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Original article

# Does the outcome of diagnostic ultrasound influence the treatment modalities and recovery in patients with shoulder pain in physiotherapy practice? Results from a prospective cohort study

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ABSTRACT

*Study design:* Prospective cohort study including patients with shoulder pain in primary care physiotherapy.
*Background:* There is an increased tendency to use diagnostic ultrasound to aid the diagnostic strategy and target treatment. It is a relatively cheap and accessible imaging technique but the implications for practice and patients are unknown.
*Objectives:* To study the influence of diagnostic ultrasound (DUS) on diagnostic work-up, treatment modalities and recovery.
*Methods:* Participants (n = 389) with a new episode of shoulder pain were assessed at baseline and followed for 6, 12 and 26 weeks. Diagnostic work-up, including the use of DUS, and treatment strategies were reported by the therapists at 3, 6 and 12 weeks.
*Results:* Most patients (41%) were diagnosed with subacromial impingement/pain syndrome after physical examination or DUS. DUS was used in 31% of the participants. Tendinopathy was the most found abnormality in this sub-population. Patients who underwent DUS were more frequently treated using exercise therapy. Patients that not had DUS were more likely to receive massage therapy, trigger point therapy or mobilisation techniques. Logistic regression analyses did not show a significant association between DUS and recovery after 26 weeks (0.88, 95%CI:0.50–1.57). Correcting for the therapist as a confounder using a multilevel binary logistic regression did not show a significant cluster effect.
*Conclusion:* Diagnostic US as a work-up component does not seem to influence diagnosis or recovery but does influence the choice of treatment modality. Conclusions are limited to observational data. High quality randomized trials should study the effect of DUS on recovery.

## 1. Introduction

Shoulder complaints are the third most common musculoskeletal complaint in the Netherlands (Kooijman et al., 2013). Studies have shown an unfavourable recovery for 40–70% of patients with shoulder pain after 6 months and high indirect costs attributed to sick leave. (Bot et al., 2005b, Karel et al., 2016, Kuijpers et al., 2006, Virta et al., 2012) In Dutch general practice about 50% of patients receive medication, 32% a wait-and-see policy and 16% are referred to a physical therapist (Dorrestijn et al., 2010).

Initial management of patients with shoulder complaints is usually conservative except for younger patients with an acute traumatic rotator cuff tear (Arce et al., 2013). When primary care treatment fails to improve the patient's symptoms, a referral to secondary care can be made.

According to the Dutch guidelines, physical therapists (PTs) and general practitioners (GPs) are recommended to classify patients into one of three groups: 1) with reduced passive range of motion

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(complaints due to glenohumeral deficit), 2) without reduced passive range of motion but with a painful abduction range (subacromial deficit), 3) without reduced passive range of motion and without a painful abduction range (shoulder instability) (Geraets et al., 2008, Jansen et al., 2011). This classification can give the clinician an indication of the nature of the complaint. Research has shown that based on history taking and physical examination a more detailed classification of diagnostic labels is not reliable and not likely to change the initial therapeutic approach chosen by the GP (Beaudreuil et al., 2009, Hegedus et al., 2007, Hughes et al., 2008).

In primary care there is an increased tendency to use diagnostic ultrasound (DUS) as an application to aid the diagnostic strategy in combination with patient history and findings from physical examination. Several studies have developed valid measurement parameters for rotator cuff pathology, like the size of the subacromial space or acromiohumeral distance or applied ultrasound for rehabilitation purposes like neuromuscular re-education, changes in morphology, localizing target areas for manual interventions or guiding needle placement (McCreesh et al., 2014, Michener et al., 2015). It is a relatively cheap and accessible imaging technique. Some clinicians believe that determining an accurate diagnosis is essential to be able to provide the appropriate treatment. On the other hand, there is a lack of correlation between rotator cuff tears and symptoms experienced by the patient (Minagawa et al., 2014). Whether the emerging use of diagnostic imaging has a potential use for the diagnostic assessment and treatment strategy for the PTs remains unknown. Therefore our aim was to study the influence of DUS on clinical reasoning, treatment modalities and recovery in physical therapy practice.

The research question was:

What is the influence of DUS on clinical reasoning of PTs, treatment modalities chosen by PTs and recovery of patients with shoulder pain in physical therapy practice?

## 2. Method

### 2.1. Design

This study was part of a prospective cohort study with a follow-up of 26 weeks in PT practice including patients with non-specific shoulder complaints: named “X”. The main purpose of the study was to evaluate physiotherapy care and prognostic factors in patients with shoulder pain. Details of the study design are published elsewhere (Karel et al., 2013). The Medical Ethics Committee of the Erasmus Medical Center approved the study protocol (MEC-2011-414).

