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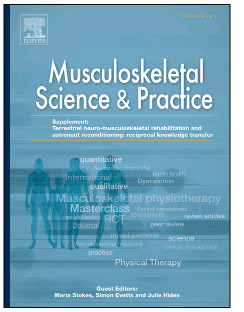

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Zohreh Jafarian Tangrood, Gisela Sole, Daniel Cury Ribeiro

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Is there an association between changes in pain or function with changes in scapular dyskinesis: a prospective cohort study

First author

Zohreh Jafarian Tangrood

Centre for Health, Activity, and Rehabilitation Research (CHARR) – School of Physiotherapy, University of Otago, New Zealand

zohreh.jafarian@postgrad.otago.ac.nz

Gisela Sole

Centre for Health, Activity, and Rehabilitation Research (CHARR) – School of Physiotherapy, University of Otago, New Zealand

gisela.sole@otago.ac.nz

Daniel Cury Ribeiro

Centre for Health, Activity, and Rehabilitation Research (CHARR) – School of Physiotherapy, University of Otago, New Zealand

daniel.ribeiro@otago.ac.nz

Corresponding author

Zohreh Jafarian Tangrood, zohreh.jafarian@postgrad.otago.ac.nz

Contact number: 0064 22 301 3366

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Ethics approval was obtained from the University of Otago Ethics Committee [Reference H17/080]

IS THERE AN ASSOCIATION BETWEEN CHANGES IN PAIN OR FUNCTION WITH CHANGES IN SCAPULAR DYSKINESIS: A PROSPECTIVE COHORT STUDY

Abstract

Objective: To assess the association between changes in pain or function with changes in scapular dyskinesis in participants with subacromial shoulder pain.

Method: Forty-four participants with subacromial shoulder pain were assessed at baseline and 8 weeks later. The outcome measures included 'pain at rest' and 'pain during movement' using Numeric Pain Rating Scale (NPRS), shoulder function using Patient Specific Functional Scale (PSFS), and observation of scapular movement pattern using the scapular dyskinesis test. Robust paired t-tests were used to compare scores between baseline and follow-up. Repeated measures correlation coefficient was used to assess the association between changes in pain or function with changes in scapular dyskinesis scores.

Results: A fair association was found between improvement in function and improvement in scapular dyskinesis (correlation coefficient = -0.4, 95% CI: -0.6 to -0.1). No associations were found between changes in 'pain at rest' (correlation coefficient = -0.1, 95% CI: -0.2 to 0.2) or 'pain during movement' (correlation coefficient = 0.28, 95% CI: 0.0 to 0.5) with changes in scapular dyskinesis.

Conclusion: Our findings showed improvement in function is associated with improvement in scapular dyskinesis scores. Future studies should explore whether there is causal effect between improvement in scapular dyskinesis and function.

Keyword: Subacromial shoulder pain, scapular dyskinesis, function

Introduction

Subacromial shoulder pain is defined as pain at the shoulder joint that may spread to the neck and elbow, and worsens during arm movements, particularly during overhead activities (Bergman et al., 2010; Littlewood. et al., 2016). Scapular dyskinesis is defined as altered scapular position at rest or during arm movements (Kibler et al., 2013; Plummer, Sum, Pozzi, Varghese, & Michener, 2017). The role of scapular dyskinesis on shoulder symptoms is debated, and some authors have suggested that poor scapular alignment might affect the mechanics of shoulder and increase the risk of shoulder pain (Hickey, Solvig, Cavalheri, Harrold, & McKenna, 2018; Kibler et al., 2013; Ludewig & Reynolds, 2009).

