The Effectiveness of Exercise Therapy in Reducing Pain and Improving Clinical Outcomes in Rotator Cuff Tendinopathy- A Systematic Review

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ABSTRACT

A systematic review of randomized controlled trials (RCTs) was performed to examine the effectiveness of exercise interventions in treating patients with rotator cuff tendinopathy. Three databases were searched- Medline OvidSP, CINAHL, and EMBASE. Ten articles examining eight different RCTs were reviewed. The clinical outcomes examined were shoulder pain, strength, range of motion, quality of life, and function. The secondary objective was to determine which parameters of exercise are most beneficial in treating this group of conditions.

A qualitative data analysis was performed. Although few conclusive statements can be made, the evidence suggests that exercise interventions can lead to improvements in all of the above-mentioned clinical outcomes. Specific shoulder exercises appear to be more effective than general, non-specific neck and upper extremity exercises. Additionally, exercises performed at a higher intensity may be more beneficial than those performed at a lower intensity. The exercise parameters used in the studies vary considerably, and therefore it is difficult to draw conclusions about the most beneficial exercise prescription. Further research is needed in order to conclusively determine the effectiveness of exercise interventions in the treatment of rotator cuff tendinopathy.

BACKGROUND

Disorders of the glenohumeral joint are relatively common in adults. Approximately half of new shoulder complaints reported in primary care progress to a chronic state whereby symptoms last over six months [1]. Due to the complexity of the shoulder, it is difficult to diagnose and treat chronic impairments [2]. Of all chronic shoulder conditions, disorders of the rotator cuff are most prevalent [1]. The tendons of the rotator cuff- subscapularis, supraspinatus, infraspinatus, and teres minor- encompass the humeral head and function in the mobility and dynamic stability of the gleno-humeral joint [3]. Several pathologies can affect the rotator cuff tendons, including acute strains and tears, chronic bursitis, tendinosis [4]*, and subacromial impingement syndrome [1]. The causes of these tendon pathologies are multifactorial, and for the sake of investigation they are all considered to contribute to rotator cuff tendinopathy.

Surgery is a common treatment for rotator cuff tendinopathy, but it presents significant risks to the patient, and clinical results are not always promising [2]. Many clinicians are uncertain how to advise their patients on the risks and benefits of surgery versus conservative treatment, and there is a lack of guidance on how long conservative care should be offered before seeking a surgical opinion [3].

Physiotherapists often prescribe shoulder exercises as a method of conservative treatment for rotator cuff tendinopathy- however, few evidence-based guidelines exist outlining the optimal parameters for exercise prescription [3]. A wide variety of research approaches examining this topic can be found in the literature, but it is difficult to draw clear conclusions from these studies. At present, it appears that treatment approaches are largely determined by the expertise of practitioners in the field rather than by well-executed clinical trials [1]. Some research has

* The term “tendonitis” has commonly been used to describe painful tendon conditions- however, “tendinosis” has recently become a more acceptable term given that there is often little evidence of inflammation in such conditions [4].

actually suggested that exercise may not be associated with clinical improvements at all [4], whereas other studies have shown that exercise is more beneficial than corticosteroid injections in long-term pain management [5]. Furthermore, new approaches to exercise therapy are surfacing in the literature- a study in 2006 [2] demonstrated positive clinical outcomes on the rotator cuff tendons using eccentric loading exercises, a practice which has previously been discouraged.

Existing systematic reviews have shown a generally positive trend towards using exercise to treat rotator cuff tendinopathy, but there are still grey areas in the literature. Two comprehensive systematic reviews [6,7] compared several methods of operative and non-operative management of rotator cuff tendinopathy- however, most of the articles examining exercise therapy in the first review were a low level of evidence [6], and the second review only investigated rotator cuff tears, but not other forms of tendinopathy [7]. A 2009 review [8] found that exercise therapy is an effective treatment for pain in subacromial impingement syndrome, but the validity of some of the conclusions made in this study have been questioned [9]. A 2010 review and exercise protocol [10] drew from the findings above, but included studies which used exercise in conjunction with manual therapy, thereby limiting the conclusions which can be made about exercise interventions alone. The authors of a 2011 systematic review [11] chose to only include studies which used loaded exercises (against gravity or resistance), and did not consider other forms of exercise such as stretching or scapular muscle retraining. Overall, it is evident that there are insufficiencies in the existing literature concerning the role of exercise programs (exclusive of other interventions) in treating the broad spectrum of rotator cuff tendinopathies.

