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EDUCATIONAL TECHNIQUE

Educational Technique: Using a Phased Approach to Integrate Diagnostic Ultrasound into Athletic Training Education

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Context: The use of point-of-care diagnostic ultrasound is increasing in health care, specifically among sports medicine clinicians as an adjunct to the physical exam. Given the role of athletic trainers in interdisciplinary sports medicine teams, athletic training educational programs should consider integrating this noninvasive imaging modality into curricula.

Objective: To provide a framework for integrating diagnostic ultrasound imaging content into existing athletic training curricula.

Background: A phased approach to incorporating ultrasound imaging into existing courses with minimal disruption is important for adoption. Foundational knowledge for skill performance begins with early exposure to ultrasound concepts and is followed by phased integration of hands-on ultrasound imaging into athletic training courses.

Description: Content delivery considerations, such as online modules and technology needs, to enhance hands-on learning is discussed. Examples of integrating diagnostic ultrasound imaging throughout the curriculum, including anatomy, clinical assessment, and manual therapy courses, are provided.

Clinical Advantage(s): Integrating ultrasound throughout curricula teaches students how to use and interpret ultrasound images as an adjunct to physical exam, enhancing the athletic trainer's value on a health care team and improving clinical practice. Ultrasound imaging can also be used as a valuable feedback mechanism during the performance of hands-on athletic training skills, including special tissue tests and manual therapy techniques.

Conclusion(s): Following initial exposure to ultrasound imaging, the inclusion of diagnostic ultrasound instruction in athletic training curricula can expose students to ultrasound imaging, basic concepts, transducer characteristics, and image interpretation, which is a valuable adjunct to clinical practice.

Key Words: Point-of-care ultrasound, musculoskeletal imaging, medical education, active learning, small group instruction

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KEY POINTS

- A phased approach to integrating diagnostic ultrasound includes basic ultrasound concepts and instrumentation, performing imaging, and application into didactic and clinical courses.
- Ultrasound concepts and activities should integrate into curriculum using the preparation, linkage, hook, engagement, and transfer approach.
- Athletic training education, at all levels, can benefit by learning and using diagnostic ultrasound to enhance clinical decision making and value on a health care team.

INTRODUCTION

The increased use of point-of-care ultrasound (or "POCUS") by physicians and other health care providers as an adjunct to the physical exam provides an interprofessional opportunity for athletic trainers. As diagnostic ultrasound imaging is more readily used at the point of care, it is appropriate for athletic training educational programs to integrate this portable and noninvasive imaging modality into the classroom. Although there may be initial challenges of funding and a paucity of trained proctors, the benefits can be significant. Exposure to ultrasound-based teaching early and continuing throughout one's athletic training professional and postprofessional education will provide learning to accomplish the goal of producing a clinician who is familiar with and trained in the use of ultrasound, thus actively contributing to the use of POCUS on an interprofessional health care team. The objective of this article is to provide a framework for integrating diagnostic ultrasound imaging content into existing athletic training curricula.

PHASED INTEGRATION INTO ATHLETIC TRAINING CURRICULUM

As educators, we appreciate the time challenges associated with integrating a new teaching modality into the classroom, particularly if theoretical and foundational concepts must be taught prior to implementing hands-on skill development. We recommend a phased approach to integrating diagnostic ultrasound imaging into a curriculum, beginning with the teaching of basic concepts of ultrasound and instrumentation, followed by techniques and nomenclature of how to use and perform imaging, and finally application into courses throughout the curriculum, beginning with anatomy and continuing into clinical evaluation courses (Figure 1).[1]

