Comparison of three types of exercise in the treatment of rotator cuff tendinopathy/shoulder impingement syndrome: A randomized controlled trial

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Abstract

Objectives To assess the efficacy of three different exercise programmes in treating rotator cuff tendinopathy/shoulder impingement syndrome.
Design Parallel group randomised clinical trial.
Setting Two out-patient NHS physiotherapy departments in Manchester, United Kingdom.
Participants 120 patients with shoulder pain of at least three months duration. Pain was reproduced on stressing the rotator cuff and participants had full passive range of movement at the shoulder.
Interventions Three dynamic rotator cuff loading programmes; open chain resisted band exercises (OC) closed chain exercises (CC) and minimally loaded range of movement exercises (ROM).
Main outcomes Change in Shoulder Pain and Disability Index (SPADI) score and the proportion of patients making a Minimally Clinically Important Change (MCIC) in symptoms 6 weeks after commencing treatment.
Results All three programmes resulted in significant decreases in SPADI score, however there were no significant differences between the groups. Participants making a MCIC in symptoms were similar across all groups, however more patients deteriorated in the ROM group. Dropout rate was higher in the CC group, but when only patients completing treatment were considered more patients in the CC group made a meaningful reduction in pain and disability.
Conclusions Open chain, closed chain and range of movement exercises all seem to be effective in bringing about short term changes in pain and disability in patients with rotator cuff tendinopathy.
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Keywords: Shoulder pain; Rotator cuff tendinopathy; Shoulder impingement syndrome; Exercise; Physiotherapy

Introduction

Shoulder pain is a common causes of primary care consultation [1], affecting 16 to 21% of the general population [2,3] and frequently persisting for many years [4]. One of the most common causes of shoulder pain is rotator cuff (RC) tendinopathy/shoulder impingement syndrome (SIS) [5] The pathoetiology is not fully understood, but thought to arise from acute and chronic changes in tendon structure and surrounding bursa [5]. Pain caused by RC tendinopathy/SIS can cause functional impairment and incur significant societal costs, estimated to be £310 m per annum in the United Kingdom [6]. Consequently, patients are frequently referred to physiotherapy to improve their symptoms. Previous studies have demonstrated that exercise shows promising results in
treating RC tendinopathy/SIS [6], with progressive loading programmes of the RC suggested to be a key component of treatment [6]. However different authors have advocated different loading strategies [7,8] and it is unclear which approach is superior. Therefore, the aim of this study was to compare the efficacy of three different progressive loading programmes in treating patients with RC tendinopathy/SIS. We hypothesised that all loading strategies would result in improvements in symptoms.

**Methods**

**Trial design**

A parallel group randomised comparison trial comparing three exercise interventions with a 1:1:1 ratio.

**Participants**

Participants were eligible for inclusion if they met the following criteria (i) shoulder pain for at least three months; (ii) no passive limitation of range of movement suggestive of adhesive capsulitis; (iii) pain on isometric rotator cuff testing; (iv) pain on Hawkins–Kennedy or empty can tests; (v) able to read and write English.

Participants were excluded according to the following criteria; (i) symptoms of cervical radiculopathy; (ii) diagnosed inflammatory disorder; (iii) neurological disorder; (iv) widespread pain condition; (v) evidence of complete rotator cuff tear (positive drop arm test or Oxford scale grade II or less strength of the rotator cuff); (vi) previous surgery to the affected shoulder. As part of ethical approval, participants were free to drop out of the study at any point without providing a reason.

**Study settings**

Patients were recruited from two out-patient physiotherapy departments in Manchester, UK between November 2005 and November 2009. Patients were referred from both primary care and secondary care. All patients with shoulder pain were sent an invitation letter and those providing written informed consent completed a pretreatment questionnaire. Participants underwent a standardised assessment and those meeting the inclusion criteria were randomised via computer-generated random number tables. Randomisation details were transposed to cards, which were sealed in opaque envelopes and opened at the time of randomisation. The interventions were delivered by eight physiotherapists, who were qualified for between 5 and 16 years. The therapists each delivered all three interventions. Patients not wishing to participate received physiotherapy as usual.

**Blinding**

It was not possible to blind participants and physiotherapists, due to the nature of the interventions. However, it was made clear in the patient information sheet that exercise had been shown to be effective for treating this condition, however it was unknown whether one type of exercise was better than another. No indication was given which suggested that any of the interventions was potentially superior and it was made clear that all three loading strategies were used for treating this condition. The authors were blinded to treatment allocation when data were analysed.

