KOZIAK, Weronika, DUDEK, Stanisław, MAKIEŁA, Michalina, BĘTKOWSKA, Aleksandra, KORNACKA, Agata, DUDEK, Wojciech, SZOSTAK, Kamila, TOMAKA, Rafał, BYRA, Anna, and MAKIEŁA, Marta. Application of Point-of-Care Ultrasound in Sports Medicine: A Narrative Review. Quality in Sport. 2025;39:58497. eISSN 2450-3118.
https://dx.doi.org/10.12775/QS.2025.39.58497
https://apcz.umk.pl/QS/article/view/58497

The journal has been 20 points in the Ministry of Higher Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Higher Education and Science of 05.01.2024. No. 32553.
Has a Journal's Unique Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 r. Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398.
Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 04.02.2025. Revised: 12.02.2025. Accepted: 14.03.2025. Published: 14.03.2025.

Application of Point-of-Care Ultrasound in Sports Medicine: A Narrative Review

Weronika Koziak [WK]

Wolski Hospital Dr. Anna Gostyńska

Marcina Kasprzaka 17, 01-211 Warsaw, Poland

weronikakoziak@icloud.com

https://orcid.org/0009-0003-5295-5765

Stanisław Dudek [SD]
University Clinical Center of the Medical University of Warsaw
Banacha 1A, 02-097 Warsaw, Poland
stanislaw.dudek0@wp.pl
https://orcid.org/0009-0002-3641-4865

Michalina Makieła [MM]
Wolski Hospital Dr. Anna Gostyńska
Marcina Kasprzaka 17, 01-211 Warsaw, Poland
michalinamakiela@gmail.com
https://orcid.org/0009-0003-4465-8584

Aleksandra Bętkowska [AB]
National Medical Institute of the Ministry of the Interior and Administration
Wołoska 137, 02-507 Warsaw, Poland
ola.betkowska@gmail.com
https://orcid.org/0009-0001-5108-4262

Agata Kornacka [AK]
University Clinical Center of the Medical University of Warsaw
Banacha 1A, 02-097 Warsaw, Poland
akornackaa13@gmail.com
https://orcid.org/0009-0007-2877-3514

Wojciech Dudek [WD]
Military University of Technology
2 Kaliskiego Street, 00-908 Warsaw, Poland
wojtek.dudek6@wp.pl
https://orcid.org/0009-0000-2404-9560

Kamila Szostak [KSz]
The Infant Jesus Teaching Hospital
Lindleya 4, 02-005 Warszawa
kamilaszostak999@gmail.com
https://orcid.org/0009-0005-6216-0864

Rafał Tomaka [RT]
University Clinical Center of the Medical University of Warsaw
Banacha 1A, 02-097 Warsaw, Poland
rafaltomaka1998@gmail.com
https://orcid.org/0009-0002-5057-6131

Anna Byra [ABy]
Medical University of Silesia in Katowice
Poniatowskiego 15, 40-055 Katowice, Poland
annabyra23@gmail.com
https://orcid.org/0009-0009-7934-5493

Marta Makieła [MMa]
Spitalzentrum Oberwallis (Visp)
Pflanzettastrasse 8, 3930 Visp, Switzerland
marta.makiela17@gmail.com
https://orcid.org/0009-0005-7199-385X

ABSTRACT

Background

Point-of-care ultrasound (POCUS) is increasingly used in sports medicine due to its portability, real-time imaging capabilities, and ability to guide clinical decision-making. As a dynamic, cost-effective, and non-invasive tool, POCUS has been incorporated into the diagnosis and management of musculoskeletal injuries among athletes.

Objective

This review evaluates the applications of POCUS in sports medicine, including its role in diagnosing soft tissue and musculoskeletal injuries, monitoring recovery, and guiding therapeutic interventions.

Results

POCUS is highly valuable for the rapid assessment of muscle, tendon, ligament, and joint injuries. It provides real-time visualization of dynamic structures, assisting in immediate decision-making and treatment planning. Compared to traditional imaging modalities such as X-ray and MRI, POCUS offers advantages in accessibility, cost, and repeatability.

Conclusion

POCUS is a crucial imaging tool in sports medicine, enabling rapid injury assessment and aiding in return-to-play decisions. However, further research is required to standardize protocols, improve operator training, and optimize its integration into clinical practice.

Keywords: point-of-care ultrasound, musculoskeletal ultrasound, sports medicine, soft tissue injuries, rehabilitation, imaging modalities

Introduction

Point-of-care ultrasound (POCUS) has become an essential imaging modality in sports medicine, enabling rapid, bedside assessment of musculoskeletal injuries. As a portable, cost-effective, and non-invasive diagnostic tool, POCUS allows clinicians to visualize soft tissue, bone, and joint structures in real-time, facilitating faster decision-making for injury management (Bakeer and Shapiro 2019). Unlike traditional imaging techniques such as radiography and MRI, POCUS provides dynamic assessments, which are particularly valuable for evaluating ligament stability, muscle function, and tendon integrity (Finnoff et al. 2016).

The role of POCUS in sports-related injuries has expanded significantly, with its application extending beyond musculoskeletal pathology to include fractures, joint effusions, traumatic brain injuries, and even ocular trauma (Hyoun Jeong and Miller-Spears 2021). POCUS has proven particularly effective in diagnosing rotator cuff tears, lateral epicondylitis, distal biceps

tendon ruptures, and anterior talofibular ligament (ATFL) injuries, which are common in athletes (Nakashima et al. 2022). Additionally, its ability to detect fractures and assess cortical integrity has made it an invaluable tool for on-field evaluations of high-impact sports injuries (Olympia, O'Neill, and Silvis 2024).

