American Medical Society for Sports Medicine (AMSSM)
Recommended Sports Ultrasound Curriculum for Sports Medicine Fellowships

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Introduction

The following sports ultrasound (SPORTS US) curriculum is a revision of the curriculum developed by the American Medical Society for Sports Medicine (AMSSM) in 2010 [1]. Several changes have been made to the curriculum with the primary aim of providing a pathway by which a sports medicine fellow can obtain sufficient SPORTS US training to become proficient in the core competencies of SPORTS US. The core competencies of SPORTS US are outlined in the learning objectives section of this document.

The term "SPORTS US" was purposefully chosen rather than "musculoskeletal ultrasound" (MSK US), since it was recognized by the panel that the evolving field of SPORTS US encompasses non-MSK applications of US such as the focused assessment with sonography for trauma (FAST) examination. While the SPORTS US core competencies in this curriculum are all MSK in nature, they represent the minimum SPORTS US knowledge a sports medicine fellow should acquire during fellowship. However, additional training in more advanced MSK and non-MSK applications of US can be provided at the fellowship director’s discretion.

Completion of this SPORTS US curriculum fulfills the American Institute of Ultrasound in Medicine’s (AIUM) requirements to perform an MSK US examination, and the prerequisites for the American Registry for Diagnostic Medical Sonography (ARDMS) MSK sonography certification examination.

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1) Overview

The educational process should include 4 components.

1. Didactic Instructional Sessions: Didactic instruction can occur via a dedicated SPORTS US course or scheduled teaching sessions during the fellowship (see section 4). Didactics should include discussions of US physics, image acquisition and optimization, normal and pathologic appearance of tissues, US artifacts, advantages and limitations of SPORTS US relative to other imaging modalities, and diagnostic and interventional techniques pertaining to major body regions encountered in a sports medicine practice.

2. Didactic Practice Sessions: Hands-on didactic practice sessions should be completed under the direct supervision of a qualified mentor. A qualified mentor is defined as an individual who has met the qualifications outlined by the AIUM Training Guidelines for...
Physicians and Chiropractors Who Evaluate and Interpret Diagnostic Musculoskeletal Ultrasound Examinations (www.aium.org). During these sessions, fellows should apply the knowledge and skills acquired during the didactic instructional sessions in a controlled and supervised environment (see section 5).

3. Mentored Clinical Experience: As knowledge and skills are acquired, the fellow should perform diagnostic scanning and interventional procedures on patients in a clinical setting under the direct supervision of a qualified mentor. As the fellow gains proficiency in the clinical application of diagnostic and interventional SPORTS US techniques, the level of supervision may be modified as allowed by institutional policy governing teaching rules.

4. Supplementary and Continuing Education: The fellow’s education should include supplementary educational experiences to reinforce the knowledge and skills gained during the didactic sessions and mentored clinical experience.
   A. Required:
      (1) Independent scanning practice sessions
   B. Recommended:
      (1) Reading reference texts and journal article
      (2) Presenting SPORTS US–related articles in journal club
      (3) Utilizing online educational material and educational DVDs
      (4) Attending SPORTS US conferences and presentations

The integration of recommended supplementary educational experiences may vary from fellowship to fellowship based on available resources and the overall curriculum structure. This natural stepwise progression of diagnostic and interventional SPORTS US education will ensure the acquisition of sufficient SPORTS US skills to allow independent practice of the core competencies of diagnostic and interventional SPORTS US upon completion of fellowship.

