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

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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 three 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 were 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.

Keywords: curriculum, diagnostics, education, physical therapy, ultrasonography.

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

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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 programme or standardised protocol used to educate clinicians, healthcare 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 programmes 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 programmes. 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 programme 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 h) 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 three instructors and 32 participants involved 2.5 h of didactic lectures and 4 h of expert-led practical skills training. The methods used for this training programme were based on a previous pilot programme for diagnostic thoracic ultrasound for physiotherapists.[6] To optimise participant learning, we included (i) pre-reading material with two comprehensive review articles that included key aspects of diagnostic thoracic[26] and muscle ultrasound,[27] (ii) evaluation of participant baseline knowledge with a pre-course questionnaire, (iii) 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/CAHPU Forms/CAHPU-Unit-Accreditation-Application-Form.pdf) and a (iv) post-workshop knowledge acquisition test. The full one-day course content and structure are detailed in Table 1.

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 optimisation procedures, the use of phantom models (for imaging of simulated pleural effusions) and

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 min	Pre-workshop quiz (15 multiple-choice questions) based on pre-reading articles
50 min	Didactic lecture: Physics of ultrasound – Knobology/image optimisation
50 min	Practical stations: Knobology and image optimisation Expert-led stations* 10 identical groups of approximately three participants, with each participant acting as models for image optimisation
15 min 15 min	Didactic Lecture: Normal anatomy: abdomen/thorax landmarks. Didactic Lecture: Normal anatomy: lower limb muscle landmarks.
60 min	Practical stations: 1 Imaging abdomen/thorax anatomy landmarks (30 min) 2 Imaging lower limb muscle anatomy landmarks (30 min) Expert/instructor-led stations* using normal individuals (each participant alternately acted as a model for imaging purposes) for image identification, acquisition and image optimisation procedures
30 min	Didactic lecture: Ultrasound diagnosis of pulmonary conditions • Pleural effusion • Pneumothorax • Lung consolidation/pneumonia • Pulmonary oedema
30 min 30 min	Didactic lecture: Ultrasound diagnosis of lower limb pathology (including muscle mass and architecture analysis techniques) Quadriceps/Tibialis anterior Practical stations: lower limb pathology 1 and 2*
40 min	Practical stations: Expert-led rotating stations (four stations with 40 min at each station)*. 1 Ultrasound diagnosis of pulmonary oedema (five patient video clips) 2 Video clip interpretation pleural effusions (four patient video clips) and participant imaging of chest ultrasound trainer torso with moderate to large effusions in each hemithorax (https://www.limbsandthings.com/au/our-products/details/chest-drain-decompression-trainer) 3 Ultrasound diagnosis of lung consolidation (four patient video clips) 4 Ultrasound diagnosis of pneumothorax (two 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 min	Didactic lecture: Ultrasound applications for physiotherapy in intensive care Didactic lecture: Current use of ultrasound guidance during acute care rehabilitation
20 min	Post-workshop participant questionnaire evaluating knowledge acquisition from course
10 min	Satisfaction survey of attendees regarding course content and structure

*Only three experts for ALL the practical stations.

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

Thirty-two physiotherapists participated in this training programme, 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).

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 out of 25 who completed all the pre-reading, the mean (SD) pre-course score was 84% (8), for the 16 of 25 participants who only partially completed the pre-reading (unknown 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 of 25 participants who completed all the pre-reading was lower than their pre-course score at 73% (9), for the 16 of 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.

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.

Course satisfaction

Of the 32 participants in the course, a maximum of 24 participants responded to the questions on course satisfaction. Twenty 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, four felt the course was too advanced. Eighteen 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. Twenty-four of the participants rated their satisfaction with of each of the didactic and practical sessions, with further detail provided in 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).

