GMR

The Original

ECCENTRIC EXERCISE VERSUS CLOSED CHAIN EXERCISE FOR PAIN AND RANGE OF MOTION IN ROTATOR CUFF TENDINOPATHY: A RANDOMIZED CONTROLLED TRIAL

D. Padmapriya[1], G. Mohanraj[2], T. Kishanth[3], B. Roshini[4], T. Aysha[5]

[1]Postgraduate student, School of Physiotherapy, Vinayaka Mission's Research Foundation (Deemed to be University), Aarupadai Veedu Medical College and Hospital Campus, Kirumampakkam, Puducherry 607 403, India. ORCID: 0009-0007-7656-3247, Email: riyadevanathan13@gmail.com
[2]Professor and Head, School of Physiotherapy, Vinayaka Mission's Research Foundation (Deemed to be University), Aarupadai Veedu Medical College and Hospital Campus, Kirumampakkam, Puducherry 607 403, India. ORCID: 0009-0001-2474-2880, Email: mohanraj.gopalakrishnan@avmc.edu.in
[3]Postgraduate student, School of Physiotherapy, Vinayaka Mission's Research Foundation (Deemed to be University), Aarupadai Veedu Medical College and Hospital Campus, Kirumampakkam, Puducherry 607 403, India. ORCID: 0009-0001-9908-4915, Email: kishanth2202@gmail.com
[4]Postgraduate student, School of Physiotherapy, Vinayaka Mission's Research Foundation (Deemed to be University), Aarupadai Veedu Medical College and Hospital Campus, Kirumampakkam, Puducherry 607 403, India. ORCID: 0009-0007-2522-5985, Email: roshininaidubabu@gmail.com
[5]Postgraduate student, School of Physiotherapy, Vinayaka Mission's Research Foundation (Deemed to be University), Aarupadai Veedu Medical College and Hospital Campus, Kirumampakkam, Puducherry 607 403, India. ORCID: 0009-0004-5888-0378, Email: ayshataj035@gmail.com

ABSTRACT

Rotator cuff tendinopathy is a leading cause of shoulder pain and disability, and loaded exercise is the accepted first-line conservative treatment; which loading mode is preferable remains unsettled. Eccentric loading is well supported for lower-limb tendinopathy, whereas closed kinetic chain loading is favoured for the joint stability it confers through reduced shear. This randomized controlled trial compared the two in patients with rotator cuff tendinopathy. Thirty adults aged 18 to 45 years with unilateral, clinically diagnosed rotator cuff tendinopathy were recruited from the physiotherapy outpatient department of a tertiary teaching hospital in Puducherry, India, and allocated by simple randomization to eccentric exercise (Group A, n = 15) or closed chain exercise (Group B, n = 15). Both groups also performed pectoralis minor and cross-body adduction stretches. Training was carried out on three alternate days each week for 12 weeks. Pain was measured with a visual analogue scale and active shoulder flexion, abduction, internal rotation and external rotation with a universal goniometer, at baseline and at 12 weeks. Both groups improved significantly on every outcome. Improvement was greater after eccentric exercise for pain, with a between-group difference in change of 1.13 points, and for flexion, abduction, internal rotation and external rotation, with between-group differences in change of 20.7, 30.0, 7.3 and 16.3 degrees respectively; all comparisons remained significant after correction for multiple testing, and analysis of covariance adjusting for baseline values reproduced the same pattern. Post-test scores alone did not separate the groups, and the between-group pain difference is close to the accepted minimal clinically important difference. Eccentric loading produced larger short-term gains than closed chain loading, but the trial was small, unblinded and unregistered, and the effect sizes should be regarded as provisional pending replication in adequately powered, blinded trials that also measure shoulder function.

KEYWORDS: Rotator cuff tendinopathy; Eccentric exercise; Closed kinetic chain exercise; Shoulder pain; Range of motion; Randomized controlled trial

INTRODUCTION

Shoulder pain ranks among the most frequent musculoskeletal complaints presenting to primary care, and its point prevalence in community surveys sits in the range of one in five adults (Urwin et al., 1998; Luime et al., 2004). Disorders of the rotator cuff account for the majority of these presentations. The condition is variously labelled rotator cuff tendinitis, rotator cuff tendinopathy, subacromial impingement syndrome or, more recently, rotator cuff related shoulder pain; the terminology has shifted as the underlying model has moved away from purely mechanical compression beneath the acromion. Its cardinal features are pain and weakness that are provoked most reliably by shoulder elevation and external rotation, together with restriction of active shoulder movement (Lewis et al., 2015).