2) Learning Objectives for SPORTS US Training During Fellowship

a) Identify and discuss the function of basic controls on a US machine console, including:
   i) Transducer selection
   ii) Presets
   iii) Depth
   iv) Focal zone/focal region
   v) Gain
   vi) Time gain compensation/depth gain compensation
   vii) Zoom (including read zoom and write zoom)

b) Discuss the basic physics principles of US, including:
   i) How a US image is generated
   ii) Interrelationship of machine controls (eg, frequency, resolution and depth)
   iii) Doppler imaging (difference between power Doppler and color Doppler)

c) Demonstrate how to optimize a US image
   i) Superficial structures
   ii) Deep structures

d) Describe the normal ultrasonographic appearance of adipose, muscle, tendon, ligament, bone, fascia, vessels, nerve, and cartilage

e) Describe the common pathological ultrasonographic appearance of adipose, muscle, tendon, ligament, bone, fascia, vessels, nerve, joint, and cartilage

f) Discuss the benefits and limitations of SPORTS US relative to other imaging modalities

g) Identify and discuss the source and/or implications of basic US artifacts, including:
   i) Anisotropy
   ii) Reverberation
   iii) Refraction
   iv) Through transmission
   v) Acoustic shadowing

h) Perform image acquisition of vascular structures including neovessels using color and power Doppler.

i) Perform a SPORTS US examination of the following regions as recommended by the AIUM Practice Guidelines for the Performance of the MSK US Examination (see Appendix 1):
   i) Shoulder
   ii) Elbow
   iii) Wrist-Hand
   iv) Hip
   v) Knee
   vi) Ankle-Foot

j) Obtain an acceptable set of SPORTS US images of the following regions as recommended by the AIUM Practice Guidelines for the Performance of the MSK US Examination (see Appendix 1):
   i) Shoulder
   ii) Elbow
   iii) Wrist-Hand
   iv) Hip
   v) Knee
   vi) Ankle-Foot

k) Demonstrate appropriate labeling of SPORTS US images
   i) Use of text insertion
   ii) Use of arrows and measurement calipers

l) Demonstrate how to capture, store, and transfer SPORTS US images

m) Generate an appropriate diagnostic SPORTS US report

n) Perform an appropriate SPORTS US evaluation to identify and appropriately document (eg, capture, label, save, and transfer images; generate a report) of the following conditions:
   i) Shoulder
      (1) Supraspinatus full thickness tear
ii) Elbow
   (1) Common extensor tendinopathy
   (2) Dynamic examination of the ulnar nerve at the elbow
   (3) Common flexor tendinopathy

iii) Wrist-Hand
   (1) DeQuervain’s tenosynovitis
   (2) Carpal tunnel syndrome

iv) Hip
   (1) Gluteus medius/minimus tendinopathy
   (2) Hamstring tendinopathy

v) Knee
   (1) Patellar tendinopathy
   (2) Baker’s cyst
   (3) Knee joint effusion

vi) Ankle-Foot
   (1) Peroneal tendinopathy (including dynamic evaluation for instability)
   (2) Achilles tendinopathy
   (3) Plantar fasciopathy

o) Describe the advantages and disadvantages of needle tracking using an in-plane versus out-of-plane approach, and provide clinical examples of when each approach may be beneficial.

p) Image a needle using an in-plane (longitudinal or long-axis) and out-of-plane (short-axis or transverse) approach using US guidance in a phantom, turkey breast, cadaveric specimen, or other imaging medium, including demonstration of the following transducer manipulations:
   i) Translation (sliding/gliding)
   ii) Rotation
      (1) Describe “cross-cut” artifact when imaging/tracking a needle during an interventional procedure
   iii) Heel-toe
   iv) Tilting (toggling/wagging)
   v) Compression

q) Demonstrate the ability to efficiently relocate a lost needle during both an in-plane and out-of-plane needle tracking approach

r) Demonstrate the ability to guide a needle into a target region or structure using both an in-plane and out-of-plane approach in a phantom, turkey breast, cadaveric specimen, or other imaging medium

s) Obtain an acceptable set of pre-, intra-, and post-procedure images of a US-guided procedure