Discussion

This novel intensive one-day diagnostic ultrasound training programme 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

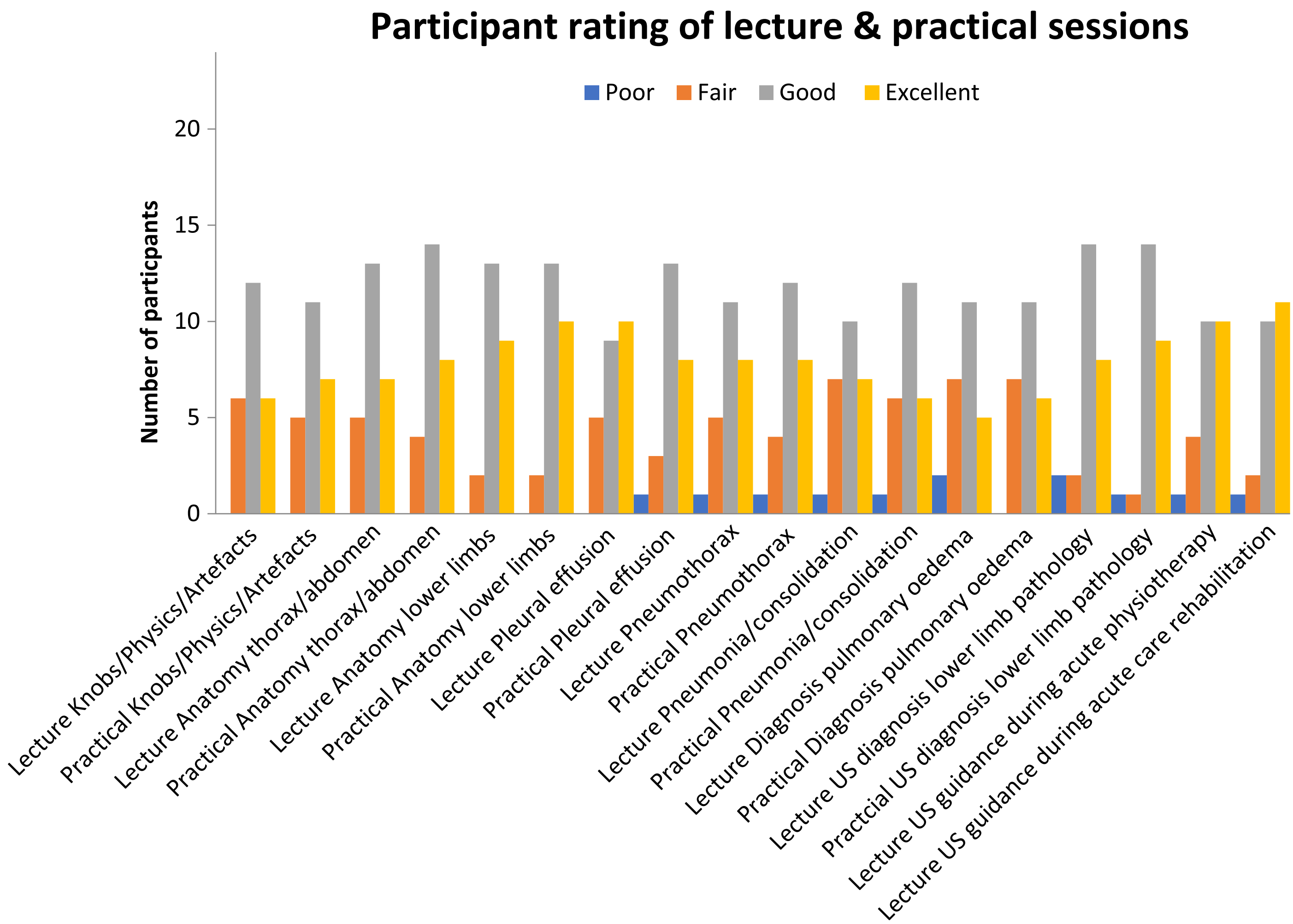

Figure 1: Participant Rating of Lecture and Practical Sessions.

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 (three participants) and optimising instructor: participant ratio to enable improved access to instructor feedback as has been recommended with previous training programmes.[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 including more suitable pre-reading material (such as video) and e-learning strategies.

This intensive one-day diagnostic ultrasound curriculum programme 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 programmes 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 logbook 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 skill 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 has been suggested by some to include at least 100 chest ultrasound procedures[30] or three months of supervised/mentored practice.[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 programme 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.

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Declarations of interest

The authors report no declarations of interest.

