

Agreement between physical therapists and radiologists of stratifying patients with shoulder pain into treatment related categories using ultrasound; an explorative study.

M. Thoomes-de Graaf PT, MSc^{# 1,2}, RPG. Ottenheijm MD, PhD^{# 3}, AP. Verhagen PT, PhD^{1,4}, E. Duijn PT, MSc^{1,2}, YHJM. Karel PT, MSc^{1,2}, MPJ. van den Borne MD⁵, A. Beumer MD, PhD⁵, J. van Broekhoven PT⁶, GJ. Dinant MD, PhD³, E. Tetteroo MD, PhD⁷, C. Lucas PT, PhD⁸, BW. Koes PhD¹, GGM. Scholten-Peeters PT, PhD⁹

¹ Department of General Practice, Erasmus MC, University Medical Centre Rotterdam, Rotterdam, the Netherlands.

² Research group diagnostics, Avans University of Applied Science, Breda, the Netherlands.

³ Department of Family Medicine, CAPHRI Care and Public Health Research Institute, Maastricht University, Maastricht, The Netherlands.

⁴ Department of physiotherapy, Graduate School of Health University of Technology Sydney, Sydney, Australia.

⁵ Department of Orthopaedic surgery, AMPHIA hospital, Breda, the Netherlands.

⁶ Monné zorg en beweging, Breda, the Netherlands

⁷ Department of Radiology, AMPHIA hospital, Breda, the Netherlands.

⁸ Department of Clinical Epidemiology, Biostatistics and Bioinformatics, Academic Medical Centre, University of Amsterdam, Amsterdam, the Netherlands.

⁹ Department of Human Movement Sciences, Faculty of Behavioural and Movement Sciences, Vrije Universiteit Amsterdam, Amsterdam Movement Sciences, The Netherlands

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Joint first authorship

Corresponding author: Marloes Thoomes-de Graaf, Email:

marloesthoomes@me.com Tel.: +31765250352. Erasmus Medical Center, Family medicine, Wytemaweg 80, 3015 CN Rotterdam, the Netherlands.

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ABSTRACT

Study design: An explorative study with secondary data analysis.

Objectives: The aim of this study is to explore the inter-professional agreement of diagnostic musculoskeletal ultrasound (DMUS) between physical therapists (PT) and radiologists, using a new classification strategy based upon the therapeutic consequences in patients with shoulder pain.

Background: DMUS is frequently used by PTs, although the agreement regarding traditional diagnostic labels between PTs and radiologists is only fair. Nevertheless, DMUS could be useful when used as a stratifying-tool.

Methods: First, a systematic overview of current evidence was performed to assess which traditional diagnostic labels could be recoded into new treatment related categories (referral to secondary care, corticosteroid injections, physical therapy, watchful waiting). Next, kappa values were calculated for these categories between PTs and radiologists.

Results: Only three categories were extracted, as none of the traditional diagnostic labels were classified into the 'corticosteroid injection' category. Overall, we found moderate agreement to stratify patients into treatment related categories and substantial agreement for the category 'referral to secondary care'. Both categories 'watchful waiting' and 'indication for physical therapy' showed moderate agreement between the two professions.

Conclusion: Our results indicate that the agreement between radiologists and PTs is moderate to substantial when labelling is based on treatment consequences. DMUS might be able to help the PT to guide treatment, especially for the category 'referral to secondary care' as this showed the highest agreement. However, as this is just an explorative study, more research is needed, to validate and assess the consequences of this stratification classification for clinical care.

1. INTRODUCTION

Shoulder pain presents an economic burden on society due to costs for sick leave and health care ([Huisstede et al., 2006](#)). A high number of patients visit a general practitioner (GP) ([Greving et al., 2012](#)). A large amount of people who have shoulder pain, visit a [physical therapist](#) (PT) at some point ([Linsell et al., 2006](#)). The prognosis, however, is moderate, as only 60% of patients recover within six months after consulting a PT ([Karel et al., 2016](#)).

The classic [clinical pathway](#) of PTs for patients presenting with shoulder pain includes [history taking](#) and physical examination, which eventually leads to a physiotherapeutic diagnosis and management plan. However, physical examination is often inadequate for establishing a diagnosis, as it lacks validity and [reproducibility](#) ([Beaudreuil et al., 2009](#); [Hegedus et al., 2008](#); [Hughes et al., 2008](#)). To overcome this flaw, diagnostic musculoskeletal [ultrasonography](#) (DMUS) is increasingly used by PTs in order to improve their diagnostics ([McKiernan et al., 2010](#)). The majority of PTs using DMUS indicate they expect DMUS to facilitate them in making a more specific clinical diagnosis or assist them in selecting the most appropriate intervention ([Karel et al., 2017](#)). However, an inter-professional agreement study showed only fair agreement of DMUS between PTs and radiologists (with an overall kappa of 0.36; varying from a kappa of 0.10 for partial [thickness](#) tears to 0.63 for full thickness tears) ([Thoomes-de Graaf et al., 2014](#)).

Traditional diagnostic labels of the shoulder (such as subacromial bursitis) have not shown to be of much additional value in clinical practice or research so far. Moreover, the Dutch guideline for shoulder pain issued by the Dutch Orthopaedic Association stated that a direct relationship between the anatomical substrate, functional loading and pain is not always explicitly present and therefore, the diagnostic term 'subacromial impingement' is incorrect ([Diercks et al., 2014](#)). A more pragmatic approach was suggested over a decade ago ([Schellingerhout et al., 2008](#)), consisting of: "general shoulder pain' or subgroups with a better prognosis and/or treatment result based on common characteristics that are easily and validly reproducible" ([Schellingerhout et al., 2008](#)), hereby linking a diagnostic label to a specific prognosis and/or an effective treatment category. This would be in concordance with the promising approach of classifying patients with low back pain and/or neck pain based on their prognosis, for example using the STarT Back Tool ([Bier et al., 2017](#); [Hill et al., 2011](#); [Koes et al., 2010](#)).

Ideally, when classifying patients, consideration is also given to biopsychosocial factors affecting prognosis. However, a generic musculoskeletal prognostic tool including these factors is not yet available. Currently, in patients with shoulder pain PTs mainly focus on pain and function ([Campbell, 2016](#)). As the prognosis of patients with shoulder pain is not particularly favorable, it is likely the patient will see several health care professionals for his/her shoulder pain. It can be frustrating and confusing if a patient receives different

38 diagnostic labels from the various health care professionals such as 'tendinitis' or
39 'impingement', as diagnostic terms have implications on patients' perceptions. Therefore, this
40 should be considered when using these different diagnostic terms. It may be in the best
41 interest of the patient and PT to refrain from using these traditional labels and use labels that
42 give direction to the treatment process.

43 Differentiating between subgroups relevant to a specific treatment, immediately impacts the
44 therapeutic process ([Lord et al., 2011](#)). The Dutch guideline for GPs states [physical therapy](#),
45 [corticosteroid](#) injections and surgery are widely used treatment modalities, and besides
46 'watchful waiting', are advised in patients with various shoulder disorders ([Winters et al.,](#)
47 [2008](#)). It is important to match these four treatment modalities with diagnostic labels based
48 on evidence of effectiveness. DMUS potentially can be used to stratify patients into different
49 treatment approaches.

