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Title: Impact of an intensive education program of diagnostic lung and lower limb ultrasound on physiotherapist knowledge: A pilot study

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Title: Impact of a novel one day education program of diagnostic lung and lower limb muscle ultrasound on physiotherapist knowledge: A pilot study

Abstract

Introduction/purpose: Diagnostic ultrasound of the respiratory system and peripheral muscular systems is increasingly being used by clinicians. The aim of this study was to evaluate the knowledge outcomes of a bespoke one day curriculum for physiotherapists that incorporated lung, diaphragm and lower limb muscle diagnostic ultrasound theory and practical training in image acquisition and analysis.

Methods: A one day course comprised of 3 instructors and 32 participants on key diagnostic ultrasound findings of the lungs, diaphragm and lower limb musculature included didactic lectures combined with expert led hands-on training in practical sessions. Participants undertook pre and post-course knowledge questionnaire covering key ultrasound findings for normal lungs, pleural/pulmonary pathologies and normal and abnormal findings for the diaphragm and key lower limb muscle groups. The pre-test and post-test questionnaire and survey results were reported using parametric descriptive statistics (means SD) as the data was normally distributed.

Results: Of the 32 physiotherapists who undertook the one-day training, 25 (78%) completed the pre and post course questionnaires. The pre-course knowledge scores (mean percentage, SD) were 63% (21) and the post-course scores were 62% (20) after training.

Discussion: This novel diagnostic ultrasound course led to limited improvements of ultrasound knowledge in the specific areas of the key ultrasound findings pulmonary system and lower limb muscle anatomy. The pre-reading material and course structure may have been too burdensome for the participants.

Conclusion: Combined lung and muscle diagnostic ultrasound course may require more than the standard one day training for appropriate knowledge acquisition and use of online pre-course video lectures may facilitate learning.
Key words: ultrasonography, curriculum, diagnostics, physical therapy, education

INTRODUCTION

In the acute care setting physiotherapists routinely utilise combinations of clinical examination, lung auscultation and the interpretation of the chest radiograph findings to assist with clinical decision making about the requirement for and response(s) to chest physiotherapy (1). Thoracic ultrasound has greater diagnostic accuracy and beneficial impact on clinical decision making by physicians for the key pulmonary (interstitial syndrome, lung collapse/consolidation) and pleural pathologies (pneumothorax, pleural effusion) when compared to the portable chest radiograph (2-5). A formal one day diagnostic thoracic ultrasound training course specifically designed for respiratory physiotherapists demonstrated improvements in ultrasound knowledge of lung and pleural pathology, image acquisition and image interpretation skills in a subset of the participants with no previous diagnostic thoracic ultrasound knowledge (6).

In addition, the evaluation of lower limb muscle quantity and muscle architectural quality utilising diagnostic ultrasound is also being increasingly used in acute care (7). Ultrasound measures of muscle mass (as a surrogate measure of muscle function) can provide accurate muscle quantification and may be combined with measures of physical function as a means of tracking patient progress and evaluating therapy effectiveness in acute care (8). The use of diagnostic muscle ultrasound for clinical and research purposes requires appropriate training (9). Currently, to the best of our knowledge there is no formal training program or standardized protocol used to educate clinicians, health care providers or researchers in the use of diagnostic ultrasound for muscle health. Importantly, reliability, reproducibility and accuracy should not be assumed with ultrasound image acquisition and any training programs must also address these aspects (8).

Diagnostic ultrasound is not new to physiotherapy (10), however to the best of our knowledge it is not routinely utilised by physiotherapists to examine the respiratory system and limb

