EXTENDED REPORT

Ultrasonography for rheumatologists: the development of specific competency based educational outcomes

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Background: A competency based approach to the education of rheumatologists in musculoskeletal ultrasonography (MSK US) ensures standards are documented, transparent, accountable, and defensible, with clear benefit to all stakeholders. Specific competency outcomes will facilitate informed development of a common curriculum and structured programme of training and assessment.

Objective: To determine explicit competency based learning outcomes for rheumatologists undertaking MSK US.

Methods: International experts in MSK US, satisfying specific selection criteria, were asked to define the minimum standards required by a rheumatologist to be judged competent in MSK US. They reviewed 115 MSK US skills, comprising bone and soft tissue pathology, in seven joints regions of the upper and lower limbs, and rated their relative importance according to specific criteria. These data are presented as specific educational outcomes within designated competency categories.

Results: 57 expert MSK US practitioners were identified and 35 took part in this study. Ten generic core competency outcomes were recognised including physics, anatomy, technique, and interpretation. Regarding specific regional competencies, 53% (61/115) were considered "must know" core learning outcomes, largely comprising inflammatory joint/tendon/bone pathology and guided procedures; 45% (52/115) were required at an intermediate/advanced level (18/115 "should know", 34/115 "could know"), and 2% (2/115) were deemed inappropriate/unnecessary for rheumatologist ultrasonographers.

Conclusions: This is the first study to developing a competency model for the education of rheumatologists in MSK US based on the evidence of international experts. A specific set of learning outcomes has been defined, which will facilitate future informed education and practice development and provide a blueprint for a structured rheumatology MSK US curriculum and assessment process.

There is increasing evidence commending the advantages to patients with rheumatic diseases of receiving an ultrasound assessment from their attending rheumatologist.^{1–14} Potential benefits include enhanced diagnostic confidence, more informed management decisions, direct visualisation of pathology, and objective monitoring of disease outcome. This has prompted more rheumatologists to develop their own musculoskeletal ultrasonography (MSK US) skills in order to address specific clinical questions in areas that are not necessarily part of the traditional MSK US service provided by the radiologist.¹⁵

However, there remains limited published information on MSK US education and few data to direct training and practice.^{16–21} A small number of European countries, such as Italy and Germany, possess their own national recommendations which state that a rheumatologist should undertake a specified number of MSK US scans as part of their training, while others (for example, Germany and Austria) suggest a structure for training. However, there are no published international recommendations for a common curriculum, a unified educational approach, or a consensus of competency standards applicable to all rheumatologist ultrasonographers.^{22–23} In addition, there are few data documenting the outcome of training in MSK US and little evidence to support the validity of a particular educational approach. The establishment of an educational framework based on appropriate evidence, with clearly defined competency standards, is crucial to promote professional rheumatologist ultrasonography.

The aim of this study was to establish the minimum standards that are required by a rheumatologist to be judged competent in MSK US, and to determine and develop a competency model of explicit learning outcomes which will provide a template for future educational development in this field.

METHODS

We sought the opinion of worldwide experts in MSK US and asked them to identify the competency standards that are required by a rheumatologist undertaking MSK US.

Criteria for expert panel selection

Each expert was required to satisfy *all* of the following selection criteria: (1) author of relevant peer reviewed publications identifiable by Medline literature review; (2) member of the teaching faculty of an established MSK US training course; (3) recognition of expert status by peer group recommendation from committee members of a recognised MSK US organisation (European League Against Rheumatism (EULAR) MSK US working group; British Society of Skeletal Radiologists (BSSR) MSK US working group; Musculoskeletal Ultrasound Society (MUSOC)).

Questionnaire design and administration

Data gathered from a previous Delphi study²¹—in which an expert consensus of knowledge, skills, indications, and

Abbreviation: MSK US, musculoskeletal ultrasonography

anatomical areas specifically appropriate for rheumatologist ultrasonographers were defined—was reviewed and organised in the form of a questionnaire. This consisted of seven tables, each containing between nine and 21 MSK US skills specific to the anatomical area in question (total number of skills = 115). All respondents were prompted to add any other MSK US skills not included in each anatomical section, or suggest removal of any items that they felt to be inappropriate or unnecessary, and provide any further comments. A local pilot study was undertaken to assess the performance of the questionnaire as a suitable data collection instrument, and this resulted in some minor changes. The final questionnaire was then distributed to our entire expert panel by electronic and postal mail. Subsequent written, email, and personal telephone reminders were made to the non-responders after four, eight, and 16 weeks.

