Musculoskeletal ultrasound education for sports medicine fellows: a suggested/potential curriculum by the American Medical Society for Sports Medicine

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ABSTRACT
The following musculoskeletal ultrasound (MSK US) curriculum was developed by the American Medical Society for Sports Medicine (AMSSM) to provide a pathway by which a sports medicine fellow can obtain adequate MSK US training during their fellowship to meet the requirements of competency outlined by the American Institute of Ultrasound in Medicine (AIUM) Training Guidelines for the Performance of MSK US Examination. Many fellowship programmes may not be able to follow all of the recommendations outlined by this document owing to their available resources. However, this curriculum can be used as a suggested/potential guideline for MSK US training within a sports medicine fellowship, and may assist programmes in developing or modifying their own internal training methods.

OVERVIEW
The educational process should include four components.

Didactic instructional sessions
The first component suggested is didactic musculoskeletal ultrasound (MSK US). This can be in the form of a dedicated MSK US course or scheduled teaching within the fellowship programme (see section Introduction 252 to MSK US—Didactic Instructional Sessions). The fellow should receive instruction on basic ultrasound physics, image optimisation, advantages and limitations of MSK US, and diagnostic and interventional techniques.

Didactic practice sessions
The second aspect of the fellow’s education should involve didactic sessions in which the diagnostic scanning and interventional techniques presented during the didactic instructional sessions are practised under the direct supervision of a mentor in order to become proficient with these skills (see section Diagnostic and Interventional MSK US 453—Didactic Practice Sessions).

Mentored clinical experience
Third, the fellow should perform diagnostic scanning and interventional procedures on patients in a clinical setting under the direct supervision of a mentor. Once competency for image acquisition and procedural execution has been determined, direct supervision may be curtailed as allowed by institutional policy governing teaching rules.

Supplementary and continuing education
The fourth component of the fellow’s education should include supplementary education such as reading reference texts and journal articles; presenting MSK US-related articles in journal club on a regular basis; utilising MSK US-related online educational material; attending MSK US conferences and presentations; and performing independent scanning. This natural stepwise progression of diagnostic and interventional MSK US education will ensure the acquisition of adequate MSK US skills to allow independent practice of diagnostic and interventional MSK US upon completion of their fellowship.

LEARNING OBJECTIVES
a) Identify and discuss the function of basic controls on an ultrasound machine console, including:
i) Transducer selection
ii) Depth
iii) Focal zone
iv) Gain
v) Time gain compensation/depth gain compensation
vi) Zoom
b) Discuss the basic physics principles of ultrasound, including Doppler imaging
c) Review a brief history of ultrasonic medicine
d) Demonstrate how to optimise an ultrasound image
e) Describe the normal ultrasonographic appearance of adipose, muscle, tendon, ligament, bone, fascia, vessels, nerve and cartilage
f) Discuss the benefits and limitations of MSK US
g) Identify and discuss the source and/or implications of basic ultrasound artefacts, including:
i) Anisotropy
ii) Reverberation
iii) Refraction
iv) Through transmission
v) Acoustic Shadowing
b) Perform image acquisition of vascular structures including neovessels using Colour and Power Doppler
i) Describe and perform a MSK US static and dynamic examination (including proper patient positioning) of the following regions as recommended by the American Institute of Ultrasound in Medicine (AIUM) Practice Guideline for the Performance of the MSK US Examination:
i) Shoulder
ii) Elbow

g) Musculoskeletal ultrasound scanning protocol checklist (see online Appendix A).
h) American Institute for ultrasound in medicine
i) Practice guideline for the performance of the musculoskeletal ultrasound examination
ii) Practice guideline for the performance of the shoulder ultrasound examination
iii) Training guidelines for the performance of musculoskeletal ultrasound examinations
iv) http://www.aium.org
i) European Society of skeletal radiology US scanning protocols
j) http://www.essr.org
j) American College of Radiology
i) Practice guideline for communication of diagnostic imaging findings
ii) http://www.acr.org

**INTRODUCTION TO MSK US—DIDACTIC INSTRUCTIONAL SESSIONS**

The introduction to MSK US didactic instructional sessions include the six basic units described in this section. Appropriate reading assignments from a reference text should be given to the fellow in preparation for each unit. Several excellent reference texts exist, many of which are listed in the Resources/References of this document. The sample curriculum provided in this document includes reading assignments from a currently available MSK US textbook (Fundamentals of MSK US by John Jacobson), but fellowship directors may substitute reading assignments from any appropriate text. We also recommend using the MSK US scanning protocols outlined in the AIUM Practice Guideline for the Performance of the MSK US Examination when instructing the fellow on scanning techniques. A MSK US Protocol Checklist based upon this document is provided in online Appendix A.