50 The main aim of this paper is to explore a clinical pathway, by stratifying shoulder patients
51 based on DMUS using a new classification strategy based on treatment effectiveness. As
52 this is an explorative paper, the aims of this study are threefold:

- 53 1) To conduct a systemic overview of current evidence on the effectiveness of 'surgery',
54 'corticosteroid injection', 'physical therapy' and 'watchful waiting' for traditional
55 diagnostic labels, in order to establish a new classification strategy of treatment
56 related categories
- 57 2) To use the findings from DMUS to stratify patients into the new treatment related
58 categories (resulting from aim 1);
- 59 3) To establish the agreement between PTs and radiologists of stratifying patients with
60 shoulder pain into the new treatment related categories (resulting from aim 2).

61
62

63 **2. METHODS**

64 **2.1 Design**

65 This study consists of two parts: First a [systematic](#) overview of current evidence was
66 conducted to establish new treatment related categories, that was followed by an inter-
67 professional agreement study. To conduct the agreement study data were used of our
68 prognostic [cohort study](#): 'Shoulder Complaints and Diagnostic Ultrasound in Physiotherapy'
69 (ShoCoDiP) ([Karel et al., 2013](#)).

70

71 **2.2. Systematic overview of current evidence**

72 **2.2.1. Search.** A research librarian, together with an author (MTG) developed the search
73 strategy and performed the electronic search (EMBASE and the Cochrane Library) from

74 inception to January 2017. The search primarily focussed on systematic reviews of treatment
75 effectiveness for patients with shoulder pain using traditional diagnostic labels. If no
76 systematic reviews were found for one or more traditional diagnostic labels, a wider search
77 was performed aimed at other types of studies.

78

79 *2.2.2. Study selection.* We selected systematic reviews describing the effectiveness of
80 surgery, [corticosteroid](#) injections, physical therapy and/or [watchful waiting](#) in patients with
81 various shoulder disorders. We searched for the traditional diagnostic labels (e.g. full- and
82 partial [thickness](#) tears, [tendinopathy](#), calcification of the [rotator cuff](#), [bursitis](#), SLAP lesions)
83 as well as their collective synonyms (e.g. [rotator cuff disorders](#), subacromial pain,
84 impingement syndrome). In the absence of systematic reviews for one or more traditional
85 diagnostic labels other types of research were included.

86

87 *2.2.3. Data extraction, risk of bias assessment and analysis.* Two of the authors (MTG, RO)
88 independently extracted data and the conclusions from these articles. Systematic reviews
89 were assessed on their Risk of Bias by two authors (MTG, RO) using the AMSTAR 2 ([Shea et al., 2017](#)).
90 The AMSTAR 2 consists of 16 items and results in an overall rating of
91 confidence in the results of the review (high, moderate, low or critically low) ([Shea et al.,](#)
92 [2017](#)). Other risk of bias tools were used if applicable. In case of discussion a third author
93 (AV) was consulted. For assigning a level of evidence we used the Center of Evidence
94 Based Medicine classification ([Howick et al., 2011](#)). Relevant items are described below:

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- Level 1: Systematic review*
- Level 2: Randomized Clinical Trial (RCT) or inception cohort study
- Level 3: Non-randomized control study or cohort study
- Level 4: Case series or case-control study
- Level 5: Mechanism based reasoning or expert opinion

100 * In case the results of the AMSTAR 2 classification were low or critically low the evidence
101 was downgraded.

102

103 Two authors (MTG, RO) independently classified the traditional labels into new treatment
104 related categories based upon the available evidence of effectiveness of 'surgery',
105 'corticosteroid injections', 'physical therapy' and 'watchful waiting' per traditional diagnostic
106 label:

107

108

- 'Referral to secondary care' for patients where referral to [secondary care](#) must be considered.

- 109 • 'Indication for corticosteroid injection' for patients where a corticosteroid injection should
110 be considered as the first-line treatment option.
- 111 • 'Indication for physical therapy management' for patients where physical therapy
112 management is considered to be the first choice of treatment.
- 113 • 'Watchful waiting' for patients most likely to recover without specific treatment
114 interferences or when no evidence or only level 5 evidence was available regarding the
115 effectiveness of physical therapy and/or surgical intervention.
- 116 In case of disagreement, consensus was reached by discussion.

117

118 **2.3. Inter-professional agreement study**

119 *2.3.1. Design.* We conducted this inter-professional agreement study by secondary analysis
120 of the findings from DMUS obtained in a previous study. The method of the original inter-
121 professional agreement study is presented in a previous study and the main characteristics
122 are summarized below ([Thoomes-de Graaf et al., 2014](#)).

123

124 *2.3.2. PTs and radiologists.* Dutch PTs trained in the use of DMUS were asked to participate.
125 All participating PTs had at least one year of DMUS post-graduation experience, and
126 performed more than 100 DMUS in this post-graduation period. In addition, the minimal
127 requirement of their ultrasound system was a [transducer](#) frequency range of at least 5–
128 10 MHz and a minimal feature of digital beamformer technology. Only experienced
129 radiologists were recruited. Both were trained in a consensus meeting to use an international
130 scanning protocol ([Jacobson, 2011](#)) and a standardized outcome form. All participating
131 radiologists (9) and PTs (13) were male. PTs had a median five years of experience
132 (interquartile range (IQR) 1.5–6), and all participating PTs made more than 100 ultrasounds
133 of the shoulder (54% made more than 200 ultrasounds). The radiologists had a median of 10
134 years of experience (IQR 5-20) and they all made more than 200 ultrasounds of the shoulder
135 ([Thoomes-de Graaf et al., 2014](#)).

136

137 *2.3.3. Patients.* Adult patients with shoulder pain were recruited from [primary care](#) physical
138 therapy clinics. Patients were excluded in the presence of serious pathology (e.g. infection,
139 cancer or fracture), [previous surgery](#) and/or if they received diagnostic [imaging techniques](#) of
140 the shoulder such as [MRI](#) and diagnostic ultrasound in the previous three months. The mean
141 age of patients was 56 years (Standard deviation (SD) 12) and 54% was male. Full
142 characteristics of the 65 participating are presented in [Table 1](#) ([Thoomes-de Graaf et al.,](#)
143 [2014](#)).

144

145 Please insert Table 1.

146

147 **2.3.4. Measurement.** Based on [history taking](#) and physical examination, the PT established
148 an initial diagnostic hypothesis, and performed a DMUS if this was needed for the diagnostic
149 work-up. Within one week, a second DMUS was performed by a radiologist, who only
150 received the initial diagnostic hypothesis from the PT. Both the patient and radiologist were
151 blinded for the DMUS diagnosis of the PT.

152 Diagnostic [ultrasound diagnoses](#) were standardized in terms of a total of 24 possible
153 outcomes based on observed disorder (diagnostic outcome category) and affected tendon.
154 We defined 10 primary diagnostic outcome categories: 1) tendinopathy, 2) calcification, 3) full
155 thickness tear or 4) partial thickness tear, 5) biceps tendon tear, 6) subacromial-subdeltoid
156 bursitis, 7) [subacromial impingement](#), 8) [osteoarthritis](#) of the acromio-clavicular joint, 9) no
157 pathology, or 10) other (eg. labral tear, capsular thickening). In case a diagnosis in category
158 1-4 was made, it was specified by adding the affected tendon; supraspinatus, subscapularis
159 and infraspinatus/teres minor ([Karel et al., 2013](#)).