Two explanatory models have historically competed. The extrinsic model, following Neer (1972), attributes tendon damage to irritation of the cuff against the overlying coracoacromial arch and, in its strong form, held that the great majority of cuff pathology arose this way. The intrinsic model instead locates the primary lesion in the tendon, where cumulative overload provokes changes in vascularity, collagen organization, proteoglycan content and cell phenotype, producing tendon thinning, fibre disorientation and fatty infiltration. Contemporary reviews regard the two as complementary rather than exclusive, and add environmental and lifestyle contributors to a multifactorial account (Lewis et al., 2015). Age above 50 years, diabetes mellitus and habitual overhead activity are the risk factors most consistently supported by pooled data (Leong et al., 2019).

Whatever the initiating mechanism, the tendon responds to mechanical loading, and loaded exercise is now the accepted first-line conservative treatment (Littlewood et al., 2012; Holmgren et al., 2012; Lewis et al., 2015). What remains contested is the mode of loading. Eccentric loading, in which the muscle-tendon unit lengthens under tension, transformed the management of Achilles and patellar tendinopathy and is thought to act by increasing tendon collagen synthesis, which peaks 24 to 72 h after loading, and by normalizing tendon structure (Murtaugh and Ihm, 2013; Camargo et al., 2014). Its transfer to the rotator cuff has been less clear-cut. Uncontrolled and pilot studies reported encouraging reductions in pain and gains in function (Jonsson et al., 2006; Bernhardsson et al., 2011; Camargo et al., 2012), but the controlled evidence has been equivocal: Maenhout et al. (2013) found added benefit only for isometric abduction strength, Dejaco et al. (2017) found isolated eccentric training beneficial but no better than a conventional programme, and the meta-analysis of Larsson et al. (2019) concluded that any advantage of eccentric over other exercise is small and probably not clinically important.

Closed kinetic chain exercise offers a different rationale. Fixing the distal segment reduces shear at the glenohumeral joint, increases joint compression and co-contraction, and is held to improve stability and delay fatigue. Heron et al. (2017), in the only substantial trial to isolate this variable, randomized 120 patients to open chain band exercise, closed chain loading or minimally loaded range of movement, and found all three reduced pain and disability with no significant difference between them. Head-to-head comparison of eccentric with closed chain loading, however, has not been reported, and the two modes are routinely offered as alternatives in Indian outpatient practice without evidence to guide the choice.

The aim of this trial was therefore to compare the effect of a 12-week eccentric exercise programme with a 12-week closed chain exercise programme, each combined with the same stretching, on pain and active shoulder range of motion in adults with rotator cuff tendinopathy. That aim was achieved: both programmes produced substantial within-group improvement, and eccentric loading produced the larger change on every outcome measured, although the magnitude of that advantage must be interpreted against the limitations set out below.

MATERIAL AND METHODS

Study design and setting

A two-arm, parallel-group randomized controlled trial with pre-test and post-test measurement was conducted in the outpatient physiotherapy department of Aarupadai Veedu Medical College and Hospital, Kirumampakkam, Puducherry, India. The protocol was approved by the Institutional Research Committee of the School of Physiotherapy, Vinayaka Mission's Research Foundation (SPT/IRC/2023/083, 9 May 2023) and the trial was conducted in accordance with the Declaration of Helsinki. Every participant gave written informed consent after reading a participant information sheet in English or Tamil. The trial was not prospectively registered.

Participants

Adults of either sex aged 18 to 45 years with unilateral shoulder pain and a clinical diagnosis of rotator cuff tendinopathy made by the treating physician were eligible. Participants were enrolled one week after their initial consultation. Exclusion criteria were cervical radiculopathy, cervical spondylosis, corticosteroid injection to the shoulder within the preceding three months, previous upper limb fracture or surgery, glenohumeral osteoarthritis, adhesive capsulitis, subacromial bursitis, and any neurological or cardiovascular disease. Thirty participants were enrolled; all 30 completed the 12-week programme and all were analysed.