POCUS is widely recognized for its applications in musculoskeletal (MSK) imaging, its utility in sports medicine extends far beyond the assessment of soft tissue and joint injuries. POCUS is increasingly being integrated into standardized trauma assessment protocols and screening programs, enhancing athlete safety through rapid, on-field diagnostics and preventive cardiac assessments. One notable example is the Focused Assessment with Sonography for Trauma (FAST) protocol, which is being utilized in contact sports to quickly evaluate internal injuries following high-impact collisions. This allows for early detection of internal bleeding, pneumothorax, or organ damage, ensuring timely medical intervention and reducing the risk of life-threatening complications (Montoya et al. 2016).

Additionally, cardiac POCUS screening protocols are emerging as vital tools for detecting cardiovascular abnormalities in athletes. The Screening the Heart of the Athlete Research Program (SHARP) has been developed to enable nonexpert examiners to assess common structural etiologies associated with sudden cardiac arrest and sudden cardiac death (Moulson et al. 2019).

With growing evidence supporting the clinical utility of POCUS in sports medicine, further research is needed to standardize protocols, enhance training for sports clinicians, and explore emerging applications (Lerchbaumer, Perschk, and Gwinner 2024). This narrative review aims to summarize the current applications of POCUS in sports medicine, highlight its advantages and limitations, and discuss potential future directions for integrating ultrasound technology into routine sports injury assessment and management.

Methodology

Study Design

This narrative review was conducted by searching the PubMed, Scopus, Google Scholar, and Web of Science databases for studies published between 2000 and 2025. Titles and abstracts were screened first, followed by an evaluation of relevant full-text publications. Only peer-reviewed articles written in English were included. Studies focusing on the clinical applications, benefits, and limitations of POCUS in sports medicine were reviewed and synthesized.

Search Strategy

The following search terms and Boolean operators were used to refine results: ("point-of-care ultrasound" OR "POCUS" OR "portable ultrasound" OR "handheld ultrasound" OR "diagnostic ultrasound") AND ("sports medicine" OR "athlete assessment" OR "sports injury" OR "musculoskeletal injury" OR "exercise-related injury" OR "rehabilitation" OR "sports performance") AND ("musculoskeletal ultrasound" OR "MSK ultrasound" OR "soft tissue imaging" OR "joint ultrasound" OR "tendon imaging" OR "ligament assessment") AND ("injury diagnosis" OR "real-time assessment" OR "tendon injury" OR "muscle strain" OR "stress fractures" OR "joint effusion" OR "cartilage damage") AND ("rehabilitation monitoring" OR "return to play" OR "injury prevention" OR "functional recovery") AND ("athletes" OR "sports professionals" OR "physically active individuals") NOT (animal OR mice OR rat OR veterinary OR "non-human studies").

Additional references were identified through backward citation tracking of key systematic reviews and meta-analyses.

Inclusion and Exclusion Criteria

Inclusion Criteria:

- Peer-reviewed studies evaluating the use of POCUS in diagnosing, monitoring, and treating musculoskeletal injuries in athletes.
- Research involving human participants, particularly athletes or physically active individuals.
- Studies assessing the accuracy, efficacy, and clinical outcomes of POCUS compared to other imaging modalities.
- Studies utilizing validated ultrasound techniques, including real-time imaging and dynamic assessment.
- Studies published in English between 2000 and 2025.

Exclusion Criteria:

- Studies conducted solely on animal models without human validation.
- Research focusing on non-sports-related musculoskeletal conditions or sedentary populations.
- Studies lacking clear methodological descriptions or clinical applicability.
- Non-peer-reviewed literature, case reports, or conference abstracts without full methodological details.
- Articles that do not explicitly define the role of POCUS in sports medicine.

Data Extraction and Analysis

Key data were extracted from eligible studies, including:

- **Study characteristics**: Author(s), year, sample size, participant characteristics (age, sex, level of athletic participation);
- **Methodology**: Study design (e.g., cross-sectional, longitudinal, randomized controlled trial), ultrasound assessment techniques, and diagnostic accuracy measures;
- **Key findings**: Clinical effectiveness of POCUS in detecting musculoskeletal injuries, guiding treatment, and supporting rehabilitation outcomes.

A qualitative synthesis was performed to identify trends, inconsistencies, and knowledge gaps across studies. Studies were categorized based on the type of clinical applications of POCUS. Methodological differences across studies were critically analyzed to assess reliability, validity, and potential biases in diagnostic accuracy.

Ethical Considerations

As this study is a literature review, it does not involve direct human or animal research and does not require ethical approval. However, all referenced studies were screened to ensure adherence to ethical research practices, as indicated by institutional review board (IRB) approvals in the original studies.

Limitations of Methodology

Several limitations should be considered in this review. Variability in ultrasound imaging protocols, operator experience, and equipment settings across studies may introduce inconsistencies in findings. Individual differences in patient anatomy, injury severity, and clinical presentation further contribute to variability in diagnostic accuracy. Additionally, most studies included in this review were conducted on professional and semi-professional athletes, limiting generalizability to recreational athletes and the general population. Future research should focus on standardized imaging protocols, larger sample sizes, and multi-center trials to enhance the applicability of POCUS in diverse sports settings.

Applications of POCUS in diagnosing sports injuries

Muscle Injuries

AMuscle injuries are among the most common musculoskeletal issues encountered in sports medicine, ranging from mild strains to complete muscle tears. POCUS has become a valuable tool for real-time visualization of muscle structure, function, and healing processes, allowing clinicians to accurately assess muscle fiber disruption, hematoma formation, and tissue swelling

(Nagae et al. 2023). Unlike MRI, which remains the gold standard for soft tissue imaging but is often expensive and less accessible, POCUS provides a cost-effective and immediate alternative, particularly useful for on-field evaluations (Ghosh et al. 2017).

Studies have demonstrated that POCUS can effectively differentiate between low-grade muscle strains and more severe ruptures, which is crucial for guiding treatment and rehabilitation protocols. In cases of partial-thickness tears, POCUS reveals fascial discontinuities, fluid collections, and increased echogenicity due to hemorrhage, while complete ruptures present with a clear disruption of muscle fibers and retraction of muscle ends (Manske et al. 2024). Furthermore, the use of dynamic ultrasound imaging enables clinicians to evaluate muscle contraction and detect hidden muscle defects, which might not be apparent in static imaging (Hyoun Jeong and Miller-Spears 2021).