It is still unclear whether scapular dyskinesis is a cause or consequence of shoulder dysfunction (Kibler et al., 2013) or whether scapular dyskinesis is correlated to shoulder symptoms (Christiansen, Møller, Vestergaard, Mose, & Maribo, 2017; Harris, Pedroza, & Jones, 2012; Lopes, Timmons, Grover, Ciconelli, & Michener, 2015; Tate, McClure, Kareha, Irwin, & Barbe, 2009). Hickey et al. (2018) showed that 35% of athletes with obvious or subtle scapular dyskinesis and 25% of athletes without scapular dyskinesis developed shoulder pain over one year. Findings from previous studies showed participants with subacromial shoulder pain present with reduced scapular upward rotation and posterior tilt, when compared with asymptomatic participants, but no changes in scapular internal rotation (Borstad & Ludewig, 2002; Hebert, Moffet, McFadyen, & Dionne, 2002; Lawrence, Braman, Laprade, & Ludewig, 2014; Lin et al., 2005; Ludewig & Cook, 2000; McClure, Michener, & Karduna, 2006; Su, Johnson, Gracely, & Karduna, 2004). Those findings bring into question the role of scapular dyskinesis as a risk factor for shoulder pain. Understanding whether changes in scapular movement and function or pain are correlated can inform the designing of new intervention strategies for managing patients with shoulder subacromial pain.

Scapular-focused interventions (i.e. scapular-focused training, scapular taping or scapular mobilization) are commonly used to improve shoulder pain or function (Başkurt, Başkurt, Gelecek, & H. Özkan, 2011; Hotta, Santos, McQuade, & de Oliveira, 2018; Moezy, Sepehrifar, & Solaymani Dodaran, 2014; Turgut, Duzgun, & Baltaci, 2017). Three systematic reviews compared the effectiveness of scapular-focused interventions, either alone or in addition to other interventions (i.e. conventional physiotherapy, range of motion or shoulder general exercise). They suggested conflicting evidence regarding the effectiveness of scapular-focused interventions for improving pain and function, and reported that strength of evidence was limited by the small number of trials included in the reviews, the small sample size from included trials or heterogeneity on the design of interventions tested (Bury, West, Chamorro-Moriana, & Littlewood, 2016; Saito, Harrold, Cavalheri, & McKenna, 2018). In addition, they indicated conflicting evidence regarding the effectiveness of this form of intervention on improving scapular movement pattern (Bury et al., 2016; Reijneveld, Noten, Michener, Cools, & Struyf, 2017).

The primary aim of this study was to assess the association between changes in pain or function with changes in scapular dyskinesis over time. We hypothesized that: (1) there would be low association between changes in ‘pain at rest’ with scapular dyskinesis test over 8 weeks; (2) there would be fair to moderate association between changes in ‘pain during movement’ with scapular dyskinesis test over 8 weeks; and (3) there would be fair to moderate association between changes in function and scapular dyskinesis test over 8 weeks. The secondary aim was to compare pain, function and scapular dyskinesis test between baseline and follow-up. These comparisons were made for assessing the magnitude of change between time points for each outcome measure. This information was used for interpreting the correlation coefficients.

Methods

Design

This was an observational, prospective, cohort study following participants with subacromial shoulder pain for 8 weeks. We followed the Strengthening and Reporting of Observational Study (STROBE) guideline (Hendriksma, Joosten, Peters, Grolman, & Stegeman, 2017). Ethics approval was obtained from the University Ethics Committee [reference H17/080]. Eligible participants signed the informed written consent form prior to taking part in the study.

Setting

Participants with subacromial shoulder pain were recruited from the local community through email to university staff and flyers placed on community notice boards.

Participants

Inclusion and exclusion criteria

We included participants aged between 18 and 65 years old with shoulder pain in this study. Inclusion and exclusion criteria were based on the British Elbow and Shoulder Society (BESS) guidelines (Brownson et al., 2015). Participants were included if they had one positive finding on the following tests: (1) painful arc movement during shoulder flexion or abduction; or (2) pain on resisted lateral rotation or abduction or (3) Jobe's test (Brownson et al., 2015). Participants were excluded if they had a self-reported history of shoulder dislocation or subluxation, shoulder surgery and cervical surgery within the last 6 months. Participants with symptoms of inflammation or systemic diseases, signs of paraesthesia in the upper extremities, hemiplegic shoulder pain, frozen shoulder, or positive clinical signs of full thickness rotator cuff tear and sign of pain in acromioclavicular joint involvement were excluded.