The first unit introduces the fellow to basic MSK US physics, the history of MSK US, scanning principles, and advantages and limitations of MSK US. Units 2–5 involve demonstration by an experienced MSK ultrasonographer of the static and dynamic scanning technique(s) for one or more regions followed by practice under the direct supervision of the mentor. The fellow should only consider this an introduction to the scanning technique for each region and should frequently practice the scanning techniques independently between didactic sessions. Unit 6 involves three individual sessions dedicated to interventional MSK US procedures. Basic information regarding interventional procedures including pharmacological principles of commonly used medications, patient selection, aseptic technique with MSK US guided procedures, risks associated with interventional procedures and treatment of common adverse events associated with interventional procedures should be addressed early in unit 6, prior to the start.
of practising the interventions. Common upper- and lower-extremity interventional procedures should be discussed, demonstrated and practised under the supervision of a mentor. Numerous mediums may be utilised for the practice of the interventional procedures. The ideal mediums are unembalmed cadaveric specimens. However, if cadaveric specimens are unavailable, the fellow can practise patient positioning and target acquisition for various interventional procedures on live models followed by practice of needle visualisation and guidance on turkey breasts, pig feet, pig legs, phantoms and/or other non-cadaveric specimens. The fellow should practice needle visualisation and guidance techniques between mentored didactic sessions to enhance their skills.

**Unit 1 Principles of MSK US and an introduction to scanning techniques**

i) **Required reading**
   - (1) Jacobson pp. 1–11

ii) **Introduction to MSK US and scanning**
   - (1) Instruction in ‘knobology’ & basic scanning techniques
   - (2) Instruction on basic US physics
   - (3) Review the history of diagnostic and interventional MSK US
   - (4) Demonstration of normal sonographic appearance of bone, cartilage, tendon, muscle, ligament, nerve and artery/vein
   - (5) Demonstration of the use of colour and power Doppler for imaging vascular and neo-vascular structures
   - (6) Demonstration of transducer movements to optimise image (translation, heel-toe, tilt, rotation, pressure/compression)
   - (7) Supervised practice

**Unit 2 MSK US examination of the knee-hip**

iii) **Reading—knee**
   - (1) Required Jacobson pp. 224–238
   - (2) Optional Jacobson pp. 238–263

iv) **Reading—hip & thigh**
   - (2) Optional Jacobson pp. 188–93

v) **Knee US scanning protocol**
   - (1) Instruction & supervised practice
   - (2) Resources
     - (a) MSK US Protocol Checklists—Knee
     - (b) AIUM Guidelines for Performance of the MSK US Examination

vi) **Hip & thigh US scanning protocol**
   - (1) Instruction & supervised practice
   - (2) Resources
     - (a) MSK US protocol checklists—Hip–Thigh
     - (b) AIUM guidelines for performance of the MSK US examination

vii) **Independent scanning**

**Unit 3 MSK US examination of the elbow-wrist-hand**

viii) **Reading—Elbow**
   - (1) Required Jacobson pp. 102–120

   - (2) Optional Jacobson pp. 120–132

   - (3) Reading—Wrist–hand
     - (1) Required Jacobson pp. 133–152
     - (2) Optional Jacobson pp. 152–177

xi) **Elbow US scanning protocol**
   - (1) Instruction & Supervised Practice
   - (2) Resources
     - (a) MSK US protocol checklists—Elbow
     - (b) AIUM guidelines for performance of the MSK US examination

