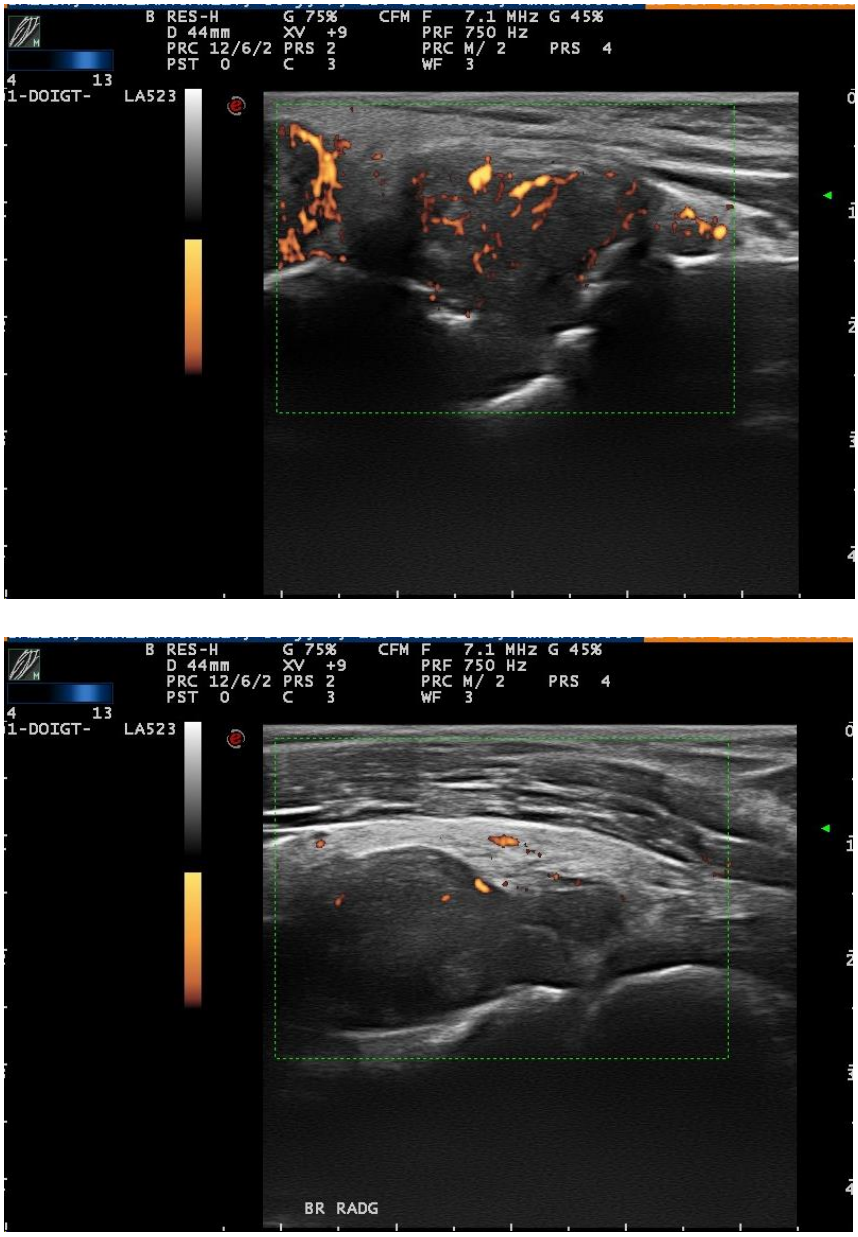


FIGURE 4. Baker's cyst or popliteal cyst, Hypoechoic zone is inflammatory infiltrate. A cyst may enlarge, decrease in size or remain the same for years. It may also rupture causing pain and swelling around the knee and lower limb. It is a differential for diagnosing Deep Venous Thrombosis (DVT).

