Does adding heavy load eccentric training to rehabilitation of patients with unilateral subacromial impingement result in better outcome? A randomized, clinical trial

Annelies G. Maenhout · Nele N. Mahieu · Martine De Muynck · Lieven F. De Wilde · Ann M. Cools

Abstract

Purpose To investigate superior value of adding heavy load eccentric training to conservative treatment in patients with subacromial impingement.

Methods Sixty-one patients with subacromial impingement were included and randomly allocated to the traditional rotator cuff training (TT) group \((n = 30, \text{ mean age } = 39.4 \pm 13.1 \text{ years})\) or traditional rotator training combined with heavy load eccentric training (TT + ET) group \((n = 31, \text{ mean age } = 40.2 \pm 12.9 \text{ years})\). Isometric strength was measured to abduction at 0°, 45° and 90° of scapular abduction and to internal and external rotation. The SPADI questionnaire was used to measure shoulder pain and function. Patients rated subjective perception of improvement. Outcome was assessed at baseline, at 6 and 12 weeks after start of the intervention. Both groups received 9 physiotherapy treatments over 12 weeks. At home, the TT group performed traditional rotator cuff strengthening exercises 1x/day. The TT + ET group performed the same exercises 1x/day and a heavy load eccentric exercise 2x/day.

Results After treatment, isometric strength had significantly increased in all directions, and SPADI score had significantly decreased. The TT + ET group showed a 15% higher gain in abduction strength at 90° of scapular abduction. Chi-square tests showed patients’ self-rated perception of improvement was similar in both groups.

Conclusion Adding heavy load eccentric training resulted in a higher gain in isometric strength at 90° of scapular abduction, but was not superior for decreasing pain and improving shoulder function. This study showed that the combination of a limited amount of physiotherapy sessions combined with a daily home exercise programme is highly effective in patients with impingement.

Level of evidence II.

Keywords Shoulder impingement syndrome · Physiotherapy · Eccentric training · Tendon

Introduction

In current clinical practice, shoulder patients make up a large part of total patient population [6]. Disorders of the rotator cuff are the most common cause of shoulder pain [37]. When Neer introduced the term “subacromial impingement” in 1972, this referred to mechanical abrasion of the subacromial structures against the anterior undersurface of the acromion and coracoacromial ligament [26]. The supraspinatus tendon is usually the most affected structure due to its position in the subacromial space. Histological examinations of the supraspinatus tendon in patients with impingement syndrome have shown degenerative changes, similar to the changes found in Achilles and patellar tendinosis [16].

The presence of tendon degeneration in patients with impingement could have important implications for treatment. Possibly physiotherapy should not only focus on...
decreasing impingement, but should additionally address this tendon degeneration. In patella and Achilles tendinopathy, eccentric training has shown to not only decrease pain and improve function but also repair tendon tissue [18, 24, 28]. The Achilles tendon was shown to respond to eccentric training load with an increased collagen production [18]. As to rotator cuff tendinopathy, three studies have been executed and have shown promising clinical results [4, 7, 14]. Jonsson et al. [14] investigated the effect of an eccentric empty can (thumb down) abduction exercise for the supraspinatus without additional treatment in 9 patients with impingement. Five patients were satisfied with treatment and showed less pain and better function after 12 weeks of training. Bernhardsson et al. [4] investigated the effect of eccentric rotator cuff training in 10 subjects with subacromial impingement and showed decreased pain in 8 of 10 subjects and better function in all subjects after 12 weeks. Due to small sample size and the lack of a control group in both studies, conclusions cannot be drawn. Recently, Camargo et al. [7] showed good results with an isokinetic eccentric training programme in a larger group of patients with impingement (n = 20). Still it remains unclear whether eccentric training would substantially augment results of traditional conservative treatment.

The aim of this study was to examine superior value of adding heavy load eccentric training to conservative rehabilitation with respect to increasing strength and decreasing pain and dysfunction. The hypothesis was first, that both groups would have increased strength and decreased pain and dysfunction after rehabilitation and second, that adding eccentric training would lead to superior results.