**Study interventions**

A literature search was performed to identify studies utilising different exercise modalities in the treatment of RC tendinopathy/SIS. All relevant articles were identified and reviewed by a panel of five experienced physiotherapists. The panel met to discuss these studies and develop the interventions based around best evidence. Generally, previous studies employed dynamic loading strategies for the RC. However, there was no clear consensus as to the optimal method of loading. Therefore three groups were decided upon; minimally-loaded range of movement exercises, open chain loading and closed chain loading exercises (see below). Participants completed three sets of 10 repetitions, twice per day. Participants were advised that they could exercise into pain, but not to the extent where increased pain resulted in a significant reduction in function or to the extent that pain was significantly worse for more than 1 hour afterwards.

In addition, all participants were taught stretching exercises for the anterior and posterior shoulder capsule [8]. These exercises were included as they were part of the protocol previously shown to be efficacious in treating shoulder pain. However, as all participants completed these exercises, the unique treatment in each group was the different loading strategy. Participants were instructed to hold each stretch for 5 seconds and perform five repetitions, twice per day. Participants attended three appointments over 6 weeks, with the exercises progressed in difficulty at each appointment. This treatment schedule was selected as it reflected usual practice in the treating departments at the time of the study. Diagrams were provided to all patients demonstrating the exercise techniques (web Appendix A in Supplementary material).

**Open chain resisted exercises (OC)**

Participants performed lateral rotation, medial rotation and abduction to approximately 30° using rubber resistance bands. The length of each band was adjusted for each patient so that the band was taught, but not stretched at the starting point of each exercise. The resistance of the band was set by the treating physiotherapist so that the participant reported that the exercise was challenging without being excessively painful and they were able to complete 10 repetitions before
needing to rest. Most participants initially started using red band and were progressed to green or black as soon as they were able to complete three sets of 10 with this band. Exercises were also progressed by increasing the magnitude of abduction to 90° [7–10].

Closed chain exercises (CC)

Participants performed exercises to activate the rotator cuff as a group [7,9], namely a double-arm wall press up, a press up in four point kneeling and an exercise whereby the participant adopted a seated position and pressed their hands into the chair, as if trying to lift their body. The exercises were progressed so that the first two exercises were performed using only the symptomatic arm and participants aimed to lift their body clear of the chair with the third exercise.

Range of movement exercises (ROM)

Participants performed range of movement exercises, initially with no resistance and then using only gravity to provide resistance. They were initially taught passive shoulder abduction using a stick, lateral rotation with the arm by the side and medial rotation using the other arm to assist in sliding their arm up their back. Exercises were progressed so participants performed active abduction to 90° and performed lateral and medial rotation exercises in 90° of abduction.

Measures

The primary outcome was change in Shoulder Pain and Disability Index (SPADI) score. The SPADI is a 13 item self-reported questionnaire assessing pain and functional status. Each item is measured on a 0 to 10 scale and a 0 to 100 score calculated. Higher scores represent greater levels of pain and disability. The SPADI has been shown to have good test-retest reliability [11,12] and be sensitive to change [13]. The minimal clinically important change in SPADI is considered to be a 10 point reduction [12,14]. Participants also completed an exercise diary reporting how frequently they performed the exercises.

Sample size calculation

For one regime to be considered superior, it would be necessary to demonstrate a clinically meaningfully larger (i.e. 10 points) decreases in SPADI score. Previous physiotherapy-based studies have reported SD in SPADI score of between 9.65 [15] and 20.90 [16], therefore a conservative figure of 15 was used. Therefore, to provide a power level of 80% and statistical significance of 0.10, 36 participants per group were required.

Follow up

Participants completed a questionnaire 6 weeks after commencing treatment re-assessing SPADI score. If participants did not return the questionnaire further questionnaires were posted out. If participants still did not return the questionnaire they were contacted by telephone.

Statistical analyses

Preliminary examination of the data

Levene and Shapiro–Wilk tests were performed to assess whether SPADI change scores met assumptions of parametric data. Intention-to-treat principles were employed and where data were missing baseline values were carried forward. Within group pre to post-treatment mean total SPADI change scores were calculated using Wilcoxon signed-rank tests and effect sizes were calculated for each group.

Primary analysis

SPADI change scores did not meet the assumptions of parametric data, therefore non-parametric analyses were performed. Between group mean total SPADI change scores were analysed using the Kruskal–Wallis test.

