

The EULAR points to consider for health professionals undertaking musculoskeletal ultrasound for rheumatic and musculoskeletal diseases

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ABSTRACT

Objectives

A European League Against Rheumatism (EULAR) task force was established to reach a consensus on the role and education and training needs of non-medical health professionals undertaking musculoskeletal ultrasound for the management of people with rheumatic and musculoskeletal diseases (RMDs).

Methods

An expert multidisciplinary task force, representing 10 European countries, defined the aims and formulated fourteen research questions to guide a comprehensive systematic search of the literature (SLR). The results of the SLR were discussed and supported the formulation and consensus of points to consider and a research agenda. The points to consider were categorised according to level and strength of evidence (A to D) and task force members rated their level of agreement (0-10) for each point to consider.

Results

Based on the SLR and expert consensus seven points to consider were formulated encompassing the role and scope of health professionals using musculoskeletal ultrasound, including the application, feasibility and added value in daily practice, and the training and competency required by health professionals. The strength of the points to consider was D based on the category of evidence (3-4). A high level of agreement (range 9.0-9.7) was reached by the task force members. Additionally, the task force agreed upon seven topics for the future research agenda.

Conclusion

The seven points to consider are intended to support the education and training needs for health professionals using musculoskeletal ultrasound to improve the management of people with RMDs across Europe, in conjunction with local and national regulations.

INTRODUCTION

Musculoskeletal ultrasound has evolved into an important method for identifying musculoskeletal abnormalities, confirming the diagnosis in patients with suspected inflammatory arthritis, monitoring disease activity and therapeutic response, influencing clinical decision making and guiding interventions (1-7). The role of the non-medical health professional has advanced with many health professionals undertaking training and using musculoskeletal ultrasound to extend their scope of practice. Health professionals are performing ultrasound scans to support their clinical diagnosis, enhance treatment strategies and guide interventions for complex patients to improve the patient pathway in rheumatology. As well as undertaking training to develop their own skills, health professionals with clinical expertise, extensive knowledge of anatomy and experience using ultrasound, are also providing training for other health professionals and medical clinicians in musculoskeletal ultrasound.

As previously described among rheumatologists (8, 9), the use of musculoskeletal ultrasound and the training undertaken by health professionals, varies significantly between different professional groups and across Europe. Guidelines to support training for rheumatologists have been formulated (10) but currently there are no recommendations to support the education and training needs of non-medical health professionals using musculoskeletal ultrasound.

METHODS

The European League Against Rheumatism (EULAR) standardised operating procedures for the elaboration, evaluation, dissemination and implementation of points to consider endorsed by EULAR were followed (11).

EULAR acknowledges that health professionals within rheumatology include a wide range of professions, of which the availability, definition, training and scope of practice may vary among countries. Moreover, regulatory and legal issues related to their training and practice may differ. Within EULAR, health professionals are considered to be those professionals involved in the care of musculoskeletal and related conditions, who are not medical practitioners but are eligible to be members of the organisation through which a country has become a EULAR health professional member.

The task force

The multidisciplinary task force comprised 18 clinical and academic experts representing ten European countries (Austria, Denmark, Estonia, France, Germany, Italy, the Netherlands, Norway, Spain, and the United Kingdom) and included rheumatologists, nurses, physiotherapists, an epidemiologist, methodologist, radiologist, radiographer and podiatrist, as well as people with rheumatic and musculoskeletal diseases (RMDs). The objectives were to formulate key questions to guide the systematic literature review (SLR), identify and critically appraise the evidence, and generate points to consider based on a combination of research-based evidence and expert consensus approach.

At the initial task force meeting members proposed key questions relating to the role of health professionals in the ultrasound assessment of RMDs, as well as the ultrasound training and competency requirements for health professionals using ultrasound for the management of RMDs. Fourteen research questions (Q1-Q14) were formulated to guide the SLR (see online supplementary file 1).