muscle systems in the acute setting. Various short courses have been developed for training medical clinicians in the use of point of care diagnostic ultrasound (POCUS) for lungs and or cardiac function utilising a variety of training methods (simulation based, e-learning, hands-on classroom based learning), different durations and methods of evaluation (11-18). The only previous evaluation of a diagnostic lung ultrasound training course for physiotherapists (6) reported it to be effective for knowledge acquisition and image interpretation in a small group of 12 respiratory physiotherapists conducted in Singapore. International experts from the key critical care societies (e.g. ESICM, AACP, SRLF) through a consensus of opinion have recommended a framework of training for intensive care physicians required to achieve competence in critical care ultrasonography (inclusive of thoracic, abdominal, vascular and echocardiography) (19, 20). Further developments include a consensus statement on characteristic ultrasound signs for key lung and pleural pathologies (21), that should be incorporated as part of thoracic ultrasound training programs. The incorporation of diagnostic ultrasound for the monitoring of lung, diaphragm and limb muscle function within acute care (8, 22, 23) provides physiotherapists with accurate bedside tools to identify pulmonary pathology amenable to chest physiotherapy (2, 22, 24), suitability for weaning from mechanical ventilation (25) and tracking of muscle function during critical illness and in response to therapy interventions (7). We are not aware of any studies reporting on the educational requirements and efficacy of a training program that combines limb muscle and thoracic diagnostic ultrasound designed for use in acute care by physiotherapy.

The primary objective of this study was to assess the participant knowledge before and after a one-day diagnostic lung, diaphragm and lower limb muscle ultrasound curriculum course (including pre-reading, didactic lectures, practical training and image recognition skills) and participant satisfaction of a group of physiotherapists.

Methods

The one day training course (total teaching time of 6.5 hours) was run as a post congress workshop at the World Confederation of Physical Therapy Conference (WCPT) and conducted on 05 July 2017 and included training of 32 qualified physiotherapists. This study received ethical approval from the University of Technology Sydney HREC (ETH171615).

The one-day diagnostic ultrasound training course comprised of 3 instructors and 32 participants involved 2.5 hours of didactic lectures and 4 hours of expert-led practical skills

training. The methods used for this training program were based on a previous pilot program for diagnostic thoracic ultrasound for physiotherapists (6). To optimize participant learning we included 1) pre-reading material with two comprehensive review articles that included key aspects of diagnostic thoracic (26) and muscle ultrasound (27), 2) evaluation of participant baseline knowledge with a pre-course questionnaire, 3) group training with instructors:trainee ratio of 1:10 (this instructor to participant ratio was used as recommended by course organisers from WCPT to ensure financial viability of the course) being less than the recommended ratio of 1:5 by the Australian Society of Ultrasound Medicine see link http://www.asum.com.au/files/public/Education/CAHPU/CAHPUForms/CAHPU-Unit-Accreditation-Application-Form.pdf) and a 4) post workshop knowledge acquisition test. The full one-day course content and structure are detailed in Table 1.

Table 1 Diagnostic Ultrasound Course Curriculum (one day course)

Pre-reading	Attendees were emailed 1 week pre-course the two review articles: 1) Via, G., et al. Lung ultrasound in the ICU: from diagnostic instrument to respiratory monitoring tool. Minerva anestesiologica 78.11 (2012): 1282-1296. (26) 2) Arts I., et al. Normal values for quantitative muscle ultrasonography in adults. Muscle Nerve (2010) 41:32-41. (27)
Duration	One day course outline
10 minutes	Pre-workshop quiz (15 multiple choice questions) based on pre-reading articles
50 minutes	Didactic lecture: Physics of ultrasound – Knobology/image optimisation
50 minutes	Practical stations: Knobology and image optimisation Expert-led stations* 10 identical groups of approximately 3 participants, with each participant acting as models for image optimization
15 minutes	Didactic Lecture: Normal anatomy: abdomen/thorax landmarks.
15 minutes	Didactic Lecture: Normal anatomy: lower limb muscle landmarks.
60 minutes	Practical stations: 1. Imaging abdomen/thorax anatomy landmarks (30 minutes) 2. Imaging lower limb muscle anatomy landmarks (30 minutes) Expert-instructor led stations* using normal individuals (each participant alternately acted as a model for imaging purposes) for image identification, acquisition and image optimization procedures

