



## Article

# Use of thoracic ultrasound by physiotherapists: a scoping review of the literature

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# 1 Use of thoracic ultrasound by physiotherapists: a scoping 2 review of the literature

## 3 ABSTRACT

### 4 Background

5 Use of diagnostic thoracic ultrasound (TUS) in medical professions to examine the pleura,  
6 lung parenchyma and diaphragm is gaining in popularity, however the ways in which  
7 physiotherapists are using TUS is unclear.

### 8 Objective

9 The aim of this scoping review is to gain an understanding of the emerging evidence base  
10 surrounding physiotherapy use of TUS to inform research and clinical practice.

### 11 Data Sources

12 A systematic search was conducted of the following databases: Cochrane, EPPI centre,  
13 PROSPERO, Medline, CINAHL, AMED, EMBASE, HMIC, and BNI.

### 14 Study Selection

15 Inclusion criteria: primary research reporting the use of diagnostic TUS; a physiotherapist as  
16 part of the study design or as the chief investigator; published in English.

### 17 Synthesis Methods

18 Data regarding demographics, design, type of conditions and anatomical structures  
19 investigated and profession leading the TUS of included papers were compiled in a tabular  
20 format.

### 21 Results

22 Of the 26 included papers, 9 studied healthy participants, 4 studied COPD and 4 studied  
23 critical care patients. Most papers (n=23) involved scanning the diaphragm. In 8 studies the  
24 physiotherapist operated the TUS.

#### 25 Limitations

26 The paper selection process was performed by one author; with no cross-checking by another  
27 individual.

#### 28 Conclusion

29 Use of TUS by physiotherapists is an emerging area in both diaphragm and lung diagnostics.  
30 A wide range of patient populations may benefit from physiotherapists using TUS. Papers in  
31 this review are heterogeneous making any generalisability difficult but does show its potential  
32 for varied uses. TUS is an innovative skill in the hands of physiotherapists, but more research  
33 is needed.

34

35 Funding: National Institute of Health Research (NIHR): Internship programme – no  
36 involvement

37

#### 38 Contribution of the paper:

- 39 • Thoracic ultrasound is gaining popularity amongst physiotherapists.
- 40 • The diaphragm is the most investigated structure by physiotherapists.
- 41 • Physiotherapists use thoracic ultrasound on a broad range of pathologies and patient  
42 populations.

43

44 Keywords: Thoracic ultrasound, lung ultrasound, physiotherapy, scoping review

45 **Introduction**

46 A growing body of evidence is now available reporting on the efficacy of thoracic ultrasound  
47 (TUS), also known as lung ultrasound (LUS) [1-5]. Within the medical profession TUS has  
48 been shown to have improved efficacy in the diagnosis of pulmonary conditions such as  
49 pneumonia [1-2] and pleural effusions [3] as well as diaphragmatic dysfunction [4-5] when  
50 compared to chest radiography (CXR).

51 Accurate diagnosis of respiratory conditions is of paramount importance to physiotherapists  
52 to enhance treatment selection and monitor treatment effectiveness [6]. TUS may provide an  
53 alternative, and more accurate, imaging option for physiotherapists that can be performed at  
54 the bedside and in real-time. This bedside imaging technique has been termed point-of-care  
55 ultrasound or “POCUS” within the literature. The ability of physiotherapists to perform TUS  
56 would allow autonomous imaging and may improve the effectiveness of physiotherapy  
57 treatment through more accurate diagnostic ability. Additionally, compared to traditional CXR  
58 or computed tomography (CT), TUS does not expose patients to ionising radiation.

59 A pioneer of POCUS acknowledged that if physiotherapists adopted the use of TUS, existing  
60 protocols could change as imaging feedback is instant [7]. Two narrative reviews focused on  
61 the potential use of TUS by physiotherapists have previously been published [8-9]. Leech et  
62 al reviewed the diagnostic performance of TUS when compared to auscultation and CXR.  
63 They found that TUS increased diagnostic accuracy of acute pulmonary pathologies and  
64 identify those amenable to physiotherapy treatments. However, they continued to report a  
65 lack of specific training standards for physiotherapists to learn TUS [8]. Le Neindre et al  
66 focused on the basics of TUS, its semiology and how physiotherapists could apply this in  
67 practice. They also highlighted how TUS performed better than CXR and auscultation and  
68 should be considered as an outcome measure to inform physiotherapy clinical decision  
69 making [9]. Both papers discussed how TUS could help to differentiate between pathologies

70 that may or may not respond to physiotherapy treatments thus potentially making  
71 physiotherapy interventions more targeted and effective [8-9].