Disclosure statement

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Authorship declaration

The authorship listing conforms with the journal's authorship policy, and all authors are in agreement with the content of the submitted manuscript.

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Appendix 1

Figure A1: Participant details.

Date:	
Please create a pseudonym (6 alphanumeric length for example 2 letters and year of birth e.g. ab1960) so we can compare you pre & post test score. Please write down your pseudonym as you will need to enter it again for the post course evaluation so we can match your pre and post course. ……………….	
Personal and work details: City: Country: Years of work as physiotherapist:	
What area of health care do you work in (circle all areas appropriate): • Intensive care • Emergency ward • Medical/surgical wards • University • Other (detail)…………	
Previous training in diagnostic ultrasound Yes/No (please detail):	
Use of diagnostic ultrasound in: • Research • Clinical work • Both • N/A	
Previous experience using diagnostic ultrasound If yes then please detail (e.g. using musculoskeletal ultrasound)	Yes/No Detail (circle all appropriate): • Peripheral muscles • Pelvic floor • Thoracic/lung • Abdominal/trunk muscles • Others (detail):
Read course pre-reading (circle):	• Yes (All) • Partially • No

Pre-course knowledge questionnaire

1. Ultrasound waves cannot pass through bone and hence are reflected back
   A True
   B False
2. Hyperechoic means
   A An increase in echogenicity when compared with the surrounding area
   B A decrease in echogenicity when compared with the surrounding area
   C An area in an image that is free of echoes and displays acoustic enhancement
3. The advantages of lung ultrasound over standard chest radiograph are:
   A Non-invasive
   B No radiation
   C Repeatable
   D Increased sensitivity, specificity and diagnostic accuracy compared with CXR for most acute pathology in ICU acute care
   E Ideal clinical and research tool
   F All of the above
4. The sliding/gliding lung sign refers to
   A Chest wall movement with breathing
   B Chest wall expansion with respiration
   C Movement of the visceral and parietal pleura past each other during respiration causing artefacts indicative of aeration of lung in that region
   D Movement of the diaphragm on respiration

E Appearance of the lung sliding beneath a pneumothorax

5. Pulmonary edema is characterized by which of the following ultrasound features?
   A Sliding-lung sign
   B Multiple comet-tail or B-lines artifacts in most regions of the lungs
   C Lung pulse or K-lines
   D Hepatization or a liver appearance
   E None of the above
6. Pleural effusions . . .
   A are seen as an echo free or anechoic space between the visceral and parietal pleura
   B are only seen through the liver
   C are only seen when scanning through the spleen
   D can only be detected when they contain over 1000 millilitres of fluid
   E may be seen with ultrasound, but are more accurately detected by plain chest radiography
7. Alveolar consolidation can demonstrate which of the following findings?
   A Hepatization of the lung
   B Double sliding-lung sign
   C Air bronchograms
   D Choices A and C
   E A, B and C
8. The lung gliding/sliding lung sign
   A should be checked for in just one location
   B is seen in normal patients
   C is a finding noted on trans-oesophageal echocardiography
   D is helpful in the evaluation of aeration on the lungs
   E is accentuated by the presence of a pleural effusion
   F can only be assessed in the anterior aspects of the chest wall
   G B and D
9. Lung ultrasound cannot assist in the detection of lung consolidation and pneumonia.
   A True
   B False
10. Which statement is true?
    A A high frequency linear transducer is useful for high resolution superficial imaging
    B A low frequency transducer is useful for imaging deep structures such as abdominal and thoracic organs.
    C Both A and B
11. Which of the following muscles have a pennate fibre arrangement?
    A Sartorius
    B flexor pollicis longus
    C Rectus femoris
    D Both B and C
12. Type 1 fibres have which of the following characteristics:
    A aerobic, fast speed of contraction and moderate fatigability
    B anaerobic, fast speed of contraction and high fatigability
    C aerobic, slow speed of contraction and low fatigability
    D anaerobic, slow speed of contraction and low fatigability