30 minutes	Didactic lecture: Ultrasound diagnosis of pulmonary conditions • Pleural effusion • Pneumothorax • Lung consolidation/ pneumonia • Pulmonary oedema
30 minutes	Didactic lecture: Ultrasound diagnosis of lower limb pathology (including muscle mass and architecture analysis techniques) Quadriceps/Tibialis anterior
30 minutes	Practical stations: lower limb pathology 1 and 2*
40 minutes	Practical stations: Expert-led rotating stations (4 stations with 40min at each station)*. 1. Ultrasound diagnosis of pulmonary oedema (5 patient video clips) 2. Video clip interpretation pleural effusions (4 patient video clips) and participant imaging of chest ultrasound trainer torso with moderate to large effusions in each hemi-thorax (https://www.limbsandthings.com/au/our-products/details/chest-drain-decompression-trainer) 3. Ultrasound diagnosis of lung consolidation (4 patient video clips) 4. Ultrasound diagnosis of pneumothorax (2 patient video clips + low fidelity simulation based on methods by Shokoohi et al http://onlinelibrary.wiley.com/doi/10.1111/j.1553-2712.2012.01431.x/epdf)
20 minutes	Didactic lecture: Ultrasound applications for physiotherapy in intensive care Didactic lecture: current use of ultrasound guidance during acute care rehabilitation
20 minutes	Post workshop participant questionnaire evaluating knowledge acquisition from course
10 minutes	Satisfaction survey of attendees regarding course content and structure

* Only 3 experts for ALL the practical stations

The two summary articles (26, 27) were emailed to participants approximately one week prior to the one-day course to enhance learning and reduce the cognitive load during the workshop. The articles covered the basics of diagnostic ultrasound theory and its practical applications in acute care including the identification of the key findings lung/pleural pathology and lower limb muscle ultrasonography in adults. At enrolment prior to course commencement a 15-item multiple-choice survey was administered to evaluate participant baseline knowledge of

lung and lower limb muscle ultrasound acquired from the pre-reading and prior experience (26, 27) (see Appendix 1 for further detail). During the course multiple teaching modalities were applied. These consisted of lecture notes for each session reporting on the educational objectives, including the specific scanning techniques, patient positioning, general anatomy and key pathological findings on ultrasound, live demonstrations using participants for ultrasound imaging of normal findings for thorax/lung/diaphragm and lower limb muscles, tutoring during live ultrasound imaging of course participants for normal image identification, acquisition and image optimization procedures, the use of phantom models (for imaging of simulated pleural effusions) and tutor guidance for the ultrasound identification lung and pleural pathology using patient video clips (de-identified). Lecture notes for each session were developed describing intended learning outcomes and included specifics on scanning techniques, patient positioning, general anatomy and clinical relevance. A post-course questionnaire was based on the ultrasound learning goals and included 30 multiple choice questions covering key aspects from the one day course (see Appendix 2).

Descriptive Statistics

Summary (mean, SD) and descriptive statistics of participants scores (percentage correct) on pre- and post- course questionnaires and the participant evaluations of course satisfaction were reported using Microsoft Excel (version 15.4).

Results

32 physiotherapists participated in this training program, with a 78% response rate (25/32) to the questionnaires (2 Australia, 5 South Africa, 3 Singapore, 2 Chile, 2 Canada, 2 Iran, 1 New Zealand, 1 Switzerland, 1 Brazil, 1 Nigeria, 1 East Africa, 2 West Africa, 1 Pakistan, 1 United Arab Emirates, 1 unknown). Participants had a median of 13 (7-21) years of clinical experience as working registered physiotherapists, and 70% of participants reported no prior experience in the use of diagnostic ultrasound with most of the remaining participants (30%) reporting some experience with use of ultrasound for musculoskeletal management (Table 2).

Table 2: Professional Experience

Professional experience	Results
Years of work (median, IQR)	13 (7-21)
Areas of work*	
Intensive care	11
Medical/surgical wards	10

University	9
Emergency ward	1
Other	7

* The participants often worked in multiple areas.

The percentage of correct answers for the 15 pre-course questions (mean, SD) were 61% (23). The question on ultrasound appearances of lung consolidation, and the 2 questions muscle fibre types and fibre arrangement scored lowest with less than 40% correct.

The percentage of correct answers for the 30 post-course questions (mean, SD) were 62% (20). Two questions on the ultrasound signs of pneumothorax and three questions on muscle fibre arrangement, recommendations for ultrasound measurement technique of tibialis anterior and muscle fibre physiology scored lowest with less than 40% correct.