Materials and methods

Prior to the intervention, baseline outcome measurements were performed. Subsequently, patients were randomly allocated to the traditional rotator cuff strength training (TT) group or the TT combined with heavy load eccentric training (TT + ET) group. All exercises were performed at home for 12 weeks. Both groups attended one physiotherapy session (30’) a week during the first period of 6 weeks and one every 2 weeks during the last period of 6 weeks (9 sessions in total). Outcome variables were reassessed at 6 and at 12 weeks after the start of the intervention.

Setting and participants

Sample size was estimated based on variability of pilot data. Isometric strength to abduction at 90° of scapular abduction was chosen to calculate sample size as this test is used for manual muscle testing of the supraspinatus. To detect a difference between groups of 10 % with a probability level of α = 0.05 and a statistical power of P = 0.80, 27 subjects were required in each group. A difference in isometric strength of 10 % or more was previously reported to be clinically significant [36]. All subjects were recruited by a specialized shoulder surgeon based on a thorough history and physical examination. The surgeon referred for technical investigation when there was doubt upon the diagnosis. The inclusion criteria were: aged over 18 years, unilateral pain for at least 3 months in the anterolateral region of the shoulder, painful arc, 2 out of 3 impingement tests positive (Hawkins [10], Jobe [13] and/or Neer [25]), 2 out of 4 resistance tests painful (full can (thumb up) abduction at 90°, resisted abduction at 0°, resisted external or internal rotation with the arm adducted) and pain with palpation of the supraspinatus and/or infraspinatus tendon insertion [8]. The exclusion criteria were as follows: demonstration of partial or full ruptures of the rotator cuff by technical investigation (either ultrasound or MRI), history of shoulder surgery, shoulder fracture or dislocation, traumatic onset of the pain, osteoarthritis, frozen shoulder, traumatic glenohumeral instability or shoulder nerve injuries. Patients with concomitant disorders, such as cervical pathology or systemic musculoskeletal disease, were also excluded from the study. No physical therapy nor corticosteroid injections could have been received within 2 months prior to the study.

The Committee on Ethics of Ghent University approved the study, and informed consent was obtained from each subject.

Intervention

The TT group performed two traditional rotator cuff strengthening exercises at home: internal and external rotation resisted with an elastic band (Thera-Band, The Hygienic Corporation, Akron, OH, USA) [Fig. 2 (“Appendix”)]. Each exercise was performed once a day for 3 sets of 10 repetitions. Patients were instructed to perform the exercises at a speed of 6”/repetition (2” concentric phase, 2” isometric phase and 2” eccentric phase). Colour of the band was chosen so that the patient did not experience significantly more pain during the exercise than at rest. Load was increased by changing colour of the elastic band as soon as pain decreased.

The TT + ET group performed the same exercises as the TT group and in addition to that a heavy load eccentric exercise. The eccentric phase of full can (thumb up) abduction in the scapular plane was performed with a dumbbell weight [Fig. 3 (“Appendix”)]. Patients were instructed to perform the eccentric phase at a speed of
5°/repetition. Three sets of 15 repetitions were performed twice a day [1]. Starting position of the eccentric phase at full scapular abduction had to be pain free, and, if not, patients were advised to stretch out the arm at a slightly lower degree of scapular abduction. Dosing the eccentric exercises was based on the pain monitoring model [34, 35]. Three conditions had to be met:

1. During the last set of 15 repetitions, the patient should feel pain exceeding the pain at rest, but no more than a score of 5 on the VAS (0–10) is allowed.
2. Pain after the exercise should not exceed 5 on the VAS and should have subsided the following morning.
3. Pain should not increase from day to day.

Whenever the pain was no longer present during the last set of repetitions, dumbbell weight was increased with 0.5 kg.

All patients completed a daily log book to record pain during the exercises and adverse events.