Randomization and blinding

Participants were allocated 1:1 to Group A (eccentric exercise) or Group B (closed chain exercise) by simple randomization. Neither participants nor the treating physiotherapist could be blinded to the allocated exercise. Outcome assessment was not blinded, and the assessor also delivered the intervention.

Interventions

Both groups trained on three alternate days per week for 12 weeks, and both performed the same stretching component before the loading exercises: a doorway lunge stretch for pectoralis minor and a cross-body horizontal adduction stretch, each held for 60 s, for 3 sets of 8 repetitions.

Group A: eccentric exercise

Three exercises were performed, all emphasising the controlled lowering phase. First, standing with an elastic band anchored under the foot of the affected side, the participant used the unaffected hand to assist the arm to 90 degrees of elevation and then lowered it slowly to 0 degrees against the band, 3 sets of 7 to 10 repetitions. Second, in side lying with the elbow flexed to 90 degrees over a folded towel, the participant retracted the scapulae and lifted the weight, then lowered it under control, 3 sets of 5 to 7 repetitions. Third, in supine with the shoulder abducted to 90 degrees and the elbow flexed to 90 degrees, with an elastic band anchored to the homolateral foot, the arm was rotated outward and lowered slowly, 3 sets of 5 to 7 repetitions.

Group B: closed chain exercise

Three exercises were performed with the distal segment fixed. First, sitting upright and gripping the seat of a chair, the participant pressed down through the hands as though lifting the body from the chair, 6 to 8 repetitions. Second, in four-point kneeling with the knees beneath the hips and the hands beneath the shoulders, the participant flexed the elbows to lower the trunk toward the floor and then straightened them slowly, 8 to 10 repetitions, progressing to loading through the symptomatic arm alone. Third, standing at arm's length from a wall with the hands placed flat at shoulder height, the participant performed a wall press-up, 8 to 10 repetitions, again progressing to the symptomatic arm alone.

Outcome measures

Pain intensity was recorded on a 10 cm visual analogue scale anchored at no pain and worst possible pain. Active shoulder flexion, abduction, internal rotation and external rotation of the affected shoulder were measured in degrees with a universal goniometer using standardized landmarks; goniometry of the shoulder shows acceptable intra-rater reliability in the clinical setting (Riddle et al., 1987). All measurements were taken at baseline and after the final session of week 12. No outcome was designated a priori as primary, and no measure of shoulder function or health-related quality of life was collected.

Sample size

The sample size of 30 (15 per group) was fixed in advance for the comparison of two independent means at a two-sided alpha of 0.05 and 80% power, taking the between-group differences reported by Dejaco et al. (2017) as the reference. This calculation was not stratified by outcome and, given that five outcomes were subsequently analysed, the trial should be regarded as powered only to detect large effects.

Statistical analysis

Analyses were performed on the complete dataset of 30 participants. Categorical variables are summarized as frequencies and percentages, continuous variables as mean and standard deviation. Within-group change from baseline to week 12 was tested with the paired t-test, and confirmed with the Wilcoxon signed-rank test where the distribution of differences departed from normality on the Shapiro-Wilk test. The pre-specified between-group comparison was the Mann-Whitney U test; because the change scores were normally distributed and of homogeneous variance (Levene's test, all $P > 0.17$), the independent-samples t-test on change scores is reported alongside it as the primary between-group analysis, with Hedges-corrected Cohen's d as the effect size (Cohen, 1988). Because groups were not perfectly balanced at baseline, analysis of covariance with the baseline value as covariate was carried out as a sensitivity analysis. Comparison of post-test scores alone is also reported for transparency. A two-sided P value below 0.05 was taken as significant; with five outcomes, a Bonferroni-corrected threshold of $P < 0.010$ is additionally applied to the between-group comparisons. Analyses were run in Python 3 (SciPy 1.17, statsmodels).

RESULTS

Participant characteristics

Thirty participants were randomized and all completed the trial. The two groups were comparable in age and, on the outcome measures, at baseline with one exception: baseline external rotation was lower in Group A than in Group B (28.7 vs 41.0 degrees, $P = 0.042$), and baseline abduction and internal rotation were also numerically lower in Group A. Women outnumbered men in Group B, though not significantly so. Baseline characteristics are given in Table 1.

Table 1. Baseline characteristics of the two groups. Values are mean ± standard deviation unless stated otherwise. VAS, visual analogue scale; ROM, range of motion.