Competency category definitions

The expert panelists were asked to rate each MSK US skill according to an explicit four point competency category scale (table 1). The group results were expressed as the overall percentage distribution of expert scores and were summarised using the median and interquartile range (IQR) to reflect the ordinal nature of the data. The final competency designation of each MSK US skill was determined using statistical criteria from the collective expert group responses (table 1).

Analysis

Data evaluation and statistical analysis was carried out using SPSS version 10. The overall group responses were collated and final competency designations were established as outlined above. The scores were further broken down according to specialty background and compared in order to evaluate any differences in responses between rheumatologists and radiologists. Non-parametric statistical tests were used to assess levels of significance (Mann–Whitney U test). Qualitative data was assessed for any common recurring themes.

Generic core competency outcomes

Our review of previous data enabled us to identify 10 general themes which appeared consistently in the feedback from expert practitioners. Group consensus agreement had formerly been established in relation to each of these competencies, which were regarded as essential knowledge and skills required by all rheumatologist ultrasonographers.²¹ The importance of these topics was corroborated by analysis of the qualitative data from the present study (see below).

These principal areas have therefore been designated generic core competency outcomes (table 4).

RESULTS

Expert panel

Fifty seven international experts (37 radiologists and 20 rheumatologists) were identified who satisfied our selection criteria; 38 (70%) agreed to take part and were sent the questionnaire, while the remainder did not respond to our invitation to participate. The overall response rate was 92% (35/38) (85% of radiologists (17/20) and 100% of rheumatologists (18/18)). The geographical distribution of the contributing experts comprised 10 European countries (United Kingdom, France, Germany, Holland, Italy, Spain, Switzerland, Austria, Finland, and Denmark), USA and Canada (3), Australia (1), Asia (1), and South America (1).

Specific competency outcomes

Within each anatomical area, the expert competency category scores for each MSK US skill were collated in order to determine their final competency designation (tables 2, 5, and 6).

Inappropriate areas for a rheumatologist

We have previously established consensus agreement among experts in MSK US regarding areas in which it would be either inappropriate or unnecessary for a rheumatologist to carry out an ultrasound examination.²¹ These include soft tissue mass, ligament and muscle pathology, and nerve lesions. These items have therefore been included in the “don’t need to know” category. As part of our present study, further opinion was sought regarding some of the more common and rheumatology specific topics within these categories. For example, carpal tunnel syndrome and Morton’s neuroma were deemed “could know” competencies, whereas ankle ligament tear and knee collateral ligament enthesopathy did not satisfy our competency criteria and have therefore not been included as rheumatology MSK US skills.

Differences between specialty backgrounds

The final expert group consisted of a near equal split of rheumatologists (n = 18) and radiologists (n = 17). Significant differences were observed between individual scores given by rheumatologists and radiologists in 14 of 115 competency items (table 2). In each of these areas, except quadriceps tendonitis, the rheumatologists’ scores placed the item in a higher final competency category than those of the radiologists. If we consider the assignment of competency category based on the specialist group responses, there was a difference in the designation between rheumatologists and radiologists for 67 of 115 (58%) of the competency items.

Table 1 Levels of knowledge and skills were divided into the following competency categories

<ul style="list-style-type: none"> ● Must know (score = 4): Core knowledge and skills required by every rheumatologist ultrasonographer and represents the minimum standard that is necessary to be judged competent. “Must know” final competency designation: median = 4 + IQR ≤ 1. ● Should know (score = 3): Rheumatologist ultrasonographers should know this but it is a little more than the minimum knowledge or skills that they require and is probably only needed at an intermediate level. “Should know” final competency designation: median = 4 + IQR > 1 or median ≥ 3 + IQR ≤ 1. ● Could know (score = 2): Only really required by a small number of rheumatologist ultrasonographers at an advanced or subspecialty level. “Could know” final competency designation: median ≥ 3 + IQR > 1 or median ≥ 2 + IQR ≤ 1. ● Don’t need to know (score = 1): Not required or appropriate for ultrasound assessment by rheumatologists. “Not required/appropriate” final competency designation: median ≥ 2 + IQR > 1 or median ≥ 1 + IQR ≤ 1.
<p>The final competency designation was defined by summary statistics of the collective expert group responses. IQR, interquartile range.</p>