INTRODUCTION TO FOUNDATIONAL CONCEPTS

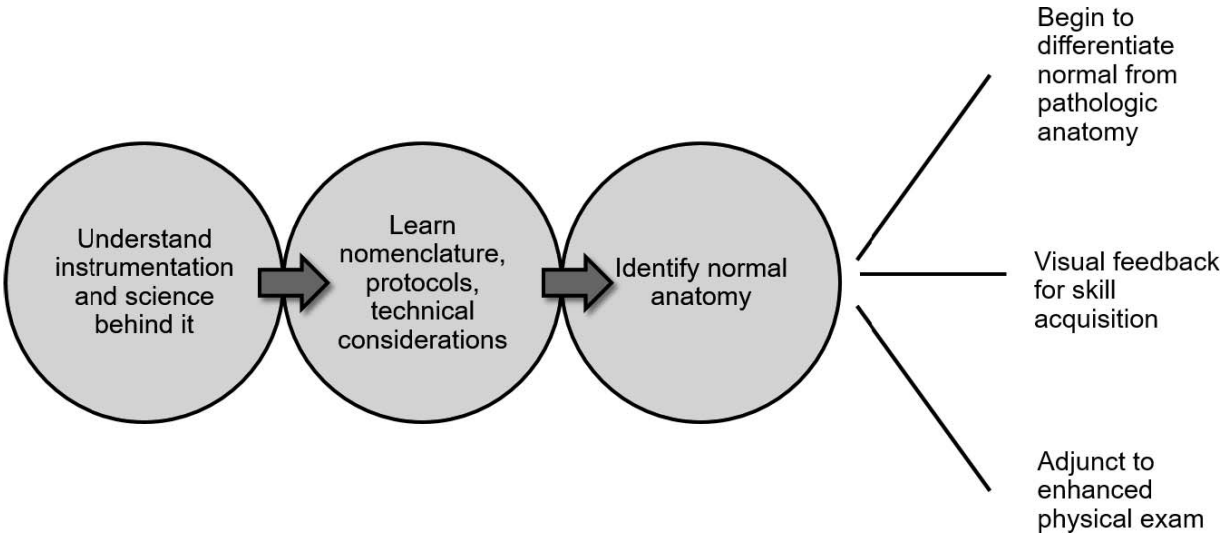
As diagnostic ultrasound imaging curricula are developed for athletic training education, it is important to produce informed, trained clinicians. This process begins with teaching the physical foundations of ultrasound as an imaging modality. Most athletic trainers are competent in ultrasound as a thermal and nonthermal therapeutic modality; therefore, it is important to compare and contrast the therapeutic modality with the diagnostic imaging modality.

The Preparation, Linkage, Hook, Engagement, and Transfer (more commonly known as "PLHET") method may be used to guide a phased approach to integration into existing curriculum.[2] The *preparation* phase begins by delivering theoretical content and setting expectations.[2] Appropriate content for basic ultrasound imaging should address propagation of ultrasound energy through tissues and the physical phenomena of energy, including reflection, scattering, and absorption. This foundational content enables a basic understanding of an ultrasound image's characteristics of hyperechoic, hypoechoic, anechoic, and anisotropy, and how ligaments, tendons, muscles, nerves, vessels, and other tissues typically appear on a grayscale ultrasound image. Once students are familiar with these basic concepts, they are taught how to use the ultrasound units. This content includes principles of instrumentation, knobology, and transducer nomenclature. Many online and textbook resources[3–10] are available to assist in identifying important and relevant basic concepts to incorporate into the preparation phase of the curriculum.

Several approaches can be used to teach the ultrasound imaging basics described above. At our institution, we have delivered this material using both a lecture and online module format. Based on our experiences, we recommend using a narrated, interactive online module prior to face-to-face class. This module should include basic ultrasound concepts and instrumentation, an overview of imaging techniques, and a review of anatomical structures. By presenting this material to students before the face-to-face class meeting, we are able to facilitate more active hands-on skill development and peer-to-peer learning in the classroom. Online modules also provide an opportunity to *link* ultrasound content to relevant athletic training patient case scenarios. Examples of clinical presentations for which ultrasound imaging may be appropriate include passive and active scanning of musculoskeletal structures to assess their integrity and scanning of abdominal organs to identify trauma related to sport participation.

