

Commentary: Integrating Diagnostic Ultrasound into Athletic Training Education Programs

Kellie C. Huxel Bliven, PhD, ATC*; Barton E. Anderson, DHSc, ATC*; Inder Raj S. Makin, MD, PhD, RDMS†

*Department of Interdisciplinary Health Sciences, Arizona School of Health Sciences, †Arizona School of Osteopathic Medicine, A.T. Still University, Mesa

Context: The use of point-of-care ultrasound (POCUS) is increasingly becoming a standard of care for sports medicine and orthopedic physicians. As such, there will be increased demand for athletic trainers to have knowledge and skills in diagnostic ultrasound.

Objective: To provide key considerations for integration of diagnostic ultrasound into athletic training education and address challenges and barriers to such integration.

Background: Advancements in designing portable, user-friendly ultrasound units have enabled clinicians to perform POCUS as an adjunct to the physical exam, resulting in improved patient care. Increased demands for POCUS across medicine have prompted medical schools to integrate diagnostic ultrasound throughout the curriculum, providing athletic training education programs a framework to consider within their curriculum.

Synthesis: Integrating diagnostic ultrasound throughout the curriculum provides focused experiences to prepare, conduct, and link imaging to clinical and physical exam skills. Diagnostic ultrasound has a role in visualizing structures in an anatomy course, as an adjunct to physical exam in medical conditions, orthopedic exam, and diagnosis courses, and as a visual feedback tool in rehabilitation courses, thus enabling it to be integrated throughout existing curriculum. Barriers to diagnostic ultrasound include cost, time, and faculty expertise.

Results: Cost sharing or use of ultrasound simulators can overcome cost barriers. Use of online educational modules to deliver content virtually is effective and allows face-to-face time to be spent in hands-on experiential learning. Finally, developing interprofessional partnerships to “teach the teacher” is an effective model in teaching faculty about diagnostic ultrasound.

Recommendation(s): Educational programs should consider ways to overcome barriers and integrate diagnostic ultrasound into curriculum equipping future athletic trainers with knowledge and skills for POCUS, thus increasing their effectiveness on a health care team.

Conclusion(s): Proactive integration of diagnostic ultrasound into athletic training education will equip graduates to add value to a health care team.

Key Words: Point of care ultrasound, musculoskeletal, imaging, clinical image assessment, curriculum and instruction

Dr Huxel Bliven is currently Professor of Clinical Anatomy in the Department of Interdisciplinary Health Sciences, Arizona School of Health Sciences at A.T. Still University. Please address all correspondence to Kellie C. Huxel Bliven, PhD, ATC, Department of Interdisciplinary Health Sciences, Arizona School of Health Sciences, A.T. Still University, 5850 East Still Circle, Mesa, AZ 85206. kbliven@atsu.edu.

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KEY POINTS

- Technological advancements have led to portable ultrasound units to enable point-of-care ultrasound imaging during a physical exam.
- There is an increased demand for skilled users of diagnostic imaging, particularly for in orthopedics and musculoskeletal practices.
- Athletic trainers have an opportunity to expand clinical skills by learning about and using diagnostic ultrasound imaging.
- Athletic training education programs should consider integrating diagnostic ultrasound into curricula. Before doing so, barriers and challenges should be clear with strategies to overcome them.

INTRODUCTION

Advancements in technology have increased the potential to significantly and positively impact health care management and delivery. One example of technology's positive influence on health care is diagnostic ultrasound. Historically, because of their size, cost, and complexity, diagnostic ultrasound units were exclusively housed in specialty medical clinics and imaging centers where they were operated by radiologists and credentialed sonographers, thus limiting accessibility to their use by other practitioners.¹ However, over the past 10 to 15 years, the ultrasound industry has improved software capabilities, created more user-friendly interfaces, and developed portable ultrasound units. Because of these advancements, the integration of diagnostic ultrasound into clinical practice by a variety of practitioners, including orthopedic physicians, podiatrists, and primary care physicians, across many different clinical settings has increased, and it is now widely accepted as an important adjunct to the physical exam.¹⁻³ This integration of diagnostic ultrasound has extended beyond research-based lab studies and is becoming part of the evaluation within the exam room, which has led to the coined phrase *point-of-care ultrasound*, or POCUS.^{4,5}