t) Demonstrate appropriate labeling of the US-guided procedure images

u) Demonstrate how to store and transfer the US-guided procedure images

v) Generate an appropriate US-guided procedure report

w) Perform and appropriately document (eg, capture, label, save, and transfer images; generate a report) the following US-guided procedures:
   i) Shoulder
      (1) Subacromial-subdeltoid bursa injection
      (2) Intra-articular glenohumeral joint injection
      (3) Intra-articular acromioclavicular joint injection
      (4) Bicipital tendon sheath injection
   ii) Elbow
      (1) Intra-articular elbow joint injection
      (2) Peri- or intra-tendinous injection of the common extensor tendon origin
      (3) Peri- or intra-tendinous injection of the common flexor tendon origin
   iii) Wrist-Hand
      (1) Carpal tunnel injection
      (2) First dorsal compartment tendon sheath injection
      (3) Intra-articular wrist injection
   iv) Hip
      (1) Intra-articular hip injection
      (2) Greater trochanteric bursa injection
      (3) Gluteus medius or minimus peri or intra-tendinous injection
   v) Knee
      (1) Intra-articular knee injection
      (2) Iliotibial band/bursa (distal) injection
   vi) Ankle-Foot
      (1) Intra-articular tibiotalar joint injection
      (2) Peroneal tendon sheath injection
      (3) Peri- or intra-plantar fascia injection
   vii) Miscellaneous
      (1) Aspiration or injection of a cyst

3) Resources/References

Books


Additional Resources

American College of Radiology (ACR) Practice Guideline for Communication of Diagnostic Imaging Findings, available free at www.acr.org
ACR Practice Guidelines for the Performance of the Musculoskeletal Ultrasound Examination, available free at www.acr.org
AIUM Practice Guideline for the Performance of the Shoulder Ultrasound Examination, available free at www.aium.org
AIUM Practice Guideline for Documentation of the Diagnostic Ultrasound Examination, available free at www.aium.org
AIUM Practice Guideline for Performance of the Diagnostic Ultrasound Examination, available free at www.aium.org
AIUM Training Guidelines for Physicians and Chiropractors Who Evaluate and Interpret Musculoskeletal Ultrasound Examinations, available free at www.aium.org
European Society of Skeletal Radiology (ESSR) Musculoskeletal Ultrasound Scanning Technique Demonstrations, available free at www.ESSR.org

4) Didactic Instructional Sessions

The SPORTS US didactic instructional sessions includes 6 basic units described in this section. Each fellowship should provide appropriate resources for fellows to preview and review the information relevant to each session (see Resource/Reference List). Whereas the number of teaching sessions can be modified as desired or necessary, all fellows should receive instruction in all listed topics. It is strongly recommended that teaching sessions for diagnostic scanning (Units 1-5) utilize established scanning protocols to guide learning and ensure compliance with accepted standards (see SPORTS US Scanning Protocol in Appendix 2). Finally, although the order of units 2-5 may be modified, fellows should master the diagnostic skills for a specific region before initiating US-guided procedure training in that region (eg, mastery of the shoulder diagnostic scans should precede formal training in US-guided shoulder interventions).

The first unit introduces the fellow to basic SPORTS US physics, image acquisition and optimization, normal and pathologic appearance of tissues, US artifacts, and the advantages and limitations of SPORTS US relative to other imaging modalities. During Units 2-5, a qualified MSK sonographer/sonologist should demonstrate the scanning protocol(s) for one or more body regions, followed by supervised practice. A qualified MSK sonographer is defined as an individual who has met the AIUM Practice Guidelines for the Performance of an MSK US examination. The fellow should only consider these sessions as an introduction to scanning and independent practice between didactic sessions is necessary to facilitate skill acquisition (see Supplementary and Continuing Education above).

Unit 6 involves at least 3 individual sessions dedicated to interventional SPORTS US procedures. Initial topics reviewed include pharmacologic principles of commonly used medications, patient selection, aseptic technique for US-guided procedures, procedural risks, and treatment of common adverse events. Thereafter, the fellow should be introduced to methods of US-guided needle image optimization, needle relocation, and dynamic needle tracking using both in-plane and out-of-plane approaches. Once these skills are mastered, the fellow should be introduced to common upper- and lower-extremity US-guided interventional procedures (with a focus on the core interventional US competencies) via discussion, demonstration, and supervised practice under the guidance of a qualified practitioner. Multiple mediums may be suitable for practicing US-guided interventional procedures. The ideal mediums are unembalmed cadaveric specimens. If unembalmed cadaveric specimens are unavailable, the fellow can practice patient positioning and target acquisition on live models, followed by practice of needle visualization and guidance on turkey breasts, pig feet, pig legs, firm tofu, phantoms, and/or other noncadaveric specimens. The fellow should practice needle visualization and guidance techniques between mentored didactic sessions to enhance his/her skills (see Supplementary and Continuing Education above).