Table 2 Expert competency category scores, summary statistics, and final competency designation

	Expert competency category score (%)				Summary statistics		
MSK US skills	4 “must”	3 “should”	2 “could”	1 “don’t need”	Median	IQR	Final competency category designation
Hand and wrist							
Synovial thickening	97	3	0	0	4	0	Must know
Synovial fluid/effusion	94	6	0	0	4	0	Must know
Tenosynovitis	91	6	0	3	4	0	Must know
Bone erosion	88	6	0	6	4	0	Must know
Tendon rupture (*p=0.03)	73	18	6	3	4	1	Must know
US guided injection	73	9	15	3	4	1	Must know
Tendonopathy	70	15	12	3	4	1	Must know
Tendon nodule	70	15	12	3	4	1	Must know
US guided aspiration	70	9	18	3	4	1	Must know
Ganglion	59	25	9	6	4	1	Must know
Enthesitis	44	34	19	3	3	1	Should know
Monitor disease activity	42	30	24	3	3	2	Could know
Monitor disease progression	42	27	27	3	3	2	Could know
Calcified cartilage	31	34	25	9	3	2	Could know
Carpal tunnel syndrome	30	36	18	15	3	2	Could know
Elbow							
Synovial thickening	97	3	0	0	4	0	Must know
Synovial fluid/effusion	97	3	0	0	4	0	Must know
Bone erosion	76	12	6	6	4	0.5	Must know
Olecranon bursitis	76	18	3	3	4	1	Must know
US guided injection	73	9	15	3	4	1	Must know
Tendonopathy	73	9	12	6	4	1	Must know
US guided aspiration	70	9	18	3	4	1	Must know
Tendon rupture	67	18	9	6	4	1	Must know
Tenosynovitis	63	16	6	16	4	1	Must know
Tendon nodule	58	24	6	12	4	1	Must know
Lateral epicondylitis	55	33	6	6	4	1	Must know
Medial epicondylitis	52	30	9	9	4	1	Must know
Enthesitis	47	38	13	3	3	1	Should know
Monitor disease activity	46	24	27	3	3	2	Could know
Monitor disease progression	39	33	24	3	3	2	Could know
Calcified cartilage	28	34	28	9	3	2	Could know
Shoulder							
Synovial thickening	82	12	3	3	4	0	Must know
Synovial fluid/effusion	79	15	3	3	4	0	Must know
Bone erosion	58	21	15	6	4	0	Must know
Subacromial bursitis	73	15	9	3	4	1	Must know
US guided injection	67	12	18	3	4	1	Must know
Rotator cuff tear (complete)(*p=0.01)	67	12	15	6	4	1	Must know
US guided aspiration	64	15	18	3	4	1	Must know
Calcific tendonitis	59	28	9	3	4	1	Must know
Ruptured biceps tendon (*p=0.03)	58	24	9	9	4	1	Must know
Bicipital tendonitis (*p=0.03)	53	28	13	6	4	1	Must know
Tendonopathy	52	18	24	6	4	2	Should know
Dislocated biceps tendon	49	33	9	9	3	1	Should know
Calcified cartilage	21	30	27	21	3	1	Should know
Enthesitis	49	21	18	12	3	2	Could know
Rotator cuff tear (partial)	39	30	18	12	3	2	Could know
Monitor disease activity	39	24	30	6	3	2	Could know
Monitor disease progression	36	27	30	6	3	2	Could know
Subacromial impingement	31	34	28	6	3	2	Could know
Hip							
Synovial fluid/effusion	76	15	6	3	4	0.5	Must know
Synovial thickening	73	12	9	6	4	1	Must know
US guided injection	55	18	21	6	4	2	Should know
US guided aspiration	52	21	21	6	4	2	Should know
Bursitis	48	39	7	7	3	1	Should know
Calcified cartilage	24	27	36	12	3	1.5	Could know
Bone erosion	42	18	33	6	3	2	Could know
Monitor disease activity	42	21	30	6	3	2	Could know
Monitor disease progression	27	36	30	6	3	2	Could know
Knee							
Synovial thickening	94	3	3	0	4	0	Must know
Synovial fluid/effusion	88	12	0	0	4	0	Must know
Popliteal cyst	88	3	6	3	4	0	Must know
US guided injection	69	9	15	6	4	1	Must know
US guided aspiration	67	12	15	6	4	1	Must know
Bursitis	63	20	13	3	4	1	Must know
Patellar tendon rupture (*p=0.02)	61	27	6	6	4	1	Must know
Quadriceps tendon rupture (*p=0.01)	61	24	6	9	4	1	Must know
Bone erosion	61	21	12	6	4	1	Must know
Patellar tendonitis	55	29	10	7	4	1	Must know
Patellar tendonopathy	52	33	9	6	4	1	Must know