Internationally, POCUS, particularly in sports and exercise medicine,^{6,7} is a well-accepted imaging modality present in most clinical settings. In fact, most patients presenting with sports medicine injuries receive ultrasound imaging during the initial exam under the premise that it is a "stethoscope" providing immediate and dynamic imaging of the problematic structures.^{6,7} Use of diagnostic ultrasound in research, particularly at the shoulder, is documented in the literature.^{8,9} However, as sports medicine and orthopedic physicians in the United States increase their use of POCUS, athletic trainers and other health care professionals who routinely work with these physicians will be expected to be knowledgeable and skilled in the use of diagnostic ultrasound. As POCUS and ultrasound imaging education in US medical schools increase,¹⁰ and with the upcoming shift of professional athletic training programs to the masters level, it would be appropriate for athletic training education to consider methods to integrate diagnostic ultrasound imaging into program curricu-

la. Integration of diagnostic ultrasound into athletic training education will help to ensure our graduates are well prepared to be active and contributing members of the health care team with respect to value, knowledge, and competence in diagnostic ultrasound. This paper provides key considerations for the integration of diagnostic ultrasound in athletic training professional programs and addresses potential challenges and barriers to such integration.

TRENDS IN DIAGNOSTIC ULTRASOUND USE IN HEALTH CARE AND EDUCATION

As manufacturers continue to deliver improved imaging capabilities to the health care arena, questions about training and education of the users are raised. In the past, formal training on diagnostic ultrasound was limited to radiologists, sonographers, and emergency department physicians.^{1,11-13} Today, physical medicine,^{9-11,13} including orthopedic, sports medicine, physical medicine and rehabilitation, and rheumatology physician specialties are increasingly integrating POCUS for musculoskeletal and soft tissue diagnostic examinations. Historically, the majority of physicians in these specialties did not receive training for diagnostic ultrasound until they entered their residency or fellowship programs; however, this delayed training is outdated and recent initiatives to integrate formal diagnostic ultrasound education and training, beginning in medical school and extending through residency and fellowship programs, have been identified.^{10,11,14} Professional societies, residency, and fellowship programs now advocate and recommend formal education and competencies in diagnostic ultrasound. In 2015, the American Medical Society for Sports Medicine recommended core competencies for sports medicine fellowships in sports ultrasound, encompassing musculoskeletal regions and non-musculoskeletal components such as abdominal scanning for traumatic injuries related to sport.¹⁴

As educational efforts impact integration of POCUS in practice by orthopedic and physical medicine specialties, the role of magnetic resonance imaging (MRI), computed tomography, and diagnostic ultrasound will need to be clarified. Historically, orthopedic and sports medicine physicians have relied on MRI for soft tissue diagnostics and computed tomography for bony pathology; however, increasing health care costs and concerns about repeated radiation exposure have helped to raise the utility of ultrasound for similar diagnostic purposes.^{2,9,15} Ultrasound is becoming the primary tool for examining superficial soft tissues, such as tendons and muscles, because it is cost-effective, is accurate, and allows for real-time, dynamic imaging in the exam room.^{9,13} Further, ultrasound imaging during in-office exams influences the physician's diagnosis and management plan.^{4,13} Goodman et al⁴ reported that physicians' confidence in their diagnosis of shoulder pathology was greater with the addition of ultrasound imaging compared to only physical exam and radiology review. Physicians noted that ultrasound was useful, and specifically that it changed the diagnosis from the initial impression in 53% of patients and

affected the management plan in 60% of patients.⁴ Athletic trainers have also reported on the role of musculoskeletal ultrasound as an adjunct to physical exam in making clinical diagnoses and injury management decisions.^{16,17} Wood et al¹⁷ presented a case study of a collegiate baseball player complaining of elbow pain. The clinical exam, performed by the athletic trainer and orthopedic physician, displayed signs of an ulnar collateral ligament sprain; the MRI was negative, yet the ultrasound exam with dynamic stress testing confirmed a torn ligament.¹⁷ Tatarski¹⁶ advocates for the use of diagnostic ultrasound in athletic training practice and education, and is working to develop a model that combines diagnostic ultrasound with manual stress tests during the physical exam for ankle sprains to assess ligament integrity and joint space changes. These articles are just a few examples of the mounting evidence supporting the use of POCUS in orthopedic and sports medicine practices.