To explore the potential impact of the participants pre-reading we report on the pre-course and post-course results. Of the three participants/25 who completed all the pre-reading the mean (SD) pre-course score was 84% (8), for the 16/25 participants who only partially completed the pre-reading (un-known which of the specific content or articles were undertaken) 60% (26) and for the remaining participants who did not do the pre-reading 52% (24). For the post-course scores the mean (SD) of the three/25 participants who completed all the pre-reading was lower than their pre-course score at 73% (9), for the 16/25 who only partially completed the pre-reading their mean post-course score was unchanged at 60% (27) and of the remaining participants who did not do the pre-reading their mean post-course score was higher at 62% (28). The participants who undertook all or partial completion of the pre-reading demonstrated better knowledge acquisition on the pre-course questionnaire. Of the participants who undertook all the pre-reading they scored higher on the post-course questionnaire than the other participants. Only the participants who did not undertake their pre-reading demonstrated greater increase in pre- to post-course knowledge scores compared with those who only partially completed or who undertook all the pre-reading. But importantly the participants who did not undertake their pre-reading achieved lower scores than those that completed the pre-reading.

Course satisfaction

Of the 32 participants in the course a maximum of 24 participants responded to the questions on course satisfaction. 20 participants felt the course pre-reading was appropriate and that the course was at an appropriate level in terms of theory and practical skill acquisition, however 4 felt the course was too advanced. 18 of the participants felt that this course would impact on their clinical practice and they felt confident that they would begin to use diagnostic ultrasound in their clinical work, but one reported the absence of an ultrasound machine in their work place as a limitation to the use of ultrasound. Of note 11 of the 23 participants felt that there was insufficient time allocated to the practical sessions. Of note several participants identified they would have preferred the course material and questionnaires to be provided in languages other than English. 24 of the participants rated their satisfaction with of each of the didactic and practical sessions, with further detail provided in the Figure 1 below. All of the sessions were most frequently rated as good (except for the lecture on the use of ultrasound for acute care respiratory physiotherapy rated equally frequently at good and excellent and the lecture on use of ultrasound for acute care rehabilitation rated most frequently as excellent).