***Please note that the educational material has been divided into units to facilitate teaching of related concepts and skills. The number of educational sessions required to teach the knowledge and skills contained in a specific unit may vary depending on scheduling and available resources.

Unit 1. Principles of SPORTS US and an Introduction to Scanning Techniques

(1) Instruction in “Knobology” and basic scanning techniques
(2) Instruction on basic US physics
(3) Demonstration of normal sonographic appearance of adipose, muscle, tendon, ligament, bone, fascia, vessels, nerve, and cartilage
(4) Discussion of the common abnormal sonographic appearances of adipose, muscle, tendon, ligament, bone, fascia, vessels, nerve, joint, and cartilage
(5) Muscle, tendon, ligament, and nerve
(6) Demonstration of the use of color and power Doppler for imaging vascular and neovascular structures
(7) Demonstration of transducer movements to optimize image (translation (sliding), rotation, heel-toe, tilt (toggling), and pressure/compression)
(8) Supervised practice

Unit 2. SPORTS US Examination of the Knee-Hip

1) Knee US Scanning Protocol
   a) Instruction and supervised practice
   b) Resources
      i) SPORTS US Scanning Protocol Checklists—Knee
      ii) AIUM and ACR Guidelines for Performance of the MSK US Examination
2) Hip and Thigh US Scanning Protocol
   a) Instruction and supervised practice
   b) Resources
      i) SPORTS US Scanning Protocol Checklists—Hip-Thigh
      ii) AIUM and ACR Guidelines for Performance of the MSK US Examination
3) Independent scanning

Unit 3. SPORTS US Examination of the Elbow and Wrist-Hand

1) Elbow US Scanning Protocol
   a) Instruction and supervised practice
   b) Resources
      i) SPORTS US Scanning Protocol Checklists—Elbow
      ii) AIUM and ACR Guidelines for Performance of the MSK US Examination
2) Wrist-Hand US Scanning Protocol
   a) Instruction and supervised practice
   b) Resources
      i) SPORTS US Scanning Protocol Checklists—Wrist-Hand
      ii) AIUM Guidelines for Performance of the MSK US Examination
3) Independent scanning

Unit 4. SPORTS US Examination of the Ankle-Foot

1) Ankle-Foot US Scanning Protocol
   a) Instruction and supervised practice
   b) Resources
      i) SPORTS US Scanning Protocol Checklists—Ankle-Foot
      ii) AIUM and ACR Guidelines for Performance of the MSK US Examination

2) Independent scanning

Unit 5. SPORTS US Examination of the Shoulder

1) Shoulder US Scanning Protocol
   a) Instruction and supervised practice
   b) Resources
      i) SPORTS US Scanning Protocol Checklists—Shoulder
      ii) AIUM Guidelines for Performance of the Shoulder Ultrasound Examination
      iii) AIUM and ACR Guidelines for Performance of the MSK US Examination
2) Independent scanning