Physiotherapy treatment sessions were firstly aimed at correcting some important factors that could contribute to subacromial impingement and prohibit good performance of the home exercises. Composition of this treatment was based on previous reviews [17, 32]. A detailed description of these treatment components can be found in Table 6 ("Appendix"). Secondly, these sessions were aimed at correcting performance of the exercises, increasing load and emphasizing the importance of adherence to the home exercises.

No other strengthening exercises were allowed to be added to the programme, and participants were requested not to seek other forms of treatment during the trial.

Outcomes and follow-up

All tests were completed at the laboratory of the Department of Rehabilitation Science and Physiotherapy of Ghent University. This investigator could not be blinded to treatment group.

A hand-held dynamometer (HHD; CompuFet; Hoggan health Industries Inc., West Jordan, UT, USA) was used to measure isometric strength. Hand-held dynamometry has been shown to exhibit acceptable reliability when tested on patients with strength deficits (ICC ranging from 0.78 to 0.85) [5, 22]. The device was calibrated prior to commencing the study and was used at low threshold to record strengths larger than 2.7 N with a sensitivity of 0.9 N.

During all tests, patients were seated without back support and with feet flat on the ground. With the non-tested arm they grasped the chair to stabilize themselves. Strength to abduction was measured at 3 arm positions: 0°, 45° and 90° of abduction in the scapular plane. These positions were verified using an Acumar™ digital inclinometer (model ACU360, Lafayette Instrument Co.; Lafayette, IN, USA). At 0° of abduction, the arm was along the body with the elbow flexed 90° and the lower arm pointing in anterior direction. The HHD was placed against the lateral epicondyle. At 45° and 90° of abduction, the arm was in a full can position with the elbow extended, and the HHD was placed at the radial distal part of the lower arm. External and internal rotation strength were measured with the arm along the body, the elbow flexed 90° and the lower arm again pointing forward. The HHD was placed against the dorsal distal part of the lower arm. Three maximal isometric contractions of 5 s duration were performed in each direction. Standardized verbal encouragement was given during isometric strength measurements. There was a rest period of 30° between trials. Peak torque of each trial was registered. For further analyses, peak torque was averaged over these three trials.

Patients filled in the SPADI questionnaire to evaluate pain and function. This questionnaire is a self-administered, shoulder-specific index consisting of 13 items, divided into two subscales, pain and function with responses to each item scored on a 10-point scale. The SPADI score has shown high test–retest reliability (ICC 0.95) in patients with rotator cuff tendinopathy and high responsiveness to change [22, 23]. All items were summed and averaged to obtain scores out of 100. Higher scores indicate more pain and disability.

Patients rated their subjective perception of improvement of their shoulder pain as “improved,” “not changed” or “worse.” If they selected “improved” or “worse,” the amount of change was scored on a 5-point scale (very little change, little change, some change, a large change, a very large change). “No change” equaled a score of 0, “better” was scored between 1 and 5 and “worse” between -1 and -5.

Statistical analysis

Data were analysed using SPSS Statistics 19 (SPSS Inc., Chicago, IL, USA). A level of 5 % was used to determine significant differences. Intention to treat principle was respected, and all patients were included in analysis as randomized. Anthropometrics and baseline outcome were compared between groups with independent sample t tests and a chi-square test. Evolution of outcome measures over the three time points was analysed for both groups using linear regression modelling with adjustment for baseline outcome levels. To determine treatment effect of the intervention over time, within-group effect sizes were calculated using Cohen’s d coefficient (Mean at week 12−Mean at week 0/(SD week 12 + SD week 0)/2). In this equation, effect size is expressed as a function of standard deviation. For example, an effect size of 0.4 reflects a difference between means of 0.4 of one standard deviation.
An effect size less than 0.2 was considered small, around 0.5 moderate and greater than 0.8 large. Difference in progression between groups was analysed using linear regression modelling with adjustment for baseline outcome levels. To determine the importance of the difference in progression between groups, between-group effect sizes were calculated as Mean ET − Mean TT/(SD ET + SD TT)/2. Model assumptions were checked by plotting obtained and expected residuals. Patients self-rated perception of improvement scores after 6 and after 12 weeks of treatment were compared between groups with chi-square tests.