Variables

Demographics

Participants' demographic characteristics were collected at baseline. These included age, gender, weight, height, self-reported hand dominance, shoulder pain side, duration of symptoms, previous shoulder pain episodes or injuries, whether or not they had received treatment for their shoulder pain before participating in the study.

Pain

Shoulder 'pain at rest' and 'pain during movement' were recorded using the Numeric Pain Rating Scale (NPRS) (Breivik et al., 2008). 'Zero' on this 11-point scale indicates 'no pain' and '10' indicates the most severe pain. A change of 2 points represents the minimal clinically important difference (MCID) (Hao et al., 2019; Ostelo et al., 2008); a change of 2 to 3 points is considered 'meaningful improvement'; and a change $\geq$ 3.5 to 4 points is considered 'very much improvement' (J. Abbott & J. Schmitt, 2014; Dworkin et al., 2008).

Function

Currently, there are no recommendations on core outcome sets for studies assessing patients with shoulder pain, with a diversity of instruments being used by trials in this area(Gagnier, Page, Huang, Verhagen, & Buchbinder, 2017; Page et al., 2015). In New Zealand, clinicians are required to use the PSFS as part of assessment of patients with musculoskeletal pain and injuries (Nicholas, Hefford, & Tumilty, 2012).

For the purpose of this study, participants' functional impairments were recorded using the Patient Specific Functional Scale (PSFS). The PSFS is an appropriate measuring tool for assessing physical functioning for between-group and within-group comparisons (J. Abbott & J. S. Schmitt, 2014). The PSFS has high construct validity for identifying functional improvement in patients who improve compared to those who do not improve (Hefford, Abbott, Arnold, & Baxter, 2012), high discriminate validity for identifying low, medium and high functional disabilities (J. Abbott & J. Schmitt, 2014), and moderate to high reliability (Hefford et al., 2012). The PSFS has different clinometric properties compared with other fixed item instruments such as SPADI and DASH questionnaires, and assesses functional impairments at individual-specific levels (J. Abbott & J. Schmitt, 2014).

When completing the PSFS, participants were asked to name up to five activities that they had difficulties performing due to their shoulder problem. Participants rated their functional difficulties associated with those activities from 0 to 10, where 0 indicated inability to perform the activity and 10 indicated ability to perform the activity the same as before shoulder pain or injury. The total score was then converted to a 0-100 score (J. Abbott & J. S. Schmitt, 2014). A 13-point score change represents a MCID; 23-point score change represents a medium clinical change, and greater than 27-point score change in score means a large clinical change for the PSFS (J. Abbott & J. Schmitt, 2014).

Scapular movement pattern

Scapular movement pattern was assessed using the 'scapular dyskinesis test'. The test consists of visual observation of the scapular positioning and movements during active arm elevation (Struyf et al., 2009). The test was performed during unloaded conditions (Kibler et al., 2002; Struyf et al., 2014) as unloaded testing has higher reliability compared with the resisted testing (Struyf et al., 2009). The scapular dyskinesis test has moderate intra-rater (Kappa coefficient = 0.49 to 0.59) (Kibler et al., 2002) and 'moderate to substantial' inter-rater reliability (Kappa coefficient = 0.49 – 0.64) (Huang, Huang, Wang, Tsai, & Lin, 2015; McClure, Tate, Kareha, Irwin, & Zlupko, 2009). Other tests (e.g. scapular protraction test, and scapular lateral slide test) assess scapular impairment in one direction only in the static position (Nijs, Roussel, Vermeulen, & Souvereyns, 2005; Struyf et al., 2009). The scapular protraction test assesses scapular protraction, and scapular lateral slide test assess scapular upward rotation. Given current evidence and tests available for clinicians to assess scapular movement pattern, the scapular dyskinesis test was deemed the most appropriate one to assess the movement fault of scapula (Struyf et al., 2009).

Participants were asked to remove their shirt or to wear a singlet or sport bra, and perform bilateral arm elevation 3 times at their preferred speed, with their arm in the scapular plane, maintaining an upright posture in standing, and keeping their thumbs upward. Scapular dyskinesis was assessed visually during both raising (concentric) and lowering (eccentric) phases of arm elevation (McClure et al., 2009). The assessor was a physiotherapist, with 8 years of clinical experience in musculoskeletal rehabilitation. During the assessment, the assessor positioned herself behind participants to observe scapular movements. The assessor was not blinded to participants' pain and function scores at baseline and follow-up.