The primary objective of this systematic review was to determine the effectiveness of exercise therapy in the conservative treatment of adults with rotator cuff tendinopathy. The clinical outcomes examined were shoulder pain, strength, range of motion, quality of life, and function. These outcome measures were selected because they have sufficient construct validity for the evaluation of musculoskeletal disorders [12]. The secondary objective was to determine the ideal exercise parameters for treating this group of conditions.

METHODS

Search Strategy

The following databases were searched: Medline OvidSP, CINAHL, and EMBASE. Search terms included variations of tendon pathology, rotator cuff, and exercise therapy (Appendix). The articles identified for review were screened for additional publications not identified through the above-mentioned databases, and a grey literature search identified other appropriate articles to be included in the review.

Study Selection

In order to provide the highest possible level of evidence, only RCTs were reviewed. The control groups in the selected articles must have served as a comparison for the treatment group in one of the following ways: they received no treatment or a placebo treatment (such as sham laser or ultrasound), they were justified as being representative of the natural progression of disease, or they received an exercise intervention which was considerably different from that of the intervention group, such that meaningful conclusions could be made about the intervention.

Participants in the included studies must have had a demonstrable pathology of one or more rotator cuff tendons, which could be any or all of tendinosis, tenosynovitis, bursitis, impingement, or a complete or partial tear. There must have been an exercise intervention aimed at treating an impairment associated with the tendinopathy. Exercise treatments could be concurrent with other physical therapy modalities or pharmacological interventions, such as non-steroidal anti-inflammatory drugs or corticosteroid injections, so long as the exclusive effect of the exercise intervention could be demonstrated (namely, subjects in both groups received the concurrent treatment). Selected articles must have used at least one clinically meaningful measure to evaluate the outcome(s) of interest.

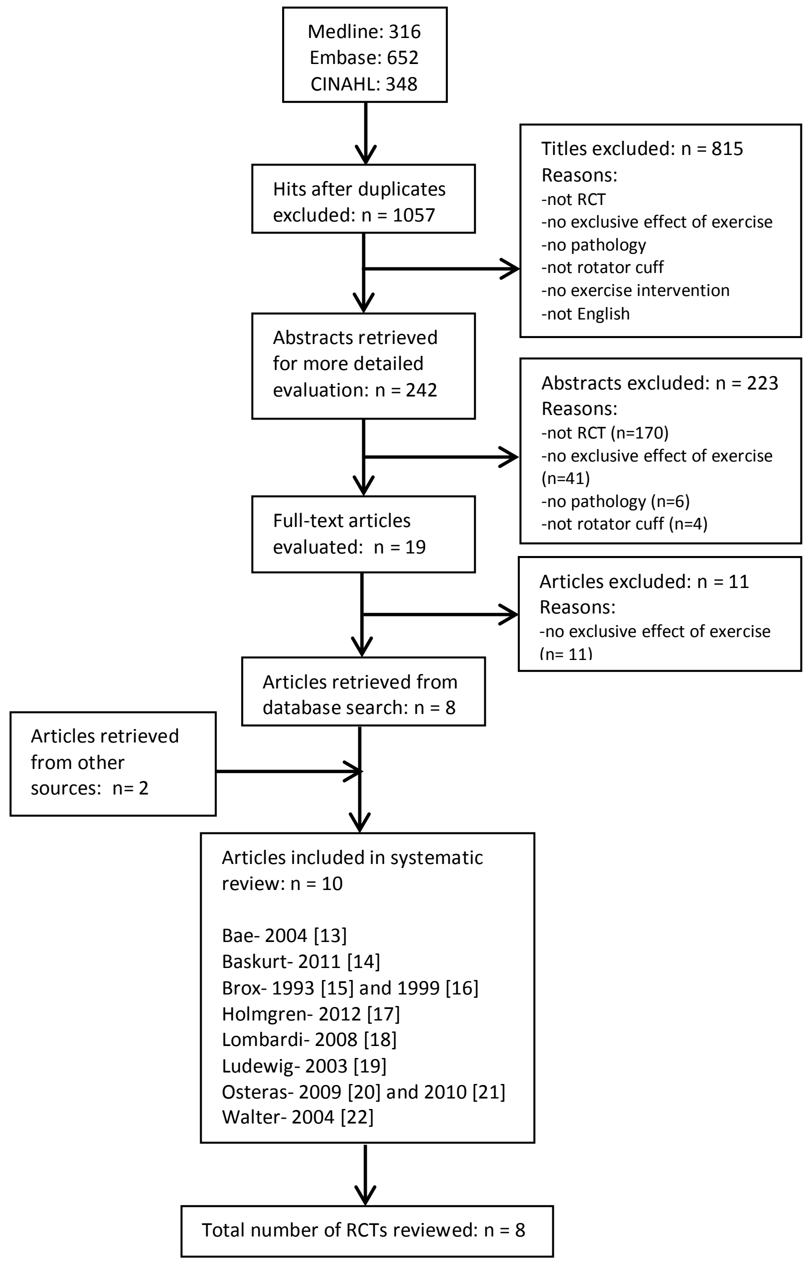

Figure 1: Study selection process.