Tendon and Ligament Injuries

Tendon and ligament injuries are common in athletes, often resulting from overuse, excessive loading, or traumatic impact (Maganaris et al. 2004). One of the primary applications of POCUS in sports medicine is evaluating tendon pathology, including tendinopathy, partial-thickness tears, and complete ruptures. Studies have shown that ultrasound imaging can detect characteristic changes in tendinopathy, such as hypoechoic areas, increased tendon thickness, and neovascularization, which are indicative of degenerative changes and inflammation (Selame et al. 2023). In cases of partial or complete tendon tears, POCUS allows clinicians to visualize fiber disruption, detect fluid accumulation in the tendon sheath, and assess dynamic movement abnormalities, which are crucial for determining the severity of the injury (Billone, Allred, and Flores 2024).

In sports involving explosive movements and repetitive stress, such as basketball, tennis, and sprinting, Achilles tendon ruptures, patellar tendinopathy, and lateral epicondylitis (tennis elbow) are prevalent. POCUS has proven highly effective in diagnosing these conditions, particularly in assessing thickening of the Achilles tendon, loss of fibrillar structure in the patellar tendon, and the presence of neovascularization in chronic tendinopathies (Clark, Walker, and Roh 2024). The use of color Doppler ultrasound further enhances assessment by detecting increased blood flow in the affected region, which is a hallmark of chronic tendinopathy (Peers, Brys, and Lysens 2003).

Similarly, ligament injuries, such as anterior talofibular ligament (ATFL) sprains, medial collateral ligament (MCL) tears, and ulnar collateral ligament (UCL) injuries, are frequent in high-impact sports. POCUS enables clinicians to evaluate ligament integrity in real-time,

identify fiber discontinuities, detect joint effusion, and assess dynamic instability (Pigozzi et al. 2024). For instance, dynamic stress ultrasound testing is commonly used in assessing UCL injuries in baseball pitchers, where valgus stress is applied to determine ligament laxity (Hanna et al. 2024).

Joint Injuries

Joint injuries are a frequent concern in sports medicine, often resulting from acute trauma, repetitive stress, or degenerative changes. POCUS has emerged as a valuable diagnostic tool for assessing joint effusions, synovial inflammation, cartilage damage, and ligamentous instability, offering real-time, dynamic imaging that traditional static modalities like radiography and MRI cannot provide. (Baburkina, Ovchynnikov, and Bludova 2023).

One of the most common applications of POCUS in joint injuries is the assessment of joint effusions and synovial inflammation, particularly in knee, shoulder, and ankle injuries (Situ-LaCasse et al. 2018). In conditions such as acute traumatic synovitis, post-traumatic arthritis, or inflammatory joint diseases like reactive arthritis, POCUS enables clinicians to visualize intra-articular fluid collections, measure synovial thickening, and detect inflammatory hyperemia using Doppler ultrasound (van Leeuwen et al. 2024).

In sports with high joint stress, such as football, basketball, and martial arts, shoulder instability and dislocations are particularly common. POCUS is instrumental in diagnosing Bankart lesions, Hill-Sachs deformities, and posterior shoulder instability, allowing for real-time assessment of joint alignment and soft tissue injuries Additionally, ultrasound-guided reduction techniques for anterior shoulder dislocations have shown promising results, allowing for safer and more precise joint repositioning. (Mati and Silver 2022).

For ankle sprains, ultrasound can visualize ligament disruptions and hematoma formation, providing critical information on the severity of the injury (Kozaci et al. 2017).

Head Injuries

POCUS is increasingly being used in the assessment of head injuries in athletes, providing rapid, real-time imaging for detecting intracranial abnormalities, skull fractures, and elevated intracranial pressure (ICP). Its portability and ease of use make it a valuable tool in on-field evaluations and emergency sports medicine settings (Särestöniemi et al. 2024).

One of the most critical applications of POCUS in head injuries is the evaluation of elevated intracranial pressure using the optic nerve sheath diameter (ONSD) measurement. Studies have shown that POCUS can effectively assess increased ICP in athletes with suspected traumatic brain injury (TBI) by measuring ONSD, which correlates with intracranial hypertension

(Sutarjono et al. 2022). This method provides a non-invasive alternative to CT scans, particularly useful in sideline assessments or resource-limited settings.

Additionally, POCUS has been used to detect skull fractures and assess cerebral blood flow using transcranial Doppler (TCD) ultrasound. Research has demonstrated that skull fractures in athletes can be rapidly identified through ultrasound, reducing the need for immediate CT scans and expediting clinical decision-making (Ackermann et al. 2024). Furthermore, transcranial Doppler ultrasound allows real-time evaluation of cerebral hemodynamics, which can be beneficial in monitoring concussion-related changes in blood flow dynamics (Aspide, Robba, and Bilotta 2022).

Another promising application of POCUS in head injuries is its role in cervical spine assessment. In athletes with head trauma and suspected cervical spine injuries, ultrasound has been used to evaluate ligamentous integrity, vertebral artery flow, and soft tissue damage (Dadabo and Jayabalan 2018).

With its ability to assess ICP, detect skull fractures, evaluate cerebral hemodynamics, and assist in concussion management, POCUS is becoming an essential tool in sports-related head injury assessment. As technology advances and AI integration improves, ultrasound-based head injury diagnostics may become a standard component of sideline and emergency sports medicine protocols (Jones et al. 2023).