160 In the present study, based on our literature study on best evidence treatment policies per
161 traditional diagnostic label, two authors (MTG, RO) categorized and recoded the 24 possible
162 outcomes into the new four treatment related categories; 'referral to secondary care',
163 'indication for corticosteroid injection', 'indication for physical therapy management' and
164 'watchful waiting'. Patients could only be labelled with one treatment label; in case of multiple
165 'traditional' diagnoses, the patient was labelled according to the highest level of care needed.
166 'Referral to secondary care' was deemed to precede 'indication for corticosteroid injection',
167 and 'indication for physical therapy management' preceded 'watchful waiting'.

168

169 **2.3.5. Analysis.** Each new treatment related category was dichotomized (patient labelled as
170 possible indication for e.g. physical therapy or not), to be able to calculate observed
171 agreement and kappa values plus 95% [confidence interval](#) (95%CI) for all treatment related
172 categories. Besides, an overall kappa was calculated (with 95% CI) based upon all treatment
173 related categories ([Kottner et al., 2011](#); [Sim and Wright, 2005](#)).

174 For the interpretation of the kappa values, the following criteria were used: almost perfect
175 (0.81–1.00), substantial (0.61–0.80), moderate (0.41–0.60), fair (0.21–0.40), slight (0.01–
176 0.20) or poor (<0.00) agreement ([Landis and Koch, 1977](#); [Viera and Garrett, 2005](#)).

177 All statistical analyses were performed using IBM [SPSS](#) Statistics 25.0 software.

178

179

180 **3. RESULTS**

181 **3.1. Systematic overview of current evidence**

182 A total of 706 articles were found based upon the original search. A search on primary
183 studies was performed for the categories [tendinopathy](#) and lesion of the biceps tendon,
184 partial [thickness](#) tendon tear and [arthritis](#) of the acromioclavicular (AC)-joint as no [systematic](#)
185 reviews were found for these categories, and another 837 articles were retrieved. For both
186 search strategies, see the appendix. After titles and abstracts were screened, a total of 85
187 were selected for assessment in full text. Papers were excluded if they did not meet our
188 selection criteria (e.g. a diagnostic study, using plasma injections etc.). Finally, a total of 32
189 articles met our selection criteria for inclusion in this study; 21 systematic reviews, one level
190 4 study, and 10 level 5 studies ([Fig. 1](#)). Results of the AMSTAR 2 assessment are presented
191 in [Table 2](#). No other risk of bias tools were applicable.

192

193 Please insert figure 1 and table 2.

194

195 Based on the available evidence of effectiveness of treatment, the traditional diagnostic
196 labels were recoded into three new treatment related categories, as none of the traditional
197 diagnostic labels was recoded into the 'indication for [corticosteroid](#) injection' as this was not a
198 first-choice treatment option. There was no disagreement between both authors. The 'full
199 thickness tear', 'biceps tendon tear' and 'SLAP- lesion' were recoded into the treatment
200 related category: 'referral to secondary care', see [Table 3](#). In this category, it is important that
201 the patient is referred to a medical doctor to perform additional diagnostic tests and/or to
202 discuss surgery. 'Calcification', 'tendinopathy' and 'partial tear' of the [rotator cuff](#),
203 'subacromial impingement' and 'bursitis' were recoded into the category 'indication for
204 physical therapy', see [Table 4](#). All others ('arthritis/arthrosis of the AC-joint' and biceps
205 disorders ('calcification' and 'tendinopathy' of the biceps) and 'no pathology') were recoded to
206 'watchful waiting', see [Table 5](#).

207

208 Please insert table 3, 4 and 5 near here.

209

210 **3.2. Inter-professional agreement study**

211 The prevalence of positive findings and kappa values per therapeutic category are reported
212 in table 6.

213

214 Please insert table 6: Results of agreement.

215

216 The overall kappa was 0.60 (95%CI 0.43–0.76), indicating the new treatment related
217 categories showed moderate agreement between PTs and radiologists. There was
218 substantial agreement within the new treatment related category 'referral to secondary care'

219 (k = 0.74) and both new treatment related categories 'indication for [physical therapy](#)
220 management' (k = 0.57) and 'watchful waiting' (k = 0.46) showed moderate agreement. All
221 treatment related categories showed high observed agreement (>85%).

222

223

224 **4. DISCUSSION**

225 The results of this study indicate that the agreement between the radiologist and PT was
226 moderate to substantial in stratifying patients with shoulder pain into the new treatment
227 related categories. It shows that there may be possibilities to use DMUS to classify patients
228 into new treatment related categories. DMUS could help the PT in order to assess if a patient
229 should be referred to [secondary care](#) or not as this new treatment related category showed
230 the highest agreement. However, as this is just an explorative study, more research
231 regarding this stratifying strategy using DMUS and treatment related categories, is needed in
232 order to implement this into clinical care.

233

234 *4.1. Comparison with the literature*

235 The main intention of this paper is to explore new possibilities to breach decades of circular
236 reasoning. Our aim was to explore a different type of [clinical reasoning](#). As this type of
237 research has not been performed before, we cannot compare our results with other studies.
238 However, the agreement between radiologists and PTs using these new treatment related
239 categories is higher than the agreement reported in our initial study using the traditional
240 diagnostic labels. Disagreement in differentiating between a partial [thickness](#) tear and a
241 [tendinopathy](#) or calcification has been mentioned before in the literature ([Bianchi et al.,](#)
242 [2005](#); [Jamadar et al., 2010](#)). With the new treatment related categories, these categories all
243 belong to the same new label, namely 'indication for physical therapy', resulting in a higher
244 agreement. The observed agreement in our study was higher than Cohen's Kappa, this is
245 due to the fact that Cohen's κ adjusts for expected agreement ([Cohen, 1960](#); [Kottner et al.,](#)
246 [2011](#)) and is therefore a common observation.

247

248 *4.2. Strength and limitations*

249 The methodology of this paper is not flawless, which is a reflection of being explorative. For
250 example, the radiologists and PTs were not informed about the use of DMUS in the way we
251 have assessed it in this study, namely as a stratifying tool. Therefore, the outcome of a new
252 treatment related category for a certain individual could have been different from recoding
253 the traditional diagnostic label if we would have asked in this specific way. We have
254 instructed PTs and radiologists to use the Jacobson protocol ([Jacobson, 2011](#)), it is unclear
255 how it would impact the agreement if we had instructed them differently. In order to minimize

256 progression bias, we chose a maximum period of one week between both tests. We assume
257 that the conditions of interest did not change within this time frame. Another limitation might
258 be the level of DMUS experience between radiologists and PTs, respectively median of 10
259 and five years. DMUS of the [rotator cuff](#) is considered to be operator-dependent with its
260 accuracy being related to the operator's level of experience. However, there is evidence that
261 there is good to excellent agreement for the detection of [rotator cuff tears](#), which only slightly
262 improves with increasing experience ([Alavekios et al., 2013](#); [Murphy et al., 2013](#); [Rutten et](#)
263 [al., 2010](#)).