Scapular movement was categorized in four patterns (Huang et al., 2015; Kibler et al., 2002):

- Pattern I: inferior medial angle of scapula or a lower third of medial border of scapula is prominent during dynamic observation, termed scapular tipping;
- Pattern II: medial border of scapula (upper two third medial border) is prominent during dynamic observation, termed scapular winging;
- Pattern III: scapula has early elevation or has excessive upward rotation, termed scapular elevation;
- Pattern IV: normal scapular movement;

Each pattern was scored as normal = 0 (no evidence of alterations), subtle = 1 (mild or questionable evidence of alteration) or obvious = 2 (clearly apparent alteration) (McClure et al., 2009). For the purpose of this study, the first three patterns (scapular tipping, winging and elevation) were combined and summed for creating a final score for classifying scapular dyskinesis. The scapular dyskinesis final score (i.e. sum of the three scores) was considered as continuous data (Carifio & Perla, 2008), showing 0 = normal scapular movement and 6 = the highest scapular dyskinesis.

Time points

Participants were assessed at two time points: at baseline and 8 weeks later. This timeframe was selected based on findings from a previous study (Trudelle-Jackson, 2006) that recommended a minimum of 8 weeks for significant changes in pain scores in patients with shoulder subacromial pain (Trudelle-Jackson, 2006).

Sample size estimation

The sample size was estimated based on simulations models (Schönbrodt & Perugini, 2013). Assuming a true correlation coefficient of 0.4, a corridor of stability on correlation coefficient estimate of 0.2, a statistical power of 0.8, the required minimum sample size was 43 participants (Schönbrodt & Perugini, 2013). This sample size estimation does not take into account repeated measure design, which increases statistical power. Hence, for the purpose of this study, the minimum sample size of 43 participants was conservative, given the repeated measure design adopted by us (Bakdash & Marusich, 2017).

Data processing

We compared scores between baseline and follow-up for each outcome measure (i.e. pain, function and scapular dyskinesis) to assess the magnitude of change between these two time points. When comparing pain or scapular dyskinesis scores, a negative difference between baseline and follow-up indicates improvement in these outcome measures. When comparing function scores between baseline and follow-up, a positive difference indicates improvement in function. Such information was used to determine whether changes in scores were greater than the minimum clinically important difference for each outcome measure.

Statistical analysis

We used R Software (RCore, 2016) and IBM SPSS statistics 25 (IBM Corp. Released 2017, IBM SPSS Statistics for Windows) for conducting our statistical analyses. Descriptive statistics were summarised using mean and standard deviation (SD) or median and range if data did not present a normal distribution at baseline or follow-up. Missing data at random were replaced by multiple imputation. The data is regarded as missing at random if there is no particular reason for missing participants in the follow-up (e.g. participants had severe pain that prevented them from participating) (Enders, 2017). We assessed our data and considered them as missing at random. Alpha was set at 0.05 for all inferential analyses.

Changes in pain, function and scapular dyskinesis scores at follow-up from baseline

Data for the outcome measures (pain, function and scapular dyskinesis) did not present a normal distribution at both time points and, for that reason, the comparisons between baseline and follow-up were implemented using the *yuend* function, through WRS2 package in R software (Mair & Wilcox, 2019). This function performs Yuen's test on trimmed means for dependent samples, is appropriate for comparing paired samples that do not present a normal distribution and is more robust than traditional non-parametric tests (Wilcox, 2012). A detailed description of this method can be found elsewhere (Mair & Wilcox, 2019; Wilcox, 2012). We used robust paired t-test based on 20% trimmed means to compare scores between baseline and follow-up for pain, function and scapular dyskinesis test (Mair & Wilcox, 2019; Wilcox, 2012).