13. Normal ‘healthy’ muscle on ultrasound has which of the following features
    A speckled ‘starry’ sky appearance and largely dark
    B non-homogenous appearance to the muscle largely hyperechoic
    C hyperechoic muscle with reduce bone echogenicity
    D None of the above
14. Pennation angle is defined as:
    A length of individual muscle fibre in cross-sectional image
    B angle between direction of muscle fibres and line of force of action represented by external tendon or aponeurosis
    C angle of a group of muscle fibres in multi-pennate muscles only
    D angle which is observed in paediatric population to describe the development of muscle fibres along the aponeurosis
15. All ‘healthy’ skeletal muscles have the same characteristic appearance on ultrasound imaging:
    A True
    B False

Appendix 2

Post-course knowledge questionnaire

1. There is enhanced ultrasound transmission through fluids
   A True
   B False
2. Anechoic means
   A An increase in echogenicity when compared with the surrounding area
   B A decrease in echogenicity when compared with the surrounding area
   C An area in an image that is free of echoes and displays acoustic enhancement
3. The advantages of lung ultrasound over standard chest radiograph are:
   A Non-invasive
   B No radiation
   C Repeatable
   D Increased sensitivity, specificity and diagnostic accuracy compared with CXR for most acute pathology in ICU acute care
   E Ideal clinical and research tool
   F All of the above
4. To identify whether your ultrasound probe is over major abdominal organs or in the thorax you should
   A Use a longitudinal view with the orientation marker on your screen pointing towards the head of the patient

B Use a transverse view to allow you to orient the anterior from posterior parts of the chest wall
C Look at the patients chest wall and abdomen whilst imaging to ensure you know where you are
D None of the above

5. The sliding/gliding sign refers to
A Chest wall movement with breathing
B Chest wall expansion with respiration
C Movement of the visceral and parietal pleura past each other during respiration causing artefacts indicative of aeration of lung in that region
D Movement of the diaphragm on respiration
E Appearance of the lung sliding beneath a pneumothorax
6. Pleural sliding/gliding is sought first on the anterior chest of a supine patient because . . .
A air collects posteriorly and interferes with visualisation of lung sliding
B air collects anteriorly, in the least gravitationally – dependent space
C the posterolateral chest wall precludes ultrasound signal transmission
D free air within thoracic cavity accumulates in the most dependent position
E it is easier and convenient
7. Pulmonary edema is characterized by which of the following ultrasound features?
A Sliding-lung sign
B Multiple comet-tail or B-lines artifacts in most regions of the lungs
C Lung pulse or K-lines
D Hepatization
E None of the above
8. All of the following could cause identification of a false lung point (indicative of pneumothorax) except . . .
A Acute Respiratory Distress Syndrome (ARDS)
B underlying pathologic lung conditions
C heart border
D esophageal reflux
E a pleural adhesion
F ultra-low tidal volume ventilation during ECMO
9. Pleural effusions . . .
A are seen as an echo free or anechoic space between the visceral and parietal pleura
B are only seen through the liver
C are only seen when scanning through the spleen
D can only be detected when they contain over 1000 millilitres of fluid
E may be seen with ultrasound, but are more accurately detected by plain chest radiography
10. One way to estimate the size of a pleural effusion is to:
A Use a curvilinear low frequency probe and see how anechoic the collection is
B Use a curved low frequency probe in a transverse view at the base of the lung at end of expiration for the septal distance of the effusions and multiply the distance in mm by 20.
C None of the above
11. The signs indicating that pulmonary oedema is resolving. . .
A a decrease in the density/number of comet tails throughout the lungs
B an increase in the number of comet tails in the upper lung fields
C an increase in the number of comet tails in the lower lung fields
D an increase in the number of lung rockets
E None of the above
12. The presence of a sliding-lung sign is . . .
A a 100 percent accurate method to detect a pneumothorax
B a sign of pulmonary contusion
C present only with a pneumothorax
D a sign ruling out a pneumothorax only in the location where it is seen
E None of the above
13. Alveolar consolidation can demonstrate which of the following findings?
A Hepatization of the lung & Air bronchograms
B Double sliding-lung sign & Air bronchograms
C Hepatization of the lung & Double sliding-lung sign
D Hepatization of the lung & Air bronchograms & Double sliding-lung sign
14. The lung pulse indicates aeration and is resultant from. . .
A the transmission of esophageal contraction through the lung parenchyma
B the transmission of diaphragmatic contraction through the lung parenchyma
C not helpful in the evaluation of a pneumothorax
D the transmission of cardiac contractions through the lung parenchyma causing movement of the pleura
15. The pleural gliding/sliding lung sign . . .
A should be checked for in just one location
B is never seen in normal patients
C is helpful in the evaluation of aeration on the lungs
D is accentuated by the presence of a pleural effusion
E can only be assessed in the anterior aspects of the chest wall
16. Lung ultrasound can assist in the detection of lung consolidation and pneumonia.
A True
B False
17. Which statement is true?
A A low frequency linear transducer is useful for superficial imaging