264 Besides, as treatment related categories are being based upon current knowledge, these
265 categories can evolve over time. For example, the traditional diagnostic labels 'bursitis' and
266 'partial thickness tear' were part of the label rotator cuff disorders/SAPS. Interestingly, there
267 were no [systematic](#) reviews or RCTs included for a solitary 'bursitis' or 'partial thickness tear'.
268 Moreover, several studies used a diagnostic label as an umbrella term, e.g. 'tendinopathy'
269 encompassing all [rotator cuff disorders](#) instead of only tendinopathy ([Desjardins-](#)
270 [Charbonneau et al., 2015](#); [Toliopoulos et al., 2014](#)). To be transparent, we reported the
271 original reported traditional diagnostic labels. We therefore chose to combine these
272 traditional labels, as it is difficult to draw conclusions on any traditional diagnostic label
273 separately.

274

275 *4.3. Implications for clinical practice*

276 At the moment, our findings cannot be implemented into clinical care. In the future, DMUS
277 might be of additional value at first [consultation](#) in order to facilitate PTs in making treatment-
278 or referral decisions. PTs could potentially use DMUS to help them stratify patients into the
279 new treatment related categories using the following interpretations: 1. It seems like a rotator
280 cuff or biceps tendon is disrupted (implication for referral to secondary care), 2. It seems like
281 there is something different than expected when compared to a "normal" structure in the
282 rotator cuff and subacromial region but it does not seem disrupted (implication [physical](#)
283 [therapy](#) management), 3. There is nothing unusual on the image or there is something
284 different than expected on a healthy subject in the AC or biceps region (indication for
285 watchful waiting).

286 Usual physical therapy assessment includes the assessment of functional limitations (range
287 of motion, strength etc.) related to the needs of the patient, which seems to be appropriate as
288 both exercises and [mobilization](#) seem to be the main interventions in the entire physical
289 therapy group. Therefore, patients categorized into the 'watchful waiting' category by DMUS
290 (as there were no unusual findings seen), could eventually still be treated by the PT, as
291 functional limitations could be an indication for physical therapy. Therefore, DMUS should
292 only be considered as an add-on test. Moreover, DMUS findings should always be placed in

293 the clinical context based on [history taking](#) and physical examination. DMUS can support the
294 PT to establish treatment- and referral decisions. Therefore, DMUS should only be
295 considered as an add-on test. Moreover, DMUS findings should always be placed in the
296 clinical context based on history taking and physical examination. DMUS can support the PT
297 to establish treatment- and referral decisions.

298 Despite the DMUS findings at the start of treatment, it is of great importance to be aware of
299 the clinical course of a patient with shoulder pain. When a patient does not recover within 6–
300 12 weeks, a referral to the general practitioner (GP) is advised ([Jansen et al., 2011](#)). Not only
301 because the results of the DMUS might not be completely accurate, but also stratifying
302 patients into the category ‘indication for physical therapy’, is based upon the first treatment
303 choice. If conservative physical therapy fails, the patient should be seen by the GP, and
304 treated according to their guidelines. For example, a [corticosteroid](#) injection or referral to
305 secondary care might then be indicated ([Winters et al., 2008](#)). Even though physical therapy
306 and a corticosteroid injection were as effective in the category ‘rotator cuff disorders’, a
307 corticosteroid injection was not rated as a first choice of treatment in this study, as
308 corticosteroids were associated with higher adverse event rates. A corticosteroid injection
309 could still be a useful second-choice treatment option in stepped care policy. Care providers
310 have to make their own decisions regarding the risks and benefits ([Stanhope et al., 2012](#)).
311 When starting treatment, PTs should also consider possible psychosocial [prognostic factors](#),
312 as these prognostic factors might affect [treatment outcome](#). Moreover, PTs should be aware
313 that observed rotator cuff disorders using DMUS could be asymptomatic ([Louwerens et al.,](#)
314 [2015](#); [Milgrom et al., 1995](#)). To prevent unnecessary treatment of asymptomatic pathology,
315 the observed findings have to be linked to medical history and physical examination.
316 Furthermore, besides screening for red flags, abnormal scan findings when using DMUS
317 could be an indication to consult the GP (e.g. neoplasm), although these findings are
318 extremely rare.

319 Future research should be focused on assessing the inter-professional agreement between
320 radiologists and other caregivers using DMUS (e.g. PTs and GPs) using DMUS and
321 treatment related categories with the concordant instructions. Moreover, it would be
322 interesting to assess whether this stratification indeed impacts the [clinical pathway](#) of
323 patients and therefore impacts the outcome of the therapeutic process (and [cost-](#)
324 [effectiveness](#), e.g. return to work).

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326 This study is approved by the Medical Ethical Committee.

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329

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TABLE 1. Characteristics of the patients.

Variable	Frequencies
Gender: N (%male)	35 (54%)
Age: Mean (SD)	56 (12)
Duration of complaints in weeks: Median (IQR)	12 (6-29)
Medication use: N (%yes)	31 (52%)
Pain Score ¹ : Median (IQR)	6 (5-7)
SPADI ² : Median (IQR)	51 (35-67)
SDQ ³ : Median (IQR)	71 (50-87)
EQ5D health status ⁴ : Median (IQR)	7 (6-8)
Data of the questionnaires of three patients missing.	

Abbreviations: N, Number; SD, Standard deviation; IQR, Interquartile range.

Legend:

1. The pain score has been measured using the Numeric Rating Scale (NRS) ranging from 0 to 10, with 0 no pain and 10 worst pain ever.
2. The Shoulder Pain and Disability Index (SPADI) ranges from 0 to 100, a higher score indicates a higher level of disability.
3. The Shoulder Disability Questionnaire (SDQ) ranges from 0 to 100, a higher score indicating more severe disability.
4. The Euroqol (EQ5D) health status ranges from 0 to 10, 0 represents the worst possible health status and 10 the best possible health status.

TABLE 2. The AMSTAR 2 assessment

Author	AMSTAR items																Overall
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Bannaru	Y	Y	Y	PY	Y	Y	N	Y	PY	N	NA	NA	Y	Y	NA	Y	Moderate
Boudreault	Y	N	Y	PY	Y	N	Y	PY	Y	N	Y	N	N	Y	N	Y	Low
Coghlan	Y	PY	Y	PY	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Moderate
Desjardins	N	N	Y	PY	Y	N	N	PY	Y	N	Y	N	Y	N	N	Y	Moderate
Downie	Y	PY	Y	PY	Y	Y	N	N	N	N	NA	NA	Y	N	NA	Y	Low
Erickson	Y	N	Y	PY	N	N	N	PY	N	N	NA	NA	N	N	NA	Y	Critically low
Frost	Y	PY	Y	PY	N	Y	N	PY	N	N	NA	NA	Y	N	NA	Y	Low
Ge	Y	Y	Y	PY	Y	Y	N	PY	PY	N	N	N	Y	N	N	Y	Low
Gebremariam	Y	PY	Y	PY	Y	Y	N	PY	Y	N	NA	NA	Y	N	NA	Y	Moderate
Gorantla	Y	PY	Y	PY	Y	Y	N	PY	N	N	NA	NA	Y	N	NA	Y	Critically low
Green	Y	PY	Y	PY	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
Hanratty	Y	Y	Y	PY	N	N	N	PY	Y	N	Y	Y	Y	Y	Y	N	Moderate
Huisstede	Y	PY	Y	PY	Y	Y	Y	PY	Y	N	NA	NA	Y	N	NA	Y	Moderate
Kelly	Y	N	Y	PY	Y	Y	N	PY	Y	N	NA	NA	Y	Y	Y	N	Moderate
Kromer	Y	PY	Y	PY	N	Y	N	PY	Y	N	NA	NA	Y	N	NA	N	Moderate
Littlewood	N	Y	Y	Y	Y	Y	Y	Y	Y	N	NA	NA	Y	N	NA	Y	Moderate
Louwerens	N	N	Y	PY	Y	N	N	N	Y	N	Y	N	N	N	N	Y	Low
Mall	Y	PY	Y	PY	Y	N	N	PY	N	N	NA	NA	Y	N	NA	Y	Low
Page	Y	Y	Y	PY	Y	Y	N	PY	Y	Y	NA	NA	Y	Y	NA	Y	Moderate
Saltychev	Y	N	Y	PY	N	N	N	Y	Y	N	N	Y	Y	N	N	Y	Low
Toliopoulos	Y	N	Y	PY	Y	N	Y	PY	Y	N	NA	NA	N	N	Y	Y	Low