To be effective, educators should be mindful of best practices for use of online learning modules. Students value learning modules with clear explanations and organization, application to practice, the ability to change the play speed, and delivery in less than 30 minutes.[11] Further, effectiveness of learning about ultrasound imaging and athletic training skills through online modules has been demonstrated, and components of such modules included narrated slides, ultrasound images, video clips of imaging, and self-assessment quizzes.[12,13] To effectively develop short online modules, we brought together a small interdisciplinary team of faculty and staff with expertise in athletic training, anatomy, diagnostic ultrasound, and institutional technology. Together, we worked to transition from delivering content through a traditional lecture format to using

Figure 1. Phased implementation of ultrasound imaging into athletic training curriculum.



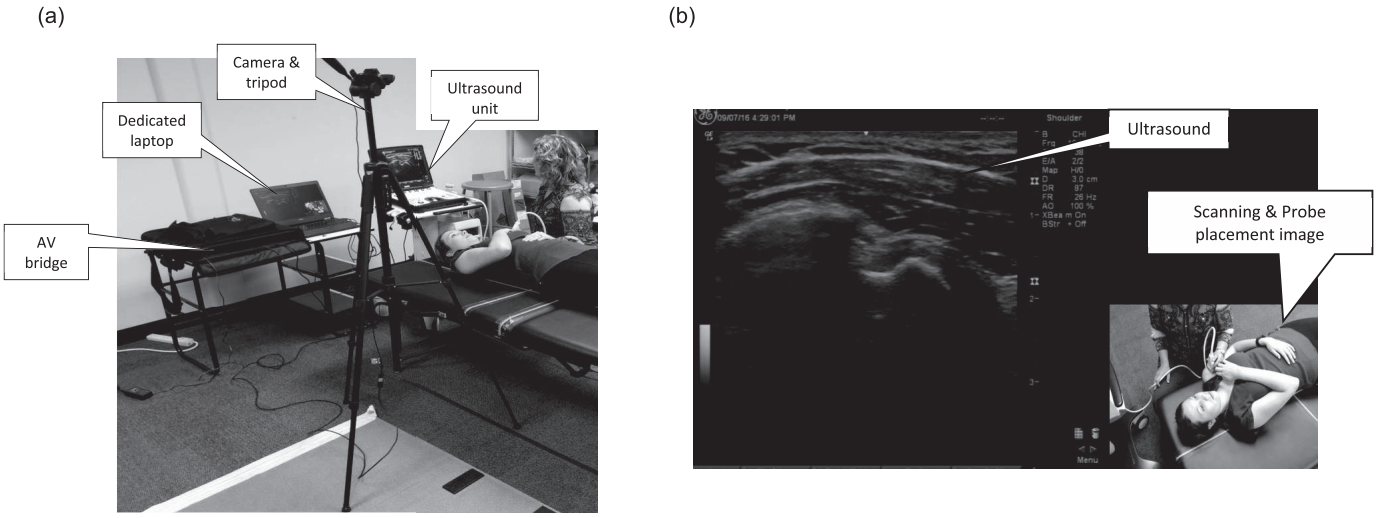
short, online interactive modules. To evaluate our programmatic goals of increased student knowledge and positive perceptions of ultrasound, we asked students to complete a short assessment following online modules. Over time, post-professional masters in athletic training students reported a better understanding of basic concepts, transducer characteristics, and how various structures appear on an ultrasound image. Further, students perceived that ultrasound has a role in athletic training curriculum and practice and that, if used appropriately, it can improve the quality of one's physical exam. It is important to remember that the overarching goals of the online modules are to build the student's knowledge base and their ability to visualize and differentiate various anatomical structures (eg, ligament, bone, tendon, muscle, nerve) on a grayscale ultrasound image to ensure they are comfortable with the upcoming hands-on learning.