Similar to athletic training, physical therapy curriculum contains competencies related to imaging; however, guidelines in both disciplines regarding depth and breadth of competencies are lacking. Boissonnault et al¹⁸ reported that most of the professional physical therapy programs studied (98%) had ~24 contact hours of imaging within their curricula, primarily as modules in several courses (eg, anatomy, musculoskeletal, biomechanics) during the first 2 years in the program. Students were required to demonstrate competence in utilization of ultrasound clinical guidelines for diagnosing and referring patients, utilization of ultrasound imaging as an adjunct to patient care, and use of ultrasound imaging to identify normal and pathological anatomy (particularly musculoskeletal).¹⁸ While diagnostic imaging is important for athletic training students to understand globally, integration of diagnostic ultrasound as a teaching tool and use as an adjunct to the physical exam will not only inform students but develop useful clinical skills. As the positive impact of ultrasound imaging as an adjunct to the physical exam and assessment of anatomy and pathology continues to be realized in medicine, its implementation by other health care providers, including athletic trainers, will necessitate diagnostic ultrasound education and training.

CONSIDERATIONS FOR INTEGRATING DIAGNOSTIC ULTRASOUND INTO ATHLETIC TRAINING CURRICULA

When developing curricula for ultrasound imaging within athletic training education, it is important to be aware of educational and training methods most commonly used. The medical education literature contains a wealth of resources on implementation of ultrasound imaging into existing curricula. Successful implementation requires early and repeated exposure throughout existing coursework.^{5,10,19} Common delivery modes that are progressive in nature and promote learning over time include didactic lectures, hands-on laboratory scanning, and clinical experiences where POCUS is used.^{11,14,18}

Given the potential of ultrasound imaging to serve as an adjunct to learning in the classroom and as a tool for clinical practice, athletic training program faculty should consider how it can and should be integrated into existing curriculum. Jurjus et al¹⁹ promote using the Preparation, Linking, Hooking, Engagement, and Transfer (PLHET) process, and Bahner et al¹⁰ present ideas for integrating focused ultrasonography exposures and experiences for students of several health care disciplines

throughout the basic science and clinical course curriculum. Together, the ideas and concepts presented by Jurjus et al¹⁹ and Bahner et al¹⁰ provide a framework for athletic training faculty to integrate diagnostic ultrasound into their programs with ease and minimal disruption. The PLHET process both teaches students how to use diagnostic ultrasound and uses diagnostic ultrasound as a learning tool. Early introduction of basic ultrasound principles and familiarization of students with portable ultrasound units set expectations, *prepare* students with needed background information to be an informed user, and equip students with skills in acquiring real-time ultrasound images and videos. Next, *linking* and *hooking* teach students to interpret ultrasound findings on acquired images. Anatomy courses are a natural fit to stimulate and *link* what is to be learned with what one already knows by using ultrasound principles to identify basic anatomical structures.¹⁹ The hands-on and real-time learning not only reinforces anatomy but *hooks* students by highlighting the relevance to clinical practice. In order for students to use ultrasound findings for clinical decision making, focused ultrasound modules should be integrated throughout clinical courses; this integration across the curriculum continues *engagement* in the material and over time leads to *transfer*, or the reinforcement and retention¹⁹ that encourage students to view ultrasound as an adjunct tool to complement their physical exam and clinical diagnostic skills. Opportunities to integrate focused ultrasound modules into athletic training curricula include musculoskeletal exams and special tests, assessing for abdominal trauma, and assessing treatment efficacy (ie, response of an intervention on swelling, activation, and cross-sectional area of muscles following an intervention). The Table provides athletic training and ultrasound imaging examples of the PLHET process at work.