**Results**

Flow of participants is illustrated in Fig. 1. In total, 83 patients were assessed for eligibility. Of these, 61 were included and randomly assigned to the TT + ET group (n = 31) and the TT group (n = 30). At the 6th week, 85% and at the 12th week 82% of included patients were available for assessment. Reasons for discontinuing the intervention are detailed in Fig. 1. Anthropometrics of both groups are presented in Table 1. Groups did not differ significantly in any of them. Group data for all outcome measures at baseline and at 6 and 12 weeks after the start of treatment are presented in Table 2 (SPADI and isometric strength). Improvements over time with corresponding within-group effect sizes are presented in Table 3, and differences in improvement over 12 weeks between the TT + ET and TT group and the corresponding between-group effect sizes are presented in Table 4.

Both groups showed an overall significant increase of isometric strength over time in direction of abduction at 0° (P < 0.001) and 45° of scapular abduction (P < 0.001) and in direction of external (P < 0.001) and internal rotation (P = 0.038). Post hoc tests (Table 3) demonstrated significant increase of strength from 0 to 6 weeks, but not from 6 to 12 weeks for abduction and external rotation strength. Internal rotation strength was only significantly increased in both groups when evaluated over the whole 12 week period (TT + ET group: P = 0.038; TT group: P = 0.006). Treatment effect on isometric strength to...
abduction at 0 and 45° and isometric strength to external and internal rotation was not significantly different between groups (Table 4).

Isometric strength to abduction at 90° of abduction increased significantly in the TT + ET group after 12 weeks of treatment (Mean difference = 14.7 N (19.7), P < 0.001, within-group effect size = 6.2) (Table 3). In the TT group, this strength was not significantly increased after 12 weeks (Mean difference = 5.1 N (19.8), n.s., within-group effect size = 0.6). The TT + ET group had a 15 % higher gain in isometric strength at 90° after 12 weeks than the TT group (P = 0.033), with respect to baseline values, with a between-group effect size of 0.7 (Table 4).

In both groups, pain and function, measured with the SPADI score, improved significantly over time (P < 0.001). Post hoc tests showed a decreased SPADI score after 6 (P < 0.001) and after 12 weeks (P < 0.001) (Table 3). When comparing between groups, improvement of the SPADI score was not significantly different (Table 4). Eighty-five per cent of patients in the TT + ET group and 89 % in the TT group achieved a reduction in the SPADI score of minimum 10 points, which has been previously reported to indicate a clinically important improvement [38].

Patients self-rated perception of improvement was not significantly different in the TT + ET and the TT group both at 6 weeks and at 12 weeks after the start of the intervention (Table 5). No patients had the impression that their shoulder got worse than prior to treatment.

### Discussion

The most important finding of this study was that the TT + ET group showed a 15 % higher gain in abduction strength at 90° of abduction than the TT group with a moderate between-group effect size. However, eccentric training did not result in less pain or better shoulder function than traditional rotator cuff training after 12 weeks. It was shown that both groups had significantly increased isometric strength, decreased pain and better function after 12 weeks of treatment. Moderate to large within-group effect sizes were demonstrated for all outcome variables. Although we did not include a third “no treatment” group to ascertain this, natural recovery is unlikely to explain these improvements of pain, function and strength. Other clinical trials found minimal changes over time in control groups receiving no treatment [20, 21].

This is the first randomized clinical trial that investigated the effect of adding eccentric training to conservative treatment in patients with subacromial impingement. Eccentric training has shown good results in treatment of several tendon disorders. This type of exercise has been shown to increase collagen production [18], decrease neovascularization [27] and normalize the pathologic tendon structure [28]. Three studies have been published on eccentric training in patients with shoulder impingement [4, 7, 14]. Jonsson et al. [14] showed less pain and better function after 12 weeks of eccentric training in patients with impingement. Main differences with our eccentric exercise were the lower dosage

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**Table 1** Anthropometrics of the eccentric and traditional training group