### 2.2. Participants, therapists

*Physical therapists* (n = 125) from the South West region on the Netherlands participated in the study and recruited patients from November 2011 till November 2012. Patients were either referred by their GP or consulted the PT through direct access.

*Patients* (n = 389) with shoulder pain were eligible when they were 18 years or over and adequately understood the Dutch language. Exclusion criteria were: patients with serious pathologies (infection, cancer or fracture), shoulder surgery in the past 12 months or diagnostic imaging techniques (musculoskeletal ultrasound, magnetic resonance imaging or radiography) performed on the shoulder in the past 3 months, so that pathologies of these scans could not influence the decision to make a diagnostic ultrasound. The PTs using DUS in usual care had to have at least one year of experience with DUS and at least made 100 US scans of the shoulder.

### 2.3. Data collection

Data from PTs were collected at baseline, 3, 6 and 12 weeks after inclusion using digital questionnaires that were developed with a panel of experts and clinicians. PTs reported the planned management at baseline in terms of initial clinical diagnosis (diagnostic label), the use of US (yes/no based on the choice of the therapist), pathological findings on DUS, changes in clinical hypothesis after DUS and initial therapeutic management of the patient (treatment goals as a picklist). The DUS could either be performed before or after physical examination. Whenever a treatment plan changed during follow-up, the PTs reported the reasons for change and the new treatment goal(s). Possible interventions were categorized into: information/advice, exercise therapy, massage, manual joint mobilisation/manipulation, extracorporeal shockwave therapy (ESWT), transcutaneous electrical nerve stimulation (TENS), trigger point therapy, taping/bracing or posture correction. Exercise therapy was subdivided in a) exercise of (muscle) function (strength/length), b) exercise of activities, c) stabilisation techniques for the rotator cuff/scapulo-thoracic sliding mechanism.

Patients received a questionnaire at baseline, 6, 12 and 26 weeks after inclusion. Informed consent was received of patients and rights were protected. Clinical characteristics of the PTs (age, sex, work experience and/or specialization) and of the patients (age, gender, pain, duration of complaints and recurrence) were reported at baseline. At each follow-up point the level of disability and recovery was measured. The Shoulder Pain and Disability Index (SPADI) was used to measure level of disability. The Numeric Rating Scale (NRS-11) was used to score pain intensity. The scale ranges from 0 to 10, with 0 representing “no pain” and 10 “severe disabling pain” (Bot et al., 2005b). The SPADI has a good internal consistency and test-retest reliability (Thoomes-de Graaf et al., 2016).

### 2.4. Outcome measures

*Diagnostic ultrasound.* The following pathological findings were listed: tendinopathy, calcification, full thickness/partial thickness tears, biceps tendon rupture, bursitis, subacromial impingement syndrome, glenohumeral discontinuity, acromion discontinuity, osteoarthritis, labrum tear/SLAP, capsular thickening, and rotator cuff atrophy. One patient could have more than one US finding but the first diagnosis was considered the most relevant to the complaints.

*Recovery.* Recovery status of the patient was measured with the Global Perceived Effect scale (GPE). The GPE uses a 7-point Likert scale indicating whether the patient's condition had improved or deteriorated since the start of their treatment. The outcome was dichotomised into “recovered” and “not recovered”, with “recovered” defined as “completely recovered” or “much improved”. The GPE is validated for patients with musculoskeletal complaints (Kamper et al., 2010).

### 2.5. Data analysis

Descriptive statistics of both baseline characteristics and outcome measures (baseline characteristics, US findings, reasons for using DUS, clinical hypothesis and the use of treatment modalities) were presented in mean scores for continuous data with a normal distribution. Otherwise, median scores and the interquartile range (IQR) were used. Pearson's chi-square test was used to compare categorical data between groups (choice of treatment modality between diagnostic groups and between diagnostic US groups). The Fisher exact test was used for small samples ($n < 10$). If distribution was non-parametric, medians were compared using the Independent Sample Median Test. Distributions was compared using the Mann-Whitney $U$ test. For the parametric distributions means were compared using the two-sample independent $t$-test. A p-value $\leq 0.05$ was considered statistically significant. Binary logistic regression analysis was used to estimate the effect of DUS (independent variable) on recovery (dependent variable), controlled for confounders. The variables age, duration of complaints, level of disability and pain were considered as possible confounders from previous literature. Crude and adjusted ORs with 95% confidence intervals (CI) were obtained. Multilevel binary logistic regression models were