As hands-on ultrasound sessions are implemented into curriculum, there are additional considerations regarding content delivery. Classroom type and class size may be a barrier to effective delivery, as it can become difficult to demonstrate ultrasound images in large classrooms unless planning and proper technology is available. To overcome this barrier, our team has implemented a mobile picture-in-picture (mPiP) system, which was supported through an internal "innovation in teaching" grant award (~$4000). Using a camera, Audio/Video (A/V) bridge, and Open Broadcaster software (freeware), the mPiP system allows a split screen to be displayed to students on projectors in the classroom (Figure 2).[1] The ultrasound machine's image is projected on most of the screen, while a limited field of the screen shows the live feed of the instructor scanning the model patient. Students can observe both the scanning actions of the instructor and the corresponding ultrasound image. Overall, the mPiP system is a cost-effective and portable approach to delivering ultrasound instruction to large classes, such as anatomy, in a variety of classrooms environments.

EARLY EXPOSURE AND IDENTIFICATION OF NORMAL ANATOMY

Once students are prepared with foundational content and a linkage is made by providing clinical scenarios with relevant ultrasound images, students should *engage* with ultrasound

Figure 2. (a) Mobile picture-in-picture system used to (b), project a split-screen display of ultrasound scanning and corresponding ultrasound image in a classroom.



units and imaging in a hands-on, peer-to-peer learning environment. Ideally, this exposure occurs early in the curriculum. We believe advanced functional or clinically oriented anatomy courses are ideal for this initial and early experience. A benefit of our interdisciplinary team is that we have buy-in from the graduate clinical anatomy faculty at our institution and recently started integrating basic ultrasound imaging into the course. Before beginning hands-on activities, we delivered the online module of foundational content and included questions related to the content in our weekly online quiz to assess knowledge. Throughout the musculoskeletal module of the course, anatomy faculty regularly included ultrasound images in lectures and took time to explain orientation and identification of structures in a normal, nonpathologic state, while emphasizing the importance of cross-sectional anatomy.

At the end of the upper extremity module, we offered a hands-on session to allow students to further *hook* and engage by using the ultrasound units to scan peers in a small group setting and identify specific upper extremity structures. The hands-on session was 50 minutes in length and included a brief overview of knobology, a short demonstration of anatomical structures by instructors, and peer-to-peer scanning in small groups. In small groups, students worked together to locate key bony landmarks (eg, bicipital groove and tubercles of humerus at shoulder, capitellum, radial head, and radial tuberosity at elbow) and associated soft tissue structures (eg, biceps brachii, tendon of long head, deltoid muscle, subscapularis insertion, biceps brachii distal insertion). During the scanning session, faculty trained in ultrasound circulated to the small groups, assisting students as needed with proper technique, image interpretation, and relevance to functional anatomy.

Following the hands-on session, another short assessment of students' knowledge, application, and perceptions was administered to evaluate program effectiveness. In addition to ultrasound basics and perceptions of ultrasound questions previously assessed, graduate clinical anatomy students were asked to identify anatomical structures on an image and apply it to a cadaveric specimen. Our initial programmatic goals were achieved; the majority of students answered basic concepts questions correctly (82%–90%), were able to apply anatomy knowledge to ultrasound images (91%), and reported the hands-on session was valuable to their understanding of cross-sectional anatomy (84%).

Similar ultrasound hands-on sessions are planned to integrate each section of anatomical content to maintain frequent exposure and learning to facilitate the preparation, linkage, hook, engagement, and transfer method. For a first experience, easy-to-identify structures should be highlighted, such as bones, bony landmarks, and large muscles. This approach is recommended because bony landmarks and muscles have unique ultrasound signatures, such as the very hyperechoic surface of bones, enabling students to feel confident in interpreting ultrasound images.[14] Smaller, more isoechoic structures (eg, ulnar collateral ligament) can be incorporated in future session once students are more comfortable with ultrasound.