The Role of POCUS in Preventive Health Screening for Athletes

One of the primary applications of POCUS in preventive screening is cardiovascular assessment, particularly in detecting conditions such as hypertrophic cardiomyopathy (HCM) and sudden cardiac death risk factors. Studies have shown that pre-participation cardiovascular screening using POCUS can complement or even replace electrocardiograms (ECG) for identifying structural heart anomalies (Cantinotti et al. 2021). This is especially relevant for young competitive athletes, where early detection of cardiac anomalies can significantly reduce mortality risks (Williams et al. 2019).

In addition to cardiovascular assessments, POCUS is instrumental in musculoskeletal screening, helping to identify asymptomatic tendon and ligament abnormalities, early signs of osteoarthritis, and joint instability. The ability to visualize early tissue damage before clinical symptoms appear allows sports medicine practitioners to implement targeted interventions, reducing the risk of overuse injuries (Jones et al. 2023). Furthermore, POCUS has been effectively used in the evaluation of ACL injuries, where dynamic ultrasound can detect

ligament laxity and micro-tears, aiding in personalized training modifications (Dávid et al. 2024).

With its ability to rapidly identify cardiovascular risks, detect early musculoskeletal changes, and guide rehabilitation protocols, POCUS is proving to be an essential tool for preventive health screening in athletes, helping sports professionals ensure optimal performance and long-term health

POCUS is becoming an essential non-invasive diagnostic tool for assessing vocal cord dysfunction (VCD) in athletes, particularly those engaged in high-intensity endurance sports where respiratory limitations can impact performance. VCD, characterized by abnormal vocal fold motion leading to airway obstruction, is often misdiagnosed as exercise-induced asthma. POCUS offers real-time imaging of vocal fold movement, helping differentiate VCD from other respiratory conditions (Wiltrakis and Gutierrez 2022).

One key advantage of ultrasound in VCD evaluation is its ability to visualize laryngeal structures dynamically without requiring invasive procedures like laryngoscopy. Studies have demonstrated that transcervical ultrasound allows for accurate assessment of vocal fold motion and airway dynamics, making it a preferred method for on-field and clinical settings (Sayyid et al. 2019).

Furthermore, POCUS can guide therapeutic interventions for athletes with VCD, such as biofeedback therapy and breathing retraining programs. A recent study highlighted the use of ultrasound-guided respiratory muscle training, which has been shown to improve diaphragmatic function and reduce laryngeal obstruction symptoms in athletes suffering from recurrent VCD episodes (Wiltrakis and Gutierrez 2022).

With its ability to provide rapid, real-time, and non-invasive assessment of vocal cord motion, POCUS is proving to be a valuable diagnostic and therapeutic tool in sports medicine, particularly for athletes experiencing unexplained dyspnea during exertion. As AI-driven ultrasound applications continue to evolve, the integration of automated motion tracking and vocal cord analysis could further improve early detection and management of VCD in athletes (Ntoumenopoulos, Andersen, and Hardingham 2024)

Role of POCUS in rehabilitation

POCUS has become an integral component in the rehabilitation of athletes, providing real-time visualization of musculoskeletal structures and aiding in the monitoring of injury recovery. By offering immediate feedback on muscle fiber integrity, tendon healing, and joint stability,

POCUS allows clinicians to tailor rehabilitation protocols to the specific needs of the athlete (Page et al. 2023).

In the context of muscle injuries, POCUS enables the accurate assessment of muscle fiber disruption, hematoma formation, and tissue regeneration, which is crucial for determining the appropriate intensity and timing of rehabilitation exercises (Sanoja and Shalaby 2024). Furthermore, POCUS is used to evaluate tendon pathologies such as tendinopathy and partial tears, guiding eccentric loading programs and other therapeutic interventions (Manske et al. 2024).

Another significant application of POCUS in rehabilitation is its role in biofeedback and patient education, allowing athletes to visualize their muscle contractions and joint movements, thereby improving neuromuscular control and enhancing adherence to rehabilitation protocols (Smith et al. 2022). Additionally, ultrasound-guided interventions such as trigger point injections and platelet-rich plasma (PRP) therapy are becoming more prevalent, providing precise treatment delivery that accelerates recovery (Smith et al. 2023).

These advancements in POCUS technology are transforming rehabilitation practices in sports medicine, allowing for quicker return-to-play decisions and reduced risk of reinjury (Bush, Umlauf, and Pickens 2024). As research continues to evolve, the integration of POCUS into rehabilitation protocols will undoubtedly enhance the effectiveness of therapeutic interventions and support optimal recovery outcomes for athletes.

POCUS as a Performance Monitoring Tool for Athletes

Studies suggest that early detection of muscle imbalances, asymmetries, and compensatory movement patterns through ultrasound can help reduce injury risk and optimize training strategies (Pigozzi et al. 2024).

POCUS is gaining recognition as an essential tool in monitoring athletic performance, enabling real-time visualization of muscle function, tendon health, and cardiovascular adaptations. Unlike traditional imaging methods, POCUS allows for on-the-spot assessment of biomechanical efficiency and tissue response to training loads, making it particularly valuable for high-performance athletes (Lau and See 2022).

One key area where POCUS is used for performance monitoring is muscle and tendon integrity. Studies have shown that dynamic ultrasound assessment can detect early signs of tendinopathy, muscle fatigue, and microtears, preventing potential overuse injuries before they escalate into chronic conditions (Ahmed and Nazarian 2010). This is especially relevant in endurance sports, where repetitive strain can lead to degenerative changes in tendons and ligaments.

In addition to musculoskeletal assessments, POCUS is also used to monitor hemodynamic responses in athletes, providing real-time insights into cardiovascular efficiency. Research has highlighted the use of Doppler ultrasound to evaluate blood flow patterns, cardiac output, and venous return, particularly in endurance athletes who require optimal cardiovascular function for peak performance (Hu et al. 2023)

Optimizing Sports Medicine with Structured POCUS Protocols

POCUS has revolutionized sports medicine diagnostics and rehabilitation, leading to the development of standardized protocols that enhance injury assessment, recovery monitoring, and cardiovascular screening. These protocols ensure consistency and accuracy in ultrasound application across different sports settings, from sideline evaluations to pre-participation screenings and rehabilitation clinics.