Unit 6. US-Guided Interventional Procedures

1) Didactic instruction and discussion
   a) Rationale for US-guided procedures
   b) Principles of US-guided procedures
      i) Patient selection
      ii) Ergonomics
      iii) Aseptic technique
      iv) In-plane and out-of-plane needle tracking
      v) Image optimization for needle location, relocation, and dynamic tracking, including transducer manipulation: translation (sliding), rotation, heel-toe, tilting (toggling), and compression
      vi) Recognizing and correcting "cross-cut" artifact when needle tracking
   c) Specific applications and techniques
      i) Joint, tendon sheath, nerve, ligament, bursa/cyst
      ii) Use of "stand-off"/oblique stand-off, hydrodissection, lavage, and aspiration
2) Demonstration, discussion and practice using unembalmed cadaveric specimens, phantoms, turkey breasts, pig feet, pig legs, firm tofu, or other appropriate medium
   a) In-plane and out-of-plane needle location and tracking
   b) Needle relocation
   c) Cross-cut artifact
   d) Commonly performed US-guided procedures. It is strongly recommended that these procedures be practiced on an unembalmed cadaveric specimen. However, if this is not feasible, then fellows should practice all aspects of needle visualization and tracking using other appropriate medium, and the
principles of the procedures listed below reviewed in a formal didactic setting.

i) Shoulder
(1) Subacromial-subdeltoid bursa injection
(2) Intra-articular glenohumeral joint injection
(3) Intra-articular acromioclavicular joint injection
(4) Bicipital tendon sheath/groove injection

ii) Elbow
(1) Intra-articular elbow joint injection
(2) Peri- or intra-tendinous injection of the common extensor tendon origin
(3) Peri- or intra-tendinous injection of the common flexor tendon origin

iii) Wrist-Hand
(1) Carpal tunnel injection
(2) First dorsal compartment tendon sheath injection
(3) Intra-articular wrist injection

iv) Hip
(1) Intra-articular hip injection
(2) Greater trochanteric bursa injection
(3) Gluteus medius or minimus peri- or intra-tendinous injection

v) Knee
(1) Intra-articular knee injection
(2) Iliotibial band/bursa (distal) injection

vi) Ankle-Foot
(1) Intra-articular tibiotalar joint injection
(2) Peroneal tendon sheath injection
(3) Peri- or intra-plantar fascia injection

vii) Miscellaneous
(1) Aspiration or injection of a cyst

3) Review of saved images from the fellow’s self-directed practice scanning sessions and provision of constructive feedback regarding study completeness, and proper image optimization, labeling, storage, and transfer. Deficiencies should be reconciled during subsequent scanning sessions.

4) Practice and demonstration of interventional skills, preferably using unembalmed cadaveric specimens. If cadaveric specimens are not available, the fellow should practice appropriate imaging of target structures on live models, and should practice needle imaging and guidance techniques using turkey breasts, pig feet, pig legs, firm tofu, phantoms, or other appropriate medium. As the fellow’s skills improve, more advanced SPORTS US examination techniques and interventional procedures should be introduced into the didactic practice sessions (eg, hydrodissection, percutaneous treatment of calcific tendinosis, etc).

5) Didactic Practice Sessions

Didactic practice sessions should be scheduled with a qualified mentor on a regular basis throughout the fellowship. A qualified mentor is one who has met the requirements outlined in the AIUM Training Guidelines for Physicians and Chiropractors Who Evaluate and Interpret Diagnostic Musculoskeletal Ultrasound Examinations (www.aium.org). During these sessions the fellow should apply the knowledge and skills acquired during the didactic instructional sessions in a controlled and supervised educational environment. The didactic practice sessions should include the following:

1) Practice and demonstration of performing a complete US evaluation of each major region listed in the scanning protocols including proper image optimization and acquisition (see Appendix 1).
2) Practice and demonstration of proper image labeling and storage. Transference of images should follow the guidelines outlined by the Health Insurance Portability and Accountability Act (HIPAA).

6) Mentored Clinical Experience

The fellow should have regularly scheduled clinical time in which they receive supervised hands-on experience performing diagnostic and interventional SPORTS US on patients. During this experience, fellows should practice and eventually demonstrate competency in all aspects of SPORTS US outlined in the learning objectives. Special attention should be paid to obtaining proficiency in performing the core competency diagnostic US examinations of the pathologic conditions and US-guided procedures listed in the learning objectives. Determining competence will be discussed further in section 8.

This component of the fellow’s SPORTS US training process is required to ensure that the fellow can proficiently perform the core diagnostic and interventional SPORTS US competencies in clinical practice.