Secondary analyses

Minimal clinically important change (MCIC) analyses

In addition to group level analysis, data were analysed for individual patients to assess whether they had made a MCIC in SPADI score. Participants whose SPADI score decreased by 10 points or more were classified as clinically significantly improved, whereas those whose SPADI score increased by 10 points or more were classified as clinically deteriorated. In addition, Drop-out rates (i.e. participants who did not provide follow up data) were compared between groups and MCICs were re-analysed including only participants providing follow up data.

Table 1

<table>
<thead>
<tr>
<th>Table showing demographic information for each treatment group.</th>
<th>ROM group</th>
<th>OC group</th>
<th>CC group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>49.5</td>
<td>50.4</td>
<td>49.8</td>
</tr>
<tr>
<td>Sex (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>25 (63%)</td>
<td>24 (60%)</td>
<td>22 (55%)</td>
</tr>
<tr>
<td>Female</td>
<td>15 (38%)</td>
<td>16 (40%)</td>
<td>18 (45%)</td>
</tr>
<tr>
<td>Not working due to shoulder pain</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Completed treatment (%)</td>
<td>31 (77%)</td>
<td>30 (75%)</td>
<td>21 (52%)</td>
</tr>
<tr>
<td>Pain duration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 months to 1 year</td>
<td>23 (58%)</td>
<td>29 (73%)</td>
<td>26 (65%)</td>
</tr>
<tr>
<td>Longer than 1 year</td>
<td>17 (43%)</td>
<td>11 (28%)</td>
<td>14 (35%)</td>
</tr>
<tr>
<td>Baseline SPADI score</td>
<td>51</td>
<td>49</td>
<td>53</td>
</tr>
</tbody>
</table>
Table 2
Mean pre–post-treatment changes and effect sizes for each treatment group.

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Pretreatment SPADI score</th>
<th>Post-treatment SPADI score</th>
<th>Mean change in SPADI score</th>
<th>Wilcoxon signed rank test significance</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of movement (n = 40)</td>
<td>51</td>
<td>42</td>
<td>9</td>
<td>0.0002</td>
<td>0.49</td>
</tr>
<tr>
<td>Open chain (n = 40)</td>
<td>49</td>
<td>37</td>
<td>12</td>
<td>0.0001</td>
<td>0.56</td>
</tr>
<tr>
<td>Closed chain (n = 40)</td>
<td>53</td>
<td>44</td>
<td>9</td>
<td>0.0002</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Table 3
Kruskal–Wallis test assessing between group differences in change in SPADI score.

<table>
<thead>
<tr>
<th>Group</th>
<th>Median pretreatment SPADI (IQR)</th>
<th>Median post-treatment SPADI (IQR)</th>
<th>Median change in SPADI (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROM (n = 40)</td>
<td>54 (35 to 66)</td>
<td>39 (24 to 56)</td>
<td>−4.0 (−5 to −17)</td>
</tr>
<tr>
<td>Open chain (n = 40)</td>
<td>48 (30 to 70)</td>
<td>34 (19 to 53)</td>
<td>−3.5 (−5 to 12)</td>
</tr>
<tr>
<td>Closed chain (n = 40)</td>
<td>54 (36 to 68)</td>
<td>49 (23 to 59)</td>
<td>−0.5 (−3 to 15)</td>
</tr>
</tbody>
</table>

Significant between-group difference in median change scores (p < 0.05).

Table 4
The proportion of participants making a Minimally Clinically Important Change (MCIC) in total SPADI score following treatment.

<table>
<thead>
<tr>
<th>Group</th>
<th>Open chain</th>
<th>Closed chain</th>
<th>Range of movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants making a MCIC improvement</td>
<td>17/40 (43%)</td>
<td>16/40 (40%)</td>
<td>16/40 (40%)</td>
</tr>
<tr>
<td>Number of participants making a MCIC deterioration</td>
<td>0/40 (0%)</td>
<td>0/40 (0%)</td>
<td>4/40 (10%)</td>
</tr>
<tr>
<td>Number of participants dropping out</td>
<td>10/40 (25%)</td>
<td>19/40 (48%)</td>
<td>9/40 (23%)</td>
</tr>
<tr>
<td>Number of participants making a MCIC improvement when only participants completing treatment are considered</td>
<td>17/30 (57%)</td>
<td>16/21 (76%)</td>
<td>16/31 (52%)</td>
</tr>
</tbody>
</table>

Table 5
Participants’ self-reported frequency of completion of the exercise regime.