Systematic literature review

An extensive systematic literature search using MEDLINE, Embase Classic+Embase, EBM Reviews - Cochrane Database of Systematic Reviews, and AMED (Allied and Complementary Medicine) databases via Ovid from inception to November 2015 (search strategy details are provided in the online supplementary file 2) was carried out to identify publications on the role of health professionals using musculoskeletal ultrasound, their competency requirements and training undertaken. In anticipation of the relative scarcity of available publications, no limitations regarding study type, research design or language were applied. In addition to peer-reviewed publications, conference abstracts from international conferences (i.e. British Society for Rheumatology Conference and EULAR Congress) and other sources (i.e. training curricula and non-peer reviewed scientific publications) were also identified. Additional articles obtained through hand searching were included and task force members were asked to review the final list of included papers before the second meeting and suggest articles and abstracts that had not been included. All abstracts were read by two reviewers (HJS and RJW) and selected full-text articles and abstracts (when full-text articles were not available) were also reviewed by a third person (MADA).

Developing the points to consider

During the second task force meeting the results of the SLR were presented to the task force members to initiate discussions and develop the points to consider for health professionals undertaking musculoskeletal ultrasound for the management of people with RMDs. In order to address the 14 research questions (Q1-Q14: online supplementary file 1), the task force members used any available evidence and, when lacking, addressed the respective questions using their expertise and a consensus approach to formulate seven points to consider. For each point to consider the category of evidence (1A highest to 4 lowest) and the strength of the statement (A highest to D lowest) defined in the EULAR standard operating procedures (11) was presented to the task force members, who were asked to independently indicate their level of agreement after the second meeting. The perceived level of agreement was recorded on a 0-10 visual analogue scale (VAS; 0 = not recommended at all, 10 = fully recommended) and reflected the research evidence and their clinical expertise.

A future research agenda was agreed upon based on the results of the literature review.

RESULTS

A total of 226 records were identified in the searches. After duplicates were removed the records were independently screened, and 57 were finally obtained and read. The reviewers identified 21 abstracts that were potentially eligible for inclusion; however there were nine that were only available in conference abstract form. During review of the full-text articles four were excluded because the sonographer was not a health professional or their profession could not be determined. Hence, a total of nine full-text articles and eight conference abstracts were included in the final review. A flow chart of the SLR is provided Figure 1.

Points to consider

An overarching principle and seven points to consider were formulated (Table 1). Two points covered the role and scope of health professionals using musculoskeletal ultrasound and one point addressed the application and feasibility in daily practice. Three points to consider focused on the training and competency required by health professionals and the final point addressed the added value in daily practice. The strength of all points to consider was D based on the category of evidence (3-4). A high level of agreement (range 9.0-9.7) was achieved between task force members. The task force agreed upon seven topics for the future research agenda.

Table 1. Points to consider for health professionals undertaking musculoskeletal ultrasound for rheumatic and musculoskeletal diseases

Overarching principle			
All health professionals may use musculoskeletal ultrasound, following appropriate training, within their scope of clinical practice and professional background.			
Points to consider	Category of evidence	Strength of statement	Level of agreement mean (95% CI)
Role and scope			
1. Health professionals may use ultrasound to detect musculoskeletal abnormalities and contribute to clinical decision-making.	3-4	D	9.2 (8.8 to 9.7)
2. Health professionals may use musculoskeletal ultrasound as a tool for research including health professional-led studies.	3-4	D	9.3 (8.7 to 9.9)
Training and competency			
3. Health professionals must be appropriately trained and assessed for competency in musculoskeletal ultrasound before applying it in clinical practice.	4	D	9.7 (9.5 to 10.0)
4. The minimal competency requirements for performing musculoskeletal ultrasound must be the same for all ultrasound practitioners. Advanced training content may be adapted according to the needs of the health professionals.	3-4	D	9.6 (9.2 to 10.0)
5. Health professionals appropriately trained may teach musculoskeletal ultrasound according to a standardised and formalised training programme.	4	D	9.5 (9.1 to 9.9)
Application and feasibility			
6. The use of musculoskeletal ultrasound by health professionals must be based on levels of competency and the individual's role within their institution/department, as directed by local and national regulations.	3-4	D	9.6 (9.4 to 9.9)
Additional value			
7. By using musculoskeletal ultrasound, health professionals may improve the clinical management of people with rheumatic and musculoskeletal diseases	3-4	D	9.0 (8.3 to 9.7)

Role and scope

Point to consider 1: Health professionals may use ultrasound to detect musculoskeletal abnormalities and contribute to clinical decision-making.