Characteristic	Group A (eccentric, n = 15)	Group B (closed chain, n = 15)	Test statistic	P
Age (years)	35.7 ± 6.0	36.9 ± 6.2	t = 0.54	0.593
Sex, male / female (n)	9 / 6	5 / 10	Fisher	0.272
VAS pain (0-10)	4.67 ± 1.23	4.73 ± 1.87	t = 0.12	0.909
Flexion ROM (degrees)	102.7 ± 31.1	108.3 ± 39.1	t = 0.44	0.664
Abduction ROM (degrees)	84.7 ± 22.5	99.7 ± 35.8	t = 1.37	0.180
Internal rotation ROM (degrees)	29.7 ± 11.1	37.0 ± 14.7	t = 1.54	0.135

Characteristic	Group A (eccentric, n = 15)	Group B (closed chain, n = 15)	Test statistic	P
External rotation ROM (degrees)	28.7 ± 13.7	41.0 ± 17.8	t = 2.13	0.042

Independent-samples t-test for continuous variables; Fisher's exact test for sex.

Within-group change

Both programmes produced statistically significant improvement in every outcome from baseline to week 12 (Table 2). In Group A, mean VAS pain fell by 2.73 points and active flexion, abduction, internal rotation and external rotation increased by 46.0, 59.3, 17.0 and 24.7 degrees respectively. In Group B the corresponding changes were 1.60 points and 25.3, 29.3, 9.7 and 8.3 degrees. All paired t-tests reached $P < 0.001$, and Wilcoxon signed-rank tests confirmed each result (all $P < 0.002$), including for VAS and for internal and external rotation in Group B, where the differences departed from normality. Mean VAS scores before and after the intervention are shown in Figure 1.

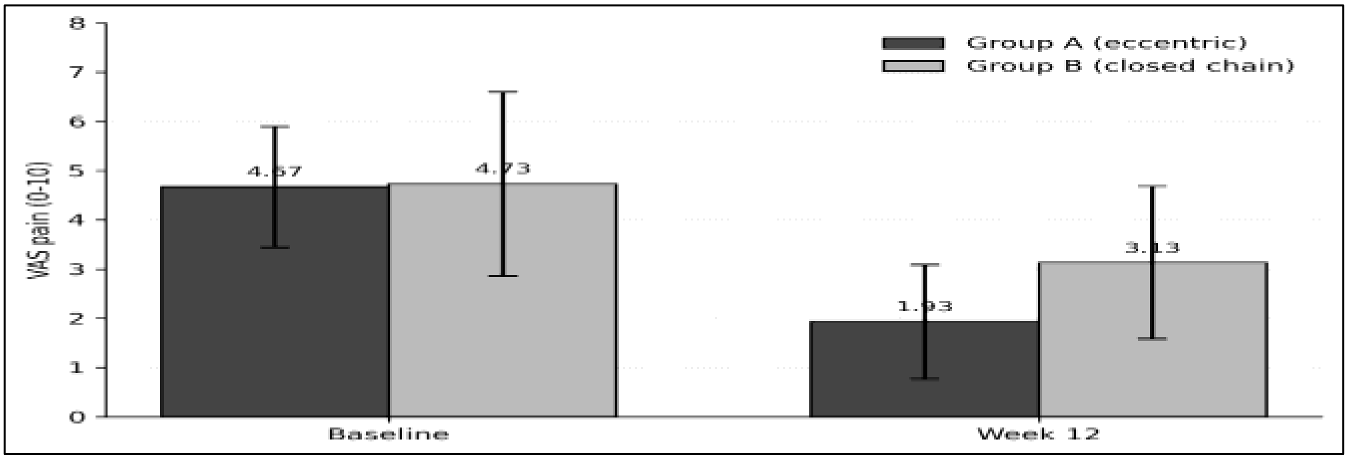

Figure 1. Visual analogue scale pain scores at baseline and at week 12 in the eccentric exercise group (Group A) and the closed chain exercise group (Group B). Bars are means; error bars are standard deviations.

Table 2. Within-group change from baseline to week 12. Values are mean ± standard deviation. MD, mean difference (post minus pre); d, standardized mean change.