<table>
<thead>
<tr>
<th>Anthropometrics</th>
<th>TT + ET (n = 31)</th>
<th>TT (n = 30)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>40.2 (12.9)</td>
<td>39.4 (13.1)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169.6 (10.4)</td>
<td>169.5 (8.5)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Body Mass (kg)</td>
<td>70.1 (14.3)</td>
<td>69.4 (10.3)</td>
<td>n.s.</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.2 (3.2)</td>
<td>24.1 (3.8)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Gender: F:M</td>
<td>16:15</td>
<td>20:10</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

**ET** eccentric training, **TT** traditional rotator cuff training, **BMI** body mass index, **F** female, **M** male, n.s. non-significant

Mean (SD)

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**Table 2** Covariate-adjusted means for outcome at baseline, at 6 and at 12 weeks after start of the intervention

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Groups</th>
<th>Week 0</th>
<th>Week 6</th>
<th>Week 12</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TT + ET</td>
<td>TT</td>
<td>TT + ET</td>
<td>TT</td>
</tr>
<tr>
<td>SPADI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isom F abd 0°</td>
<td>42.0 (11.0)</td>
<td>44.3 (11.5)</td>
<td>25.4 (11.9)</td>
<td>17.7 (12.0)</td>
</tr>
<tr>
<td>Isom F abd 45°</td>
<td>127.9 (27.6)</td>
<td>123.2 (28.0)</td>
<td>150.8 (27.6)</td>
<td>142.7 (27.5)</td>
</tr>
<tr>
<td>Isom F abd 90°</td>
<td>71.2 (12.3)</td>
<td>68.2 (12.3)</td>
<td>79.7 (12.0)</td>
<td>81.7 (12.0)</td>
</tr>
<tr>
<td>Isom F ext rot</td>
<td>64.7 (12.6)</td>
<td>63.0 (12.7)</td>
<td>74.8 (12.3)</td>
<td>72.5 (12.3)</td>
</tr>
<tr>
<td>Isom F int rot</td>
<td>82.9 (12.5)</td>
<td>83.4 (12.9)</td>
<td>94.3 (12.2)</td>
<td>90.5 (12.5)</td>
</tr>
<tr>
<td>Isom F int rot</td>
<td>121.7 (17.9)</td>
<td>119.0 (18.2)</td>
<td>126.5 (17.6)</td>
<td>123.2 (17.5)</td>
</tr>
</tbody>
</table>

Values are mean of groups (SD, adjusted for baseline scores, from linear mixed model. Isometric strength in newton)

Isom F isometric strength, abd abduction, ET eccentric training, TT traditional rotator cuff training

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and the use of the empty can position in the study of Jonsson and colleagues. It has been shown that the empty can position, being internal rotation in an abducted position, narrows the subacromial space, and exercising in this position could further impinge the rotator cuff tendons [29]. Moreover, Reinold et al. [30] have shown that the full can exercise is best to maximize supraspinatus activity with the least amount of deltoid muscle activity. Bernhardsson et al. [4] showed decreased pain and better function after 12 weeks of eccentric rotator cuff training. The exercises were performed in side-lying and aimed for infraspinatus and supraspinatus, but further details on performance are lacking. Recently, Camargo et al. investigated the effect of eccentric isokinetic training (abduction from 20° to 80°) in 20 patients with shoulder impingement. Pain and disability had significantly decreased after 6 weeks, but isokinetic variables were only moderately changed over time in the isokinetic strength evaluations in the study of Camargo et al. A limitation of this study is the inability to transfer the results to clinical practice as isokinetic devices are rarely available in this setting.