TABLE 3. Possible indications for referral to secondary care

Diagnostic category	Evidence	Level of evidence CEBM
Full thickness tear	1) Moderate evidence that surgery more effective than physical therapy (exercise therapy) in the mid and long term. 2) Limited evidence that surgery may improve outcome in patients aged 60 years and older. 3) Inconsistent evidence regarding the timing of surgery.	1) Level 1: (Huisstede et al. , 2011) 2) Level 2*: (Downie and Miller, 2012) 3) Level 1: (Huisstede, Koes, 2011) Level 2*: (Mall et al. , 2013)
Biceps tendon tear (long head)	1) Surgical treatment showed better outcome on strength and days of sick leave compared to nonsurgical treatment but not on arm pain. 2) Regardless the type of surgery, improvement in postoperative outcomes was shown.	1) Level 4: (Mariani et al. , 1988) 2) Level 2*: (Frost et al. , 2009, Ge et al. , 2015)
SLAP lesion	1) Limited evidence that an arthroscopic repair shows better outcomes for individuals not involved in throwing or overhead sports. 2) Limited evidence that surgery shows good outcomes in an older cohort of patients. 3) No evidence concerning conservative treatment of a SLAP-lesion.	1) Level 2*: (Gorantla et al. , 2010) 2) Level 2*: (Erickson et al. , 2015)

TABLE 4. Possible indication for physiotherapy management

Diagnostic category	Evidence	Level of evidence CEBM
Rotator cuff disorder	<p>1) Limited evidence for no important differences between manual therapy and exercise and arthroscopic subacromial decompression on pain, function, active range of motion and strength or global treatment success.</p> <p>2) Limited evidence for no clinically important differences between manual therapy and exercise and glucocorticoid injection on pain, function, quality of life, night pain and active range of motion.</p> <p>3) Limited evidence that corticosteroid injections show better results compared to physical therapy at short term only. However, corticosteroid injections are associated with an increased risk of facial flushing.</p> <p>4) Limited evidence for no difference in effect between various conservative treatments. Mainly exercise and mobilization/manipulation have been evaluated.</p>	<p>1) Level 1: (Page et al. , 2016)</p> <p>2) Level 1: (Page, Green, 2016)</p> <p>3) Level 1: (Green et al. , 2003)</p> <p>4) Level 1: (Green, Buchbinder, 2003)</p>
Subacromial impingement	<p>1) Moderate to strong evidence that surgery and physical therapy (physiotherapist-led exercises) are equally effective on either functional outcome scores or pain relief. Generally, surgical interventions are associated with more complications and higher costs than conservative treatment.</p> <p>2) Limited evidence that corticosteroid injections shown positive results compared to physical therapy in the short term only. Injections were associated with adverse effects.</p> <p>3) Limited evidence that physical therapy (mobilization, home-based strengthening exercises, strapping, advice on posture, and electrotherapy) is more effective than no treatment.</p> <p>4) Moderate evidence that exercises + manual therapy is more beneficial than exercises alone.</p> <p>5) Moderate evidence for no differences between physiotherapy-led exercises or home-based exercises.</p>	<p>1) Level 1: (Coghlan et al. , 2008, Gebremariam et al. , 2011, Green, Buchbinder, 2003, Kromer et al. , 2009).</p> <p>Level 2*: (Saltychev et al. , 2015).</p> <p>2) Level 1: (Green, Buchbinder, 2003)</p> <p>3) Level 1: (Kelly et al. , 2010, Kromer, Tautenhahn, 2009)</p> <p>4) Level 1: (Kromer, Tautenhahn, 2009)</p> <p>5) Level 1: (Hanratty et al. , 2012)</p>
<i>Partial thickness tear solely</i>	<p>1) Several level 5 studies indicated that conservative management is the first line treatment and surgery is only indicated if conservative treatment has failed. No evidence concerning the effectiveness of conservative treatments in partial thickness tears solely.</p>	<p>1) Level 5: (Finnan and Crosby, 2010, Franceschi et al. , 2011, Shin, 2011, Tashjian, 2012, Wolff et al. , 2006)</p>

<p><i>Tendinopathy solely</i></p>	<p>1) Moderate evidence that surgery and physical therapy (supervised exercises) are equally effective. 2) Low to moderate evidence that oral NSAIDs and corticosteroids injections are equally effective in reducing pain or improving function in the short term. Inconsistent evidence concerning adverse event with corticosteroids injections. The review does not support the use of corticosteroid injections 3) Limited evidence that laser therapy showed better results compared to oral NSAIDs or placebo in reducing pain. 4) Moderate evidence that physical therapy (supervised as well as home-based exercises, incorporating a loading strategy) is effective in terms of pain and functional disability compared to no intervention and placebo. There is low to moderate evidence manual therapy can decrease pain; however, it is unclear whether it can improve function.</p>	<p>1) Level 1: (Littlewood et al. , 2012) Level 2*: (Toliopoulos, Desmeules, 2014) 2) Level 2*: (Boudreault et al. , 2014) 3) Level 2*: (Boudreault, Desmeules, 2014) 4) Level 1: (Desjardins-Charbonneau, Roy, 2015, Littlewood, Ashton, 2012)</p>
<p><i>Calcification solely</i></p>	<p>1) Moderate evidence that surgery and conservative treatment (graded physical therapy strengthening program/ physical therapy program of exercise and education/ exercise program) are equally beneficial. Conservative treatment is preferred because of lower complication risks. 2) Moderate evidence that high-energy extracorporeal shockwave therapy (high-energy ESWT) is superior to placebo for chronic calcific tendinitis. 3) No evidence exists on the effectiveness of ESWT compared to physical therapy.</p>	<p>1) Level 1: (Gebremariam, Hay, 2011) 2) Level 1: (Bannuru et al. , 2014) Level 2*: (Louwerens et al. , 2014)</p>
<p><i>Bursitis solely</i></p>	<p>1) There were no adequate studies reporting the efficacy of therapies on bursitis.</p>	<p>1) Level 1: (Green, Buchbinder, 2003)</p>