72 The two previously mentioned reviews did not include a formal search strategy. Neither did  
73 they comment on the differing patient populations that may benefit from physiotherapists use  
74 of TUS. The aim of this scoping review was to collate the emerging evidence around  
75 physiotherapy and the use of TUS in order to create an understanding of how the  
76 international physiotherapy community is using TUS to inform their research and clinical  
77 practice.

78

## 79 **Methods**

80 This scoping review followed the guidance of Arksey and O'Malley [10] and Levac et al [11].  
81 Its purpose was to examine and present a broad overview of the emerging evidence  
82 available irrespective of the quality to identify gaps or common usage, clarify key concepts  
83 and report on the types of evidence that address and inform practice in an emerging topic  
84 area [10-11].

85

## 86 Research Question

87 The Participants, Concept and Concept (PCC) method [12] has been employed to formulate  
88 the following research question:

89 "In what ways do physiotherapists use TUS to inform their clinical or research practice?"

90

91 P (Participants) – Human adult and paediatric participants.

92 C (Concept) – The use of TUS where a physiotherapist was involved.

93 C (Context) – Any publication type, except review, was included in this review. No limitation  
94 on location, outcome measure or date has been imposed.

95

96 Objectives

97 To explore the current evidence base use of TUS by physiotherapists with regards to:

98 a) Design

99 b) Type of conditions investigated

100 c) Anatomical structures investigated

101 d) Profession operating the TUS

102

103 Search strategy

104 A systematic electronic search was conducted of the following databases: Cochrane  
105 database of systematic reviews, EPPI centre, PROSPERO, Medline, CINAHL, AMED,  
106 EMBASE, HMIC, and BNI. The search string was developed to capture as wide a selection  
107 of papers as possible. The search was conducted up until November 2016. Following the  
108 initial database searches, grey literature searching was performed. A second search using  
109 all identified keywords and index terms was then undertaken across all included databases.

110

111 “physio\*.ti.ab” OR “(physical AND therap\*).ti.ab” OR “(respiratory AND therap\*).ti.ab”

112 AND

113 “lung\*.ti.ab” OR “thora\*.ti.ab” OR “diaphragm\*.ti.ab” OR “respirat\*.ti.ab” OR “chest\*.ti.ab”

114 AND

115 “ultras\*.ti.ab” OR “sonogr\*.ti.ab”.

116

117 Paper selection

118 Papers were included when all the following inclusion criteria were observed:

119 1) primary research reporting the use of TUS.

120 2) involvement of a physiotherapist as part of the study design OR a physiotherapist as the  
121 chief investigator (This was achieved by cross referencing with ResearchGate).

122 3) published in the English language.

123 Research abstracts from conference or meeting proceedings were included. There was no  
124 limitation of the search based on publication date, or participant age. Papers were excluded  
125 when they were review articles or when they involved animal or tissue studies. Hand  
126 searching of reference lists were undertaken on the papers deemed eligible to ensure a  
127 comprehensive search was undertaken (Figure1).

128

129 Data analysis

130 Data was extracted and analysed by one reviewer ("X"). Extracted data included: first author,  
131 year of publication, country, sample size, study design, subject population, outcome  
132 measures, comparison, profession of the ultrasound operator and findings. Methodological  
133 design of the papers can be found in the characteristics of included papers table (Table 1).

134

135 Key definitions

136 "Thoracic ultrasound - TUS"

137 TUS can be used to describe the use of US when examining the pleura, lung parenchyma  
138 and diaphragm. LUS can, in some instances, be used to describe the examination of the  
139 pleura and lung parenchyma without direct involvement of the diaphragm. These two terms

140 along with chest US are used interchangeably throughout the literature. TUS will be the term  
141 used throughout this scoping review.