B The frequency of transducer does not matter when imaging superficial structures
C A high frequency linear transducer is useful for high resolution superficial imaging
D A curved low frequency transducer can image to about 6 cm depth.

18. Findings consistent with pneumonia on ultrasound include . . .
A stone pulse
B lung pulse
C air esophagrams
D hepatization of the lung tissue with a similar appearance to the liver or spleen

19. Dynamic air bronchograms . . .
A are only seen in intubated patients
B are hyperechoic areas that represent air moving through small airways (dilating during inspiration) within areas of lung consolidation
C are a highly specific sign suggestive of esophageal rupture
D are commonly seen during prolonged apneic episodes

20. Which of the following statements regarding A-line artifacts is incorrect?
A A-line artifacts are commonly encountered in normal lungs
B A-line artifacts are only seen in pathologic conditions
C A-lines are a type of horizontal reverberation artifact
D A-line artifacts can be seen with pneumothorax

21. The presence of only one or two comet-tail artifacts in one zone
A indicates pulmonary edema
B is consistent with a pleural effusion
C is common in patients and is considered normal
D is seen with a pneumothorax
E indicates absent aeration of lung

22. Which of the following muscles have a pennate fibre arrangement?
A Sartorius
B flexor pollicus longus
C Rectus femoris
D Both B and C

23. Type 1 fibres have which of the following characteristics:
A aerobic, fast speed of contraction and moderate fatigability
B anaerobic, fast speed of contraction and high fatigability
C aerobic, slow speed of contraction and low fatigability
D anaerobic, slow speed of contraction and low fatigability

24. Normal ‘healthy’ muscle on ultrasound has which of the following features
A speckled ‘starry’ sky appearance and largely dark
B non-homogenous appearance to the muscle largely hyperechoic
C hyperechoic muscle with reduce bone echogenicity
D None of the above

25. Pennation angle is defined as:
A length of individual muscle fibre in cross-sectional image
B angle between direction of muscle fibres and line of force of action represented by external tendon or aponeurosis
C angle of a group of muscle fibres in multi-pennate muscles only
D angle which is observed in paediatric population to describe the development of muscle fibres along the aponeurosis

26. All ‘healthy’ skeletal muscles have the same characteristic appearance on ultrasound imaging:
A True
B False

27. Recommendation for quadriceps imaging are:
A Minimal compression technique, landmarks AIIS and superior border of patellar, 2/3 or " distance between landmarks
B Maximal compression technique, landmarks ASIS and superior border of patellar, 2/3 or " distance between landmarks
C Minimal compression technique, landmarks ASIS and superior border of patellar, 2/3 or " distance between landmarks
D Maximal compression technique, landmarks AIIS and superior border of patellar, 3/5 distance between landmarks

28. Recommendations for tibialis anterior imaging are:
A Minimal compression technique, landmarks tibial plateau and superior border of lateral malleolus, 1/3 distance between landmarks
B Maximal compression technique, landmarks tibial plateau and superior border of lateral malleolus, 1/3 distance between landmarks
C Minimal compression technique, landmarks tibial plateau and superior border of lateral malleolus, 15 cm inferior to tibial plateau
D Minimal compression technique, landmarks tibial plateau and inferior border of lateral malleolus, 1/3 distance between landmarks

29. An increase in fascicle length results in a greater number of sarcomeres in parallel?
A True
B False

30. For muscle ultrasound imaging international standardised protocols exist for describing methods for training, image acquisition, analysis and reporting:
A True
B False