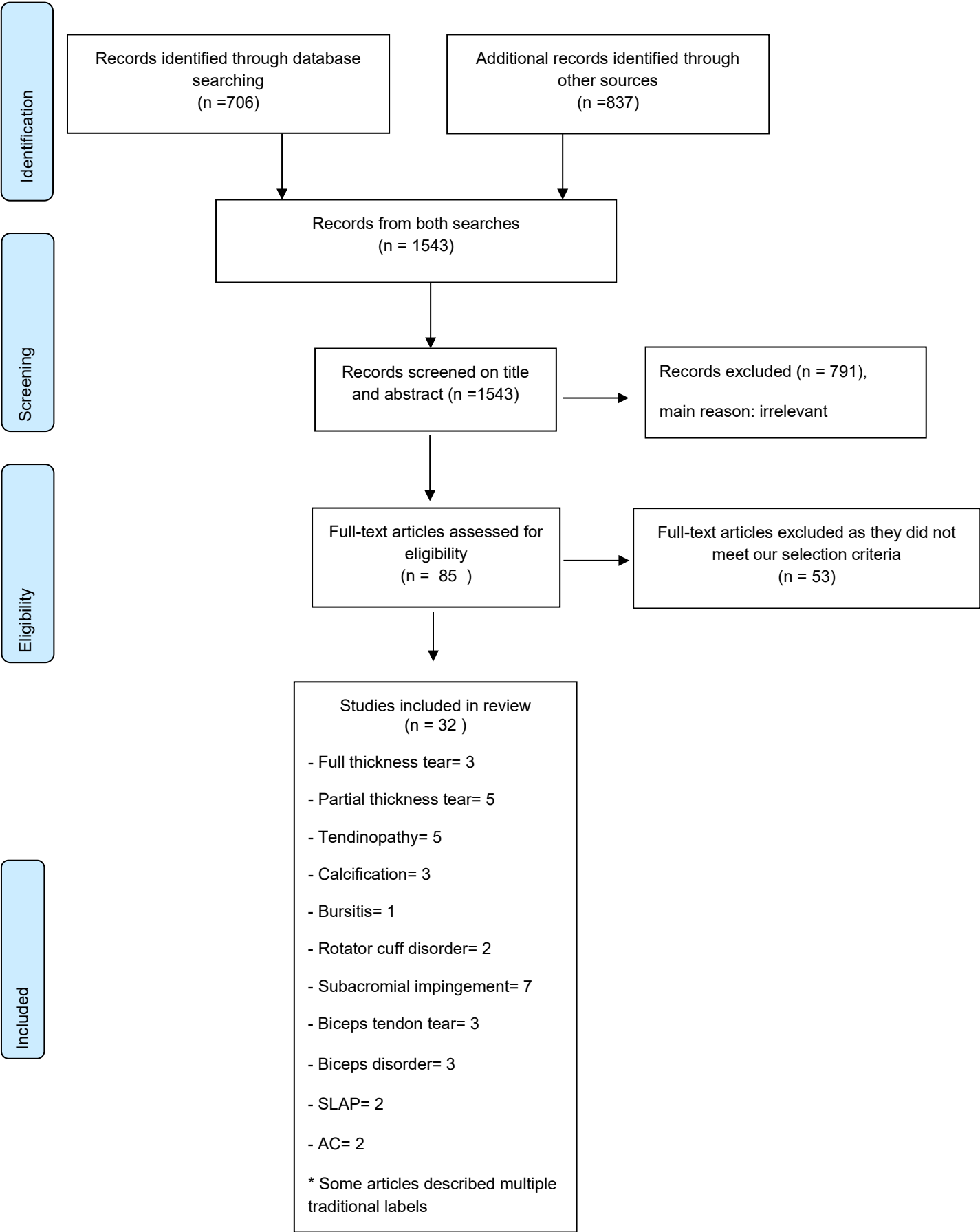
TABLE 5. Watchful waiting

Diagnostic category	Evidence	Level of evidence CEBM
Arthritis/ osteoarthritis of the Acromioclavicular -joint	1) No evidence concerning the effectiveness of conservative treatments in osteoarthritis of the AC joint	1) Level 5: (Buttaci et al. , 2004, Docimo et al. , 2008)
Biceps disorder	1) No evidence concerning the effectiveness of conservative treatments in biceps disorders (tendinopathy and calcification). Several level V studies indicated treatment should begin with conservative treatment, but no data on effectiveness was presented	1) Level 5: (Khazzam et al. , 2012, Nho et al. , 2010, Snyder et al. , 2012)
No specific pathology or not interpretable image	If “no pathologies” are found using diagnostic US, watchful waiting or monitoring is regarded	None. Clinical reasoning.

TABLE 6. Results of agreement

Category	Frequency	Cohen's kappa (95%CI)	Observed agreement
Overall		0.60 (0.43-0.76)	90%
Possible indication for surgery	PT: 8 Radiologist: 10 Both: 7	0.74 (0.50-0.99)	94%
Possible indication for physiotherapy management	PT: 53 Radiologist: 48 Both: 45	0.57 (0.33-0.82)	85%
Watchful waiting	PT: 4 Radiologist: 8 Both: 3	0.46 (0.04-0.87)	91%

FIGURE 1. Inclusion



Appendix. Search

EMBASE

((('shoulder injury'/de OR 'shoulder impingement syndrome'/de OR 'rotator cuff injury'/exp OR (((shoulder* OR 'rotator cuff' OR subacromial OR biceps) NEAR/3 (bursitis OR syndrome OR injur* OR impingement* OR disorder*)))):ab,ti OR (Shoulder/de OR 'biceps brachii muscle'/de OR 'rotator cuff'/de OR 'acromioclavicular joint'/de OR (shoulder* OR labrum OR labral):ab,ti) AND (Tendinitis/de OR Calcification/de OR rupture/de OR 'tendon rupture'/de OR 'ligament lesion'/de OR 'tendon lesion'/de OR atrophy/de OR arthritis/de OR osteoarthritis/de OR (Tendinitis OR Tendinopath* OR Calcificat* OR rupture* OR lesion OR tear* OR atroph* OR arthrit* OR osteoarthritis*):ab,ti)) AND ('evidence based medicine'/de OR 'meta analysis'/de OR 'systematic review'/de OR ('evidence based' OR 'meta analysis' OR 'systematic review'):ab,ti) AND (therapy/exp OR 'treatment outcome'/exp OR therapy:lnk OR (therap* OR treat*):ab,ti)

COCHRANE

(((((shoulder* OR 'rotator cuff' OR subacromial OR biceps) NEAR/3 (bursitis OR syndrome OR injur* OR impingement* OR disorder*)))):ab,ti OR ((shoulder* OR labrum OR labral):ab,ti) AND ((Tendinitis OR Tendinopath* OR Calcificat* OR rupture* OR lesion OR tear* OR atroph* OR arthrit* OR osteoarthritis*):ab,ti)) AND ((therap* OR treat*):ab,ti)

EMBASE

(Shoulder/de 'shoulder injury'/de OR 'biceps brachii muscle'/de OR 'acromioclavicular joint'/de OR (shoulder* OR labrum OR labral OR biceps OR acromioclavicul*):ab,ti) AND (Tendinitis/de OR Calcification/de OR rupture/de OR 'tendon rupture'/de OR 'ligament lesion'/de OR 'tendon lesion'/de OR arthritis/de OR osteoarthritis/de OR (Tendinitis OR Tendinopath* OR Calcificat* OR rupture* OR lesion OR tear* OR atroph* OR arthrit* OR osteoarthritis*):ab,ti) AND (therapy/exp OR 'treatment outcome'/exp OR therapy:lnk OR surgery:lnk OR (therap* OR treatment* OR repair* OR surg* OR operat*):ab,ti) AND ('controlled clinical trial'/exp OR (((control*) NEAR/3 (trial*)) OR random* OR ((double OR single) NEAR/3 blind*)):ab,ti)