142 “Physiotherapist”

143 For ease of consistency throughout this scoping review the term “Physiotherapist” will  
144 encompass the roles of a “Respiratory Therapist” or “Physical Therapist”. There are  
145 international differences between job titles and job roles within physiotherapy and to get a  
146 truly global indication of the use of TUS these alternate titles were acknowledged and  
147 included.

## 148 **Results**

149 A total of 3075 titles and abstracts were identified in the database searches. All titles were  
150 evaluated for relevance to the research question. Once shortlisted the remaining papers  
151 were screened against the inclusion and exclusion criteria and a total of 3049 papers were  
152 excluded. The remaining 26 papers were obtained in full and assessed for their eligibility. An  
153 additional 7 papers were identified thorough the hand searching of reference lists. Seven  
154 papers were subsequently excluded as physiotherapists were not part of the research  
155 design (Figure 1).

156

### 157 The current evidence base of physiotherapy use of TUS.

158 Following study selection 26 papers were included in this scoping review (Table 1): five  
159 randomised controlled trials (RCTs) [13-17], nine cross-sectional studies [18-26], two case  
160 series [27-28], four case reports [29-32], five conference abstracts [33-37], one audit [38]  
161 (Table 1). Five papers were in conference abstract form only [33-37] without a corresponding  
162 full published paper therefore only minimal methodological information could be gathered.  
163 Included studies were published over a 19-year period between the years of 1997 and 2016.  
164 No qualitative studies were found that focused on the experiences of physiotherapists using



165 TUS in their practice or research. Based on the country of the lead author, the majority of  
166 studies were conducted by authors residing in Brazil and Australia (Table 1). The  
167 participants included in the studies ranged in age from 3 months through to 80 years old.

168 Of the twenty-six papers nine were performed on healthy subjects [17,20,22,23,25,28,33-35]  
169 which accounted for 220 of the total 849 study participants (26%). Pathologies or conditions  
170 investigated included; post-operative upper abdominal surgery [15,26], chronic obstructive  
171 pulmonary disease (COPD) [13,14,24,29,30], critical care patients [19,32,36,37], post  
172 cerebral vascular accident (CVA) [21], spinal cord injury (SCI) [27,31], morbidly obese [16],  
173 adolescents with scoliosis [18] and healthy infants [35] (Table 1).

174 A clear majority of papers (23 of the 26) included in this review involved the use of TUS to  
175 scan the diaphragm. The three remaining papers involved scanning the pleura and lung  
176 parenchyma [32,36,38]. These include a prospective audit on a TUS training curriculum by  
177 See et al [38] and two papers on the use of TUS in critical care and included a conference  
178 abstract by Riley et al [36] and a case report by Leech et al [32]. See et al [38] is the only  
179 paper that looked at the training of physiotherapists in TUS.

180 Either a radiologist/radiographer (termed sonographer) or one of the research team's  
181 physiotherapists would perform the TUS (termed operator). As can be seen in Figure 2, up  
182 until 2013 most of the US scanning was performed by a non-physiotherapist. However, since  
183 2013 at least eight of the sixteen papers that did report the profession of the US operator  
184 have been physiotherapists. The other six of the remaining eight papers did not report on the  
185 TUS operator's profession.

## 186 **Discussion**

187 This scoping review explored the current evidence base of physiotherapy use of TUS on study  
188 design, type of condition, type of anatomical structures, and professionals operating the TUS.  
189 It found that across a widely varying research design, the diaphragm of healthy participants,

190 patients with COPD or patients on critical care was most often investigated. In a minority of  
191 the papers physiotherapists operated the TUS, and these have taken place since 2013.

192 The evidence of the papers varied widely, ranging from case reports to randomised control  
193 trials. Across the included papers there were numerous scanning techniques, used with  
194 different methodologies, on a wide range of patients/populations. Very few of them have any  
195 overlap making the applicability of TUS in clinical and research practice difficult. The  
196 previously mentioned review Leech et al [8] also discussed that it remains unclear how the  
197 increased accuracy TUS affords physiotherapists will be applicable without further research.