**Table 1**
Baseline characteristics of patients.

| Baseline characteristics | Total N = 389 | Non-US group N = 267 | US-group N = 122 |
|---|---|---|---|
| Male n (%) | 171 (45) | 115 (44) | 54 (47) |
| Age mean (sd) | 49.9 (13.2) | 48.5 (12.8) | 53.2 (13.6)* |
| Age groups n (%) | | | |
| ≤34 | 50 (13) | 37 (14) | 13 (11) |
| 35-44 | 78 (21) | 62 (24) | 16 (14) |
| 45-54 | 108 (29) | 78 (30) | 30 (26) |
| 55-64 | 79 (21) | 53 (21) | 26 (23) |
| ≥65 | 59 (16) | 29 (11) | 30 (26)* |
| Duration of complaints in weeks, median (IQR) | 12 (6–26) | 12 (6–26) | 12 (7–28) |
| Disability SPADI, mean (SD) | 47 (21) | 45 (22) | 52 (20)* |
| Pain NRS-11, median, (IQR) | 6 (4–7) | 6 (4–7) | 7 (5–7)* |
| Recurrent complaint yes, n (%) | 158 (43) | 106 (42) | 52 (46) |
| Cause yes (%) | | | |
| Unexpected movement | 23 (6) | 13 (5) | 10 (9) |
| Overuse | 132 (36) | 100 (39) | 32 (28) |
| Trauma | 24 (7) | 16 (6) | 8 (7) |
| Sports injury | 32 (9) | 21 (8) | 11 (10) |
| Unclear | 128 (35) | 85 (33) | 43 (38) |
| Other | 29 (8) | 20 (8) | 9 (8) |

N Number, SD Standard Deviation, IQR Inter Quartile Range, SPADI Shoulder Pain And Disability Index, NRS Numeric Rating Scale, US Ultrasound.
*p-value < 0.05.

constructed in order to account for the clustering of patients within practices. A random intercept logistic regression model is used to allow the intercept to vary randomly across clusters. Complete case analysis was used on all the analyses. The number of missings was reported for all data. SPSS 22.0 was used for all analyses.

## 3. Results

### 3.1. Study population

A total of 389 patients with a mean age of 50 years were included. In total 267 patients received a treatment solely based on history taking and physical examination (non-US-group), and 122 patients underwent DUS at baseline performed by a PT and were treated based on a post-ultrasound diagnosis (US-group).

### 3.2. Baseline

There was no significant difference in the gender distribution between the US and non-US-group (Table 1). The mean difference of 4.7 years in age (95% CI 1.8–7.6) between the patients in the US and non-US-group was small but statistically significant. When divided into age groups, there were significantly more patients in the age group between 35 and 44 years and in the age group of 65 years and older in the US-group (Table 1).

The median duration of complaints at inclusion in both groups was 12 weeks. The mean difference in disability score (SPADI) was 6.68 (95%CI 1.98–11.37). The pain intensity score (NRS-11) at time of inclusion was significantly higher for the US-group (Table 1).

In the non-US-group 39% of the patients stated that their complaints were caused by overuse. This was significantly more compared to the US-group in which overuse accounted for 28% of the cases. There was no difference between the two groups for other probable causes of shoulder pain. An overview of the PT characteristics is presented in Table 2.

### 3.3. Diagnostic ultrasound findings

Of the 122 patients who underwent DUS 99 had complete data. The number of abnormalities ranged from 0 to 5 per patient. The majority of patients (n = 42) had 2 abnormalities, 1 patient had 5.

Tendinopathy was the most observed abnormality (30.8%), followed by calcification (19.5%), partial-thickness tendon tears (10.2%) and subacromial impingement (8.8%). The supraspinatus tendon was the most affected tendon. In 7 patients (3.1%) no pathology was observed (Fig. 1).

**Table 2**
Characteristics of physiotherapists.

| | Total (n = 102) | PTs without DUS machine (n = 64) | PTs with DUS machine (n = 38) |
|---|---|---|---|
| Sex men, N (%) | 91 (77) | 43 (68) | 35 (92)* |
| Age in years, mean (SD) | 44 (11) | 44 (12) | 45 (9) |
| Experience in years, N (%) | | | |
| < 5 | 20 (20) | 14 (22) | 6 (16) |
| 5–10 | 21 (21) | 14 (22) | 7 (18) |
| > 11 | 61 (60) | 36 (56) | 25 (66) |
| Specialization, N (%) | | | |
| Manual therapist | 51 (50) | 34 (53) | 17 (45) |
| Sports | 21 (21) | 11 (17) | 10 (26) |
| Geriatrics | 2 (2) | 2 (3) | 0 |
| Pediatrics | 2 (2) | 2 (3) | 0 |
| Psychosocial | 1 (1) | 1 (2) | 0 |
| Vocational | 5 (5) | 3 (5) | 2 (5) |
| Lymphatic | 6 (6) | 3 (5) | 3 (8) |
| Worktime, N (%) | | | |
| Parttime | 28 (22) | 21 (36) | 7 (19) |
| fulltime | 67 (54) | 38 (64) | 29 (81) |

N number, SD standard deviation, DUS Diagnostic Ultrasound.
*p-value < 0.05.