CHALLENGES AND BARRIERS TO INTEGRATING DIAGNOSTIC ULTRASOUND INTO CURRICULA

There are challenges to integrating diagnostic ultrasound imaging into educational curricula, with funding perhaps being the greatest. There are significant costs associated with purchasing and maintaining quality diagnostic ultrasound machines. Athletic training programs should weigh the pros and cons of important factors, such as cost and accessibility, of various equipment on the market. For example, portable, standard laptop-size systems with multiple transducer probes (eg, linear and curvilinear probes) cost, on average \$30 000 to \$45 000, while handheld and simulator programs cost, on average \$1000 to \$10 000. Standard portable ultrasound systems have a wide range of capabilities and allow students to engage in real-time hands-on scanning to produce images that can be saved, annotated, and interpreted, as one would do in clinical practice. Handheld simulator devices with integrated software may serve a role in providing basic imaging principles, learning correct probe placement, and visualizing grayscale images in a library that can be accessed in or outside of the classroom. To overcome the high cost associated with ultrasound units or teaching simulators, programs may explore opportunities to purchase refurbished systems, work with companies on a loaner program, or ask about educational discounts and incentives. Internally, programs may look for opportunities to collaborate with other departments in developing a proposal targeted at both cost-sharing equipment and curricular development and implementation, particularly if goals can be accomplished using interprofessional education strategies.

Table. Integration of the Preparation, Linking, Hooking, Engagement, and Transfer (PLHET) Process into Athletic Training and Ultrasound Imaging Curriculum^a

Phase	Purpose	Athletic Training Example	Ultrasound Imaging Example
Preparation	Delivery of theoretical content; establish expectations	Module delivering of clinical presentation of various shoulder injuries in an injury evaluation course	Module delivering of introductory background on imaging and instrumentation principles and practices
Hook	Elicit excitement through clinical application	Present patient case scenarios of shoulder injuries and discuss how ultrasound imaging may be used and its benefits to clinical examination and decision making	See Athletic training example
Linkage	Stimulate interest in students by relating to existing knowledge/skills	Review relevant joint-specific anatomy using a variety of resources (eg, images, models, cadavers) and relate anatomy to joint and injury mechanics	Review anatomy using a variety of resources (eg, images, models, cadavers) and relate anatomy from resources to anatomy visualized on ultrasound images
Engagement	Application and integration of existing knowledge/skills that stimulate new learning	Demonstrate individual evaluation skills (ie, range of motion, manual muscle test, special tests) and discuss clinical decision-making process	Demonstrate step-by-step of how to image relevant structures in the joint and how to interpret ultrasound images
Transfer	Reinforce new learning through practice and application to new scenarios	Practice joint-specific evaluation process and use approach with another body region	Practice ultrasound imaging techniques and identification of anatomical structures passively and dynamically at various body regions

^a Modified from Jurjus et al. 2014.¹⁹

Another common and difficult barrier to overcome is time.^{11,18,20} Faculty are frequently asked to add additional content to an already full curriculum. A seemingly plausible solution that could minimize time needed to deliver didactic content is to develop online, self-paced learning modules. Although development of such modules requires significant time, once developed, these modules can be used repeatedly without additional time requirements. Interestingly, online learning modules do not appear to be widely used in residency and fellowship programs,¹¹ yet research indicates they are effective in introducing hands-on clinical skills, particularly in athletic training.²¹ Despite a perception that live, face-to-face delivery is optimal, online learning modules can be an effective, accessible, and cost-effective method to efficiently deliver both theoretical content and applied hands-on skills. Use of such modules then enables face-to-face time to be prioritized for advanced skill development and clinical decision reasoning.²¹ To this point, research comparing knowledge and satisfaction between didactic lectures and online learning modules in radiology residents reported that both groups' knowledge in anatomy, instrumentation, and pathology improved following the delivery of content.²⁰ Residents who received didactic lectures performed slightly better than the online learning module residents; however, the difference was not statistically significant.²⁰ Lam et al²¹ conducted a pilot study on postprofessional athletic training students' knowledge and skill acquisition of talocrural joint mobilizations following online delivery of 2 short modules about theory and hands-on application of joint mobilizations. They found a significant improvement in students' knowledge and ability to perform hands-on skills following online delivery of content. The online learning modules used in these studies used Microsoft PowerPoint (Redmond, WA) and videos (MP4 files) and contained narrated presentations, narrated videos of skill application,