Our results are in line with the above described studies, but though the TT + ET group showed a 15 % higher gain in abduction strength at 90° of abduction, this made no difference for the SPADI score after 12 weeks. A difference in isometric strength of 10 % is considered clinically significant [36]. As our TT + ET group performed the eccentric abduction exercise, this is evidently the reason

### Table 3 Covariate-adjusted mean differences within groups

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Week 0–12</th>
<th>Week 0–6</th>
<th>Week 6–12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isom F abd 0°</td>
<td>26.7 (15.8)</td>
<td>25.7 (15.8)</td>
<td>23.6 (15.3)</td>
</tr>
<tr>
<td>Isom F abd 45°</td>
<td>11.6 (13.8)</td>
<td>11.1 (13.9)</td>
<td>10.6 (13.8)</td>
</tr>
<tr>
<td>Isom F abd 90°</td>
<td>11.6 (13.8)</td>
<td>11.1 (13.9)</td>
<td>10.6 (13.8)</td>
</tr>
<tr>
<td>Isom F ext rot</td>
<td>12.1 (14.2)</td>
<td>12.2 (14.1)</td>
<td>12.0 (14.2)</td>
</tr>
<tr>
<td>Isom F int rot</td>
<td>5.6 (13.1)</td>
<td>5.6 (13.1)</td>
<td>5.6 (13.1)</td>
</tr>
</tbody>
</table>

Values are mean difference within groups over time (SD). Isometric Strength in Newton. Positive values indicate improvement.

### Table 4 Covariate-adjusted mean differences between groups

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Difference between groups in progression from 0 to 12 weeks</th>
<th>P value</th>
<th>Between-group effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPADI</td>
<td>1.3 (7.0 to 9.7)</td>
<td>n.s.</td>
<td>0.2</td>
</tr>
<tr>
<td>Isom F abd 0°</td>
<td>14.2 (8.8 to 57.1)</td>
<td>n.s.</td>
<td>0.3</td>
</tr>
<tr>
<td>Isom F abd 45°</td>
<td>0.4 (9.7 to 10.4)</td>
<td>n.s.</td>
<td>0.2</td>
</tr>
<tr>
<td>Isom F abd 90°</td>
<td>9.6 (0.7 to 19.9)</td>
<td>0.033</td>
<td>0.7</td>
</tr>
<tr>
<td>Isom F ext rot</td>
<td>3.0 (6.7 to 12.6)</td>
<td>n.s.</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Values are mean difference between groups (95 % CI) in progression between 0 and 12 weeks. Isometric Strength in Newton. Positive values favour the eccentric training group.

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"Isom F" isometric strength, "abd" abduction, "ET" eccentric training, "TT" traditional rotator cuff training.

n.s. non-significant
why they had a higher strength gain compared to the TT group. Isometric full can abduction at 90° is used as a clinical test to assess supraspinatus pain and function [12, 15]. To attribute the higher increase in isometric strength in this position to the supraspinatus is not appropriate since there are no data on tendon healing nor on EMG muscle activity of the supraspinatus available in this study.

There is still no consensus on the underlying mechanism of eccentric training. In patients with Achilles tendinopathy, it is believed that strengthening is not the only responsible factor for clinical improvement after eccentric training [2]. Effects on neovascularization [27] and tendon properties [24] have been suggested to explain the good results. Future studies should investigate the immediate and long-term effect of a heavy load eccentric exercise on specific properties of the supraspinatus muscle and tendon. Perhaps eccentric training should not be performed to improve clinical symptoms but to strengthen the tendon and restore degeneration.

It should be noted that this study might have been underpowered for detecting differences between groups in the SPADI score. Previous studies have reported a sample size of 60 patients in each group is required to detect differences in treatment effect [3, 9]. Moreover, future trials should distinguish between subpopulations, based on responsible mechanism for tendinopathy [19] and accounting for age, gender and activity level. A next step, after investigating the influence of adding eccentric training, could be to compare between traditional training and eccentric training.

As both groups improved over time, traditional rotator cuff home exercises combined with physiotherapy treatment seems to have determined improvement of pain and function in our patients with subacromial impingement, while adding an eccentric training programme did not alter this. Rotator cuff training with an elastic band has been the standard home exercise programme for patients in our area for a long time. A loss of rotator cuff strength has been associated with upward humeral translation [11, 31, 33]. By strengthening the rotator, cuff clinicians aim to increase downward translation of the humeral head during abduction and keep the subacromial space large enough.