INTEGRATION INTO ATHLETIC TRAINING COURSES

Although early experience with diagnostic ultrasound imaging in advanced anatomy courses is ideal, it is important to provide reinforcement with ultrasound-based instruction throughout the athletic training curriculum, at either the professional or postprofessional level, to provide necessary engagement and *transfer* of learning to clinical practice. Our team has identified several courses throughout our postprofessional masters in athletic training curriculum where integrating diagnostic ultrasound imaging is appropriate and beneficial, both to enhance the students' understanding of anatomical structures and to provide real-time, visual feedback for hands-on clinical skills. A natural progression of integration following anatomy is in the examination and diagnosis course(s). As students learn about the clinical examination process and presentation of injuries and conditions, a review of anatomical structures is important. During this anatomical review, students are required to visualize, using ultrasound, structures specific to the region of study. In addition to visualizing anatomical structures, transfer occurs when diagnostic ultrasound imaging is introduced as an adjunct, or tool, to one's physical exam. For example, we have effectively used diagnostic ultrasound imaging as an adjunct to physical exam during ankle laxity and glenohumeral range of motion modules of examination and diagnosis course(s).

The anterior drawer test is a commonly used selective tissue test to identify pathology and laxity of the anterior talofibular ligament. To become proficient in the administration of this test, students must be able to appropriately perform the test and to be able to appreciate differences between normal and pathologic test results. The hands-on laboratory session included the use of ultrasound imaging while students performed the anterior drawer test on a lab partner's ankle. Students were able to visually see the anterior movement of the talus during the test, and this visual feedback allowed them to estimate the amount of laxity and compare between ankles with and without history of injury. Additionally, using the image capture capabilities of the ultrasound units, students were able to measure and compare talar translation values from one person to another in both neutral and end range positions, thus estimating the amount of laxity present in the joint. Tatarksi[15] identified the use of ultrasound imaging as an adjunct to the physical examination of the ankle, specifically for the identification of syndesmotic ankle sprains. In these cases, visualization of the ligament integrity and the amount of joint movement occurring during tissue testing serves as an adjunct to the physical examination. Exposing students to the benefits of ultrasound imaging as an adjunct to the physical examination early in their professional education can create informed clinicians who can contribute to the health care team and collaborate with other providers who use ultrasound imaging.

The shoulder module focused on "the throwing shoulder," highlighting specific bony and soft tissue adaptations that occur in this population. In conjunction with lecture and discussion classroom formats, we held a hands-on laboratory session that included goniometric and validated ultrasound measurements of glenohumeral range of motion to enable students to identify and calculate bony and soft tissue contributions to overall joint motion.[16] Our postlaboratory assessment indicated students were able to accurately interpret and effectively apply the range of motion measurements obtained using the goniometer in conjunction with the ultrasound imaging to a case scenario of a right-handed baseball pitcher and analyze whether calculated range of motion values were within normal limits. Students also

reported positive perceptions of integrating diagnostic ultrasound imaging into the curriculum and clinical practice and saw the value of it as an adjunct to the physical evaluation process.

In addition to serving as an adjunct to physical exam, imaging capabilities of diagnostic ultrasound allow it to serve as a powerful tool for providing visual feedback. We have used diagnostic ultrasound imaging for this purpose in our examination and diagnosis course and in our manual therapy course. As described previously, ultrasound imaging was used during the performance of the anterior drawer test at the ankle to demonstrate its value as an adjunct to the physical exam. During this experience, it also served as a valuable feedback tool to help students refine their performance of the test. By visualizing the movement of the joint surfaces and the stresses placed on the soft tissues, students were able to fine-tune the direction and amount of applied force to ensure appropriate testing mechanics. Following the hands-on lab, students provided positive feedback on the use of ultrasound imaging as a teaching tool, including being able to link the feel of laxity within the ankle joint to the visual movement observed through ultrasound.