Currently there are not any studies presented in the literature that formally address the role and scope of practice of health professionals undertaking musculoskeletal ultrasound for RMDs. Table 2 provides a summary of studies identified in the SLR in which musculoskeletal ultrasound was performed by health professionals, which indirectly informs the role and scope of practice being undertaken.

The descriptive studies by Bowen et al. (12) and Thoomes-de Graaf et al. (13) evaluated the inter-observer agreement between a radiologist and podiatrist or physiotherapist respectively in the use of musculoskeletal ultrasound.

Table 2. The role and scope of musculoskeletal ultrasound undertaken by health professionals for people with rheumatic and musculoskeletal diseases

Role of health professional and scope of practice	Studies (*abstract only)
<i>Nurse</i>	
Assessment of inflamed knee joints	El Miedany & Palmer (14)
Detection of sub-clinical synovitis and erosions	Rutherford et al.* (15)
Perform MSUS to monitor and assess disease activity	Jakobsen et al.* (16)
Nurses believe they can't, but doctors believe the nurses could be involved in musculoskeletal sonography	Loan et al.* (17)
Patients do not see a role for nurses in ultrasonography	Vasile et al.* (18)
<i>Physical therapist and occupational therapist</i>	
Ordered diagnostic ultrasounds	Kennedy et al.* (19) and Passalent et al.* (20)
<i>Physiotherapist</i>	
Ultrasound assessment of hand osteoarthritis	Brandon et al.* (21)
Ultrasound-guided subacromial corticosteroid injection	Roddy et al. (22)
Diagnostic ultrasound of the shoulder; detecting rotator cuff tears	Thoomes-de Graaf et al. (13)
Point of care ultrasonography for the assessment of acute haemarthrosis and haemophilic arthropathy	Strike et al. (23)
<i>Podiatrist</i>	
MSUS assessment of the forefoot in patients with RA. Ultrasonography is a 'gold standard' requirement and advanced resource for a podiatry service	Bowen et al. (12 , 24) Williams et al. (25)
Ultrasound examination of foot and ankle disease and identification of inflammation in patients with JIA	Hendry et al. (26 , 27)
<i>Registered health professional</i>	
Ultrasound assessment of hands, wrists and feet in rheumatoid arthritis	Bacon et al.* (28)

MSUS: musculoskeletal ultrasound; RA: rheumatoid arthritis; JIA: juvenile idiopathic arthritis

Point to consider 2: Health professionals may use musculoskeletal ultrasound as a tool for research including health professional-led studies.

Seven studies have described the use of musculoskeletal ultrasound by health professionals as an outcome measure in research studies. Hendry et al. ([27](#)) report the findings from an exploratory randomised controlled trial in which musculoskeletal ultrasound is performed by an experienced podiatrist as a secondary outcome measure. However, musculoskeletal ultrasound was an outcome measure used in both arms of the study; hence the evidence only provides a description of the role of the podiatrist and not as a comparator with another imaging modality or health professional. Roddy et al. ([22](#)) also describe the role of physiotherapists using musculoskeletal ultrasound in the study protocol for a randomised controlled trial to identify an abnormality and guide an intervention. The results will enable a comparison between ultrasound-guided injections versus blind injections performed by physiotherapists. The remaining studies ([13](#), [14](#), [21](#), [24](#), [26](#)) are descriptive studies, including comparative studies in which health professionals use musculoskeletal ultrasound as part of the research protocol - these also include non-medical health professional-led studies.

Training and competency

Point to consider 3: Health professionals must be appropriately trained and assessed for competency in musculoskeletal ultrasound before applying it in clinical practice.

The literature describes a combination of informal sonography training and post-graduate university courses undertaken by non-medical health professionals. In studies where musculoskeletal ultrasound is performed as an outcome measure, health professionals are described as being ‘trained in sonography’ with no further information given ([21](#), [26](#)). There is evidence to suggest that health professionals are undertaking sonography training by professional bodies, for example the British Society for Rheumatology (BSR) and EULAR ([12](#), [16](#)), and are being supervised and mentored in practice by both rheumatologists and radiologists ([12](#), [14](#)).