### 3.4. Reasons for using DUS

In 34% (42/122) of all patients receiving DUS, the reason was that the PT expected this would lead to a more specific clinical diagnosis, and in 13% (16/122) that it would help the PT in selecting the most appropriate intervention. In 12% of the patients (15/122) the PTs used the US findings to confirm their initial diagnosis and in another 11% (14/122) to better inform the patient about their complaints. Other reasons were 1) that it was a routine procedure in the physical examination, 2) that it would serve as a baseline measurement, 3) it was a request by a colleague and 4) that it would improve their professional position towards other health professionals. These were not selected frequently. Results suggest that US was most frequently performed when there was a suspicion of subacromial pathology.

### 3.5. Clinical diagnoses

Subacromial impingement syndrome (SIS) was the most reported diagnosis overall (Table 3). In the non-US-group this was followed by a disorder of the cervicothoracic spine (CTS) and costae, frozen shoulder/capsulitis and instability of the glenohumeral joint. In the US-group this was followed by a non-specific diagnosis, sprain or strain and instability of the glenohumeral joint (Table 2). In the US-group 75 patients also had a pre-US diagnosis, based on history taking with or without physical examination. SIS was the most occurring pre-US diagnosis (57.3%), followed by sprain or strain (12%), another non-specific diagnosis (6.7%) and acromioclavicular (AC) or sternoclavicular (SC) joint disorder. The clinical hypothesis changed in 29% (35/122) of patients after DUS. In 31% (11/35) the clinical hypothesis changed from various diagnoses to a sprain (trauma) or strain.

### 3.6. Treatment

Patients were usually treated with a selection of different treatment

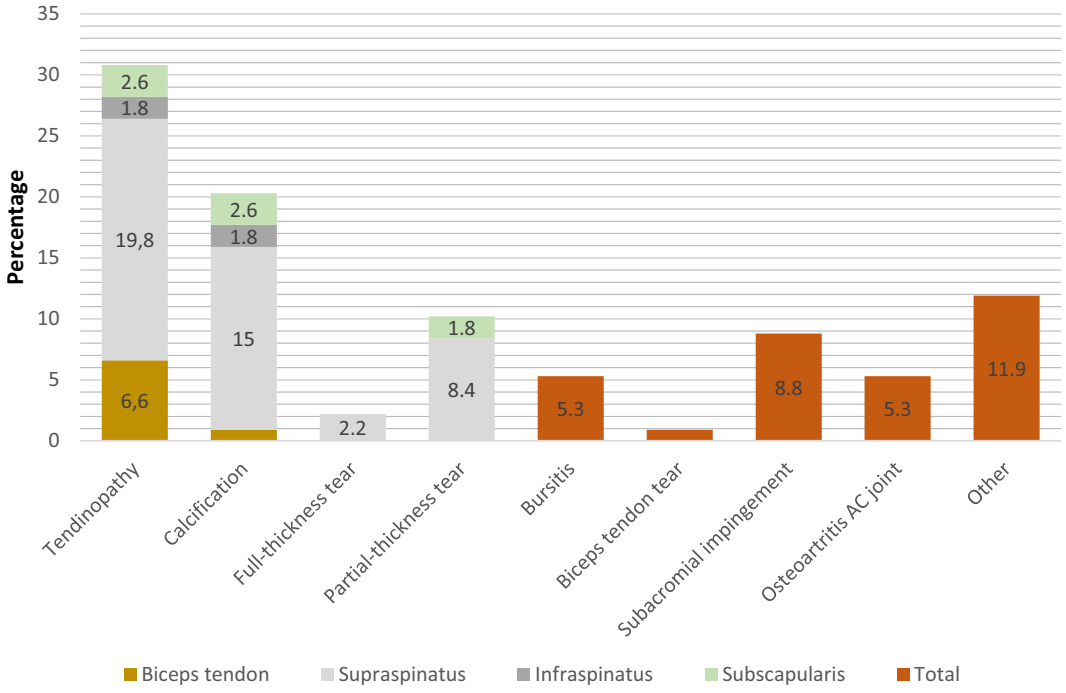


**Fig. 1.** Percentage of ultrasound findings per pathology for each anatomical structure in the shoulder (colours) (n = 116, missing data n = 6). AC Acromioclavicular. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

modalities. In the non-US-group the maximum number of different modalities (including the different forms of exercise therapy) was 7. In the US-group there was a maximum number of 6 different modalities. In both groups the median of different modalities was 3 (p = 0.13).