Outcome	Group	Baseline	Week 12	MD	t (df = 14)	d
VAS pain (0-10)	A	4.67 ± 1.23	1.93 ± 1.16	-2.73 ± 0.70	15.04	3.88
	B	4.73 ± 1.87	3.13 ± 1.55	-1.60 ± 0.51	12.22	3.16
Flexion (degrees)	A	102.7 ± 31.1	148.7 ± 20.6	+46.0 ± 15.0	11.86	3.06
	B	108.3 ± 39.1	133.7 ± 31.9	+25.3 ± 10.1	9.73	2.51
Abduction (degrees)	A	84.7 ± 22.5	144.0 ± 19.5	+59.3 ± 17.4	13.20	3.41
	B	99.7 ± 35.8	129.0 ± 31.5	+29.3 ± 12.9	8.78	2.27
Internal rotation (degrees)	A	29.7 ± 11.1	46.7 ± 10.1	+17.0 ± 6.2	10.60	2.74

Outcome	Group	Baseline	Week 12	MD	t (df = 14)	d
	B	37.0 ± 14.7	46.7 ± 11.9	+9.7 ± 7.2	5.21	1.34
External rotation (degrees)	A	28.7 ± 13.7	53.3 ± 13.6	+24.7 ± 10.1	9.47	2.45
	B	41.0 ± 17.8	49.3 ± 13.4	+8.3 ± 6.5	5.00	1.29

All paired t-tests $P < 0.001$. Wilcoxon signed-rank test confirmed every comparison (all $P < 0.002$).

Between-group comparison

Comparison of change scores favoured eccentric exercise on all five outcomes (Table 3). Pain fell by a further 1.13 points in Group A (95% CI 0.67 to 1.59; $P = 0.000024$), and active flexion, abduction, internal rotation and external rotation gained a further 20.7, 30.0, 7.3 and 16.3 degrees respectively. Effect sizes were large for every outcome except internal rotation, where the effect was moderate to large ($d = 1.09$). Every comparison remained significant at the Bonferroni-corrected threshold of $P < 0.010$, and the pre-specified Mann-Whitney U test reproduced each result. Mean changes in range of motion are shown in Figure 2.

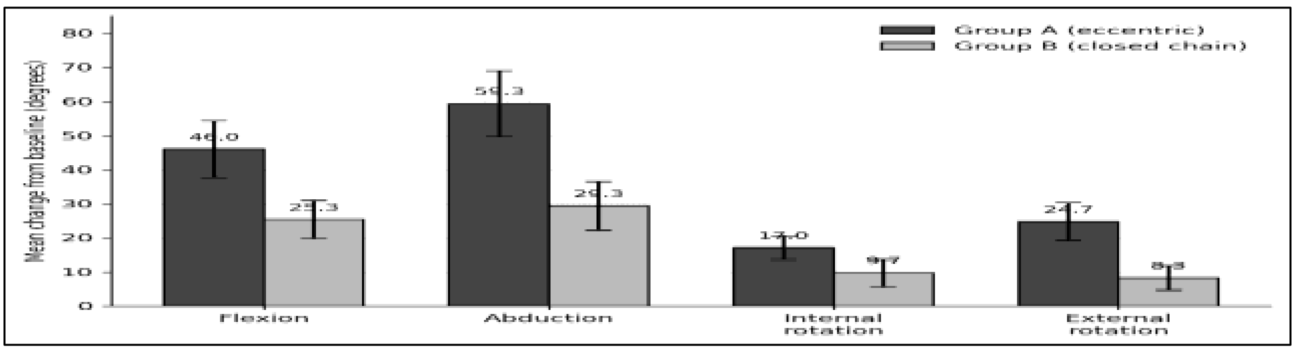

Figure 2. Mean change in active shoulder range of motion from baseline to week 12 in the eccentric exercise group (Group A) and the closed chain exercise group (Group B). Bars are mean changes; error bars are 95% confidence intervals.