Table 2 Continued

MSK US skills	Expert competency category score (%)				Summary statistics		Final competency category designation
	4 "must"	3 "should"	2 "could"	1 "don't need"	Median	IQR	
Enthesitis	50	31	16	3	3.5	1	<i>Should know</i>
Meniscal cyst	18	36	27	18	3	1	<i>Should know</i>
Collateral ligament tear	18	33	27	21	3	1	<i>Should know</i>
Monitor disease activity	42	27	27	3	3	2	<i>Could know</i>
Quadriceps tendonitis (**p=0.03)	36	36	23	7	3	2	<i>Could know</i>
Quadriceps tendonopathy	36	36	18	9	3	2	<i>Could know</i>
Calcified cartilage	36	24	30	9	3	2	<i>Could know</i>
Monitor disease progression	33	33	30	3	3	2	<i>Could know</i>
Meniscal tear	3	15	36	46	2	1	<i>Could know</i>
Collateral ligament enthesopathy	24	24	36	15	2	1.5	<i>Don't need</i>
Ankle and heel							
Synovial thickening	88	12	0	0	4	0	<i>Must know</i>
Synovial fluid/effusion	88	9	3	0	4	0	<i>Must know</i>
US guided injection	73	9	15	3	4	1	<i>Must know</i>
Achilles tendon rupture	72	13	9	3	4	1	<i>Must know</i>
Tenosynovitis (*p=0.045)	70	18	6	6	4	1	<i>Must know</i>
US guided aspiration	70	12	15	3	4	1	<i>Must know</i>
Achilles tendonopathy	67	18	9	6	4	1	<i>Must know</i>
Tendonopathy	61	18	15	6	4	1	<i>Must know</i>
Tendon rupture (*p=0.009)	61	18	9	6	4	1	<i>Must know</i>
Bursitis	58	23	13	7	4	1	<i>Must know</i>
Plantar fasciitis (*p=0.008)	61	15	18	6	4	1.5	<i>Should know</i>
Bone erosion	61	15	18	6	4	1.5	<i>Should know</i>
Enthesitis	50	31	16	3	3.5	1	<i>Should know</i>
Paratenonitis	49	27	18	6	3	1.5	<i>Could know</i>
Calcified cartilage	24	39	27	9	3	1.5	<i>Could know</i>
Plantar fascia rupture (*p=0.002)	42	30	18	9	3	2	<i>Could know</i>
Monitor disease activity	42	21	30	6	3	2	<i>Could know</i>
Monitor disease progression	36	30	27	6	3	2	<i>Could know</i>
Ankle ligaments enthesopathy	21	24	33	21	2	1	<i>Could know</i>
Ankle ligaments tear (*p=0.008)	12	27	36	24	2	1.5	<i>Don't need</i>
Forefoot							
Synovial thickening	91	3	6	0	4	0	<i>Must know</i>
Synovial fluid/effusion	91	6	3	0	4	0	<i>Must know</i>
Bone erosion	70	15	9	6	4	1	<i>Must know</i>
US guided injection	66	13	18	3	4	1	<i>Must know</i>
Tenosynovitis	64	27	3	6	4	1	<i>Must know</i>
Ganglion	59	19	16	6	4	1	<i>Must know</i>
US guided aspiration	64	12	21	3	4	1.5	<i>Should know</i>
Tendon rupture (*p=0.04)	58	18	18	6	4	1.5	<i>Should know</i>
Tendonopathy	52	24	18	6	4	1.5	<i>Should know</i>
Tendon nodule	44	34	16	6	3	1	<i>Should know</i>
Enthesitis	42	33	21	3	3	1.5	<i>Could know</i>
Monitoring disease progression	46	27	21	6	3	2	<i>Could know</i>
Intermetatarsal bursitis (*p=0.03)	46	27	18	9	3	2	<i>Could know</i>
Monitoring disease activity	42	27	24	6	3	2	<i>Could know</i>
Morton's neuroma	39	21	24	15	3	2	<i>Could know</i>
Calcified cartilage	30	30	21	18	3	2	<i>Could know</i>