References

- Alavekios DA, Dionysian E, Sodl J, Contreras R, Cho Y, Yian EH. Longitudinal analysis of effects of operator experience on accuracy for ultrasound detection of supraspinatus tears. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons* [et al]. 2013.
- Bannuru RR, Flavin NE, Vaysbrot E, Harvey W, McAlindon T. High-energy extracorporeal shock-wave therapy for treating chronic calcific tendinitis of the shoulder: A systematic review. *Annals of Internal Medicine*. 2014;160:542-9.
- Beaudreuil J, Nizard R, Thomas T, Peyre M, Liotard JP, Boileau P, et al. Contribution of clinical tests to the diagnosis of rotator cuff disease: a systematic literature review. *Joint Bone Spine*. 2009;76:15-9.
- Bianchi S, Martinoli C, Abdelwahab IF. Ultrasound of tendon tears. Part 1: general considerations and upper extremity. *Skeletal radiology*. 2005;34:500-12.
- Bier JD, Scholten-Peeters WGM, Staal JB, Pool J, van Tulder MW, Beekman E, et al. Clinical Practice Guideline for Physical Therapy Assessment and Treatment in Patients With Nonspecific Neck Pain. *Physical therapy*. 2017.
- Boudreault J, Desmeules F, Roy JS, Dionne C, Fremont P, Macdermid JC. The efficacy of oral non-steroidal anti-inflammatory drugs for rotator cuff tendinopathy: a systematic review and meta-analysis. *J Rehabil Med*. 2014;46:294-306.
- Buttaci CJ, Stitik TP, Yonclas PP, Foye PM. Osteoarthritis of the acromioclavicular joint: a review of anatomy, biomechanics, diagnosis, and treatment. *American journal of physical medicine & rehabilitation / Association of Academic Physiatrists*. 2004;83:791-7.
- Campbell M. Problems With Large Joints: Shoulder Conditions. *FP Essent*. 2016;446:25-30.
- Coghlan JA, Buchbinder R, Green S, Johnston RV, Bell SN. Surgery for rotator cuff disease. *Cochrane Database Syst Rev*. 2008:CD005619.
- Cohen J. A coefficient of agreement for nominal scales. *Educational and Psychological Measurement* 1960;20:37-46.
- Desjardins-Charbonneau A, Roy JS, Dionne CE, Frémont P, MacDermid JC, Desmeules F. The efficacy of manual therapy for rotator cuff tendinopathy: a systematic review and meta-analysis. *The Journal of orthopaedic and sports physical therapy*. 2015;45:330-50.
- Diercks R, Bron C, Dorrestijn O, Meskers C, Naber R, de Ruitter T, et al. Guideline for diagnosis and treatment of subacromial pain syndrome: a multidisciplinary review by the Dutch Orthopaedic Association. *Acta orthopaedica*. 2014;85:314-22.
- Docimo S, Jr., Kornitsky D, Futterman B, Elkowitz DE. Surgical treatment for acromioclavicular joint osteoarthritis: patient selection, surgical options, complications, and outcome. *Current reviews in musculoskeletal medicine*. 2008;1:154-60.
- Downie BK, Miller BS. Treatment of rotator cuff tears in older individuals: a systematic review. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons* [et al]. 2012.
- Erickson J, Lavery K, Monica J, Gatt C, Dhawan A. Surgical treatment of symptomatic superior labrum anterior-posterior tears in patients older than 40 years: a systematic review. *The American journal of sports medicine*. 2015;43:1274-82.
- Finnan RP, Crosby LA. Partial-thickness rotator cuff tears. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons* [et al]. 2010;19:609-16.
- Franceschi F, Papalia R, Del Buono A, Maffulli N, Denaro V. Repair of partial tears of the rotator cuff. *Sports medicine and arthroscopy review*. 2011;19:401-8.
- Frost A, Zafar MS, Maffulli N. Tenotomy versus tenodesis in the management of pathologic lesions of the tendon of the long head of the biceps brachii. *The American journal of sports medicine*. 2009;37:828-33.
- Ge H, Zhang Q, Sun Y, Li J, Sun L, Cheng B. Tenotomy or tenodesis for the long head of biceps lesions in shoulders. *PLoS ONE*. 2015;10.

- Gebremariam L, Hay EM, Koes BW, Huisstede BM. Effectiveness of surgical and postsurgical interventions for the subacromial impingement syndrome: a systematic review. *Archives of physical medicine and rehabilitation*. 2011;92:1900-13.
- Gorantla K, Gill C, Wright RW. The outcome of type II SLAP repair: a systematic review. *Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association*. 2010;26:537-45.
- Green S, Buchbinder R, Hetrick S. Physiotherapy interventions for shoulder pain. *Cochrane Database Syst Rev*. 2003:CD004258.
- Hanratty CE, McVeigh JG, Kerr DP, Basford JR, Finch MB, Pendleton A, et al. The effectiveness of physiotherapy exercises in subacromial impingement syndrome: a systematic review and meta-analysis. *Semin Arthritis Rheum*. 2012;42:297-316.
- Hegedus EJ, Goode A, Campbell S, Morin A, Tamaddoni M, Moorman CT, 3rd, et al. Physical examination tests of the shoulder: a systematic review with meta-analysis of individual tests. *British journal of sports medicine*. 2008;42:80-92; discussion
- Hill J, Whitehurst DG, Lewis M, Bryan S, Dunn KM, Foster NE, et al. Comparison of stratified primary care management for low back pain with current best practice (STarT Back): a randomised controlled trial. *Lancet*. 2011;Oct 29;378:1560-71.
- Howick J, Chalmers I, Glasziou P, Greenhalgh T, Heneghan C, Liberati A, et al. "The Oxford 2011 Levels of Evidence". Oxford Centre for Evidence-Based Medicine <http://www.cebm.net/index.aspx?o=5653>. 2011.
- Hughes PC, Taylor NF, Green RA. Most clinical tests cannot accurately diagnose rotator cuff pathology: a systematic review. *The Australian journal of physiotherapy*. 2008;54:159-70.
- Huisstede BM, Bierma-Zeinstra SM, Koes BW, Verhaar JA. Incidence and prevalence of upper-extremity musculoskeletal disorders. A systematic appraisal of the literature. *BMC musculoskeletal disorders*. 2006;7:7.
- Huisstede BM, Koes BW, Gebremariam L, Keijsers E, Verhaar JA. Current evidence for effectiveness of interventions to treat rotator cuff tears. *Manual therapy*. 2011;16:217-30.
- Jacobson JA. Shoulder US: anatomy, technique, and scanning pitfalls. *Radiology*. 2011;260:6-16.
- Jamadar DA, Robertson BL, Jacobson JA, Girish G, Sabb BJ, Jiang Y, et al. Musculoskeletal sonography: important imaging pitfalls. *AJR Am J Roentgenol*. 2010;194:216-25.
- Jansen MJ, Brooijmans F, Geraets JJXR, Lenssen AF, Ottenheijm RPG, F. PLI, et al. KNGF Evidence Statement Subacromiale klachten. *Nederlands Tijdschrift voor Fysiotherapie*. 2011;121.
- Karel Y, Scholten-Peeters GGM, Thoomes-de Graaf M, Duijn E, van Broekhoven JB, Koes BW, et al. Physiotherapy for patients with shoulder pain in primary care: a descriptive study of diagnostic- and therapeutic management. *Physiotherapy*. 2017;103:369-78.
- Karel YH, Scholten-Peeters WG, Thoomes-de Graaf M, Duijn E, Ottenheijm RP, Koes BW, et al. Current management and prognostic factors in physiotherapy practice for patients with shoulder pain: design of a prospective cohort study. *BMC musculoskeletal disorders*. 2013;14:62.
- Karel YH, Verhagen AP, Thoomes-de Graaf M, Duijn E, van den Borne MP, Beumer A, et al. Development of a Prognostic Model for Patients With Shoulder Complaints in Physiotherapy. *Physical therapy*. 2016.
- Kelly SM, Wrightson PA, Meads CA. Clinical outcomes of exercise in the management of subacromial impingement syndrome: a systematic review. *Clin Rehabil*. 2010;24:99-109.
- Khazzam M, George MS, Churchill RS, Kuhn JE. Disorders of the long head of biceps tendon. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al]*. 2012;21:136-45.
- Koes BW, van Tulder M, Lin CW, Macedo LG, McAuley J, Maher C. An updated overview of clinical guidelines for the management of non-specific low back pain in primary care. *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society*. 2010;19:2075-94.