Comparison of post-test scores alone gave a different picture. Only VAS pain differed significantly between the groups at week 12 (1.93 vs 3.13, $P = 0.024$); flexion (148.7 vs 133.7 degrees, $P = 0.137$), abduction (144.0 vs 129.0 degrees, $P = 0.128$), internal rotation (46.7 vs 46.7 degrees, $P = 1.000$) and external rotation (53.3 vs 49.3 degrees, $P = 0.423$) did not. This discrepancy is explained by the lower baseline range of motion in Group A: a larger gain from a lower starting point can leave the two groups at a similar end point. Analysis of covariance, which adjusts each week-12 score for its own baseline value, resolved the discrepancy in favour of the change-score analysis. The adjusted advantage of eccentric over closed chain exercise was 1.15 points of pain (95% CI 0.75 to 1.55; $P < 0.001$), 19.1 degrees of flexion (95% CI 12.8 to 25.4; $P < 0.001$), 26.3 degrees of abduction (95% CI 15.7 to 36.9; $P < 0.001$), 5.3 degrees of internal rotation (95% CI 0.8 to 9.8; $P = 0.023$) and 12.9 degrees of external rotation (95% CI 6.9 to 18.8; $P < 0.001$).

Table 3. Between-group comparison of change from baseline to week 12. MD, difference in mean change (Group A minus Group B); d, Cohen's d; U, Mann-Whitney U statistic.

Outcome	Change, Group A	Change, Group B	MD (95% CI)	d	t (df = 28)	P
VAS pain (0-10)	-2.73 ± 0.70	-1.60 ± 0.51	-1.13 (-1.59 to -0.67)	1.85	5.06	<0.001
Flexion (degrees)	+46.0 ± 15.0	+25.3 ± 10.1	20.7 (11.1 to 30.2)	1.62	4.42	<0.001
Abduction (degrees)	+59.3 ± 17.4	+29.3 ± 12.9	30.0 (18.5 to 41.5)	1.96	5.36	<0.001
Internal rotation (degrees)	+17.0 ± 6.2	+9.7 ± 7.2	7.3 (2.3 to 12.4)	1.09	2.99	0.006

Outcome	Change, Group A	Change, Group B	MD (95% CI)	d	t (df = 28)	P
External rotation (degrees)	+24.7 ± 10.1	+8.3 ± 6.5	16.3 (10.0 to 22.7)	1.93	5.28	<0.001

Mann-Whitney U test gave the same conclusions: VAS U = 27.0, $P < 0.001$; flexion U = 197.0, $P < 0.001$; abduction U = 203.5, $P < 0.001$; internal rotation U = 180.5, $P = 0.004$; external rotation U = 204.0, $P < 0.001$. All P values survive Bonferroni correction for five outcomes (threshold $P < 0.010$).

DISCUSSION

In this trial, 12 weeks of eccentric loading of the rotator cuff produced greater reductions in pain and greater gains in active shoulder range of motion than 12 weeks of closed chain loading, when both were added to the same stretching programme. The advantage was consistent across all five outcomes, survived correction for multiple testing, was reproduced by a non-parametric test, and persisted after adjustment for baseline imbalance. The mechanistic rationale is plausible. Eccentric loading imposes high tension on the lengthening muscle-tendon unit, and tendon collagen synthesis rises for one to three days afterwards; repeated exposure is thought to remodel the degenerate matrix and restore load tolerance (Murtaugh and Ihm, 2013; Camargo et al., 2014). Closed chain loading, by contrast, is designed to increase joint compression and reduce shear, which may improve stability and neuromuscular control without imposing the tensile stimulus that drives tendon adaptation.

The size of the advantage found here, however, sits uncomfortably with the best controlled evidence, and this discrepancy deserves emphasis rather than concealment. Dejaco et al. (2017) randomized 36 patients with rotator cuff tendinopathy to a 12-week isolated eccentric programme or a conventional programme and reported that eccentric training improved shoulder function and pain but was no more beneficial than the comparator. Larsson et al. (2019), pooling the available trials, concluded that eccentric exercise confers at most a small reduction in pain relative to other exercise, of doubtful clinical importance, on evidence of low certainty. Heron et al. (2017), who did compare closed chain loading directly against other loading modes in 120 patients, found no significant difference between groups on the Shoulder Pain and Disability Index. Maenhout et al. (2013) found that adding heavy-load eccentric training to conventional rehabilitation improved isometric abduction strength but not pain or self-reported function. Trials contrasting eccentric loading with concentric or with general shoulder exercise have likewise found the modes broadly equivalent for pain and self-reported function (Blume et al., 2015; Chaconas et al., 2017). Against this background, an advantage of 30 degrees of abduction and 1.13 points of pain is larger than the literature would predict, and the most economical explanation is that features of the present design inflated it.