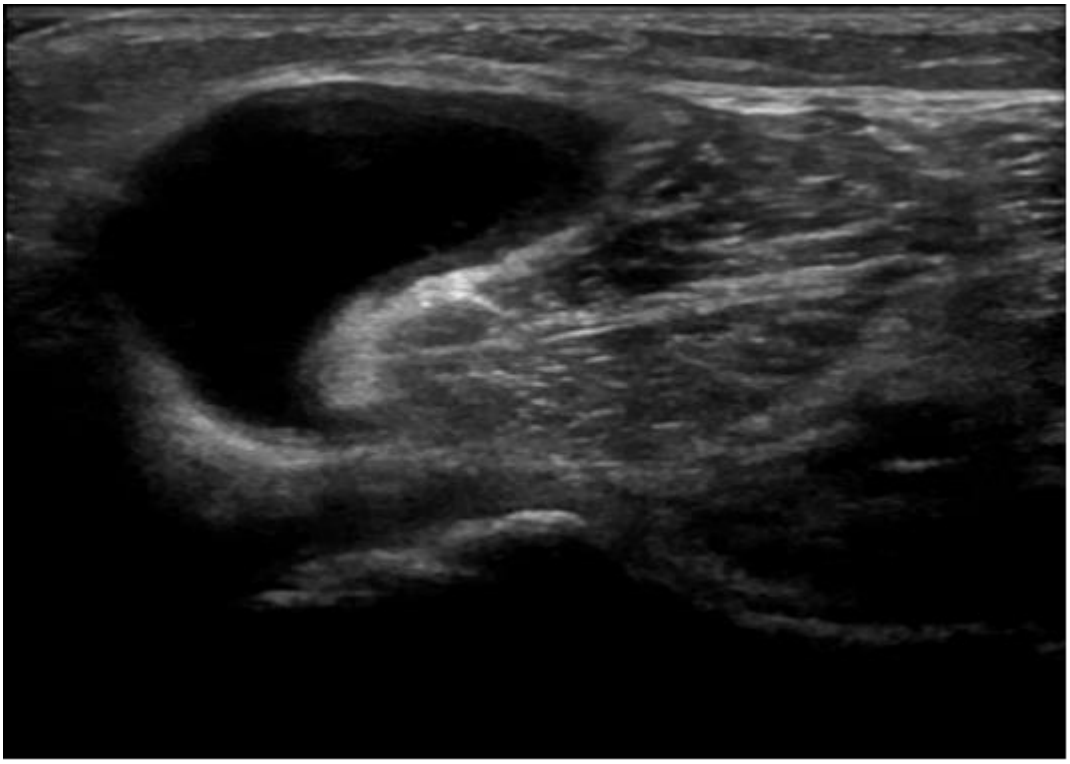


FIGURE 5. Wrist synovitis grade II metacarpophalangeal joint. (a) longitudinal and (b) transverse views (Reproduced with permission by J. Raftakis)

a)

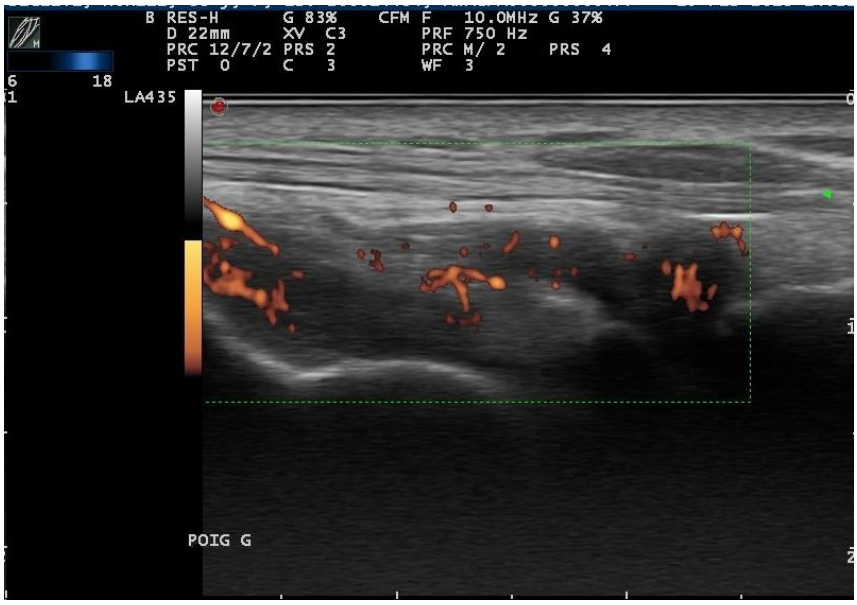
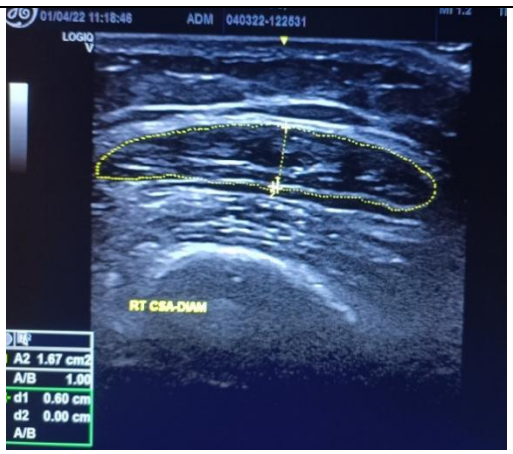