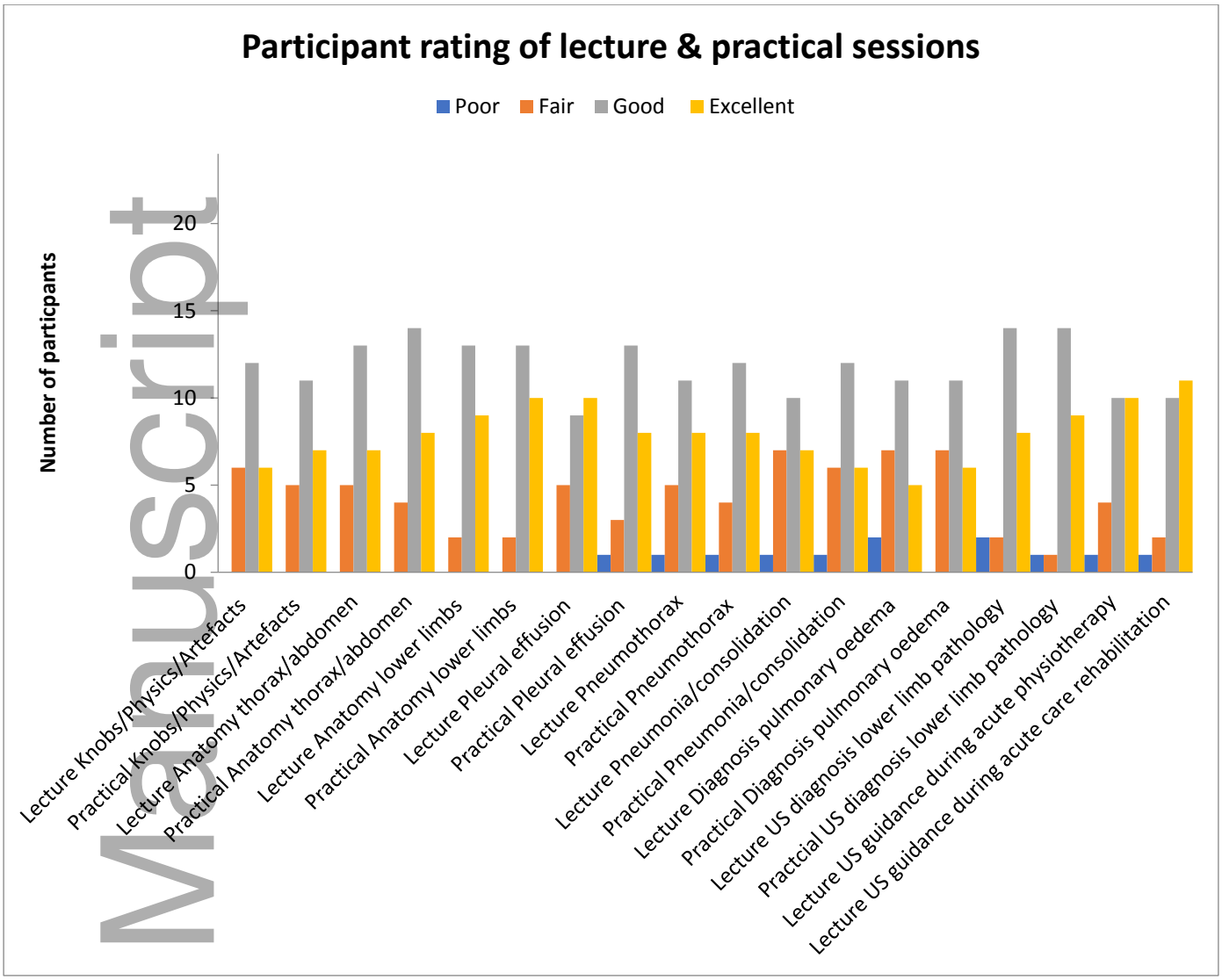

Figure 1: Participant rating of lecture & practical sessions

Discussion

This novel intensive one-day diagnostic ultrasound training program of lung, diaphragm and lower limb muscle for physiotherapists failed to improve short-term knowledge acquisition. The high participant to tutor ratio (10:1) and the combination of lung/diaphragm and lower limb muscle ultrasound content to be covered in a single day of training (as compared with previous lung ultrasound alone courses) may have been too burdensome for the participants and provided insufficient training to facilitate further knowledge acquisition beyond the pre-reading material. In addition, the detailed pre-course reading material may have also been too burdensome.

In a previous report of the effectiveness of the impact of a curriculum for a one-day lung ultrasound course (6), more of the participants (58% vs 12%) reported they had read the recommended pre-course material. For this course and the previous one-day lung ultrasound

course (6) the pre-course assessment results (mean, SD) for participants who completed all the pre-reading was similar at 84% (8) and 81% (8.9), respectively. For the participants in this course who only partially completed the pre-reading, the pre-course assessment results (mean, SD) were also similar at 60% (26) as compared to 62% (16.4) for the lung ultrasound course, respectively. As only 12% of participants in this course completed all of the pre-reading, this indicates that potentially the time available for reading or the amount of pre-reading material may have been an issue for participants. The absence of improvement in post-course knowledge questionnaire scores for this current course with combined lung and muscle diagnostic ultrasound may be due to the curriculum content and/or practical skills workshops being too burdensome or inadequate in terms of allocated time and the high participant to instructor ratio. As highlighted previously 48% of the participants felt that there was insufficient time allocated to the practical sessions. Participant suggestions to improve the course included an increase in the course duration to 2 days (by 10 participants), more time for practical training (3 participants) and optimising instructor:participant ratio to enable improved access to instructor feedback as has been recommended with previous training programs (28)

For this course and the previous lung ultrasound course (6) the lung ultrasound knowledge sections of the questionnaire where participants scored poorly (<40%), were the questions associated with the evaluation of lung aeration such as the sliding sign or signs of pneumothorax. The muscle ultrasound questions answered poorly (<40%) related to the understanding of muscle physiology and ultrasound measurement techniques for the tibialis anterior. This should be addressed in future course potentially by included more suitable pre-reading material (such as video) and e-learning strategies.