*Significant differences between radiologist and rheumatologist scores (rheumatologist score > radiologist score).

**Significant differences between radiologist and rheumatologist scores (radiologist score > rheumatologist score).

IQR, interquartile range; US, ultrasound.

Using these specialist group scores alone rather than the overall or combined group scores changed the competency category for several items: the rheumatologists' ratings result in an adjustment to the competency category in 29 of 115 areas (21 upgrades and eight downgrades of category) and the radiologists' scores cause a modification in 59 of 115 areas (two upgrades and 57 downgrades of category).

Qualitative data themes

Additional free text comments were made by only 15 of the 35 experts (43%) (table 3).

DISCUSSION

We have undertaken a rigorous, systematic, curriculum defining process employing evidence provided by MSK US experts. This has resulted in the establishment of 10 generic core competencies and 61 anatomically specific "must know" core competencies (tables 4, 5, and 6) which represent the

minimum standard of knowledge and skills required by all rheumatologists who undertake MSK US examinations. In addition, 52 MSK US skills were deemed most appropriate at an intermediate (18 of 115 "should know") or advanced level (34 of 115 "could know"), and 28 were considered inappropriate or unnecessary for rheumatologist ultrasonographers (tables 5 and 6).

Our proposed competency based approach to the education of rheumatologists in MSK US, including the development of specific learning outcomes, has several advantages. Learning outcomes are broad statements of what is achieved and assessed at the end of a training programme²⁴ and as such, these outcomes form criteria against which the students and ultimately the course may be judged.²⁵ Explicit learning outcomes enable effective planning and delivery of an appropriate teaching and learning programme to permit learners to achieve these standards. They also enable the development of the most appropriate system of assessment to

Table 3 Qualitative data themes

1. Suggested additions to skill list mentioned by more than one respondent (two experts):
Loose body (elbow)
Ganglion (ankle)
Foreign body (forefoot)
2. Suggested additions to skill list mentioned by a single respondent (six experts):
Soft tissue mass lesions (eg, rheumatoid nodule, gouty tophus, loose body, ganglion, foreign body, abscess, neoplasm, vascular lesions)
Muscle pathology (eg, gluteal tears)
Nerve lesions (eg, tunnel syndromes at the elbow and foot)
Ligament injuries
Degenerative arthritis (eg, osteophytes in the hip and knee)
Others: periosteal reaction
additional MSK US guided procedures, eg, biopsy; needle agitation/barbotage (shoulder calcific tendonitis)
3. Suggested deletions to skill list (three experts):
Calcified cartilage (elbow and shoulder)
Tenosynovitis (elbow)
4. Other comments (one to three experts):
i. Nomenclature, eg, tendonitis v tendinopathy; enthesitis v epicondylitis
ii. Precise localisation of pathological site particularly in relation to bursae and entheses
iii. Need for further evidence to establish the precise role of MSK US for certain indications, eg, epicondylitis, carpal tunnel syndrome, tendon rupture, monitoring disease activity/progression
iv. Training, learning curve, and competency issues
v. The role and extent of practice of rheumatologist ultrasonographers (specific skills and anatomical regions v all indications and sites)
vi. The importance of a detailed knowledge of functional anatomy, appropriate indications, limitations of MSK US, and structured examination technique
vii. The infrastructure required for an MSK US imaging service, particularly the requirement for clinically relevant reporting and a permanent image archive

demonstrate achievement of these outcomes. Additionally, students know exactly what is expected of them, allowing them to take responsibility and learn more effectively. Teachers can design and plan appropriate student learning programmes based on the outcome template, using effective teaching strategies and employing efficient use of resources.²⁶ Specific competency outcomes encourage future informed educational development as they can be matched to the content of the curriculum and assessment process.²⁷