One of the key protocols in sports medicine is the ESCAPE (Emergency Sonography for Clinical Assessment in the Prehospital Environment) Protocol, which is widely used for on-field injury assessments. This protocol enables rapid identification of musculoskeletal injuries, including ligament disruptions, joint effusions, and muscle tears, reducing the need for immediate MRI or radiography. Particularly useful in contact sports such as rugby, football, and combat sports, the ESCAPE Protocol allows clinicians to quickly differentiate between injuries requiring immediate intervention and those manageable with conservative care (Finnoff et al. 2016).

For cardiac screening, the SHARP (Sports Heart Assessment with Rapid POCUS) Protocol has become a non-invasive alternative to electrocardiograms (ECG) and echocardiography in detecting cardiac abnormalities such as hypertrophic cardiomyopathy (HCM), arrhythmogenic right ventricular cardiomyopathy (ARVC), and other conditions linked to sudden cardiac death in athletes. By integrating rapid two-dimensional ultrasound imaging with Doppler analysis, SHARP allows non-cardiologists to effectively screen athletes for cardiac risk factors before competitions, ensuring that individuals with underlying conditions are identified early (Moulson et al. 2019)

Another important protocol, the Montreal POCUS Score, plays a crucial role in rehabilitation and return-to-play decision-making. This ultrasound-based scoring system monitors muscle healing following acute injuries, providing objective criteria for determining the progression of muscle regeneration and scar tissue formation. It has been particularly useful in assessing hamstring strains, quadriceps tears, and calf injuries, where improper rehabilitation or premature return to activity increases reinjury risks. By standardizing ultrasound findings such

as muscle echogenicity, thickness, and dynamic tissue movement, this protocol helps guide progressive loading and individualized rehabilitation plans for athletes recovering from soft tissue injuries (Gendron et al. 2024).

In addition to musculoskeletal and cardiac protocols, the adaptation of the FAST (Focused Assessment with Sonography for Trauma) Protocol for sports injuries has enhanced the diagnosis of internal trauma and thoracic injuries in athletes. Originally developed for emergency medicine, the FAST protocol has been modified to rapidly assess rib fractures, pneumothorax, and abdominal trauma in sports like hockey, American football, and extreme sports, where high-impact collisions are common. It is particularly valuable for triaging athletes in pre-hospital settings, allowing medical teams to determine whether emergency imaging or conservative management is necessary (Hahn et al. 2020)

With the standardization of ESCAPE, SHARP, Montreal POCUS Score, FAST adaptations, POCUS is becoming indispensable in sports medicine, offering real-time, cost-effective, and dynamic assessment tools that facilitate faster diagnoses, personalized rehabilitation strategies, and safer return-to-play decisions.

AI-Driven POCUS: Advancing Sports Medicine

Artificial intelligence (AI) is revolutionizing POCUS in sports medicine, enhancing diagnostic precision, efficiency, and predictive analytics. AI-powered POCUS applications are now being integrated into sports medicine to automate image analysis, detect injury patterns, and assist clinicians in real-time musculoskeletal assessments (Yammouri and Ait Lahcen 2024).

One of the primary advantages of AI-driven POCUS is its ability to automate measurements of muscle thickness, joint space narrowing, and soft tissue abnormalities, reducing inter-observer variability and increasing diagnostic reliability. Studies show that machine-learning algorithms can detect subtle changes in tendon integrity and muscle architecture, enabling early identification of overuse injuries and degenerative conditions (Mora 2023).

Another area where AI-integrated POCUS is transforming sports medicine is in cardiac and vascular assessments for endurance athletes. AI-powered Doppler ultrasound is now being used to monitor hemodynamic changes, cardiac output, and vascular compliance, offering non-invasive, real-time evaluation of cardiovascular efficiency during training sessions (Baba Ali et al. 2024)

With AI-enhanced automation, predictive injury modeling, and real-time diagnostic capabilities, AI-driven POCUS is poised to become an indispensable tool in sports medicine, enabling faster, more precise, and personalized care for athletes. As research progresses, the

integration of AI into POCUS will continue to bridge the gap between diagnostics, performance optimization, and injury prevention, ultimately reshaping the future of sports healthcare..

Discussion

The findings of this narrative review highlight the growing role of POCUS in sports medicine, particularly in the diagnosis, management, and rehabilitation of musculoskeletal injuries. As a portable, real-time imaging tool, POCUS has demonstrated significant advantages over traditional imaging modalities such as MRI and X-ray, particularly in on-field settings where rapid decision-making is required. The ability of POCUS to provide dynamic assessments of muscles, tendons, ligaments, and joints enhances its clinical value, offering immediate insights into injury severity and guiding appropriate treatment strategies.

Despite its numerous advantages, challenges remain in the widespread adoption of POCUS in sports medicine. One major concern is the operator-dependent nature of ultrasound imaging, which requires specialized training to ensure accurate interpretation of findings. Variability in skill levels among clinicians may lead to inconsistencies in diagnosis and treatment decisions. Standardizing training programs and certification processes for sports medicine practitioners could enhance the reliability of POCUS assessments and facilitate broader implementation.

Another limitation involves the lack of standardized imaging protocols for POCUS in sports medicine. While some conditions, such as rotator cuff injuries and Achilles tendinopathy, have well-established ultrasound criteria, others—particularly subtle ligamentous injuries and chronic overuse syndromes—may require further research to refine diagnostic accuracy. Future studies should focus on developing evidence-based guidelines to optimize POCUS application in different sports-related injuries and ensure consistency across clinical settings.