In our manual therapy course, students used ultrasound imaging to visualize movement of peripheral nerves during the assessment of neural tension and the performance of neural gliding techniques. Using both longitudinal and cross-sectional views, students were able to visualize the targeted peripheral nerve and observe how the tissue was impacted with different movements of the upper extremity during testing and treatments. The anterior drawer test and peripheral nerve glides are just 2 examples of how ultrasound imaging can be used as a visual feedback tool for students learning how to perform hands-on clinical skills.

CONCLUSIONS

Athletic training education programs, professional or post-professional, are well positioned to integrate diagnostic ultrasound imaging across curricula to enhance the learning environment and develop a sought-after skill in clinical practice. Using an established method of teaching necessary components of ultrasound, this paper provides specific examples of integrating ultrasound imaging throughout a curriculum, including advanced or clinical anatomy, examination and diagnosis, and manual therapy courses. Frequent and purposeful exposure to ultrasound imaging will allow students to learn cross-sectional anatomy using ultrasound, enhance hands-on skills using ultrasound for visual feedback, and implement it as an adjunct to physical exam.

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REFERENCES

1. Huxel Bliven KC, Anderson BE, Makin IRS. Commentary: integrating diagnostic ultrasound into athletic training education program. *Athl Train Educ J*. 2018;13(4):367–371.
2. Jurjus RA, Dimorier K, Brown K, et al. Can anatomists teach living anatomy using ultrasound as a teaching tool? *Anat Sci Educ*. 2014;7(5):340–349.
3. Bahner DP, Blickendorf JM, Bockbrader M, et al. Language of transducer manipulation: codifying terms for effective teaching. *J Ultrasound Med*. 2016;35(1):183–188.
4. Royer DF. The role of ultrasound in graduate anatomy education: current state of integration in the United States and faculty perceptions. *Anat Sci Educ*. 2016;9(5):453–467.
5. Society of Ultrasound in Medical Education Web site. http://www.susme.org/. Accessed October 19, 2018.
6. Manual of diagnostic ultrasound. World Health Organization Web site. http://apps.who.int/iris/bitstream/10665/43881/1/9789241547451_eng.pdf. Accessed October 19, 2018.
7. Ultrasound tutorials. Ultrasound Ohio State University Web site. http://www.osuultrasound.com/tutorials. Accessed October 19, 2018.
8. Ultrasound in Medical Education, University of California, Irvine. School of Medicine Web site. http://www.ultrasound.uci.edu/. Accessed October 19, 2018.
9. University of South Carolina, School of Medicine. Ultrasound Institute Web site. http://ultrasoundinstitute.med.sc.edu/. Accessed October 19, 2018.
10. American Institute of Ultrasound in Medicine Web site. http://www.aium.org/. Accessed October 19, 2018.
11. Pettit RK, Kinney M, McCoy L. A descriptive, cross-sectional study of medical student preferences for vodcast design, format and pedagogical approach. *BMC Med Educ*. 2017;17(1):89.
12. Lam KC, Hoch MC, Anderson BE, Bay RC, Welch CE. The effectiveness of online video modules in improving knowledge and hands-on clinical skills: a pilot study. *Athl Train Educ J*. 2015;10(suppl 1):S-14–S-15.
13. Maloney E, Hippe DS, Paladin A, Chew FS, Ha AS. Musculoskeletal ultrasound training for radiology residents: lecture versus interactive learning module. *Acad Radiol*. 2016;23(7):789–796.
14. Dreher SM, DePhilip R, Bahner D. Ultrasound exposure during gross anatomy. *J Emerg Med*. 2014;46(2):231–240.
15. Tatarksi RL. Collaboration between sonographers and athletic trainers: potential for an expedient injured athlete's triage. *J Diagn Med Sonogr*. 2017;33(3):161–162.
16. Myers JB, Oyama S, Goerger BM, Rucinski TJ, Blackburn JT, Creighton RA. Influence of humeral torsion on interpretation of posterior shoulder tightness measures in overhead athletes. *Clin J Sport Med*. 2009;19(5):366–371.