There are several interesting findings in the assignment of the final competency designations. MSK US skills associated with inflammatory arthritis scored highly with little diversity of opinion within the expert group, perhaps reflecting a common indication for a rheumatologist to undertake an ultrasound assessment²⁰ and an area in which there may be less conflict with radiology practice. Tendon pathology around the shoulder and knee was assigned a range of final competency categories that perhaps indicates the increased specialisation required to carry out a competent MSK US assessment for these indications. The use of MSK US to guide practical procedures such as joint aspiration and injection was judged a core skill in all anatomical areas except the hip, where it can be a more technically difficult procedure and may demand a more advanced level of knowledge and proficiency. Intermetatarsal bursitis was classified as “could know” and plantar fasciitis “should know”, although if the rheumatologists’ responses alone were used, these items

would have reached “must know” grade. In our experience, these are areas in which MSK US can provide important clinically relevant information, so they should be considered as valuable skills for rheumatologists.

If the data are divided by specialty, it is possible to make several observations. Significant differences in responses between the two specialist groups were more commonly seen with respect to skills in the larger joints rather than the peripheral smaller joints. The rheumatologists tended to place items in a higher competency category than the radiologists. The radiologists therefore imply that competency requires a higher level of specialisation, skill, and experience together with a more thorough and prolonged period of training. That is not to say that they think that rheumatologists should not be undertaking MSK US for these indications, as only seven of 115 items were categorised as “don’t need to know” by the radiologist experts. Indeed, most of the areas considered inappropriate for rheumatologist ultrasonography have already been identified,²¹ which allowed the construction of a more informed data collection instrument resulting in a low rate of rejection of items. The diversity of responses between specialist groups in some areas may partly be related to the enthusiasm of the rheumatologist to develop and apply a new, clinically useful skill, versus a more moderate opinion from the radiologist that there should be some control over how much MSK US it is appropriate for a non-radiologist to undertake, based on the level of technical skill and training

Table 4 Generic core competency outcomes**A rheumatologist ultrasonographer must be able to...**

1. Understand the basic principles of physics underlying the use of ultrasound.
2. Understand the indications and limitations for performing an ultrasound assessment.
3. Correctly set up an ultrasound machine for scanning with optimisation of machine settings.
4. Carry out an ultrasound assessment of each anatomical area using a structured system of examination.
5. Correctly identify normal musculoskeletal anatomy using ultrasound.
6. Correctly identify and demonstrate appropriate musculoskeletal pathology using ultrasound (see specific competencies).
7. Optimise the ultrasound image with manipulation of machine settings.
8. Understand the principles of colour and power Doppler and be able to appropriately utilise these techniques.
9. Understand the clinical relevance of the ultrasound findings and appropriately apply this to patient management.
10. Write a written report of ultrasound findings and record appropriate images in a suitable archive.

Table 5 Specific competency outcomes – upper limb

Final competency category designation	Anatomical area/MSK US skills		
	Hand + wrist	Elbow	Shoulder
"Must know"	Synovial thickening Synovial fluid/effusion Bone erosion Tenosynovitis Tendonopathy Tendon nodule Tendon rupture Ganglion Ultrasound guided aspiration Ultrasound guided injection	Synovial thickening Synovial fluid/effusion Bone erosion Tenosynovitis Tendonopathy Tendon nodule Tendon rupture Medial epicondylitis Lateral epicondylitis Olecranon bursitis Ultrasound guided aspiration Ultrasound guided injection	Synovial thickening Synovial fluid/effusion Bone erosion Complete rotator cuff tear Calcific tendonitis Bicipital tendonitis Ruptured biceps tendon Subacromial bursitis Ultrasound guided aspiration Ultrasound guided injection
"Should know"	Enthesitis	Enthesitis	Tendonopathy Dislocated biceps tendon
"Could know"	Calcified cartilage Carpal tunnel syndrome Monitoring disease activity Monitoring disease progression	Calcified cartilage Monitoring disease activity Monitoring disease progression	Enthesitis Calcified cartilage Partial rotator cuff tear Subacromial impingement Monitoring disease activity Monitoring disease progression
"Don't need to know"	Soft tissue mass Ligament pathology Muscle pathology Other nerve lesions	Soft tissue mass Ligament pathology Muscle pathology Nerve lesions	Soft tissue mass Ligament pathology Muscle pathology Nerve lesions