Articles were excluded if they involved participants under age 18 or non-human models, were published prior to 1991, or were not published in English. Articles were excluded if subjects had significant co-morbidities such as hemiplegia, polio, spinal cord injury, or cancer. Studies examining other shoulder pathologies, such as osteoarthritis or adhesive capsulitis, were also excluded.

At each stage of review, articles were screened for inclusion by two independent reviewers. In the case of any disagreement, the article in question was brought to the group of remaining researchers in order to determine its eligibility for the review. Figure 1 outlines the study selection process.

Quality Assessment

The PEDro Scale [23] was used to assess the quality of the RCTs included in this study. The scale has a maximum possible score of 11 and provides information regarding the internal validity of the trial and the potential for statistical analysis [24]. Two assessors, blinded to each other's scores, reviewed each article. In the case of a discrepancy between scores, the items in question were re-assessed. Any unresolved disagreements were brought to the remainder of the group for discussion and consensus. Because there were only a small number of RCTs which met the inclusion criteria, no cutoff was established which would exclude low-scoring articles from the review. Furthermore, in most physiotherapy interventions it is not usually feasible to satisfy all scale items, such as blinding of the study participants or of the therapists administering treatment, thereby limiting the maximum possible score. PEDro scores ranged from 5 to 10 out of 11. Although a quantitative data analysis was not performed, the scores were accounted for in the interpretation of the results.

Data Management and Analysis

Of the ten articles selected, there were two pairs of articles which were based on the same clinical trials (primary authors Brox [15, 16] and Osteras [20, 21]). For the purpose of data analysis, each pair of articles was interpreted as one- therefore, a total of eight different RCTs were reviewed. Several studies had multiple experimental groups- however, since it was not the objective of this review to compare the effectiveness of exercise to surgery or other interventions, data was only extracted from the exercise and control groups.

Two researchers were assigned to extract data from each article. There were two cases in which authors were contacted regarding missing data, although neither was able to provide further information [13, 22]. Due to the small number of studies, the considerable heterogeneity in the types of experimental and control groups used and the outcome measures examined, and general lack of reported means and standard deviations, it was not feasible to perform a meta-analysis. Therefore, the researchers analyzing the data (EK and TM) performed a qualitative analysis of the literature.

RESULTS

Study Characteristics

Table 1 summarizes the characteristics of the studies reviewed. The length of exercise interventions ranged from 4 to 26 weeks. Three studies [14, 18, 22] used interventions between 6 and 8 weeks in duration, which is consistent with the proposed timeline for soft tissue healing. Three studies [16, 20-22] were modeled after the duration of typical group or home-based exercise programs and lasted 12 to 13 weeks. Bae [13] used a relatively short intervention of 3

Primary author	PEDro score	Duration of intervention (weeks)	Weekly exercise dosage	Measurement times (weeks)	PT Supervision[1]	Type of program	Type of exercise	Control Group	Details of exercise program progression
Bae [13]	5	4	3.75 hours	0 4	Full	Individual	Scapular motor control and strengthening	Conservative	Without pain
Baskurt [14]	5	6	3 sessions (time not stated)	0 6	Full	Individual	Scapular stabilization	Conservative	Without substantial pain or fatigue
Brox [15,16]	7/6	13-26	7 hours	0 13 26 130	Partial (decreasing with time)	Individual	ROM/strengthening of rotator cuff and scapular stabilizers	Placebo	Not defined
Holmgren [17]	10	12	4.6 hours for first 8 weeks, 2.3 hours for last 4 weeks	0 13	Partial (decreasing with time)	Individual	Eccentric rotator cuff strengthening, and strengthening of scapular stabilizers	Pseudo-control[2]	As per pain monitoring model described in article
Lombardi [18]	9	8	30 minutes	0 8	Full (not explicitly stated)	Individual	Progressive strengthening of rotator cuff	No intervention	Based on percentage of 6RM, respecting pain threshold
Ludewig [19]	7	8	2 hours	0 8	Minimal	Individual	Strengthening/stretching rotator cuff and scapular stabilizers	No intervention	Increasing repetitions and then weight with pain free completion
Osteras [20,21]	7/8	13	3 hours	0 13 39 65	Full	Group-based	High dosage semi-global and global strengthening exercises, and aerobic exercises	Conservative	Pain-free
Walther [22]	7	12	1.25 hours	0 6 12	Minimal (4 sessions)	Individual	Strengthening and stretching of rotator cuff	Pseudo-control	Not stated whether exercises were progressed