Several such features are identifiable. Neither participants, therapist nor assessor was blinded, and the same investigator delivered the intervention and measured the outcomes; goniometry of active range of motion is effort-dependent and therefore particularly vulnerable to this. Allocation was by simple randomization without concealment, and baseline external rotation differed significantly between the groups, which is itself evidence that concealment was imperfect or that chance imbalance occurred in a sample this small. No outcome was pre-specified as primary and the trial was not registered, so the analysis reported here cannot be distinguished from one selected after inspecting the data. Finally, the between-group difference in pain, though highly significant, is 1.13 points on a 10-point scale, close to and possibly below the minimal clinically important difference conventionally cited for the visual analogue scale in musculoskeletal pain; statistical significance and clinical importance are not the same claim, and only the first is established here.

The between-group difference in range of motion, by contrast, is large enough that measurement bias alone is an uneasy explanation, and it is compatible with the observation that eccentric loading increases fascicle length and passive tissue extensibility. It is also worth noting that Group A began with less range of motion, and regression to the mean will have contributed to its larger apparent gain; the analysis of covariance addresses this in part but cannot eliminate it. That the two groups finished at statistically indistinguishable post-test values on three of the four range-of-motion outcomes is a result that a reader should weigh alongside the change scores, and it is reported here for that reason.

The trial has further limitations. It measured only pain and active range of motion, and no validated measure of shoulder function, such as the Constant-Murley score, the Shoulder Pain and Disability Index or the Western Ontario Rotator Cuff Index, was collected; since function is what matters to patients, the clinical significance of the present findings cannot be judged. Passive range of motion, muscle strength, girth and endurance were not assessed. The sample was small, drawn from a single centre, and restricted to adults aged 18 to 45 years, whereas rotator cuff tendinopathy is most prevalent above 50 years (Leong et al., 2019); the findings therefore do not generalize to the age group most often affected. Diagnosis rested on clinical assessment without confirmatory imaging or a standardized battery of special tests. There was no follow-up beyond the end of the intervention, so nothing can be said about durability, and no untreated or placebo arm, so the within-group improvements cannot be separated from natural history and regression to the mean.

The clinical inference that survives these caveats is modest but not empty. Both loading strategies produced large within-group improvements over 12 weeks, consistent with the broader finding that the type of exercise matters less than the fact of loading (Heron et al., 2017; Larsson et al., 2019). Where a clinician must choose, the present data provide preliminary support for eccentric loading, and no evidence that it is harmful or poorly tolerated. What is needed is an adequately powered, prospectively registered trial with concealed allocation and a blinded assessor, a pre-specified primary outcome that includes shoulder function, participants across the full age range at risk, and follow-up of at least six months. Until such a trial is done, the effect sizes reported here should be treated as hypothesis-generating.

CONCLUSION

Twelve weeks of eccentric exercise and 12 weeks of closed chain exercise, each combined with stretching, both substantially reduced pain and improved active shoulder range of motion in adults with rotator cuff tendinopathy. Improvement was significantly greater with eccentric exercise on every outcome, including after adjustment for baseline differences and correction for multiple testing. Because the trial was small, unblinded, unregistered and confined to patients aged 18 to 45 years, and because the between-group difference in pain approximates the minimal clinically important difference, these results should be interpreted as preliminary and require confirmation in a blinded trial that also measures shoulder function.

ACKNOWLEDGMENTS

The authors thank the Director of the School of Physiotherapy, Dr. K.S.I. Murali Sankar, and the staff of the Department of Physiotherapy, Aarupadai Veedu Medical College and Hospital, for institutional support, and the members of the Institutional Research Committee for their review of the protocol. The authors thank all participants who gave their time to this study. All named individuals have agreed to be acknowledged.

Conflicts of interest

The authors declare that they have no financial, personal or professional interests that could be construed to have influenced this study.

Ethics Approval: Institutional Research Committee, School of Physiotherapy, Vinayaka Mission's Research Foundation, Puducherry (reference SPT/IRC/2023/083, 9 May 2023). Written informed consent was obtained from every participant in English or Tamil.