**Unit 4 MSK US examination of the ankle-foot**

xiii) **Reading**
   - (1) Required Jacobson pp. 264–287
   - (2) Optional Jacobson pp. 287–331

xiv) **Ankle–foot US scanning protocol**
   - (1) Instruction & supervised practice
   - (2) Resources
     - (a) MSK US protocol checklists—Ankle–foot
     - (b) AIUM guidelines for performance of the MSK US examination

xv) **Independent scanning**

**Unit 5 MSK US examination of the shoulder**

xvii) **Shoulder US scanning protocol**
   - (1) Instruction & supervised practice
   - (2) Resources
     - (a) MSK US protocol checklists—shoulder
     - (b) AIUM guidelines for performance of the shoulder US examination
     - (c) AIUM guidelines for performance of the MSK US examination

xviii) **Independent scanning**

**Unit 6 Interventional procedures using MSK US**

xxi) **Peritendinous injection of the common extensor tendon origin**
   - (a) Lecture and hands-on practice using phantoms, turkey breasts, pigs feet or other non-cadaveric specimens
   - (b) AIUM guidelines for performance of the upper extremity cadaveric specimen
     - i) Subacromial-subsheath injection
     - ii) Intra-articular glenohumeral joint injection
     - iii) Intra-articular acromioclavicular joint injection
     - iv) Bicipital tendon sheath/groove injection
     - v) Intra-articular elbow joint injection
     - vi) Peritendinous injection of the common extensor tendon origin

xxii) **Lectures & hands-on sessions**
   - (1) Injection principles and practice
   - (a) Lecture and hands-on practice using phantoms, turkey breasts, pigs feet or other non-cadaveric specimens
   - (b) AIUM guidelines for performance of the upper extremity cadaveric specimen
     - i) Subacromial-subsheath injection
     - ii) Intra-articular glenohumeral joint injection
     - iii) Intra-articular acromioclavicular joint injection
     - iv) Bicipital tendon sheath/groove injection
     - v) Intra-articular elbow joint injection
and interpretation of diagnostic MSK US examinations. It is important for the fellow to be able to communicate their findings to other healthcare professionals. It is recommended that the fellow use the American College of Radiology Practice Guideline for Communication of Diagnostic Imaging Findings to assist in formulating appropriate diagnostic and/or interventional MSK US procedure notes. Those utilising electronic medical record (EMR) may be able to develop preset reporting protocols.

This component of the sports medicine fellow’s MSK US training process is imperative. It provides the fellow with a supervised environment in which to practise diagnostic and interventional MSK US skills in order to prepare them for independent practice. Fellows should be exposed to a wide variety of pathology during their diagnostic MSK US examination experiences, as well as a multitude of common interventional MSK US procedures. The fellow should be instructed on obtaining informed consent prior to performing interventional ultrasound procedures.

**SUPPLEMENTARY AND CONTINUING MSK US EDUCATION**

The fellow’s MSK US education should not be restricted to the formal educational activities outlined in the sections Introduction 252 to MSK US—Didactic Instructional Sessions, Diagnostic and Interventional MSK US 433—Didactic Practice Sessions and Diagnostic and Interventional MSK 461 US—Mentored Clinical Experience. The number of hours to accomplish this will vary from programme to programme and from fellow to fellow. Rather, the fellow should be encouraged to:

1. Read MSK US journals and texts on a regular basis
2. Review MSK US related articles on regular basis. It is recommended that the fellow present a MSK US related journal article during journal club at least on a quarterly basis
3. Participate in online MSK US related courses
4. Read online MSK US related educational material
5. Attend MSK US related conferences
6. Independently practice MSK US examinations and interventional procedures on volunteers and models, respectively
7. Consider membership to the AIUM

**MSK US RECORD KEEPING AND COMPETENCY**

The sports medicine fellow should maintain meticulous records of all MSK US educational activities that they participate in throughout their fellowship. In addition, the fellow should maintain a procedure log of all diagnostic and interventional MSK US procedures that they observed and performed. This information can assist when determining competency in diagnostic and interventional MSK US upon completion of their fellowship. The fellowship should attempt to meet the competency criteria outlined by the AIUM Training Guidelines for the Performance of MSK US Examinations. The portion of this document that applies to a sports medicine fellow provides the following competency guideline:

Completion of a residency or fellowship program supervised by a physician qualified to perform musculoskeletal ultrasound that provides structured musculoskeletal ultrasound training, including the performance, interpretation, and reporting of 150 musculoskeletal ultrasound examinations. Unless within 2 years of completion of a residency and/or fellowship, the physician will also need to have completed
40 hours of AMA PRA Category 1 Credits specific to MSK ultrasound, including at least 1 MSK ultrasound course that includes hands-on training.

In addition to completing the fellowship’s MSK US curriculum and meeting the minimum requirements outlined by the AIUM training guidelines (see above), it is recommended that the fellowship director/teaching faculty develop an objective system of measurement (e.g., practicum and/or written test) to determine the fellow’s knowledge and skill in diagnostic and interventional MSK US and establish competency.

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