interactive (eg, clickable options) and animated (eg, video clips to demonstrate concept) features using case-based scenarios, annotated images and drawings, and intermittent quiz questions for self-assessment.^{20,21} These studies demonstrate that online learning modules can be effective in improving one's knowledge of diagnostic ultrasound and hands-on skills related to clinical practice. Athletic training courses on diagnosis and management of sport-related injuries may be well suited for integration of online delivery of content to facilitate hands-on learning using ultrasound imaging as an adjunct to enhance clinical examination skills.

Another identified barrier is a lack of faculty expertise in diagnostic ultrasound imaging to effectively deliver course content.^{11,18,20} Although lack of faculty experience is a barrier, there are several strategies for increasing faculty exposure to and proficiency in diagnostic ultrasound, including continuing education courses offered by private companies and professional societies and peer teaching ("teach the teacher"), all of which ideally focus on hands-on exposure and practice with ultrasound imaging.^{11,18} In a review of continuing education courses on the Board of Certification's Web site,²² 13 courses related to diagnostic or musculoskeletal ultrasound were advertised and offered between January 1, 2016, and June 13, 2017. The majority of the courses listed were 1.0 units in category A, used the live lecture format, and identified the difficulty level as essential. The content descriptions included lecture on concepts and principles of diagnostic ultrasound and imaging, identifying indications and contraindications for diagnostic ultrasound use, and using images or demonstrations to characterize normal and pathologic anatomy. Overall, the continuing education courses appear to provide foundational content, but do not engage the athletic trainer in hands-on instruction.

In an effort to gain more hands-on instruction, athletic training programs may work to identify a local and willing expert in sonography (eg, radiologist, orthopedic surgeon, sonographer, faculty in another department) to facilitate hands-on training sessions for faculty from various disciplines aligned with interprofessional and educational objectives for courses or modules in which diagnostic ultrasound imaging will be used. This approach can be successful in overcoming the lack of faculty experience, promoting interprofessional collaboration and education, and accomplishing student achievement of learning objectives, regardless of who delivers the content. Jurjus et al¹⁹ demonstrated that sonography experts do not have to be the only faculty delivering ultrasound imaging content and instruction for it to be effective. While faculty may not become experts or credentialed sonographers, faculty must commit significant time to undergo appropriate training and practice performing ultrasound imaging before becoming proficient enough to introduce it into the classroom. Jurjus et al¹⁹ used a “teach the teacher” model where credentialed sonographers trained anatomy faculty in ultrasound using didactic and hands-on methods before faculty implemented the content in anatomy laboratory modules.¹⁹ Regardless of the instructor, clinician or anatomy faculty, students had positive perceptions of the both instructor types and identified the ultrasound experience as being helpful to their understanding of the anatomy.¹⁹

CONCLUSION

With the increased use of POCUS among sports medicine and orthopedic physicians, future athletic trainers are going to have increased demands for knowledge and skills in diagnostic ultrasound imaging. To better prepare athletic training students to enter the workforce and be contributing members to the health care team, athletic training educational programs should explore options for integrating diagnostic ultrasound imaging into existing athletic training curricula. Teaching foundational concepts of ultrasound imaging, and providing repeated exposure to and use of ultrasound imaging in anatomy, exam and diagnosis, and imaging courses, in conjunction with clinical experiences where POCUS is utilized will provide students with the necessary education and training to utilize diagnostic ultrasound in their future clinical practice. Barriers including cost, time, and expertise can be overcome with strategic planning and creative use of resources including interprofessional collaboration. Proactive integration of diagnostic ultrasound into athletic training education will equip graduates to add value to a health care team and ultimately advance the profession and the care provided to our patients.

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