Table 1: Summary of articles included in the systematic review. Note that Brox and Osteras refer to two articles each. ROM=range of motion; 6RM=maximal amount of weight to perform 6 repetitions to fatigue.

[1] Partial supervision was defined as greater than 1 hour per week with a PT with some component of home exercise. Minimal supervision was defined as less than 1 hour per week of PT supervision.
[2] Pseudo-control groups received an active intervention that the authors predicted would have no effect on the outcome.

weeks duration. Brox [15-16] did not use a standardized timeline; the duration of the exercise intervention ranged from 13-26 weeks. All studies took baseline and endpoint measurements. In addition, Baskurt [14] took mid-point measurements at 6 weeks. Brox took mid-point measurements at 3 and 6 months [15] and follow-up measurements after 2.5 years [16]. Osteras [21] took follow-up measurements 9 and 15 months after baseline.

Four studies had full supervision by a physiotherapist during the exercise intervention [13-14, 18, 20-21]. Two interventions were partially supervised by a physiotherapist, and this supervision decreased with time [15-17]. The other two studies had less than one hour of physiotherapist supervision per week [19, 21]. Osteras [20-21] administered treatments in a group setting, whereas all other studies implemented interventions on an individual basis.

Three studies had true control groups- two of these groups received no intervention whatsoever [18-19], and the other received placebo detuned laser [15-16]. Two studies used pseudo-control groups, which received an active intervention that the authors predicted would have no effect on the outcome [17, 22]. Holmgren used non-specific range of motion exercises of the cervical spine and upper limb [17], while Walther used a functional shoulder brace [22]. The remaining three studies used a conservative treatment group as their control [13-14, 20-21]. In these studies, the experimental and control groups both received exercise therapy, but the experimental group's program was of a higher volume. Therefore, conclusions could be made about the dose-response effect of exercise.

Interventions consisted of one or more of the following types of exercise: scapular retraining, rotator cuff strengthening, stretching, and/or aerobic exercise. Six studies included scapular retraining exercises [13-17, 19-21], and six included rotator cuff strengthening [15-22]. Stretching was a component of three interventions [19-22], and only one study utilized aerobic exercise [20-21]. All studies but one progressed exercises when pain was at or below a particular threshold; the study by Walther [22] did not state whether exercises were progressed at all.

Outcome Measures

Table 2 summarizes the outcome measures reported and whether significant between-group differences were found.

Pain

Pain scores were reported in all studies except one [13]. Five of the seven studies reported a significant between-group difference in at least one pain outcome [15-21]. Five studies [14,17-18, 20-22] measured pain at rest using a visual analog scale (VAS), and two of these studies reported a significant difference [18, 20-21]. Two studies reported significant differences on the VAS for pain at night [17] and with activity [18]. At the 2.5 year follow-up, Brox [16] found significant differences in pain between the exercise and placebo laser groups in the 9 point questionnaire subscales and in the Neer pain subscale. One study [19] reported a significant difference in an overall work-related pain score.