MSK US, musculoskeletal ultrasonography.

Table 6 Specific competency outcomes – lower limb

Final competency category designation	Anatomical area/MSK US skills			
	Hip	Knee	Ankle + heel	Forefoot
"Must know"	Synovial thickening Synovial fluid/effusion	Synovial thickening Synovial fluid/effusion Bone erosion Quadriceps tendon rupture Patellar tendonitis Patellar tendonopathy Patellar tendon rupture Bursitis Popliteal cyst Ultrasound guided aspiration Ultrasound guided injection	Synovial thickening Synovial fluid/effusion Tenosynovitis Tendonopathy Tendon rupture Achilles tendonopathy Achilles tendon rupture Bursitis Ultrasound guided aspiration Ultrasound guided injection	Synovial thickening Synovial fluid/effusion Bone erosion Tenosynovitis Ganglion Ultrasound guided injection
"Should know"	Bursitis Ultrasound guided aspiration Ultrasound guided injection	Enthesitis Meniscal cyst Collateral ligament tear	Bone erosion Enthesitis Plantar fasciitis	Tendonopathy Tendon nodule Tendon rupture Ultrasound guided aspiration
"Could know"	Bone erosion Calcified cartilage Monitoring disease activity Monitoring disease progression	Calcified cartilage Quadriceps tendonitis Quadriceps tendonopathy Meniscal tear Monitoring disease activity Monitoring disease progression	Calcified cartilage Paratenonitis Plantar fascia rupture Ankle ligament enthesopathy Monitoring disease activity Monitoring disease progression	Enthesitis Calcified cartilage Intermetatarsal bursitis Morton's neuroma Monitoring disease activity Monitoring disease progression
"Don't need to know"	Soft tissue mass Ligament pathology Muscle pathology Nerve lesions	Collateral ligament enthesopathy and other ligament pathology Soft tissue mass Muscle pathology Nerve lesions	Ankle ligament tear and other ankle ligament pathology Soft tissue mass Muscle pathology Nerve lesions	Soft tissue mass Ligament pathology Muscle pathology Other nerve lesions

MSK US, musculoskeletal ultrasonography.

required and the possible overlap with their own practice. This situation may also be influenced by a background culture of more traditional orthopaedic related ultrasound practice, with a bias towards a more surgically oriented management strategy—as opposed to the less well established rheumatological approach incorporating an MSK US

examination at the same time as clinical assessment, often by the same physician, as a complementary tool to facilitate diagnosis and management decisions or assess disease activity and outcome. These observations may also be reflected in the relatively reduced response rate of radiologists compared with rheumatologists. However, all of our

panelists, regardless of their specialty background, fulfil our strict expert selection criteria, so although it is interesting to highlight areas of disparity between the different specialists, it is important to consider the responses of the expert group as a whole to ensure an appropriate balance of opinion and therefore an objective conclusion. In addition, the inclusion of relevant stakeholders from different informed specialty backgrounds adds to the validity of these data.

Critical appraisal of each MSK US skill and free text comments were encouraged throughout the questionnaire. It was intended to use these qualitative data to provide further insights into the justification and reasons for the respective opinions and to explain or resolve any differences. However, this qualitative data analysis resulted in the reclassification of only a single skill, with the designation of calcified cartilage in the shoulder to the “could know” competency category. There were no other sufficiently frequent themes to justify modification of competency category designations among the remainder of the MSK US skills, and the comments that were made merely endorsed their suitability. This may reflect the satisfaction of the experts with both the rheumatology MSK US skill set presented to them in the questionnaire and their firm opinion with regard to the designation of appropriate competency categories. This provides further corroboration of the accuracy and validity of the final generic and specific competency outcomes.