<table>
<thead>
<tr>
<th>Percentage of prescribed exercises completed</th>
<th>Range of movement</th>
<th>Open chain</th>
<th>Closed chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>76 to 100%</td>
<td>12 (86%)</td>
<td>10 (83%)</td>
<td>11 (85%)</td>
</tr>
<tr>
<td>51 to 75%</td>
<td>2 (14%)</td>
<td>2 (17%)</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>26 to 50%</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>&lt;25%</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

Results

120 participants were recruited to the study (see Fig. 1 of Supplementary material for Consort diagram). There were no significant differences in baseline demographic factors (Table 1).

Preliminary analysis of the data

All three groups showed statistical significant reductions in SPADI score at six week follow up (Table 2).

Primary analysis

There were no statistically significant differences between the groups on the Kruskal–Wallis test (Table 3).

Drop outs

Significantly more participants failed to complete the intervention and did not provide follow up data in CC group (n = 19; 48%) than the OC (n = 10, 25%) or ROM (n = 9; 23%) groups.

MCIC analysis

There were no differences in the proportion of patients making a clinically important improvement in SPADI score at follow up. However, 10% of patients in the ROM group reported a clinically meaningful deterioration in symptoms, compared to zero in the OC and CC groups. When only participants who provided follow up data were considered, the proportion making a clinically meaningful improvement rose to 76% for the CC group, 57% for OC and 52% for ROM (Table 4).

Exercise compliance

Exercise diaries were completed by 14 participants in the ROM group, 12 in the OC and 13 in the CC. Table 5 shows frequency of exercise completion amongst participants. Although participant reported compliance with the exercise programme was generally good, qualitative feedback from clinicians was that some patients were unable to reproduce their exercises independently, despite reporting compliance upwards of 75%.

Discussion

The aim of this study was to establish which type of RC loading programme was most effective in patients with RC
tendinopathy/SIS. The primary analysis demonstrated that all three groups showed improvement in shoulder pain and disability but no approach resulted in superior outcomes. This may suggest that the specific exercise is not important, so long as the RC is dynamically loaded.

It should be noted however that the drop-out rate was higher than anticipated, meaning that the analyses lacked power to make definitive conclusions. That said, examination of the SPADI change scores revealed that none of the programmes came close to approaching an improvement of 10 points more than the other groups. Moreover, participants who did not provide follow up data were still included in the analyses, albeit assuming no changes had occurred in their symptoms. Although further research is required to conclusively confirm these findings, the current results do not provide any suggestion that one exercise approach may be superior to another in treating RC tendinopathy.

It has previously been suggested that the improvements in tendinopathy symptoms following exercise could be attributed to structural changes within the tendon [17]. However, a recent review suggested that only heavy slow resistance training demonstrated a clear relationship between changes in tendon structure and improvement in symptoms [18]. For other types of exercise, either inconsistent or negative findings were observed. Given that slow heavy resistance training was not utilised in this study, it is unclear whether improvements can be attributed to tendon restructuring. Other mechanisms have been suggested to account for improvements in tendinopathy, such as biochemical changes, or reductions in sensitivity of the central and peripheral nervous system [18].

That symptoms can improve without tendon structure changes may account for why all three programmes used in this study proved to be beneficial. Feasibly, repeated activation of the RC may have reduced peripheral and/or central neurological sensitivity, or resulted in reductions in biochemical nociception. It is also possible that changes in psychosocial factors may have contributed to the improvements observed. Re-assurance from the treating clinician and gradual exposure to increasing use of the shoulder may have reduced psychological risk factors, which have been shown to be related to pain and disability in other musculoskeletal conditions [19]. However, the mechanisms underpinning the beneficial effects of exercise in tendinopathy are currently poorly understood and further research is warranted.

Given the lack of group-level differences in the primary analysis, it is worth noting that some interesting differences emerged in the secondary analyses. Firstly, significantly more participants dropped out from the CC intervention. This may suggest that some exercise regimes are less acceptable to patients than others. Interestingly, although dropout rate was higher in the CC group, participants who continued with the programme were more likely to make a MCIC in pain and disability (76% vs 52% and 57%). This may merely be reflective of the greater dropout rate in the CC group meaning fewer participants provided data showing a lack of clinical improvement. However, it is also possible that CC exercises do confer some additional benefit if participants are able to persist with them, but patients are also more likely to dis-engage from treatment.

A possible explanation for the greater drop-out rate in the CC group may be the influence of patients’ expectations and exercise preferences. Several of the clinicians involved in the study reported that participants felt that the CC exercises were not “specific” enough for their problem. It is feasible that this led to some patients dis-engaging from treatment, whereas those who persisted obtained further benefit. It should also be noted that in the participating departments, usual practice prior to the study was to treat RC tendinopathy predominantly with OC exercises and it is possible that therapists’ preferences may have influenced outcome. If the clinicians held a strong preference for one type of exercise, they may have been less enthusiastic or confident in their explanations as to why other exercises would be beneficial. This may have affected patients’ adherence to the exercises.