The median number of treatment sessions in both groups was 7 and did not differ statistically significant between the US and non-US groups.

In the non-US-group 8.3% of the patients were referred (back) to their GP, 3.8% were referred to another healthcare professional (HP). In the US-group 13.2% were referred to their GP and 8.3% to another HP. The difference between the two groups for referral to GP or another HP was not statistically significant.

Informing, advising, counselling and coaching were the most used approaches regardless of the clinical diagnosis (Table 4). Table 4 shows the number of patients receiving a treatment modality per clinical diagnosis (left side of the table) and overall between the US and the non-US group (right side of the table).

Patients labelled with SIS received statistically significant more often stabilisation of the rotator cuff in the non-US group compared with the US group. There were significantly more patients treated with trigger point therapy through stretching and/or dry needling in the non-US-group (12.7% vs 1.7%).

For patients labelled with a disorder of the cervicothoracic spine statistically significant more patients were treated with triggerpoint therapy in the non-US-group compared to the US-group.

A statistical significantly higher number of patients in the US-group received advice, counselling and coaching or extracorporeal shockwave therapy. Patients that did not had DUS were more likely to receive massage therapy, trigger point therapy or manipulation and mobilisation techniques.

Also, more patients in the US group were treated with ESWT. Pts could use ESWT in case of calcifications but only 33.6% of patients with calcifications were treated with ESWT.

**Table 3**
Clinical diagnosis for each group.

| Diagnostic groups (n, %) | Total (n = 340) | Non-US-group[^] (n = 241) | US-group[v] (n = 99) |
|---|---|---|---|
| Subacromial impingement syndrome | 139 (40.9) | 79 (32.8) | 60 (60.6) |
| Disorder of cervicothoracic spine (CTS) and costae | 53 (15.6) | 51 (21.2) | 2 (2) |
| Frozen shoulder/capsulitis | 29 (8.5) | 27 (11.2) | 2 (2) |
| Instability of the glenohumeral joint | 27 (7.9) | 22 (9.1) | 5 (5.1) |
| Sprain or strain in neck/shoulder region | 19 (5.6) | 12 (5.0) | 7 (7.1) |
| Internal (posterior) impingement syndrome | 18 (5.3) | 17 (6.4) | 1 (1) |
| Acromioclavicular (AC) or sternoclavicular (SC) joint disorder | 15 (4.4) | 13 (5.4) | 2 (2) |
| Biceps tendinopathy | 10 (2.9) | 6 (2.5) | 4 (4) |
| Myofascial trigger point in neck/shoulder | 2 (0.6) | 2 (0.8) | 0 |
| SLAP lesion (Superior Labral tear from Anterior to Posterior) | 1 (0.3) | 0 | 1 (1) |
| Muscular hypertonia in neck/shoulder | 0 | 0 | 0 |
| Other non-specific | 21 (6.2) | 11 (4.6) | 12 (12.1) |
| Unclear/Not possible to specify a clear diagnosis | 4 (1.2) | 1 (0.4) | 3 (3) |

US Ultrasound.
[^] Non-US-group = diagnosis set after history and/or physical examination.
[v] US-group = diagnosis set after ultrasound. Missings non-US-group: 26; US-group: 23.