Moreover, while POCUS is highly effective for superficial and dynamic musculoskeletal assessments, its limited ability to visualize deep structures remains a drawback. For complex intra-articular injuries or cases requiring high-resolution soft tissue evaluation, MRI remains the gold standard. However, emerging advancements in ultrasound technology, including high-frequency probes, elastography, and AI-assisted image interpretation, may help bridge this gap and improve the diagnostic capabilities of POCUS.

An exciting frontier for POCUS in sports medicine lies in its application for preventive health screening and performance monitoring. The ability to detect early signs of overuse injuries, muscle imbalances, and cardiovascular abnormalities could allow for proactive intervention strategies, reducing the risk of injuries and optimizing athlete performance. The integration of

artificial intelligence (AI) and machine learning algorithms into ultrasound technology presents a promising avenue for enhancing diagnostic accuracy and automating injury risk assessment.

Conclusion

POCUS has established itself as an indispensable tool in sports medicine, facilitating rapid and accurate musculoskeletal assessments. Its ability to provide real-time imaging at the point of care enhances decision-making, allowing for timely interventions and improved patient outcomes. The integration of POCUS into athlete screening, injury prevention, and rehabilitation protocols has demonstrated potential to optimize recovery and minimize downtime.

Despite its many advantages, the widespread adoption of POCUS presents challenges. The lack of standardized training and certification requirements may contribute to variability in diagnostic accuracy across practitioners. Additionally, while POCUS is a valuable adjunct, it should not replace comprehensive imaging techniques like MRI when deeper structures require evaluation. Future advancements, particularly in AI-driven image analysis, may further streamline the use of POCUS, reducing the dependency on operator expertise and expanding its role in allied health professions.

Further research is required to validate the use of POCUS as a routine screening tool in athletes, establish best practice guidelines, and quantify its impact on injury detection and management. With technological advancements and structured training programs, POCUS is poised to become an essential component of sports medicine, improving patient care and enhancing athlete performance.

Disclosure

Authors do not report any disclosures.

Authors' contributions

Conceptualization: WK, SD;

Methodology: WK, AB;

Software: n/a; check: WK, AB, SD;

Formal analysis: WK, AK, KSz;

Investigation: WK, AB, SD, AK, KSz, MMa;

Resources: WK, KSz, RT, MM, MMa;

Data curation: AB, SD, MM, AK, ABy;

Writing - rough preparation: WK, RT, KSz, ABy, WD;

Writing - review and editing: WK, AB, AK, MM, WD, MMa;

Visualization, WK, SD, KSz, AB, WD;

Supervision: WK, SD, AB;

Project administration: WK, AK, AB, MM, MMa;

Receiving funding: n/a.

All authors have read and agreed with the published version of the manuscript.

Funding statement

This research received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data availability statement

Not applicable.

Acknowledgments

The authors declare that there are no acknowledgments for this study.

Conflict of Interest Statement

The authors declare no conflict of interest.

References

Ackermann, Ole, Christian A. Fischer, Kay Grosser, Christina Hauenstein, Sebastian Kluge, Jörg D. Moritz, Lars Berthold, Constantin v Kaisenberg, and Christian Tesch. 2024. 'Fracture sonography—review of literature and current recommendations', *Archives of Orthopaedic and Trauma Surgery*, 144: 3025-43.

Ahmed, R., and L. N. Nazarian. 2010. 'Overview of musculoskeletal sonography', *Ultrasound Q*, 26: 27-35.

Aspide, Raffaele, Chiara Robba, and Federico Bilotta. 2022. 'POCUS Application in Neurocritical Care Patients: Transcranial Doppler (TCD/TCCS) as a Part of POCUS, from the Brain Ultrasound to Monitoring the Systemic Complications.' in Camilo N. Rodríguez, Claudio Baracchini, Jorge H. Mejia-Mantilla, Marek Czosnyka, Jose I. Suarez, László Csiba, Corina Puppo and Eva Bartels (eds.), *Neurosonology in Critical Care : Monitoring the Neurological Impact of the Critical Pathology* (Springer International Publishing: Cham).

Baba Ali, Nima, Sogol Attaripour Esfahani, Isabel G. Scalia, Juan M. Farina, Milagros Pereyra, Timothy Barry, Steven J. Lester, Said Alsidawi, David E. Steidley, Chadi Ayoub, Stefano Palermi, and Reza Arsanjani. 2024. 'The Role of Cardiovascular Imaging in the Diagnosis of Athlete's Heart: Navigating the Shades of Grey', *Journal of Imaging*, 10: 230.

Baburkina, Olena, Oleg Ovchynnikov, and Maryna Bludova. 2023. 'DIAGNOSTIC CAPABILITIES OF ULTRASOUND EXAMINATION OF THE KNEE JOINT AT THE CURRENT STAGE (LITERATURE REVIEW)', *ORTHOPAEDICS TRAUMATOLOGY and PROSTHETICS*: 101-09.

Bakeer, N., and A. D. Shapiro. 2019. 'Merging into the mainstream: the evolution of the role of point-of-care musculoskeletal ultrasound in hemophilia', *F1000Res*, 8.

Billone, Lisa M., Sarah J. Allred, and Dyan V. Flores. 2024. 'US of Acute Tendon Tears', *RadioGraphics*, 44: e240060.

Bush, M., J. Umlauf, and B. Pickens. 2024. 'Point of Care Ultrasound Guided Management of Lateral Ankle Sprains: A Case Series', *Int J Sports Phys Ther*, 19: 1020-33.

Cantinotti, Massimiliano, Raffaele Giordano, Nadia Assanta, Martin Koestenberger, Eliana Franchi, Pietro Marchese, Alberto Clemente, Shelby Kutty, and Flavio D'Ascenzi. 2021. 'Echocardiographic Screening of Anomalous Origin of Coronary Arteries in Athletes with a Focus on High Take-Off', *Healthcare*, 9: 231.

Clark, H. Y., C. Walker, and E. Y. Roh. 2024. 'Advanced Visualization of Musculoskeletal Pathologies Using MV-Flow Ultrasound: A Case Series', *Cureus*, 16: e73453.