Although data were collected regarding exercise compliance, insufficient participants completed the diaries to enable meaningful analysis. Moreover, most participants reported excellent compliance with the exercises, however anecdotal reports from clinicians suggested that this was not always an accurate reflection of a participant’s compliance. It is possible that patients reported excellent compliance in an effort to please their clinician whilst in reality performing the exercises less often. It is therefore difficult to analyse the role that exercise compliance played in this study.

An interesting area for future study would be to employ qualitative methods to assess patients’ opinions as to why they persisted or discontinued certain exercise programmes. This will help to clarify which factors maximise patients’ compliance with exercise and may therefore aid clinicians in prescribing exercise programmes that are most acceptable to patients and therefore most efficacious.

A second interesting finding to emerge from the secondary analyses was that all participants who deteriorated by a clinically meaningful amount were in the ROM group. It is unlikely that this is due to excessive loading of the RC, as the ROM group was likely to have placed the least demand on the shoulder, as no external resistance was added. Conversely, it is possible that greater loading intensities may be more effective in increasing the likelihood of a positive response to exercise, as shown in other musculoskeletal conditions [20].

It should be noted that only four participants reported a clinical deterioration and therefore strong conclusions cannot be drawn based on such low numbers. Nevertheless, given that ROM exercises were no better at reducing pain and disability, but were more likely to result in clinical deterioration, it would seem prudent to prescribe either OC or CC exercises in preference to ROM exercises. Furthermore, a combination of both types of exercises may be most effective, as it may draw on the positive aspects of both forms of exercise. Alternatively, it is plausible that a key component in successful rehabilitation of RC tendinopathy is patient compliance.
Given that the current study did not conclusively demonstrate superiority of one type of exercise, patient’s exercise preference should be sought when prescribing exercises. Moreover, if one exercise modality is excessively exacerbating symptoms, a useful strategy may be to switch to an alternative loading programme.

Comparison to previous studies

The current study supports previous work demonstrating that loading exercises can bring about positive short and longer term changes in patients with RC tendinopathy/SIS [8–10,21]. Unfortunately, these studies have employed different outcome measures, precluding direct comparison of the efficacy of the interventions employed in these studies.

Limitations

The current study has some limitations which are worthy of note. Firstly, there was a high dropout rate amongst participants, particularly in the CC group. It is possible that participants who discontinued treatment did so because of worsening symptoms, which may mean that the current study over-estimated the efficacy of the studied interventions. Conversely, given that missing data were entered assuming no change, it is possible that the current study underestimated the true effect of each exercise programme. When the analyses were performed utilising only participants providing data, there were still no significant differences between the groups, but the changes in SPADI score were much higher (OC = 15, CC = 16, ROM = 12; data not presented). That said, future studies should employ alternative methods of post-treatment data collection, such as online questionnaires or telephone follow up to maximise data collection.

Secondly, data were only collected for 6 weeks after commencing treatment. It is possible that some participants continued to exercise and improve beyond this timeframe, which may have led to greater improvements if longer follow up was performed. Furthermore, the short follow up period means that the long term efficacy of the exercise regimes is unclear from this study.

Thirdly, all groups performed stretching exercises and the study did not include a no-treatment or stretching only group. As no significant differences emerged between groups, it is possible that the effective component of treatment was the stretching exercises. Whilst some studies of other tendinopathies report stretching exercises as effective as loading exercises [22,23], others have reported inferior outcomes when stretching alone has been utilised [20]. However, given that at the time of the initiation of the study there were few studies exploring the role of exercise in RC tendinopathy/SIS and that studies which had demonstrated the efficacy of exercise had included these stretches in their programmes, the authors felt it important to offer treatment based around best available evidence.

Conclusions

Monitored home exercise programmes appear to be an effective short-term treatment for RC tendinopathy/SIS, however the content of the exercise programme does not appear to affect group-level outcome. That said, participants treated with CC exercises were more likely to obtain a MCIC if they persisted with the exercises, however were also more likely to dis-engage from treatment. It is plausible that a mixture of open and closed chain exercises, taking into account participants’ preferences and response to exercise may be the most effective treatment regime.

Ethical approval: Ethical approval was provided by the North Manchester Local Research Ethics Committee, REC Ref. No. 05/Q1406/90.

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Conflict of interest: The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.physio.2016.09.001.

References