**Table 4**
Treatment modalities per clinical diagnosis and for the non-US-group and the US-group.

| Treatment modalities (n, %) | Total n = 387 | Sub-acromial impinge-ment n = 139 | Disorder CTS/ costae n = 53 | Frozen shoulder n = 29 | Instability n = 27 | Sprain/ Strain n = 19 | Internal impinge-ment n = 18 | AC/SC Joint n = 15 | Biceps tendino-pathy n = 10 | Other non-specific n = 21 | non-US group n = 265 | US-group n = 122 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Informing, advising, counselling and coaching | 332 (85.8) | 128 (92.1) | 49 (92.5) | 29 (100) | 23 (85.2) | 15 (78.9) | 17 (94.4) | 11 (73.3) | 10 (100) | 20 (95.2) | 222 (83.8) | 110 (90.2) |
| Exercise therapy: | 320 (82.7) | 133 (95.7) | 37 (69.8) | 23 (79.3) | 26 (96.3) | 18 (94.7) | 17 (94.4) | 12 (80) | 9 (90) | 17 (81) | 209 (78.9) | 111 (91)*** |
| exercise of (muscle) function | 230 (59.4) | 88 (63.3) | 27 (50.9) | 22 (75.9) | 20 (74.1) | 17 (89.5) | 7 (38.9) | 8 (53.3) | 8 (80) | 16 (76.2) | 155 (58.5) | 75 (61.5) |
| exercise of activities | 76 (19.6) | 22 (15.8) | 12 (22.6) | 8 (27.6) | 8 (29.6) | 5 (26.3) | 4 (22.2) | 3 (20) | 2 (20) | 5 (23.8) | 54 (20.4) | 22 (18) |
| stabilisation rotator cuff/ scapula | 212 (54.8) | *99 (71.2) | 13 (24.5) | 11 (37.9) | 22 (81.5) | 14 (73.7) | 14 (77.8) | 6 (40) | 4 (40) | 7 (33.3) | 142 (53.6) | 70 (57.4) |
| Massage | 33 (8.5) | 6 (4.3) | 13 (24.5) | 5 (17.2) | 1 (3.7) | 1 (5.3) | 1 (5.6) | 3 (20) | 0 | 1 (4.8) | 28 (10.6) | 5 (4.1)*** |
| Manipulation and mobilisation techniques | 215 (55.6) | 73 (52.5) | 49 (92.5) | 19 (65.5) | 7 (25.9) | 6 (31.6) | 13 (72.2) | 13 (86.7) | *5 (50) | 11 (52.4) | 159 (60) | 56 (45.9)*** |
| Extracorporeal shock wave therapy | 41 (10.6) | 29 (20.9) | 1 (1.9) | 1 (3.4) | 0 | 0 | 5 (27.8) | 1 (6.7) | 0 | 0 | 23 (8.7) | 18 (14.8)*** |
| Passive modalities | 5 (1.3) | 0 | 0 | 2 (6.9) | 0 | 1 (5.3) | 0 | 1 (6.7) | 0 | 0 | 3 (1.1) | 2 (1.6) |
| Trigger point therapy (stretching/dry needling) | 32 (8.3) | *11 (7.9) | **5 (9.4) | 3 (10.3) | 2 (7.4) | 2 (10.5) | 3 (16.7) | 2 (13.3) | 0 | 2 (9.5) | 27 (10.2) | 5 (4.1)*** |
| Stabilisation shoulder tape/ bandaging | 54 (14) | 26 (18.7) | 0 | 0 | 11 (40.7) | 2 (10.5) | 4 (22.2) | **3 (20) | 0 | 2 (9.5) | 32 (12.1) | 22 (18) |
| No treatment | 2 (0.5) | 1 (0.7) | 0 | 0 | 1 (3.7) | 0 | 0 | 0 | 0 | 0 | 2 (0.8) | 0 |
| Other | 37 (9.6) | *7 (5) | 8 (15.1) | 5 (17.2) | 0 | 1 (5.3) | 2 (11.1) | 3 (20) | 3 (30) | 3 (14.3) | 31 (11.7) | 6 (4.9)*** |

*p-value ≤0.05 = statistically significant in favour of the non-US-group *within that specific diagnostic group*.
**p-value ≤0.05 = statistically significant in favour of the US-group *within that specific diagnostic group*.
*** 2-sided p-value for comparison between non-US-group and US-group (the last two columns).
ESWT = extracorporeal shock wave therapy, CTS = cervicothoracic spine, AC = Acromioclavicular, SC = sternoclavicular.
Treatment for SLAP lesion and Unclear diagnosis are not shown in this table, due to small sample sizes.
No patients were diagnosed with muscular hypertonia.

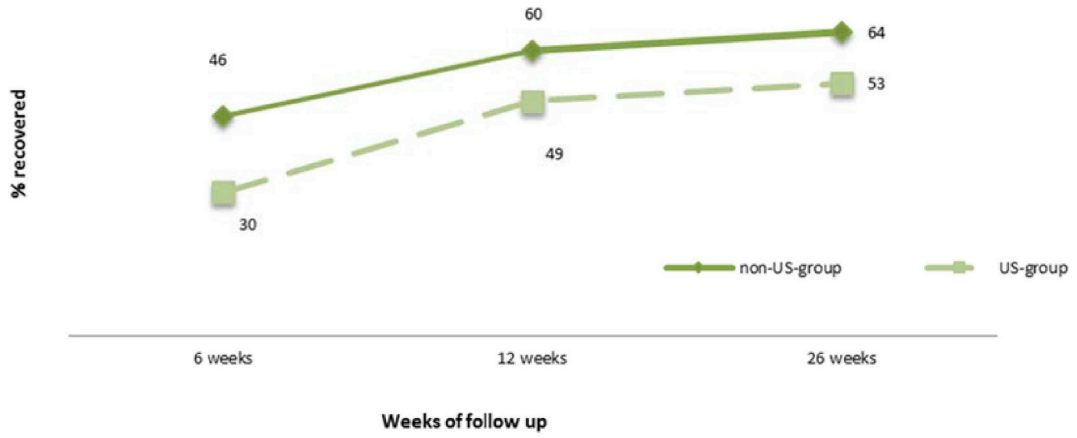


**Fig. 2.** Number of patients that reported to be recovered on the GPE scale per group (missings non-US-groups and US-group at 6 weeks: 26% and 30%, 12 weeks: 33% and 25%, 26 weeks: 33% and 23% resp).