7) Supplementary and Continuing SPORTS US Education

The fellow’s SPORTS US education should not be restricted to the formal educational activities outlined in sections 4 through 6. The fellow should be required to participate in independent practice scanning, during which time they can practice diagnostic scanning techniques, positioning for procedures, and scanning protocols using volunteers. During this time, the fellow should also acquire studies for review with their mentor, as previously discussed. The fellow should also be required to independently practice US-guided needle tracking using the appropriate medium (eg, cadaver, phantom, etc).

In addition to the above-required supplementary and continuing SPORTS US education experiences, as time and resources allow, the fellow should be encouraged to participate in one or more of the following:
1) Reading SPORTS US journals and texts on a regular basis
2) Reviewing SPORTS US—related articles on regular basis. It is recommended that the fellow present a SPORTS US—related journal article during journal club at least on a quarterly basis
3) Participating in online SPORTS US—related courses or DVDs
4) Reading online SPORTS US—related educational material
5) Attending SPORTS US—related conferences

8) Record Keeping and Competency

The fellow should maintain detailed records of all SPORTS US educational activities in which they participate throughout the fellowship. The fellow should also maintain a procedure log of all diagnostic and interventional SPORTS US procedures, including their role in the procedure (eg, observation, performance, interpretation, or reporting). Detailed recording keeping serves multiple purposes:

1) Assists with credentialing
2) Assists in practice accreditation
3) Supports application for certification examinations

Although maintaining records of the type and number of diagnostic and interventional US procedures is important, performing a specific number of US procedures does not necessarily determine competence. A milestone system is a more appropriate way of determining competence and is in agreement with graduate medical education competency assessment recommendations by the Accreditation Council for Graduate Medical Education. Milestones use a 5-point ordinal scale of escalating skill level, with competence determined when a level 3 or higher has been achieved. Milestones for each learning objective in the SPORTS US should be developed, and the fellow should achieve competence in all of the milestones upon completion of their fellowship. Sample diagnostic and interventional US milestones are provided in Appendix 2.

Finally, it is recommended that an objective written and practical test be developed to assist with assessing the sports medicine fellow’s SPORTS US knowledge and skill.

Reference

### Appendix 2

**SPORTS US Milestone Examples**

#### Diagnostic ultrasound (US) examination of a full-thickness supraspinatus tear

<table>
<thead>
<tr>
<th>Level</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
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<tbody>
<tr>
<td>Ability</td>
<td>Able to verbally describe the indications for a diagnostic US of the shoulder and list the structures that need to be imaged during a complete sonographic shoulder examination</td>
<td>Able to correctly identify and sonographically image all portions of the supraspinatus tendon in long and short axis in a normal shoulder</td>
<td>Able to correctly identify and sonographically image a full-thickness supraspinatus tear; acquire, label, and save an appropriate image; and generate an appropriate report</td>
<td>Able to consistently and independently perform the skills outlined in level 3. Integrates current research and literature with guidelines to recommend management</td>
<td>Demonstrates expertise in the sonographic evaluation of supraspinatus tendon tears at a level expected of a subspecialist. Performs research related to imaging of the supraspinatus tendon</td>
</tr>
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#### Ultrasound-guided glenohumeral joint injection

<table>
<thead>
<tr>
<th>Level</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability</td>
<td>Able to verbally describe the indications, contraindications, risks and benefits of a US-guided glenohumeral joint injection. Able to verbally describe the procedure</td>
<td>Able to correctly position a patient, perform a preprocedure diagnostic scan, identify the target and relevant adjacent structures</td>
<td>Able to perform a US-guided glenohumeral joint injection, acquire and label appropriate pre-, intra-, and postprocedure images, and generate a procedure note</td>
<td>Able to consistently and independently perform the skills outlined in level 3. Integrates current research and literature with guidelines relevant to the procedure</td>
<td>Demonstrates expertise in the performance of US-guided glenohumeral joint injections at a level expected of a subspecialist. Performs research related to this skill.</td>
</tr>
</tbody>
</table>