REFERENCES

1. Bernhardsson S, Klintberg IH and Wendt GK (2011). Evaluation of an exercise concept focusing on eccentric strength training of the rotator cuff for patients with subacromial impingement syndrome. *Clin. Rehabil.* 25: 69-78.
2. Blume C, Wang-Price S, Trudelle-Jackson E and Ortiz A (2015). Comparison of eccentric and concentric exercise interventions in adults with subacromial impingement syndrome. *Int. J. Sports Phys. Ther.* 10: 441-455.
3. Camargo PR, Alburquerque-Sendin F and Salvini TF (2014). Eccentric training as a new approach for rotator cuff tendinopathy: review and perspectives. *World J. Orthop.* 5: 634-644.
4. Camargo PR, Avila MA, Alburquerque-Sendin F, Asso NA, et al. (2012). Eccentric training for shoulder abductors improves pain, function and isokinetic performance in subjects with shoulder impingement syndrome: a case series. *Rev. Bras. Fisioter.* 16: 74-83.
5. Chaconas EJ, Kolber MJ, Hanney WJ, Daugherty ML, et al. (2017). Shoulder external rotator eccentric training versus general shoulder exercise for subacromial pain syndrome: a randomized controlled trial. *Int. J. Sports Phys. Ther.* 12: 1121-1133.
6. Cohen J (1988). Statistical power analysis for the behavioral sciences. 2nd edn. Lawrence Erlbaum Associates, Hillsdale.
7. Dejaco B, Habets B, van Loon C, van Grinsven S, et al. (2017). Eccentric versus conventional exercise therapy in patients with rotator cuff tendinopathy: a randomized, single blinded, clinical trial. *Knee Surg. Sports Traumatol. Arthrosc.* 25: 2051-2059.
8. Heron SR, Woby SR and Thompson DP (2017). Comparison of three types of exercise in the treatment of rotator cuff tendinopathy/shoulder impingement syndrome: a randomized controlled trial. *Physiotherapy* 103: 167-173.
9. Holmgren T, Bjornsson Hallgren H, Oberg B, Adolfsson L, et al. (2012). Effect of specific exercise strategy on need for surgery in patients with subacromial impingement syndrome: randomised controlled study. *BMJ* 344: e787.
10. Jonsson P, Wahlstrom P, Ohberg L and Alfredson H (2006). Eccentric training in chronic painful impingement syndrome of the shoulder: results of a pilot study. *Knee Surg. Sports Traumatol. Arthrosc.* 14: 76-81.
11. Larsson R, Bernhardsson S and Nordeman L (2019). Effects of eccentric exercise in patients with subacromial impingement syndrome: a systematic review and meta-analysis. *BMC Musculoskelet. Disord.* 20: 446.
12. Leong HT, Fu SC, He X, Oh JH, et al. (2019). Risk factors for rotator cuff tendinopathy: a systematic review and meta-analysis. *J. Rehabil. Med.* 51: 627-637.
13. Lewis J, McCreesh K, Roy JS and Ginn K (2015). Rotator cuff tendinopathy: navigating the diagnosis-management conundrum. *J. Orthop. Sports Phys. Ther.* 45: 923-937.
14. Littlewood C, Ashton J, Chance-Larsen K, May S, et al. (2012). Exercise for rotator cuff tendinopathy: a systematic review. *Physiotherapy* 98: 101-109.
15. Luime JJ, Koes BW, Hendriksen IJ, Burdorf A, et al. (2004). Prevalence and incidence of shoulder pain in the general population: a systematic review. *Scand. J. Rheumatol.* 33: 73-81.

16. Maenhout AG, Mahieu NN, De Muynck M, De Wilde LF, et al. (2013). Does adding heavy load eccentric training to rehabilitation of patients with unilateral subacromial impingement result in better outcome? A randomized, clinical trial. *Knee Surg. Sports Traumatol. Arthrosc.* 21: 1158-1167.
17. Murtaugh B and Ihm JM (2013). Eccentric training for the treatment of tendinopathies. *Curr. Sports Med. Rep.* 12: 175-182.
18. Neer CS (1972). Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. *J. Bone Joint Surg. Am.* 54: 41-50.
19. Riddle DL, Rothstein JM and Lamb RL (1987). Goniometric reliability in a clinical setting: shoulder measurements. *Phys. Ther.* 67: 668-673.
20. Urwin M, Symmons D, Allison T, Brammah T, et al. (1998). Estimating the burden of musculoskeletal disorders in the community: the comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. *Ann. Rheum. Dis.* 57: 649-655.