Bae 2011 [13] Baskurt 2011 [14] Brox 1993 [15], 1999 [16] Holmgren 2012 [17] Lombardi 2008 [18] Ludewig 2003 [19] Osteras 2009 [20], 2010 [21] Walther 2004 [22]	**Studies reporting measure**	**Significant between-group difference reported**	**Significance favoring exercise (E) or control (C) group**
PAIN			
Visual Analog Scale			
-Pain at rest	14,17-18, 20-22	18, 20-21[1]	E,E
-Pain at night	17, 22	17	E
-Pain with activity	14, 17-18	18	E
-Pain with load	22	-	-
Neer pain subscale	15-16	16	E
Standard questionnaire (9 point scale)			
-Pain on activity	15-16	16	E
-Pain at rest	15-16	16	E
-Pain at night	15-16	16	E
SF-36 pain score	18	-	-
Overall work related pain score	19	19	E
STRENGTH			
Flexion	18, 20-21	-	-
Extension	18	18[3]	E
Abduction	18, 20-21	21[4]	E
Adduction	18	-	-
Internal rotation	13,18,20-21	13[2]	E
External rotation	13,18,20-21	13, 21[4]	E,E
Lower trapezius	14	14	E
Middle trapezius	14	14	E
Upper trapezius	14	14	E
Serratus anterior	14	14	E
Supraspinatus	14	-	-
Subscapularis	14	-	-
Infraspinatus	14	-	-
Constant-Murley subscale	22	22	C
RANGE OF MOTION			
Flexion	13-14, 18	13	E
Extension	13, 18	13, 18	E,E
Abduction	13-14, 18	13,18	E,E
External rotation	13-14, 18	13	E
Internal rotation	13-14, 18	13	E
Neer Active ROM subscale	15-16	16	E
QUALITY OF LIFE			
Hopkins Symptom Checklist (emotional distress)	15-16	16	E
EQ-5D	17	17	E
EQ VAS	17	-	-
Satisfaction Score	19	19	E
Satisfaction Scale	20-21	21[4]	E
Work Related Disability	19	19	E
COMBINED FUNCTIONAL MEASURES			
Neer functional subscale	15-16	16	E
DASH	17	17	E
-DASH 2 (laborers)	18	18	E
-DASH 3 (ADLs)	18	18	E
Constant Murley scale	17, 22	17	E
-mobility subscale	22	-	-
SRQ	19-21	19-21	E,E
SPADI	13	13	E
WORC	14	-	-
Joint position sense	14	14	E

Table 2: Studies reporting significant differences between exercise and control groups.

[1] Significant difference reported at 9 and 15 month follow-up only
[2] Significant difference reported testing at 180deg/s and not at 60deg/s
[3] Significant difference reported for total work but not peak torque
[4] Significant difference reported at 9 month follow-up only

SF-36= Brazilian version of Short Form 36, ROM = range of motion, EQ-5D and EQ VAS= EuroQol instrument, DASH= Disability of Arm, Shoulder and Hand, ADLs= activities of daily living, SRQ= Shoulder Rating Questionnaire, SPADI= Shoulder Pain and Disability Index, WORC= Western Ontario Rotator Cuff Index.

Strength

Five studies included one or more of rotator cuff strengthening, scapular stabilization exercises, or general shoulder strengthening [13-14, 18, 20-22]. Some studies measured strength in terms of isolated shoulder movements (flexion, extension, abduction, adduction, internal and external rotation) while others measured the strength of individual muscles. Lombardi reported significant gains in total work (but not peak torque) in shoulder extension only [18]. Osteras found significant improvements in shoulder abduction and external rotation in their 2010 study only [21]. Baskurt found significant between-group improvements in the strength of the scapular stabilizing muscles (serratus anterior and lower, middle, and upper fibers of trapezius) but not in any of the rotator cuff muscles [14]. Surprisingly, Walther found a significant increase in strength on the Constant-Murley subscale, but this increase was reported in the control group rather than in the intervention group [22].

Range of motion

Four studies reported on range of motion measurements [13-15,18]. One of the four studies found no significant improvements in any measurements [14], whereas one found significant improvements in all measured planes of motion [13]. Lombardi demonstrated a significant difference in shoulder abduction and extension only [18]. At the 2.5 year follow-up, Brox reported a significant improvement over placebo laser in the Neer active range of motion subscale, a combined score measuring range of motion in all planes [16].

Quality of life

Four studies utilized a stand-alone measure of quality of life in their analysis [15-17,19-21], and each used a different outcome measure to do so. All four studies reported significant improvements between groups in at least one measure of quality of life.

Function- combined measures

Upper extremity function was considered to be a more global measure encompassing one or more of the above-mentioned outcomes. All eight studies included an outcome measure that assessed some combination of pain, strength, range of motion, or quality of life. In most cases, the individual subscales for these outcomes were not available and only the overall score was provided. All but one study reported significant improvements with exercise [13-21].

DISCUSSION

The primary objective of the current review was to synthesize the highest quality evidence available in order to determine the effectiveness of exercise interventions in the conservative treatment of rotator cuff tendinopathy. The secondary objective was to discern the ideal frequency, intensity, duration, and type(s) of exercise to prescribe. When considering the heterogeneity of the studies examined, the current systematic review provides level 1a(-) evidence [25]. The effectiveness of the exercise interventions was evaluated through changes in shoulder pain, range of motion, strength, quality of life, and function. In all but one study [22], exercise was found to be comparable to or more beneficial than placebo treatment or control/comparison groups in all clinical domains.