Descriptions of academic training programmes are given in the literature ([13](#), [15](#), [22](#), [23](#), [28](#)). Formal post-graduate courses delivered by universities and learning institutions for health professionals provide theoretical education, together with technical and practical training during the course and after with a clinical mentor until competency is achieved ([13](#), [15](#), [16](#), [23](#), [28](#)). Some of the courses described are specific to the clinical speciality ([15](#), [23](#), [28](#)), the health professionals individual profession ([13](#), [16](#)) or the ultrasound-guided intervention ([22](#)).

Point to consider 4: The minimal competency requirements for performing musculoskeletal ultrasound must be the same for all ultrasound practitioners. Advanced training content may be adapted according to the needs of the health professionals.

Information in the literature regarding the competency assessment process for health professionals using musculoskeletal ultrasound is only available from universities in the UK and Canada ([23](#), [28](#)). Descriptions of post-graduate academic training programmes in the UK indicate that rheumatologists and health professionals are required to meet the same minimal competencies for courses accredited by the Consortium for the Accreditation of Sonographic Education (CASE) ([15](#), [22](#), [28](#)).

Reliability studies and trial protocols indicate that rheumatologists/radiologists/rehabilitation consultants/GPs and health professionals are required to meet the same minimal competency requirements for using musculoskeletal ultrasound in research studies ([12](#), [13](#), [15](#), [22](#)).

Sonography courses provided by professional bodies, including BSR and EULAR are open to non-medical health professionals that meet the entry requirements. Health professionals are required to meet the same minimal competencies for BSR and EULAR courses as rheumatologists and other medical professionals completing the courses ([12](#), [16](#)).

Point to consider 5: Health professionals appropriately trained may teach musculoskeletal ultrasound according to a standardised and formalised training program.

The evidence from the literature is very weak but indicates that non-medical health professionals (specifically sonographers) are able to teach and assess musculoskeletal ultrasound techniques. In the trial protocol reported by Roddy et al ([22](#)) interface clinicians (including rheumatologists, rehabilitation medicine specialists and GPs) and physiotherapists are assessed by a consultant musculoskeletal sonographer prior to commencement of the study. Post-graduate academic training programmes in the UK (CASE accredited) and Canada are delivered and assessed by non-medical health professionals ([23](#)).

Health professionals are eligible to undertake the EULAR Advanced Ultrasound Course, which provides those who complete the course requirements with the competency necessary to teach musculoskeletal ultrasound ([29](#)).

Application and feasibility

Point to consider 6: The use of musculoskeletal ultrasound by health professionals must be based on levels of competency and the individual's role within their institution/department, as directed by local and national regulations.

The training and competency requirements for non-medical health professionals have been outlined above. In addition, the task force acknowledged that, within the multiple professional groups that are encompassed under the umbrella of EULAR health professionals, the application and feasibility of using musculoskeletal ultrasound must also be based on the individual professional roles, the requirements of the individual's institution and/or department as well as local and national regulations.

Comparative studies and clinical reports define the role of the individual health professional within their clinical competency. Physiotherapists are using musculoskeletal ultrasound to influence clinical decision making in the management of symptomatic hand osteoarthritis (21) and using ultrasound to assess the shoulder and guide interventions (13, 22); podiatrists are using ultrasound to assess the foot and ankle (12, 24, 26, 27), and nurses are using ultrasound to monitor and assess disease activity (16). Rheumatology departments have recognised the need to provide focused academic training courses, which include diagnosing subclinical synovitis in the hands, wrists and feet only, and can be undertaken by nurses and other health non-medical professionals (15, 28).

Additional value

Point to consider 7: By using musculoskeletal ultrasound, health professionals may improve the clinical management of people with rheumatic and musculoskeletal diseases.