Dadabo, Joseph, and Prakash Jayabalan. 2018. 'Chapter 33 - Acute management of cervical spine trauma.' in Brian Hainline and Robert A. Stern (eds.), *Handbook of Clinical Neurology* (Elsevier).

Dávid, Tihanyi, Németh Kinga, Csákvári Zsófia, Ribes Kitti, Szűcs Attila, and Varga Marcell. 2024. 'Dynamic point of care ultrasound is effective in the early diagnosis of anterior cruciate ligament injuries in children and adolescents', *Injury*, 55: 111729.

Finnoff, Jonathan T., Jeremiah Ray, Gianmichael Corrado, Deanna Kerkhof, and John Hill. 2016. 'Sports Ultrasound:Applications Beyond the Musculoskeletal System', *Sports Health*, 8: 412-17.

Gendron, Patrick, Martin Lamontagne, Camille Fournier-Farley, and Dany H. Gagnon. 2024. 'Prognosticating Return-To-Play Time Following a Hamstring Strain Injury Using Early Flexibility Asymmetry and Musculoskeletal Ultrasound Imaging Outcomes: An

Exploratory Study Among Canadian University Football Players', *Clinical Journal of Sport Medicine*, 34: 436-43.

Ghosh, N., D. Kruse, M. Subeh, S. Lahham, and J. C. Fox. 2017. 'Comparing Point-of-care-ultrasound (POCUS) to MRI for the Diagnosis of Medial Compartment Knee Injuries', *Journal of Medical Ultrasound*, 25: 167-72.

Hahn, Marlee, Jeremiah Ray, Mederic M. Hall, Ian Coe, Elaine Situ-LaCasse, and Anna L. Waterbrook. 2020. 'Ultrasound in Trauma and Other Acute Conditions in Sports, Part I', *Current Sports Medicine Reports*, 19: 486-94.

Hanna, Adeeb Jacob, Brian E. Fliegel, John Hayden Sonnier, Matthew B. Sherman, Michael G. Ciccotti, Robert A. Jack, and Steven B. Cohen. 2024. 'Impact of Climate on Stress Ultrasound Findings of the Elbow Ulnar Collateral Ligament in Professional Baseball Pitchers: An 18-Year Study', *Orthopaedic Journal of Sports Medicine*, 12: 23259671241245149.

Hu, Hongjie, Hao Huang, Mohan Li, Xiaoxiang Gao, Lu Yin, Ruixiang Qi, Ray S. Wu, Xiangjun Chen, Yuxiang Ma, Keren Shi, Chenghai Li, Timothy M. Maus, Brady Huang, Chengchangfeng Lu, Muyang Lin, Sai Zhou, Zhiyuan Lou, Yue Gu, Yimu Chen, Yusheng Lei, Xinyu Wang, Ruotao Wang, Wentong Yue, Xinyi Yang, Yizhou Bian, Jing Mu, Geonho Park, Shu Xiang, Shengqiang Cai, Paul W. Corey, Joseph Wang, and Sheng Xu. 2023. 'A wearable cardiac ultrasound imager', *Nature*, 613: 667-75.

Hyoun Jeong, Dae, and Erica Miller-Spears. 2021. 'POCUS in Sports Medicine.' in James M. Daniels and William W. Dexter (eds.), *Basics of Musculoskeletal Ultrasound* (Springer International Publishing: Cham).

Jones, J. C., C. Schultz, C. Podvin, D. Mikhail, and L. C. Radel. 2023. 'Point-of-Care Ultrasound (POCUS) for Sideline Youth Sports Coverage', *Curr Rev Musculoskelet Med*, 16: 493-500.

Kozaci, Nalan, Mehmet Oguzhan Ay, Mustafa Avci, Sadullah Turhan, Eda Donertas, Ahmet Celik, Ertan Ararat, and Emrah Akgun. 2017. 'The comparison of point-of-care ultrasonography and radiography in the diagnosis of tibia and fibula fractures', *Injury*, 48: 1628-35.

Lau, Y. H., and K. C. See. 2022. 'Point-of-care ultrasound for critically-ill patients: A mini-review of key diagnostic features and protocols', *World J Crit Care Med*, 11: 70-84.

Lerchbaumer, M. H., M. Perschk, and C. Gwinner. 2024. 'Ultrasound in sports traumatology', *Rofo*, 196: 440-49.

Maganaris, C. N., M. V. Narici, L. C. Almekinders, and N. Maffulli. 2004. 'Biomechanics and pathophysiology of overuse tendon injuries: ideas on insertional tendinopathy', *Sports Med*, 34: 1005-17.

Manske, R. C., C. Wolfe, P. Page, and M. Voight. 2024. 'MSK Ultrasound: A Powerful Tool for Evaluating and Diagnosing Pectoralis Major Injuries in Healthcare Practice', *Int J Sports Phys Ther*, 19: 366-71.

Mati, B., and M. A. Silver. 2022. 'Diagnosing and Treating an Acute Anterior Shoulder Dislocation Using Point-of-Care Ultrasound in an Urgent Care Setting', *Perm J*, 26: 135-38.

Montoya, J., S. P. Stawicki, D. C. Evans, D. P. Bahner, S. Sparks, R. P. Sharpe, and J. Cipolla. 2016. 'From FAST to E-FAST: an overview of the evolution of ultrasound-based traumatic injury assessment', *Eur J Trauma Emerg Surg*, 42: 119-26.

Mora, Mendez. 2023. 'Deep Generative Machine Learning to Create Synthetic 2D Ultrasound Images for Rare Disease Research', *Master's Theses*.

Moulson, N., Z. Jaff, V. Wiltshire, T. Taylor, H. M. O'Connor, W. M. Hopman, and A. M. Johri. 2019. 'Feasibility and Reliability of Nonexpert POCUS for Cardiovascular Preparticipation Screening of Varsity Athletes: The SHARP Protocol', *Can J Cardiol*, 35: 35-41.