Association between pain or function and scapular dyskinesis scores

We used repeated measures correlation analysis for assessing associations between changes in pain or function with changes in scapular dyskinesis test scores. The repeated measures correlation coefficient (r_{rm}) was calculated using the *rmcorr* function from the *rmcorr* package in R (Bakdash & Marusich, 2017). The Repeated measures correlation analysis assesses the overall intra-individual association between measurements (Bakdash &

Marusich, 2017; Bland & Altman, 1995), and its advantage is to assess the association between variables over time with greater statistical power (Bakdash & Marusich, 2017). The assumptions required for running this test are: linearity, equal variance, and errors must have a normal distribution (Bakdash & Marusich, 2017). We assessed these assumptions for each pair of correlation analysis and the assumptions were met.

We analysed the following repeated measure correlations: (1) changes in 'pain at rest' and scapular dyskinesis test scores; (2) changes in 'pain during movement' and scapular dyskinesis test scores; (3) changes in PSFS scores and scapular dyskinesis test scores. The strength of correlation between variables was interpreted as follows: correlation coefficient of 0.25 or less was considered as low; 0.26 to 0.50 considered as fair; 0.51 to 0.75 considered as good; and greater than 0.76 considered as strong correlation (Portney, 2009).

Results

Demographic characteristics

The demographic and clinical characteristics of 44 participants at baseline are presented in Table 1.

Seven participants (5 women and 2 men) did not complete the follow-up session, reporting that they were unavailable for reasons including being busy (n = 4) or out of town for unexpected reasons (n = 3). Multiple imputation was used to impute the missing values at follow-up time points for these 7 participants. Thirty-seven participants completed follow-up measurements. Of these, 24 participants reported receiving physiotherapy treatment during the 8-week period, while 13 participants received no forms of treatment.

Changes in pain, function and scapular dyskinesis at follow-up from baseline

Changes in pain, function and scapular dyskinesis test over 8 weeks are presented in Table 2. On average, participants presented with no clinical improvements in 'pain at rest', meaningful clinical improvements in 'pain during movement' and large clinical improvement in function. No significant changes were observed in scapular dyskinesis test scores between baseline and follow-up.

Table 1. Baseline demographic and clinical characteristics of participants with subacromial shoulder pain (n=44).

Table 2. Scapular dyskinesis test, pain and function scores at baseline and follow-up and the difference between the two time points (N=44)

Association between pain or function and scapular dyskinesis scores

The correlation coefficients between changes in pain or function scores with scapular dyskinesis test scores are presented in Table 3 and illustrated in Figure 1. The repeated measures correlation coefficient indicates that 16% of the variability of the changes in PSFS can be explained by changes in scapular dyskinesis.

Table 3 Repeated measure correlation with 95% Confidence Interval (CI) between changes in pain or function with scapular dyskinesis test

Figure 1 The scatter plot illustrating repeated measures correlation with scores from baseline and follow-up between: (a) pain at rest and scapular dyskinesis test (sum score); (b) pain during arm movement and scapular dyskinesis test (sum score); (c) patient specific functional scale (PSFS) and scapular dyskinesis test (sum score).

Discussion

We assessed the association between changes in pain or function with changes in scapular dyskinesis test scores over an 8-week period in participants with acute or chronic subacromial shoulder pain. Participants did not present clinical improvement in ‘pain at rest’, presented meaningful/medium improvement in ‘pain during movement’(Hao et al., 2019; Ostelo et al., 2008) and large improvement in function (J. Abbott & J. Schmitt, 2014). On average, scapular dyskinesis scores did not show significant changes, but change in scores ranged from -3 to +3. That range of change in scapular dyskinesis scores allowed us to perform correlation analyses. We found a fair association between PSFS and scapular dyskinesis, demonstrating that improved function was associated with decreases in scapular dyskinesis. We found no association between changes in pain and changes in scapular dyskinesis scores.

Association between changes in pain with scapular dyskinesis scores

The results of this study did not show associations between changes in ‘pain at rest’ or ‘pain during movement’ with change in scapular dyskinesis test. The results of a previous cross-sectional study showed that pain intensity was not associated with having obvious scapular dyskinesis or normal scapular movement pattern in athletic participants with subacromial shoulder pain (Tate et al., 2009). Based on our findings and that previous study (Tate et al., 2009), it seems that pain intensity or changes in pain levels may not be associated with changes in scapular movement pattern.