198 Healthy participants were used to test reliability or validity of assessing the diaphragm using  
199 TUS. This is a normal first step into introducing a new method into a profession [4] and fits  
200 with this novel assessment tool. Use of TUS in patients with COPD was reported in five  
201 papers and in a critical care environment and four papers (Table 1). It highlights potential  
202 areas where the use of TUS by physiotherapists to assess the pleura, lung parenchyma and  
203 diaphragm could enhance diagnosis and improve patient outcomes, as previously  
204 highlighted by Leech et al [8]. Additionally, this scoping review highlights the potential that  
205 TUS might have in other areas such as CVA, morbidly obesity and paediatrics. There are  
206 only two papers that have investigated physiotherapists' use of TUS on a paediatric  
207 population [31,35]. There is a need for significant work into this population especially  
208 considering the added safety benefits of US when compared to the ionising radiation of CXR  
209 and CT.

210 A large proportion of the papers looked at the use of TUS to assess the diaphragm as a way  
211 to influence physiotherapy practice. The papers included reported on multiple ways to  
212 assess diaphragm function. However, those assessments involved numerous different  
213 scanning techniques making comparisons difficult. This scoping review has demonstrated a  
214 lack of research aimed specifically at the physiotherapy professions use of TUS to assess  
215 the pleura or lung parenchyma.

216 This review found a progressive increase in papers involving physiotherapists use of TUS,  
217 with more published in the last three years than in the preceding sixteen, indicating that this  
218 assessment tool is gaining in popularity.

219 Training of physiotherapists in the use of TUS is necessary for the use of this assessment  
220 tool to researched further. See et al [38] hinted at the ability of non-medically trained  
221 personnel to become proficient in image acquisition and image interpretation. When these  
222 skills are used to inform clinical reasoning, it takes the operator beyond the role of a  
223 “technician” to that of a professional. This issue is raised by both Leech et al [8] and Le  
224 Neindre et al [9] as the greatest challenge facing physiotherapists wishing to gain  
225 competency in TUS. This is something that has also been highlighted in the medical  
226 literature [1]. Guidance can be found in the international expert statement on training in TUS  
227 for non-physiotherapists [39] and much of this information will be relevant to inform future  
228 physiotherapy focused training programmes. The difficulty lies in negotiating the medico-  
229 legal and governance structures for each individual country depending on that professions  
230 scope of practice. In the future it seems prudent to adapt currently existing, robust,  
231 competency based US training programmes to meet the needs of physiotherapists as a  
232 priority if they are to take advantage of this diagnostic technology.

233 Many aspects of the use of TUS by physiotherapists warrants further investigation. Robust  
234 methods of training for physiotherapists need to be established. Ways in which TUS can be  
235 used as a diagnostic tool and as an outcome measure to assess the effectiveness of  
236 physiotherapy interventions also warrants further work. There is also a need to show how  
237 these new diagnostic and assessment skills, in the hands of physiotherapists, affect patient  
238 outcomes and experiences as well as a financial benefit to health providers or society as a  
239 whole.

240

241 **Limitations**

242 Papers in other languages were excluded from this review which may have added bias to  
243 the selection process. As previously mentioned a thorough critical appraisal of the quality of  
244 papers within this review was not completed as the aim was to report on as wide a scope of  
245 TUS use as possible. The paper selection process was performed by one author; with no  
246 cross-checking by another individual leaving this review open to selection bias, however due  
247 to the sparsity of papers in this topic the 26 papers included seem a fair representation of the  
248 evidence in this area.

249

## 250 **Conclusion**

251 Use of TUS by physiotherapists is an emerging area regarding both diaphragm and lung  
252 diagnostics. There are a wide range of patient populations that might be able to benefit from  
253 physiotherapists using TUS as well as the different applications of TUS itself. The collection  
254 of papers in this review is heterogeneous in their research questions, participant populations  
255 and methodology. This variety makes any generalisability difficult but does show the  
256 potential diverse uses of TUS. The evidence suggests that even within this emerging  
257 discipline, critical illness and COPD are two popular areas being investigated. However,  
258 robust methods of training for physiotherapists need to be established. The potential of TUS  
259 and its impact on patients from diagnosis through to monitoring long term outcomes on  
260 society need to be explored. This makes TUS a potentially very novel and innovative skill in  
261 the hands of the physiotherapy profession.

262

263 **Ethical Approval:** Ethical approval was not required for this study.

264 **Funding:** National Institute of Health Research (NIHR): Internship programme – no  
265 involvement

266 **Conflicts of interest:** None

267

268

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