The lack of literature to support health professionals using musculoskeletal ultrasound equates to limited evidence of the benefit to people with rheumatic and musculoskeletal diseases. Descriptive studies, which compare the use of musculoskeletal ultrasound by non-medical health professionals to clinical examination, indicate the potential to improve the detection of subclinical disease and clinical decision-making with the use of musculoskeletal ultrasound by health professionals (21, 26).

The authors of a clinical study provide a summary of patient's feedback following the use of ultrasound-guided injections by a rheumatology nurse (14); however all procedures were carried out under the supervision of a rheumatologist and no comparisons were made between the role of the rheumatologists and the nurse.

Regional guidelines developed in the UK recommend the use of ultrasonography in 'gold standard' podiatry services for the management of foot health problems associated with rheumatoid arthritis (25). 'One stop clinics', which include nurses utilising ultrasound for the management of new patients with inflammatory arthritis offer the potential for rapid diagnosis and management, whilst reducing the delay and costs caused by follow-up and further investigations (15).

Future research agenda

The EULAR Task Force identified the most important topics for future research (Table 3) based on the limited evidence available and current clinical practice of non-medical health professionals. Future research is intended to increase the level of evidence to support the use of musculoskeletal ultrasound by health professionals.

Table 3. Future research agenda

1. To determine the musculoskeletal ultrasound training needs of European League Against Rheumatism (EULAR) health professionals and how they intend to use ultrasound.
2. To develop a structured EULAR advanced musculoskeletal ultrasound training programme specific to the needs of health professionals.
3. To determine the provision of mentorship that health professionals will require to support their training needs in musculoskeletal ultrasound.
4. To understand the impact of health professionals performing musculoskeletal ultrasound on the care of people with rheumatic and musculoskeletal diseases.
5. To determine the cost effectiveness of models of care in which health professionals are using musculoskeletal ultrasound.
6. To determine and standardise the minimum requirements for reporting musculoskeletal ultrasound examinations performed by health professionals.
7. To evaluate the influence of the EULAR points to consider on the use of musculoskeletal ultrasound by health professionals.

DISCUSSION

These are the first points to consider produced by a EULAR task force for non-medical health professionals using musculoskeletal ultrasound for the management of people with RMDs.

The task force acknowledge that there is minimal evidence to support the seven points to consider, which therefore were developed using a combination of research-based evidence and expert consensus approach. The majority of evidence has been published in recent years (2012-2015) and with approximately half in abstract form only. The use of musculoskeletal ultrasound by health professionals in both clinical practice and research is increasing in popularity, hence these points to consider are timely and it is envisaged that they will need to be revisited in the near future when new evidence becomes available, in accordance with the EULAR standardised operating procedures (11).

In summary, the seven points to consider are intended to support the education and training needs for non-medical health professionals using musculoskeletal ultrasound to improve the management of people with RMDs across Europe. It is important to note that these points to consider should be used in conjunction with local and national regulations. The role and scope of ultrasound practice does not differ significantly from that undertaken by rheumatologists and therefore the training and competency levels should be the same for all medical and non-medical health professionals using musculoskeletal ultrasound in their clinical practice and for the purposes of undertaking research.

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Competing interests

None

Contributors

HJS was the research fellow for the project, undertaking the SLR. RJW was the project convener; PM, DA and TPVV provided epidemiology direction for the SLR and project. HJS and RJW were responsible for drafting the manuscript. All those listed as authors were responsible for developing the points to consider and reading, commenting on, and approving the final manuscript. All contributors were independent from the study funders in conducting the research.