### *3.7. Recovery*

The proportion of missing data on recovery was high for both the non-US-group and the US-group, ranging from 23% to 33% (Fig. 2). At 6 weeks there were statistical significantly more patients in the non-US-group (46.2%) that reported being recovered compared to the US-group (30.2%). The difference in recovery was not statistically significant at 12 and 26 weeks but still the proportion of patients reporting recovery was higher for the non-US-group.

### *3.8. Association between DUS and recovery*

Binary logistic regression analysis found a statistically significant crude OR of 0.53 (CI 0.30–0.92), meaning a negative association between DUS and recovery at 6 weeks. After 12 weeks (0.66, CI:0.39–1.11) and 26 weeks (0.68, CI:0.40–1.15) the crude OR were not statistically significant. The estimate changed after adjusting for confounders to 0.64 (0.36–1.14) at 6 weeks and was not statistically significant anymore. Both adjusted ORs after 12 weeks (0.73, CI:0.42–1.28) and 26 weeks (0.88, CI:0.50–1.57) were also not statistically significant.

Adding the therapist as a level 2 in multilevel binary logistic regression model resulted in a non-significant random effect estimate of 0.060 ($p = 0.73$) for the 6 weeks follow-up. SPSS was unable to compute random effect estimates for 12 and 26 weeks of follow-up because the variation in the random intercept was too small.

## 4. Discussion

The most common clinical diagnosis was SIS and for the US-group the clinical diagnosis did not change after the DUS. The referral rate was slightly higher in the US-group but not statistically significant. The use of DUS did not seem to have some influence on the applied treatment modalities by the PTs. There were slightly more patients treated with exercise therapy in the US-group, but when subdivided in different subgroups of exercise therapy, no statistically significant differences were found. In the non-US-group statistically significant more patients were treated with manipulation and mobilisation techniques, massage and triggerpoint therapy. No major differences were found in other diagnostic groups. In the non-US-group more patients reported being recovered. The difference was only significant at 6 weeks follow-up. The use of DUS seemed to have a negative effect on recovery at 6 weeks but this effect might be confounded by indication: i.e. patients with a worse prognosis based on for example age, duration of symptoms, level of disability and pain and/or variable which we did not measure have a higher chance to receive a DUS. No cluster effects were found on the therapist level.

### *4.1. Comparison with the literature*

Baseline characteristics were similar to other studies done in primary care. This study had slightly more (56%) female patients, which was in line with other literature (Bot et al., 2005a, Picavet and Schouten, 2003, Van der Windt et al., 1995). Most patients were between 45 and 64 years of age; this age group consults their PT most often for all kind of musculoskeletal complaints in the Netherlands (Barten et al., 2013). Similar to the results in our study, SIS, in particular rotator cuff tendinopathy, is the most frequently diagnosed disorder (Thoomes-de Graaf et al., 2014).

In our study, DUS revealed tendinopathy in the majority of patients, and only 5.2% of the patients had a full-thickness tear. A retrospective observational study under 240 patients who were referred by GPs to make a DUS, concluded that in most cases there was a calcific tendonitis (29%), a tendinopathy in 11% of cases and a full-thickness tear in 8% (Ottenheijm et al., 2010). A prospective study where patients with acute shoulder pain were referred to a radiologist for DUS also showed calcific tendonitis to be the most frequently observed pathology (50.4%) followed by tendinopathy (28.7%) and full thickness tears (3.1%) (Ottenheijm et al., 2015). A systematic review with secondary care studies, showed that tendinopathy (30–39%) and full thickness tears (24–70%) were the most observed disorders (Ottenheijm et al., 2010). The differences of pathologies on DUS between studies can be attributed to the different criteria used for obtaining a DUS or selection criteria of patients. PTs with sufficient experience were selected but no explicit criteria were set for performing a DUS; it was left to the discretion of the PT. This might influence the validity of the pathological findings. The majority of PTs in this study used US to identify a more specific clinical diagnosis.