The quality appraisal scores for the articles in this review ranged from 5-10 out of a possible 11 on the PEDro scale (Table 3). Blinding proved to be a notable constraint in most studies, and as a result it was difficult for studies to achieve a high score. Only one study [17] was able to achieve blinding of all subjects, likely because the nature of exercise interventions makes it challenging to satisfy this criterion. Some studies were able to blind the assessors measuring clinical outcomes [15-18], but no studies blinded the therapists who administered the intervention. Osteras [20-21] identified the absence of a blinded assessor as being a major limitation in their study. Although significant between-group improvements in pain, strength, function, and quality of life were reported in the intervention group, these findings must be interpreted with caution as the lack of blinding may have confounded the results.

	1. Eligibility criteria specified	2. Subjects randomly allocated	3. Allocation concealed	4. Groups similar at baseline	5. Blinding of all subjects	6. Blinding of all therapists	7. Blinding of all assessors	8. Measures obtained from at least 85% of subjects	9. All subjects received treatment or control as allocated	10. Between- group statistics reported	11. Point measures and measures of variability	**TOTAL SCORE**
Bae 2011 [13]	x	x		x						x	x	5
Baskurt 2011 [14]	x	x		x						x	x	5
Brox 1993 [15]	x	x					x	x	x	x	x	7
Brox 1999 [16]	x	x						x	x	x	x	6
Holmgren 2012 [17]	x	x	x	x	x		x	x	x	x	x	10
Lombardi 2008 [18]	x	x	x	x			x	x	x	x	x	9
Ludewig 2003 [19]	x	x	x	x				x		x	x	7
Osteras 2009 [20]	x	x	x	x				x		x	x	7
Osteras 2010 [21]	x	x	x	x				x	x	x	x	8
Walther 2004 [22]	x	x		x				x	x	x	x	7

Table 3: PEDro quality appraisal scores.

Pain was reported in all but one study [13]. Five studies found significant between-group improvements in the exercise group [15-21], whereas two studies found within-group improvements in pain post-intervention, but not between groups [14, 22]. The study by Walther [22] found significant within-group improvements in pain on the Constant-Murley score for all groups, including the control group in which subjects were given a shoulder brace to wear throughout the intervention period. The authors had initially thought that the brace would mimic the natural progression of the disease- however, after completion of the study it was acknowledged that this was not an ideal "control" treatment because a previous study had demonstrated improvements with bracing in patients with shoulder tendinopathy [26]. Additionally, the bracing group showed significant improvements in shoulder girdle strength compared to both intervention groups (conventional physiotherapy and self training). The authors hypothesized that this improvement was because the brace provided support to allow for increased activation of the shoulder muscles. The results of this study suggest that the brace may have actually served as a treatment for subacromial impingement syndrome. Further studies are needed to investigate the effectiveness of bracing as a treatment for rotator cuff tendinopathy.

Strength outcomes were reported in five studies, all of which reported significant improvements in one or more domains [13-14, 18, 20-22]. There was considerable variation among the studies with respect to the types and duration of exercise. Interventions included but were not limited to global shoulder strengthening exercises (with or without concurrent aerobic exercise), scapular stabilization exercises, scapular muscle strengthening, scapular motor control training, and concentric/eccentric rotator cuff strengthening. Despite growing evidence in favour of eccentric exercise [2], only one study [17] included eccentric loading of the rotator cuff muscles in their intervention, and found significant improvements in function, night pain, and quality of life in the exercise group (Table 2). This suggest that eccentric loading may be a valuable tool in treating rotator cuff tendinopathy, and future studies should compare eccentric and concentric exercise programs to evaluate whether one is superior. The duration of the exercise interventions also varied considerably, ranging from 4-13 weeks. It is possible that improvements in strength are related to a dose-response effect of exercise, but because of the considerable variety among the exercise programs in these studies, it is difficult to determine which exercise parameters are most effective in improving shoulder strength.

In the study by Baskurt [14], both the intervention and control group received the same rotator cuff stretching and strengthening exercises, but the intervention group received an additional scapular stabilizing exercise program. No statistically significant between-group differences in pain were reported, although the intervention group demonstrated significant improvements in scapular muscle strength. This suggests that specificity is an important training principle to consider when prescribing strengthening programs to patients with rotator cuff tendinopathy. The study by Lombardi [18] found no significant between-group improvements in strength, but reported a significant improvement in physical function, emotional role limitations and mental health as measured by the SF-36 compared to the control group. This suggests that exercise may be effective in improving pain, function, and quality of life without concurrent improvements in rotator cuff muscle strength.