REFERENCES

1. Wakefield RJ, Gibbon WW, Conaghan PG, O'Connor P, McGonagle D, Pease C, et al. The value of sonography in the detection of bone erosions in patients with rheumatoid arthritis: a comparison with conventional radiography. *Arthritis Rheum.* 2000 Dec;43(12):2762-70.
2. Karim Z, Wakefield RJ, Conaghan PG, Lawson CA, Goh E, Quinn MA, et al. The impact of ultrasonography on diagnosis and management of patients with musculoskeletal conditions. *Arthritis Rheum.* 2001 Dec;44(12):2932-3.
3. Terslev L, Torp-Pedersen S, Savnik A, von der Recke P, Qvistgaard E, Danneskiold-Samsøe B, et al. Doppler ultrasound and magnetic resonance imaging of synovial inflammation of the hand in rheumatoid arthritis: a comparative study. *Arthritis Rheum.* 2003 Sep;48(9):2434-41.
4. d'Agostino MA, Ayral X, Baron G, Ravaud P, Breban M, Dougados M. Impact of ultrasound imaging on local corticosteroid injections of symptomatic ankle, hind-, and mid-foot in chronic inflammatory diseases. *Arthritis Rheum.* 2005 Apr 15;53(2):284-92.
5. Brown AK, Quinn MA, Karim Z, Conaghan PG, Peterfy CG, Hensor E, et al. Presence of significant synovitis in rheumatoid arthritis patients with disease-modifying antirheumatic drug-induced clinical remission: evidence from an imaging study may explain structural progression. *Arthritis Rheum.* 2006 Dec;54(12):3761-73.
6. Koski JM, Saarakkala S, Helle M, Hakulinen U, Heikkinen JO, Hermunen H, et al. Assessing the intra- and inter-reader reliability of dynamic ultrasound images in power Doppler ultrasonography. *Ann Rheum Dis.* 2006 Dec;65(12):1658-60.
7. Naredo E, Collado P, Cruz A, Palop MJ, Cabero F, Richi P, et al. Longitudinal power Doppler ultrasonographic assessment of joint inflammatory activity in early rheumatoid arthritis: predictive value in disease activity and radiologic progression. *Arthritis Rheum.* 2007 Feb 15;57(1):116-24.
8. Naredo E, D'Agostino MA, Conaghan PG, Backhaus M, Balint P, Bruyn GA, et al. Current state of musculoskeletal ultrasound training and implementation in Europe: results of a survey of experts and scientific societies. *Rheumatology (Oxford).* 2010 Dec;49(12):2438-43.
9. Mandl P, Naredo E, Conaghan PG, D'Agostino MA, Wakefield RJ, Bachta A, et al. Practice of ultrasound-guided arthrocentesis and joint injection, including training and implementation, in Europe: results of a survey of experts and scientific societies. *Rheumatology (Oxford).* 2012 Jan;51(1):184-90.
10. Terslev L, Hammer HB, Torp-Pedersen S, Szkudlarek M, Iagnocco A, D'Agostino MA, et al. EFSUMB Minimum Training Requirements for Rheumatologists Performing Musculoskeletal Ultrasound. *Ultraschall Med.* 2013 Jun 17.
11. van der Heijde D, Aletaha D, Carmona L, Edwards CJ, Kvien TK, Kouloumas M, et al. 2014 Update of the EULAR standardised operating procedures for EULAR-endorsed recommendations. *Ann Rheum Dis.* 2015 Jan;74(1):8-13.
12. Bowen CJ, Dewbury K, Sampson M, Sawyer S, Burridge J, Edwards CJ, et al. Musculoskeletal ultrasound imaging of the plantar forefoot in patients with rheumatoid arthritis: inter-observer agreement between a podiatrist and a radiologist. *J Foot Ankle Res.* 2008;1(1):5.
13. Thoomes-de Graaf M, Scholten-Peeters GG, Duijn E, Karel YH, van den Borne MP, Beumer A, et al. Inter-professional agreement of ultrasound-based diagnoses in patients with shoulder pain between physical therapists and radiologists in the Netherlands. *Manual therapy.* 2014 Oct;19(5):478-83.
14. El Miedany Y, Palmer D. Musculoskeletal US: examining the joints. *British journal of nursing (Mark Allen Publishing).* 2012 Mar 22-Apr 11;21(6):340-4.
15. Rutherford A, Scott Russell A, Smith J, Jassim I, Withrington R, Bacon P, et al. Abstract 188. The evaluation of musculoskeletal ultrasound in the management of inflammatory arthritis. *Rheumatology (Oxford).* 2012;51(Suppl 3):iii120-iii1.
16. Jakobsen B, Kildal NH, Koksvik HS. OP0009-HPR Development and Implementation of A Musculoskeletal Ultrasound Training Program for Nurses. *Annals of the Rheumatic Diseases.* 2014 June 1, 2014;73(Suppl 2):63.