In the absence of a significant evidence base, we used authoritative testimony from international experts, who represented a broad heterogeneous sample of experienced informed professionals with a track record of teaching, research, and active MSK US practice over a number of years. All experts satisfied strict criteria to justify such a status in an attempt to maximise the validity of our findings, with a balance of specialty backgrounds in radiology and rheumatology. To ensure continuity of development, all of these experts had been involved in the preceding stages of the project.^{20 21} This contributed to an excellent response rate, which may also reflect the high level of importance, interest, and motivation from expert MSK US practitioners in this study. These factors increase the prospect of widespread acceptance and implementation of our recommendations.

Exhaustive efforts were undertaken to ensure that the MSK US skills included in the data collection document were comprehensive, valid, and reliable. A clinical context is integral to the role of MSK US within rheumatology practice and attempts were made to reflect this with the development of an MSK US skill set that accurately reflects both rheumatology and appropriate radiology practice. This is supported by the participation of a near equal mix of rheumatologist and radiologist experts. This process involved a thorough Medline literature review, focus group interviews with radiologists and rheumatologists, together with analysis of expert practice data.²⁰ In addition, the MSK US skills that were eventually included in the questionnaire had all been classified by expert consensus agreement as necessary knowledge and skills for rheumatologist ultrasonographers.²¹ Even though some of these MSK US skills lack formal definition, all were derived from relevant evidence and consultation. Indeed, as part of their ongoing engagement in this process, each expert was given the opportunity on at least two previous occasions to interact and modify this list. This ensures a precise and reliable skill set and consistent understanding and interpretation of the nomenclature by all respondents in the context of rheumatology practice. The suitability of these competency items was reflected in the qualitative data, with relatively few modifications being recommended by the expert panel, despite prompting. The suggested alterations mainly consisted of additional skills that almost exclusively fell into the categories of soft tissue

mass lesion, muscle, ligament and nerve pathology, and degenerative arthritis—all previously designated as not appropriate or necessary for MSK US examination by a rheumatologist.²¹ The remainder were suggested by a single expert and represent more specialist areas, thereby justifying non-inclusion in this list of key rheumatology MSK US skills.

We considered using Delphi methodology²¹ by presenting feedback of the group responses from this present study to the individual experts and offering them time to reflect and change their original answers in the light of the collective opinion of the group. However, our previous experience with the same expert panel revealed relatively little change in individual scores between rounds.²¹ This perhaps reflects the confidence of experienced practitioners who have developed their own firm views that are unlikely to be changed by the opinions of others. This implies that despite a lack of formal feedback, our data are likely to represent accurate and consistent judgments. It may be more constructive to present these data to another expert group such as other radiologists or rheumatologists in order to further enhance the validity and reliability of our findings. For example, it may be advantageous to obtain the opinion of other rheumatologists as to the clinical relevance of these proposals and incorporate these views in the development of such a syllabus. Acknowledging these requirements may encourage wider dissemination of this imaging technique by providing more clearly defined, clinically focused learning outcomes in line with both imaging expert and consumer rheumatologist opinion. In addition, it would be pertinent to submit our data and proposals to relevant rheumatology and radiology authorities as a stimulus for discussion on the formal endorsement of recognised guidelines for MSK US training and practice.

Limited guidance is available for rheumatologists undertaking MSK US, current practice is not universally standardised, and there is no unified international approach to training or assessment, which is often undertaken in the absence of published evidence based educational requirements. However, good clinical practice demands that competency standards are clear, realistic, justifiable, documented, and available to all stakeholders. We have therefore conducted a thorough analysis to establish specific, expert derived, competency based learning outcomes for rheumatologist ultrasonographers. We have established a set of robust principles based on the evidence of experienced expert MSK US practitioners, which represent a foundation for further informed educational development. This competency model provides a framework for the future training of rheumatologists in MSK US and signifies a significant step forward in this expanding discipline. We hope that this study provides relevant information to promote consultation between all of the appropriate stakeholders with the aim of establishing a universal agreement of standards for education and practice for the rheumatologist ultrasonographer.

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