Findings from previous a laboratory-based study indicated that experimental pain changes scapular rotations (Wassinger, Sole, & Osborne, 2013). In asymptomatic participants, experimentally induced subacromial pain increased scapular upward rotation (Wassinger et al., 2013). In our study, we did not observe an association between changes in pain with changes in scapular dyskinesis. The difference between our study and that by Wassinger et al. (2013) could be due to different study designs. Our participants had shoulder pain for 16 months, while Wassinger et al. (2013) used experimental induced pain in asymptomatic individuals. Future studies could assess the association between changes in pain with changes in scapular dyskinesis in patients with subacromial shoulder pain and stratify the analysis based on acute or chronic pain.

Association between changes in function with scapular dyskinesis scores

There was a fair association between changes in PSFS and changes in scapular dyskinesis scores. This suggests improvement in function was associated with improvement in scapular dyskinesis. Different results were reported by previous studies using a cross-sectional design. One study reported that patients with (subtle or obvious) scapular dyskinesis had higher functional ability compared with patients with normal scapular movement (Harris et al., 2012). Lopes et al. (2015) found that patients with obvious scapular dyskinesis had significantly greater functional limitations compared with those with normal scapular movements. Christiansen et al. (2017) found that the magnitude of function scores at baseline and the magnitude of change in function were similar for patients with obvious scapular dyskinesis and those with normal scapular movement pattern. It is possible that scapular dyskinesis is an adaptive process and does not, necessarily, imply a maladaptive response to mechanical stimuli. These divergent findings indicate that scapular dyskinesis may be one of multiple factors influencing functional recovery. Other factors might influence pain and function levels. For example, in participants with atraumatic symptomatic rotator cuff tears, factors such as gender (being female) and higher education level are correlated with high disability levels, while being male and having atrophy of supraspinatus and infraspinatus are correlated with low disability levels (Harris et al., 2012). The effect of scapular dyskinesis on function needs to be further explored.

Clinical implications

Our findings indicate that scapular movement pattern and shoulder function co-vary over time. In patients with subacromial shoulder pain, 16% of functional improvement, as measured by changes of the PSFS, is explained by improvement in scapular dyskinesis. Findings from previous systematic reviews indicate that scapular focused strengthening exercises may help to improve function in patients with subacromial shoulder pain (Bury et al., 2016; Reijneveld et al., 2017; Saito et al., 2018), however, the strength of evidence is very low due to limitations of included trials. To confirm the causal effect of scapular dyskinesis on shoulder function and pain, future well-designed clinical trials with low risk of bias are required to assess the efficacy of interventions designed to improve scapular dyskinesis on function in patients with subacromial shoulder pain.

Limitations

We did not control for potential confounding factors (e.g. symptom duration, age, physical demands and pain catastrophizing, form of intervention) (Braun, Hanchard, Handoll, & Betthauser, 2018) that may influence both exposure (scapular dyskinesis) and outcomes (pain or function). Hence, the association between scapular dyskinesis scores and shoulder function could be spurious.

There is a risk of observer bias for scoring the scapular dyskinesis test as the assessment was undertaken by only one examiner who was not blinded to the magnitude of pain and function. As demonstrated by a study, non-blinded examiners tend to allocate higher scapular dyskinesis scores when compared with blinded examiner (Plummer et al., 2017). Additionally, when using this test, it was difficult to differentiate between 'subtle' dyskinesis and 'normal' scapular movement. This test was shown to have high concurrent validity (by comparing kinematic measures obtained from electromagnetic motion tracking system) if patients present with 'obvious' scapular dyskinesis in one or more scapular patterns compared with normal scapular movements (Lopes et al., 2015; Tate et al., 2009). In our study, only 14 out of 44 participants were identified with 'obvious' scapular dyskinesis in one or two scapular patterns at baseline. This may have increased the chance of measurement error. On the other hand, using this test increases the external validity of our findings as that test can be used by musculoskeletal physiotherapists in clinical practice. To address this limitation, future studies could measure scapular movement using motion analysis or inertial sensors (Lempereur, Brochard, Leboeuf, & Remy-Neris, 2014).