In our study no pathology on DUS was found in 6% of the patient, which is in contrast to the 40% described in previous literature where US was performed by radiologists in a primary care population (Ottenheijm et al., 2014). This might indicate that PTs already use DUS in a patient group where they suspect to find pathology. In line with other literature the supraspinatus tendon was the most frequently affected tendon (Kim et al., 2007, Ottenheijm et al., 2014).

Research shows that after the 5th decade an increase in asymptomatic rotator cuff tendon tears are found, linearly increasing every decade (Milgrom et al., 1995). In the US-group in our study 26% of the patient were 65 years or older confirming the earlier results. In this group less patients had US diagnosed tendinopathy and calcifications. These US findings may have been due to degeneration and may not have been the cause of the symptoms described by the patients. Furthermore, more than one abnormality was frequently observed in patients, but they may not have had any clinical implications. Research

performed in 51 men without complaints of the shoulder, showed that in 96% asymptomatic abnormalities were observed (Girish et al., 2011). Subacromial bursal thickening was observed in 78%, osteoarthritis of the AC joint in 65% and supraspinatus tendinosis in 39% (Girish et al., 2011).

A cross-sectional study has shown that MRI and DUS have equally high accuracy for identifying biceps pathology and rotator cuff tears, while physical examination has modest accuracy (Ardic et al., 2006). In addition, US could not detect glenoid labral tears and bone erosion (Ardic et al., 2006). This confirms that the choice for the use of additional imaging should be based on clinical information and might not be helpful as a standard method of assessment. Otherwise no assessment of the relevance of the abnormalities found trough US can be made.

### 4.2. Strengths and limitations

Our study was set in a primary care patient population. Little is known about US findings in primary care populations. Most studies on DUS are performed in secondary care where US is usually used for the work-up to a surgical intervention (Ottenheijm et al., 2010, Ottenheijm et al., 2014).

Our study was first to observe and evaluate the use of DUS performed by PTs in their clinical practice. Most literature on the accuracy of DUS is done by radiologists. PTs in contrast to radiologists tend to find more tendinopathy and partial-thickness tears (Thoomes-de Graaf et al., 2014). Furthermore, the reliability between PTs and radiologists in this study is borderline substantial for full-thickness tears only (Thoomes-de Graaf et al., 2014). These results suggests that the diagnosis after DUS performed may have questionable validity.

The PTs who participated in this study had knowledge of DUS and showed interest in determining its value in the diagnostic process. However, DUS is very operator dependant and a great variability existed in the experience with DUS between therapists, that this might have influenced the validity of the pathologies that were observed. The main purpose of the study was to observe the clinical practice of physiotherapists in patients with shoulder pain and thus no minimal criterium for experience was used in this study.

Furthermore, the PTs decided which patients were to have an US, therefore there might be a selection in the patients that received an US. Patients suspected of having shoulder pain related to a disorder of the cervical or thoracic spine were less likely to have a DUS and therefore mobilisations and manipulations might be used more significantly in the group that did not receive an US. Baseline factors between these groups did also differ whereas patients that received a DUS were significantly older and had higher disability scores.

Furthermore, there is no uniformity in the definition of the various diagnostic labels used in different studies and the labels only have fair to moderate inter-observer reproducibility. This challenges validity clinical diagnosis that were set by our PTs and the ability to compare various study results (Schellingerhout et al., 2008).

### 4.3. Implications

The need for a specific diagnosis is mainly driven by the desire to influence the outcome of a patient by a specific treatment modality and thereby establish a more efficient and cost-effective treatment plan. Where patients with calcification should be treated with rest and analgesics due to its self-limiting nature, ESWT can be considered or a referral in younger patients with an acute traumatic rotator cuff tear (Arce et al., 2013, Jansen et al., 2011). In our study only 33.6% of patients with calcifications were treated with ESWT. Of all patients with full thickness tears only one was referred to the GP and none were referred to other health care professionals. As full thickness tears may not heal and may require surgery, especially in the younger athlete, the orthopaedic surgeon will have to consider which management would be appropriate. This advice is also recommended in the evidence statement for PTs (Jansen et al., 2011). The evidence statement recommends exercise therapy, which most PTs used in their treatment regime. Whether DUS provided more information to choose exercise therapy more often remains unknown. Trigger point therapy was still used in a small number of patients while the evidence statement discourages this.

## 5. Conclusion

DUS as a work-up component does not seem to influence diagnostic work-up, and recovery but the choice of treatment differed between the groups. The patients who underwent DUS were more frequently treated using exercise therapy. Patients that did not have a DUS were more likely to receive massage therapy, trigger point therapy or manipulation and mobilisation techniques. High quality randomized trials should study the effect of DUS on recovery.

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## Appendix A. Supplementary data

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