Nagae, Masaaki, Hiroyuki Umegaki, Akito Yoshiko, and Kosuke Fujita. 2023. 'Muscle ultrasound and its application to point-of-care ultrasonography: a narrative review', *Annals of Medicine*, 55: 190-97.

Nakashima, Yuko, Toru Sunagawa, Rikuo Shinomiya, Akira Kodama, and Nobuo Adachi. 2022. 'Point-of-care ultrasound in musculoskeletal field', *Journal of Medical Ultrasonics*, 49: 663-73.

Ntoumenopoulos, George, Tiina Andersen, and Nicola M. Hardingham. 2024. 'Upper airway assessment and its implications for interventions by respiratory physiotherapists', *Physiotherapy Theory and Practice*, 40: 184-89.

Olympia, R.P., R. O'Neill, and M.L. Silvis. 2024. *Urgent Care Medicine Secrets E-Book: Urgent Care Medicine Secrets E-Book* (Elsevier).

Page, P., R. C. Manske, M. Voight, and C. Wolfe. 2023. 'MSK Ultrasound - An IJSPT Perspective', *Int J Sports Phys Ther*, 18: 1-10.

Peers, Koen H. E., Peter P. M. Brys, and Roeland J. J. Lysens. 2003. 'Correlation between power Doppler ultrasonography and clinical severity in Achilles tendinopathy', *International Orthopaedics*, 27: 180-83.

Pigozzi, Fabio, Hashel Al Tunaiji, Yannis Pitsiladis, Yung Shu Hang Patrick, Raymond So, Kirill Micallef Stafrace, Murat Dalkilinc, Ashokan Arumugam, Kate Jordan, Ramzy Ross, Wasim Labban, and Glen Hagemann. 2024. 'Congress Abstracts: 38th FIMS World Congress of Sports Medicine. Dubai, UAE, October 24-27, 2024', *Translational Exercise Biomedicine*, 1: 1-77.

Sanoja, A. J., and M. Shalaby. 2024. 'Use of Point-of-care Ultrasound to Diagnose Rectus Abdominis Strain in the Acute Setting: A Case Report', *Clin Pract Cases Emerg Med*, 8: 159-62.

Särestöniemi, Mariella, Daljeet Singh, Mikael von und zu Fraunberg, and Teemu Myllylä. 2024. 'Microwave Technique for Linear Skull Fracture Detection—Simulation and Experimental Study Using Realistic Human Head Models', *Biosensors*, 14: 434.

Sayyid, Zahra, Varun Vendra, Kara D. Meister, Catherine D. Krawczeski, Noah J. Speiser, and Douglas R. Sidell. 2019. 'Application-Based Translaryngeal Ultrasound for the Assessment of Vocal Fold Mobility in Children', *Otolaryngology–Head and Neck Surgery*, 161: 1031-35.

Selame, L., L. Walsh, M. Schwid, N. Al Jalbout, M. R. Gray, M. Dashti, and H. Shokoohi. 2023. 'Point-of-Care Ultrasound Unveiling Rotator Cuff Injuries in the Emergency Department: A Case Series', *Cureus*, 15: e47665.

Situ-LaCasse, E., R. W. Grieger, S. Crabbe, A. L. Waterbrook, L. Friedman, and S. Adhikari. 2018. 'Utility of point-of-care musculoskeletal ultrasound in the evaluation of emergency department musculoskeletal pathology', *World J Emerg Med*, 9: 262-66.

Smith, Mike, Gráinne M. Donnelly, Lucia Berry, Sue Innes, and Jane Dixon. 2022. 'Point of care ultrasound in pelvic health: scope of practice, education and governance for physiotherapists', *International Urogynecology Journal*, 33: 2669-80.

Smith, Mike, Sue Innes, Stuart Wildman, and David Baker. 2023. 'A proposed framework for point of care musculoskeletal ultrasound and ultrasound image-guided interventions by physiotherapists: scope of practice, education and governance', *The Ultrasound Journal*, 15: 15.

Sutarjono, Bayu, Jennifer Carter, Mahfuzul Majumdar, Matthew Carr, Ernest Rin, Matthew Kessel, Joseph Rauscher, Dorian Alexander, and Ekjot Grewal. 2022. 'Focused

Assessment with Sonography for Trauma (FAST) Integration and Serial Monitoring of Traumatic Brain Injury (TBI) Patients' Optic Nerve Sheath Diameter (ONSD) Using Point of Care Ultrasound (POCUS) - The FAST-POP Pilot Study', *SSRN Electronic Journal*.

van Leeuwen, Flora Hendrica Pieternella, Wouter Foppen, Pim A. de Jong, Wobke E. M. van Dijk, Johan Blokzijl, Kathelijn Fischer, and Merel A. Timmer. 2024. 'Ultrasound in addition to clinical assessment of acute musculoskeletal complaints in bleeding disorders: impact on patient management', *Research and Practice in Thrombosis and Haemostasis*, 8: 102372.

Williams, Elizabeth A., Hank F. Pelto, Brett G. Toresdahl, Jordan M. Prutkin, David S. Owens, Jack C. Salerno, Kimberly G. Harmon, and Jonathan A. Drezner. 2019. 'Performance of the American Heart Association (AHA) 14‐Point Evaluation Versus Electrocardiography for the Cardiovascular Screening of High School Athletes: A Prospective Study', *Journal of the American Heart Association*, 8: e012235.

Wiltrakis, Susan M., and Peter Gutierrez. 2022. 'Use of POCUS in the Diagnosis of Paradoxical Vocal Cord Movement', *Pediatric Emergency Care*, 38: e1085-e86.

Yammouri, Ghita, and Abdellatif Ait Lahcen. 2024. 'AI-Reinforced Wearable Sensors and Intelligent Point-of-Care Tests', *Journal of Personalized Medicine*, 14: 1088.