Conclusion

Based on our findings, we conclude that improvements in function are associated with improvements in scapular dyskinesis scores. We did not find associations between changes in 'pain at rest' or 'pain during movement' with changes in scapular dyskinesis scores. Further studies are required to improve our understanding for the role of scapular dyskinesis on shoulder pain and function in patients with subacromial shoulder pain.

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Table 1 Baseline demographic and clinical characteristics of participants with subacromial shoulder pain (n=44)

	Mean (SD)	Range
Age (years)	44.7 (10.4)	23 to 64
Weight (kg)	79.1 (14.0)	46.8 to 105.7
Height (cm)	171.2 (9.9)	153 to 196
BMI (kg/m^2)	26.9 (4.2)	18.5 to 38.1
Female sex N (%)	25 (57%)	
Shoulder pain duration (months) (median, min to max)	16	0.5 to 384
Acute and subacute shoulder pain (<3 months), N (%)	6 (14%)	
Chronic shoulder pain (>3 months), N(%)	38(86%)	
Hand dominance right side N (%)	Right side: 38 (86%)	
Affected side N (%)	Right side: 27 (61%) Left side: 17 (39%)	
Previous history of shoulder pain N (%)	10 (22%)	
Previous treatment of the shoulder	11 (25%)	
Obvious scapular dyskinesis, N (%)	14 (32%)	
Subtle scapular dyskinesis, N (%)	25 (57%)	
Normal scapular dyskinesis, N (%)	5 (11%)	

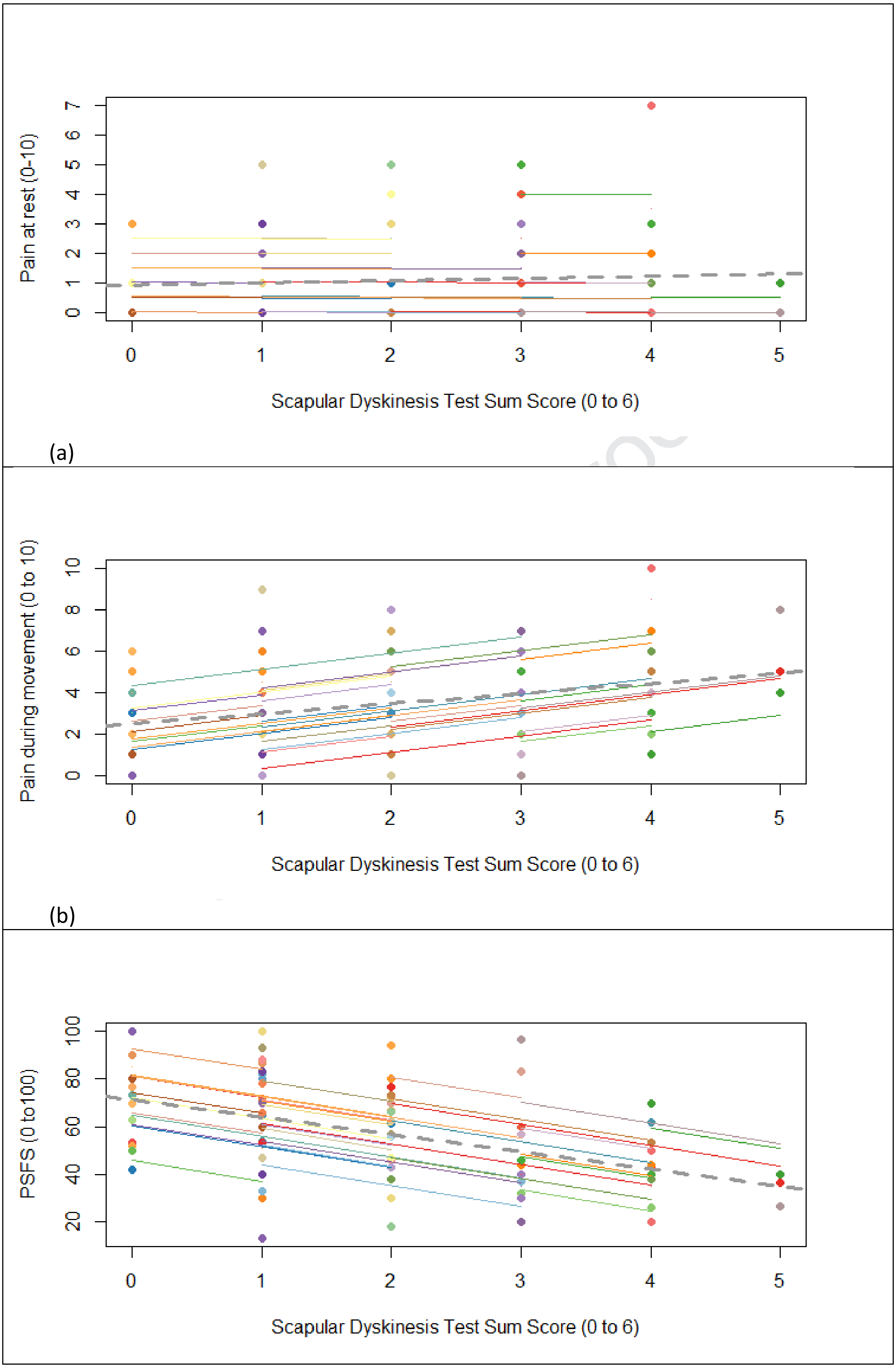
Table 2 Scapular dyskinesis test, pain and function scores at baseline and follow-up and the difference between the two time points