Three of the four studies that reported on range of motion found significant improvements favouring the exercise intervention [13,15,18]. It is difficult to determine the effect of particular exercise parameters on improvements in range of motion because a variety of interventions were utilized, but only a limited number of studies reported on range of motion. Similarly, of the four studies which reported on quality of life, each one used a unique outcome measure, which limits the ability to make generalizations about which exercise parameters are ideal.

All of the included studies reported on at least one functional outcome measure which evaluated some combination of pain, strength, range of motion, and/or quality of life [13-22]. Again, a myriad of different outcome measures were used, making comparisons between studies difficult. All but one of the above studies found significant improvements in upper extremity function favouring the exercise intervention. The one study that did not find improved function used a bracing control group, but then later determined that the brace in fact served as an active treatment [22].

The improvements in the various outcomes examined in this review may not be mutually exclusive; for example, it is difficult to determine whether improvements in function or quality of life are due to improvements in range of motion or strength, to decreased pain, or to a combination of the above. Although the heterogeneity across studies makes it difficult to draw clear conclusions, it can be said that even with significant improvements in just one of pain, strength, range of motion, or quality of life, exercise interventions can have a significant positive effect on overall functional measures in adults with rotator cuff tendinopathy.

The studies included in this review varied considerably in certain other respects. The progression of the exercise programs was not consistent across studies. Several studies progressed the prescribed exercise programs when subjects were able to achieve full pain-free range of motion during a task. One study [22] failed to identify whether progression of the exercise intervention occurred at all. A second study [15-16] reported that exercises were progressed, but failed to explain how this progression was executed. There was also variation across studies in terms of the amount of physical therapist supervision, and whether the exercise interventions were group-based or individual. Two studies [18-19] used control groups which received no treatment whatsoever (ie. no placebo or comparative form of exercise)- therefore, the patient-therapist interaction in the intervention group may have impacted the results.

The current systematic review has some limitations. It is possible that the systematic search process missed articles which could have been retrieved from other databases. Studies were limited to those published in English, and therefore articles written in other languages were overlooked. Another limitation is that a meta-analysis could not be performed due the heterogeneity of the data. Both authors that were contacted to provide missing data were unable to provide further information [13, 22]. The quality of the evidence may also be a limitation, since no cutoff PEDro score was established which would exclude low-scoring articles.

This review set out to determine the effectiveness of exercise in treating rotator cuff tendinopathy, an umbrella term which describes several conditions: “tendonitis,” tendinosis, impingement syndromes, bursitis, and complete or partial tendon tears. All articles which met the inclusion criteria reported on some aspect of subacromial impingement, but few other forms of tendinopathy were examined. In fact, some authors excluded subjects from their studies who presented with complete rotator cuff tears [15, 20-22]. This may limit the generalizations which can be made regarding the effectiveness of exercise for patients with other forms of tendinopathy besides subacromial impingement syndrome. However, it seems that patients who present with signs and symptoms of specific rotator cuff impingement may not always be properly diagnosed. For example, in the study by Brox, all subjects were initially diagnosed with stage II impingement [20-21]. Many subjects who were originally assigned to the placebo or exercise group eventually decided to undergo surgery, but were then found to have additional complications such as complete rotator cuff tendon rupture, biceps tendon involvement, or arthritis of the acromioclavicular joint. Hegedus [27] acknowledges that both the Neer and Hawkins-Kennedy impingement tests used to diagnose subacromial impingement syndrome have low specificity. Therefore, the term "subacromial impingement syndrome," which has commonly been used in the literature, may actually represent more shoulder conditions than rotator cuff tendon impingement alone.

There are definite faults with current definitions of shoulder pathologies, and with the diagnostic procedures used to identify clinical sub-groups. If these sub-groups are in fact heterogeneous, then it is very difficult to evaluate the effectiveness of exercise interventions which target specific pathologies. Diagnostic criteria, as well as current definitions of "tendinopathy," may need to be evaluated more rigorously in order to allow for more consistency in the inclusion and exclusion of study populations.