- Kottner J, Audige L, Brorson S, Donner A, Gajewski BJ, Hrobjartsson A, et al. Guidelines for Reporting Reliability and Agreement Studies (GRRAS) were proposed. *International journal of nursing studies*. 2011;48:661-71.
- Kromer TO, Tautenhahn UG, de Bie RA, Staal JB, Bastiaenen CH. Effects of physiotherapy in patients with shoulder impingement syndrome: a systematic review of the literature. *J Rehabil Med*. 2009;41:870-80.
- Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33:159-74.
- Linsell L, Dawson J, Zondervan K, Rose P, Randall T, Fitzpatrick R, et al. Prevalence and incidence of adults consulting for shoulder conditions in UK primary care; patterns of diagnosis and referral. *Rheumatology (Oxford, England)*. 2006;45:215-21.
- Littlewood C, Ashton J, Chance-Larsen K, May S, Sturrock B. Exercise for rotator cuff tendinopathy: a systematic review. *Physiotherapy*. 2012;98:101-9.
- Lord SJ, Staub LP, Bossuyt PM, Irwig LM. Target practice: choosing target conditions for test accuracy studies that are relevant to clinical practice. *BMJ (Clinical research ed)*. 2011;343:d4684.
- Louwerens JK, Sierevelt IN, van Hove RP, van den Bekerom MP, van Noort A. Prevalence of calcific deposits within the rotator cuff tendons in adults with and without subacromial pain syndrome: clinical and radiologic analysis of 1219 patients. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al]*. 2015;24:1588-93.
- Louwerens JKG, Sierevelt IN, van Noort A, van den Bekerom MPJ. Evidence for minimally invasive therapies in the management of chronic calcific tendinopathy of the rotator cuff: A systematic review and meta-analysis. *Journal of Shoulder and Elbow Surgery*. 2014;23:1240-9.
- Mall NA, Lee AS, Chahal J, Sherman SL, Romeo AA, Verma NN, et al. An evidenced-based examination of the epidemiology and outcomes of traumatic rotator cuff tears. *Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association*. 2013;29:366-76.
- Mariani EM, Cofield RH, Askew LJ, Li GP, Chao EY. Rupture of the tendon of the long head of the biceps brachii. Surgical versus nonsurgical treatment. *Clinical orthopaedics and related research*. 1988:233-9.
- McKiernan S, Chiarelli P, Warren-Forward H. Diagnostic ultrasound use in physiotherapy, emergency medicine, and anaesthesiology. *Radiography*. 2010;16:154-9.
- Milgrom C, Schaffler M, Gilbert S, van Holsbeeck M. Rotator-cuff changes in asymptomatic adults. The effect of age, hand dominance and gender. *The Journal of bone and joint surgery British volume*. 1995;77:296-8.
- Murphy RJ, Daines MT, Carr AJ, Rees JL. An independent learning method for orthopaedic surgeons performing shoulder ultrasound to identify full-thickness tears of the rotator cuff. *The Journal of bone and joint surgery American volume*. 2013;95:266-72.
- Nho SJ, Strauss EJ, Lenart BA, Provencher MT, Mazzocca AD, Verma NN, et al. Long head of the biceps tendinopathy: diagnosis and management. *The Journal of the American Academy of Orthopaedic Surgeons*. 2010;18:645-56.
- Page MJ, Green S, McBain B, Surace SJ, Deitch J, Lyttle N, et al. Manual therapy and exercise for rotator cuff disease. *The Cochrane database of systematic reviews*. 2016:CD012224.
- Rutten MJ, Jager GJ, Kiemeny LA. Ultrasound detection of rotator cuff tears: observer agreement related to increasing experience. *AJR Am J Roentgenol*. 2010;195:W440-6.
- Saltychev M, Aarimaa V, Virolainen P, Laimi K. Conservative treatment or surgery for shoulder impingement: systematic review and meta-analysis. *Disability and rehabilitation*. 2015;37:1-8.
- Schellingerhout JM, Verhagen AP, Thomas S, Koes BW. Lack of uniformity in diagnostic labeling of shoulder pain: time for a different approach. *Manual therapy*. 2008;13:478-83.
- Shea BJ, Reeves BC, Wells G, Thuku M, Hamel C, Moran J, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ (Clinical research ed)*. 2017;358:j4008.

- Shin KM. Partial-thickness rotator cuff tears. *The Korean journal of pain*. 2011;24:69-73.
- Sim J, Wright CC. The kappa statistic in reliability studies: use, interpretation, and sample size requirements. *Physical therapy*. 2005;85:257-68.
- Snyder GM, Mair SD, Lattermann C. Tendinopathy of the long head of the biceps. *Medicine and sport science*. 2012;57:76-89.
- Stanhope J, Grimmer-Somers K, Milanese S, Kumar S, Morris J. Extended scope physiotherapy roles for orthopedic outpatients: an update systematic review of the literature. *J Multidiscip Healthc*. 2012;5:37-45.
- Tashjian RZ. Epidemiology, natural history, and indications for treatment of rotator cuff tears. *Clinics in sports medicine*. 2012;31:589-604.
- 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;19:478-83.
- Toliopoulos P, Desmeules F, Boudreault J, Roy JS, Frémont P, MacDermid JC, et al. Efficacy of surgery for rotator cuff tendinopathy: a systematic review. *Clinical Rheumatology*. 2014.
- Viera AJ, Garrett JM. Understanding interobserver agreement: the kappa statistic. *Family medicine*. 2005;37:360-3.
- Winters JC, Van der Windt DAWM, Spinnewijn WEM, De Jongh AC, Van der Heijden GJMG, Buis PAJ, et al. NHG-Standaard Schouderklachten (Tweede herziening). *Huisarts Wet* 2008.
- Wolff AB, Sethi P, Sutton KM, Covey AS, Magit DP, Medvecky M. Partial-thickness rotator cuff tears. *The Journal of the American Academy of Orthopaedic Surgeons*. 2006;14:715-25.