This intensive one day diagnostic ultrasound curriculum program that combined thoracic and lower limb ultrasound pre-reading, didactic lectures and practical sessions paired with less than adequate instructor:participant ratio was not optimally effective in improving the basic knowledge and image interpretation skills for a cohort of physiotherapists from diverse clinical and or academic backgrounds. Only the participants who did not undertake any of their pre-reading improved their post-test knowledge scores. Potentially the pre-reading provided a useful a strategy in preparation for the workshop, but as the number of participants who undertook all the pre-reading was so limited, alternative strategies should be used for future courses (e-learning or limit the quantity of reading material). Additional time may be

required (2 days) for courses such as this which combine lung and muscle ultrasound training so as to provide sufficient time for practice and develop knowledge and skills during the practical workshops.

Future programs could be improved by including the ability to image patients' real time with key pathologies during the practical training. Given that this will be difficult to arrange, the use of computerised mannequins and phantom models allow for the greater understanding of the key ultrasound findings with lung and or pleural pathologies (17, 29). For competence to be developed we recommended that the clinicians need to apply the ultrasound skills within their own clinical practice with an expert mentor to further guide image acquisition and interpretation skills, with the participants using a log-book to record and review mentored image acquisitions. The training requirements for physiotherapists to reach competence in diagnostic ultrasound for point of care purposes should include an understanding of the ultrasonographic features of common normal anatomy of the thorax (lungs, heart, pleura) and abdomen (liver, spleen, kidney) and detail acute pleural diseases such as pleural effusion, pneumothorax and parenchymal diseases such as pulmonary oedema, lung collapse and pneumonia (20) and lower limb muscle ultrasonography (27). Physiotherapists would need to be able to demonstrate correct acquisition and interpretation of these ultrasound images real time with the correct integration of the ultrasound findings with clinical assessments to facilitate safe and effective practice of physiotherapy. Participants also need to appreciate the limitations of diagnostic ultrasound imaging, understand the clinical governance issues and requirements for further training and skills development (ongoing mentored training) to attain competence. Participants also need to appreciate and be taught about care of the ultrasound machine/probe, especially infection control strategies (either following their hospital's local guideline or a relevant body's guideline)

The number of ultrasound procedures required to achieve competence have been suggested by some to include at least 100 chest ultrasound procedures (30) or three months of supervised/mentored practise (31). Some have suggested that if ultrasound procedures are included as part of daily patient care, then diagnostic thoracic ultrasound competence may be achieved within 6 weeks (32). The requirements for the acquisition of limb muscle ultrasound knowledge and competence are unknown. The instructors in the course did not specify or recommend a particular credentialing pathway for attainment of competence as the participants originated from many different countries. We however did identify the principles

of having an expert mentor at their place of work and utilising a logbook to document procedures undertaken.

There are several limitations to our study. This was a small study and single group intervention with physiotherapists from a wide variety of clinical and or academic backgrounds. We did not evaluate which of the pre-reading material (lung and or muscle ultrasound) the participants had reviewed. The lack of information gathered on the knowledge retention beyond the course (3-6 months) limited our understanding of knowledge retention. The multiple-choice questions pre- and post- course differed both in number and in content and hence we are unclear as to the real impact of the one day training. However, we wanted to ascertain the impact of the training course and hence specifically designed the pre-course assessment to test the knowledge attained from the pre-reading material. Also as some of the participants identified a preference for the teaching material and assessments to be provided in their native languages this must have limited their knowledge acquisition and ability to answer the questionnaire and satisfaction assessments. Importantly, the course was overall favourably reviewed by participants in terms of satisfaction.

Larger investigations are required to evaluate level of training required for physiotherapists to acquire diagnostic ultrasound skills, to apply them in clinical practice, evaluate the quality of imaging and interpretation and then explore the impact of diagnostic ultrasound on clinical-decision making by physiotherapists.

CONCLUSION

This pilot program demonstrated that a novel intensive single day diagnostic ultrasound training course in lung, diaphragm and lower limb muscle failed to lead to improvements of ultrasound knowledge of lung, pleural pathology and lower limb muscle in a diverse group of physiotherapists with predominantly nil previous diagnostic ultrasound skills. Limiting the course content, utilising alternative pre-course learning materials, increased time allocation for practical skill acquisition and greater tutor to participant ratio should translate to improved knowledge acquisition, but requires further investigation.

DECLARATIONS OF INTEREST

The authors report no declarations of interest.

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