	Baseline (N=44)	Follow-up (N=44)	Mean difference (95% confidence interval)	p-value
NPRS at rest#	1.0 (0.0 to 7.0) #	0.0 (0.0 to 5.0) #	-1.0 (-1.7 to -0.3)	0.004*
NPRS during movement #	5.0 (1.0 to 10.0) #	1.0 (0.0 to 7.0) #	-3.0 (-4.3 to -2.3)	0.000*
PSFS§	44.9 (17.9) §	70.3 (19.1) §	28.0 (20.6 to 35.4)	0.000*
Scapular dyskinesis test#	2.0 (0.0 to 5.0) #	1.0 (0.0 to 4.0) #	-0.4 (-0.9 to 1.0)	0.141

#: median and minimum and maximal values reported. §: mean and standard deviation reported. NPRS: Numeric Pain Rating Scale. PSFS: Patient Specific Functional Scale. * = statistically significant. Negative differences indicates improvement in pain or in scapular dyskinesis. Positive differences in PSFS scores suggest improvement in function. Data in the follow-up are imputed.

Table 3 Repeated measures correlation coefficient (r_{rm}) with 95% Confidence Interval (CI) between changes in pain or disability with scapular dyskinesis test

Changes in score	Scapular dyskinesis test (scoring 0-6)	p-value
NPRS at rest (scoring 0-10)	-0.1 (95% CI: -0.2 to 0.2)	0.927
NPRS during movement (scoring 0-10)	0.28 (95% CI: 0.0 to 0.5)	0.060
PSFS (scoring 0-100)	-0.4 (95% CI: -0.6 to -0.1)	0.010


Pain at rest (0-10)
Scapular Dyskinesis Test Sum Score (0 to 6)
(a)
Pain during movement (0 to 10)
Scapular Dyskinesis Test Sum Score (0 to 6)
(b)
PSFS (0 to100)
Scapular Dyskinesis Test Sum Score (0 to 6)

(c)

Figure 1. The scatter plot illustrating repeated measures correlation with scores from baseline and follow-up between: (a) pain at rest and scapular dyskinesis test (sum score); (b) pain during arm movement and scapular dyskinesis test (sum score); (c) patient specific functional scale (PSFS) and scapular dyskinesis test (sum score).

Highlights

- Improvements in function were positively associated with scapular dyskinesis
- We found no association between changes in pain and scapular dyskinesis
- The role of scapular dyskinesis as a cause or consequence of pain is unclear