FIGURE 6. Transverse view of rectus femoris cross sectional area and diameter in an ICU patient: a) on 1st day of ICU admission b) 4 weeks later.

a)



b)

FIGURE 7. Ultrasound images of iliopsoas muscle, on day 15 of onset, with echogenic calcifications (arrows) A) longitudinal view (B) Transverse

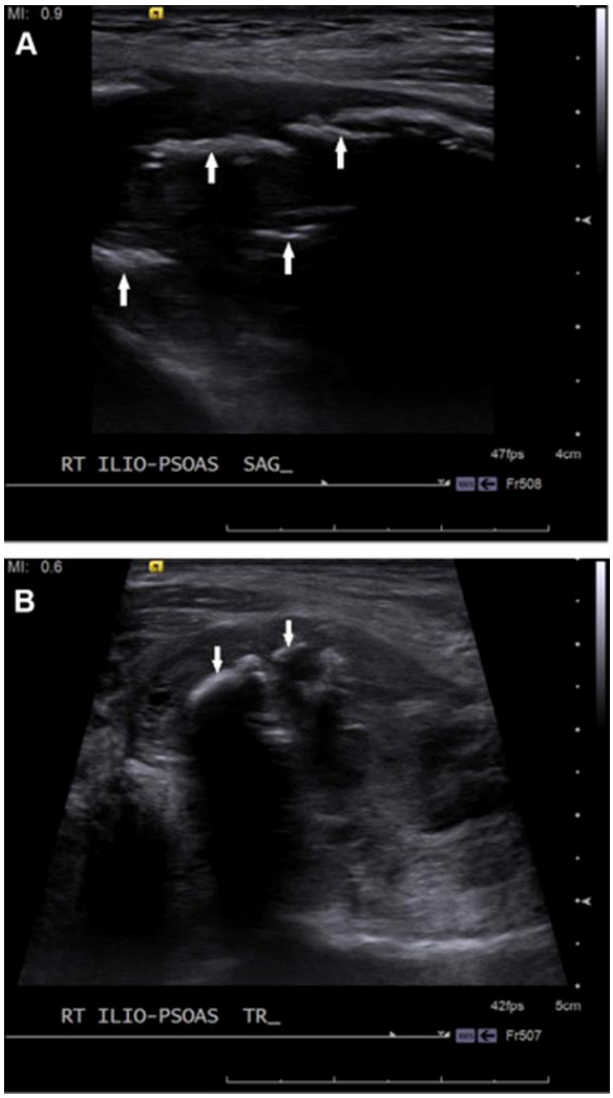


TABLE 1. Common physiotherapy musculoskeletal ultrasound imaging applications.

Ultrasound Application	Conditions Assessed	Physiotherapy Goals
Musculoskeletal lesions and sports Injuries	Muscle strains, ligament sprains, tendon injuries, bursitis, enthesitis	Injury diagnosis, measurement and post treatment recovery monitoring
Joint Pathology	Arthritis, acute inflammation, cartilage degeneration, edema	Abnormality real time imaging, measurements, goal setting and monitoring of recovery
Muscle atrophy	Muscle cross sectional area & diameter (due to injury, icu acquired weakness, disuse, or neurological conditions)	Muscle size atrophy pre and post intervention, assessment of strengthening programs, and recovery.
Peripheral nerve conditions	Peripheral nerve cross sectional area, (e.g., carpal & cubital tunnel syndrome, sciatica, etc.)	Monitor neural edema and inflammation and guidance of rehabilitation exercises
Bone fractures and degeneration	Acute and stress fractures, early detection of heterotopic ossification and calcifications, osteophytes, and bone erosions	Early detection and treatment planning and monitoring
Respiratory conditions	Diaphragm and peripheral muscle disuse atrophy, in COPD, intercostal muscles wasting	Respiratory Assessment and treatment and pulmonary rehabilitation monitoring
Research (Whittaker JL et al, 2019)	Valid and reliable outcome measure pre and post intervention effect on soft tissue healing and edema reduction and muscle weakness recovery	Quantification of the efficacy of physiotherapy interventions
Physiotherapy Education (Strike, Karen, et al. 2023)	Real time demonstration of anatomical structures and images, for educational purposes in Physiotherapy curricula	Improvement of the physiotherapy student's surface anatomy and assessment skills