17. Loan C, Berghea F, Vasile D, Predeteanu D, Nastase D, Otoi L, et al. AB0818-HPR Doctors and nurses do not share the same vision regarding the future role of a specialised nurse. *Annals of the Rheumatic Diseases*. 2013 June 1, 2013;72(Suppl 3):A1090.
18. Vasile DM, Ioan C, Berghea F, Iacob M, Predeteanu D, Canea F, et al. AB0819-HPR Is the rheumatic patient ready to accept a more specialised health management offered by his nurse? *Annals of the Rheumatic Diseases*. 2013 June 1, 2013;72(Suppl 3):A1090.
19. Kennedy C, Warmington K, Soever L, Passalent L, Lineker S, Thomas R, et al. RR-PO-301-13-Tue Advanced clinician practitioner in arthritis care (ACPAC) program-trained therapists in ontario: impact on system integration and change. *Physiotherapy*. 2011;97(Supplement S1):eS1156.
20. Passalent L, Kennedy C, Soever L, Warmington K, Brooks S, Shupak R, et al. SAT0477 The impact of advanced clinician practitioner in arthritis care (ACPAC) program-trained extended role practitioners on healthcare delivery in ontario: A two year prospective study. *Annals of the Rheumatic Diseases*. 2013 June 1, 2013;71(Suppl 3):634.
21. Brandon M, Friel L, Budai S, Madhok R, Turner D, Woodburn J. FRI0474-HPR Ultrasound imaging and the therapeutic planning of targeted corticosteroid injections for symptomatic hand osteoarthritis. *Annals of the Rheumatic Diseases*. 2013 June 1, 2013;71(Suppl 3):749.
22. Roddy E, Zwierska I, Hay EM, Jowett S, Lewis M, Stevenson K, et al. Subacromial impingement syndrome and pain: protocol for a randomised controlled trial of exercise and corticosteroid injection (the SUPPORT trial). *BMC Musculoskelet Disord*. 2014;15:81.
23. Strike KL, Iorio A, Jackson S, Lawson W, Scott L, Squire S, et al. Point of care ultrasonography in haemophilia care: recommendations for training and competency evaluation. *Haemophilia*. 2015 Nov;21(6):828-31.
24. Bowen CJ, Hooper L, Culliford D, Dewbury K, Sampson M, Burridge J, et al. Assessment of the natural history of forefoot bursae using ultrasonography in patients with rheumatoid arthritis: a twelve-month investigation. *Arthritis Care Res (Hoboken)*. 2010 Dec;62(12):1756-62.
25. Williams AE, Davies S, Graham A, Dagg A, Longrigg K, Lyons C, et al. Guidelines for the management of the foot health problems associated with rheumatoid arthritis. *Musculoskeletal Care*. 2011 Jun;9(2):86-92.
26. Hendry GJ, Gardner-Medwin J, Steultjens MP, Woodburn J, Sturrock RD, Turner DE. Frequent discordance between clinical and musculoskeletal ultrasound examinations of foot disease in juvenile idiopathic arthritis. *Arthritis Care Res (Hoboken)*. 2012 Mar;64(3):441-7.
27. Hendry GJ, Watt GF, Brandon M, Friel L, Turner DE, Lorgelly PK, et al. The effectiveness of a multidisciplinary foot care program for children and adolescents with juvenile idiopathic arthritis: an exploratory trial. *J Rehabil Med*. 2013 May;45(5):467-76.
28. Bacon P, Smith J, Richardson A, Giancola G, Soh V, Spencer S, et al. 44. Development of an accredited, innovative, focused ultrasound training course for registered health professionals. *Rheumatology (Oxford)*. 2012;51(Suppl 3):iii67.
29. Naredo E, Bijlsma JW, Conaghan PG, Acebes C, Balint P, Berner-Hammer H, et al. Recommendations for the content and conduct of European League Against Rheumatism (EULAR) musculoskeletal ultrasound courses. *Ann Rheum Dis*. 2008 Jul;67(7):1017-22.

FIGURE LEGENDS

Figure 1: Flow chart of the systematic literature review.