It is important to mention that the largest progression was made during the first 6 weeks. Isometric strength to internal rotation was the only direction of strength in which no significant improvement was present after the first 6 weeks. The low amount of strength deficit of the painful side compared to the healthy side could give a plausible explanation for this finding. Possibly internal rotation strength was least affected.

Most improvement of pain and function also took place during these first 6 weeks. This time period might be a good guideline for therapists, when to expect an effect of their treatment, and for patients performing home exercises, when to expect improvement.

At least three limitations must be taken into account when interpreting the results. Firstly, the treating physiotherapist and the investigator that collected data could not be blinded to treatment group so the influence of their expectations about treatment cannot be excluded. As both groups show marked improvement over time, the effect of these beliefs was probably marginal. Secondly, the lack of stratification for gender in randomization resulted in unequally distributed gender among the groups. The TT + ET group contained more men and was consequently stronger at baseline. We corrected for this difference by adjusting for baseline isometric strength values in statistical analysis. Thirdly, this study could not provide information on long-term follow-up of the patients so it is not clear how long improvements lasted.

### Table 5

<table>
<thead>
<tr>
<th>Patients self-rated perception of improvement at 6 and 12 weeks after the start of the intervention (% of group)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6 weeks follow-up</strong></td>
</tr>
<tr>
<td><strong>TT + ET</strong></td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>0 (no change)</td>
</tr>
<tr>
<td>1 (very small improvement)</td>
</tr>
<tr>
<td>2 (small improvement)</td>
</tr>
<tr>
<td>3 (some improvement)</td>
</tr>
<tr>
<td>4 (large improvement)</td>
</tr>
<tr>
<td>5 (very large improvement)</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

*ET eccentric training, TT traditional rotator cuff training, N number of subjects*
The investigators standardized the intervention in a way that corresponded well with current clinical practice. This augments the clinical relevance and ability to transfer results of this study to clinical practice. The home exercises are very easy to perform and might decrease the need for hands-on physiotherapy, reducing medical costs.

**Conclusion**

It was shown that a 12-week traditional rotator cuff home training combined with 9 physiotherapy treatments was successful in increasing isometric strength and decreasing shoulder pain and dysfunction in patients with subacromial impingement. Adding heavy load eccentric training resulted in a higher gain of isometric strength at 90° of scapular abduction. This study supports the integration of an eccentric training programme into a multimodal rehabilitation programme. In addition, this study provided evidence that combining a limited amount of physiotherapy treatment session with a home exercise programme is highly effective. Largest progression should be expected in the first 6 weeks of rehabilitation.

**Acknowledgments**

The authors are deeply grateful to the volunteers that participated in this study.

**Appendix**

See Figs. 2 and 3; Table 6.

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**Fig. 2** Resisted internal a and external rotation b with rubber band

**Fig. 3** Eccentric full can abduction exercise
Table 6: Additional individualized physiotherapy treatment

<table>
<thead>
<tr>
<th>Treatment component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>Information on basic anatomy of the shoulder (humerus, glenoid and scapula and position of the rotator cuff tendons) and pathology of subacromial impingement</td>
</tr>
<tr>
<td>Glenohumeral mobilization</td>
<td>Traction perpendicular to the glenoid surface with patient lying supine</td>
</tr>
<tr>
<td></td>
<td>Inferior translation of the humeral head with patient lying supine</td>
</tr>
<tr>
<td>Scapulothoracic mobilization</td>
<td>Mobilization of the scapula towards upward/downward rotation, posterior/anterior tilt, elevation/depression and retraction/ protraction</td>
</tr>
<tr>
<td>Scapula setting</td>
<td>Motor learning with patient prone and seated, manual feedback onto coracoid process and inferior angle of the scapula or onto the lower trapezius muscle to facilitate contraction</td>
</tr>
<tr>
<td>Posture correction</td>
<td>Patients were instructed to erect the thoracic spine by diminishing the curve of thoracic kyphosis. Manual feedback was provided</td>
</tr>
</tbody>
</table>

References