Previous systematic reviews examining the effectiveness of exercise intervention in the treatment of rotator cuff tendinopathy have found mixed results. Several studies [8, 11, 28-31] are in agreement with the current review that exercise is beneficial, while others [6, 12, 32] could not support or refute the effectiveness of exercise. To our knowledge, no studies have found that exercise has a detrimental effect on subjects with rotator cuff tendinopathy. A recent systematic review [11] identified a lack of high quality evidence in the literature, which agrees with the present study. The current systematic review adds to the literature by discussing the impact of specificity and exercise dosage in treating rotator cuff tendinopathy, but the ideal dosage parameters cannot be determined. Future studies should examine how different exercise parameters promote long-term adherence and improvements in clinical outcomes.

CONCLUSION

The current review cannot provide conclusive statements about the effectiveness of exercise in the treatment of rotator cuff tendinopathy- however, this study did identify a general trend supporting exercise as a conservative treatment approach in all clinical outcomes examined. Specific strength training of the rotator cuff muscles appears to be more beneficial than a general, non-specific training program, and high-intensity exercise may be more beneficial than low-intensity exercise. More high quality RCTs are needed in order to conclusively determine the effectiveness of exercise interventions in the treatment of rotator cuff tendinopathy, as well as the ideal parameters for its prescription. Future trials should utilize standardized methodologies and protocols, appropriate control groups, and blinding of all subjects, therapists, and assessors.

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APPENDIX

DATABASE SEARCH STRATEGIES

Medline OvidSP

1. exp Tendinopathy/
2. tendon*.mp.
3. tendin*.mp.
4. exp Tendon Injuries/
5. tendon injur*.mp.
6. exp Bursitis/
7. bursiti*.mp.
8. or/1-7
9. Rotator Cuff/
10. rotator cuff.mp.
11. supraspinatus.mp.
12. infraspinatus.mp.
13. teres minor.mp.
14. subscapularis.mp.
15. Shoulder/
16. shoulder*.mp.
17. or/9-16
18. 8 and 17
19. Shoulder Impingement Syndrome/
20. subacromial impingement syndrome*.mp.
21. shoulder impingement syndrome*.mp.
22. or/19-21
23. 18 or 22
24. exp Exercise/
25. exp Exercise Therapy/
26. exp Exercise Movement Techniques/
27. exercis*.mp.
28. exercise therap*.mp.
29. (pilates or yoga or tai chi or tai ji).mp.
30. (eccentric adj (exercis* or train*)).mp.
31. or/24-30
32. 23 and 31

EMBASE

1. exp tendinitis/
2. tendon*.mp.
3. tendin*.mp.
4. exp tendon injury/
5. tendon injur*.mp.
6. bursitis/
7. bursiti*.mp.
8. or/1-7
9. rotator cuff/
10. rotator cuff.mp.
11. supraspinatus.mp.
12. infraspinatus.mp.
13. teres minor.mp.
14. subscapularis.mp.
15. exp shoulder/
16. shoulder*.mp.
17. or/9-16
18. 8 and 17
19. exp rotator cuff injury/
20. rotator cuff injur*.mp.
21. subacromial impingement syndrome*.mp
22. shoulder impingement syndrome*.mp.
23. or/19-22
24. 18 or 23
25. exp exercise/
26. exp kinesiotherapy/
27. kinesiotherap*.mp.
28. exercis*.mp.
29. exercise therap*.mp.
30. (pilates or yoga or tai chi or tai ji).mp.
31. (eccentric adj (exercis* or train*)).mp.
32. or/25-30
33. 24 and 32

CINAHL

1. MH ("Tendinopathy+") OR (MH "Tendon Injuries+")
2. S2 tendin* or tendon* or tendon injur*
3. (MH "Bursitis") OR (MH "Periarthritis")
4. bursiti* OR periarthritis
5. MH "Shoulder Injuries"
6. shoulder injur*
7. S1 or S2 or S3 or S4 or S5 or S6
8. (MH "Rotator Cuff+")
9. Rotator Cuff
10. supraspinatus OR infraspinatus OR teres minor OR subscapularis
11. (MH "Shoulder")
12. shoulder
13. S8 or S9 or S10 or S11 or S12
14. (S8 or S9 or S10 or S11 or S12) and (S7 and S13)
15. (MH "Shoulder Impingement Syndrome")
16. (shoulder impingement syndrome) OR (subacromial impingement syndrome)
17. S15 or S16
18. S14 or S17
19. (MH "Exercise+")
20. (MH "Physical Activity")
21. (MH "Therapeutic Exercise+")
22. exercise OR pilates OR (exercise movement techni*)
23. (eccentric exercise) OR (eccentric train*)
24. yoga OR (tai chi)
25. S19 or S20 or S21 or S22 or S23 or S24
26. S14 and S25