2015

Efficacy of utilizing an eccentric-based exercise program in the treatment of subacromial impingement syndrome

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CRITICALLY APPRAISED TOPIC

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Clinical Scenario: The patient who led me to pursue this question is a 35 y/o female with a diagnosis of Subacromial Impingement Syndrome. Medical treatment to date has included: (1) physical therapy involving joint mobilizations, range of motion treatment (passive range of motion, active range of motion, and active-assisted range of motion), rhythmic stabilization exercises, rotator cuff strengthening exercises, neuromuscular coordination and periscapular exercises; (2) use of oral prednisone over a 9 day period as prescribed by a primary care physician and (3) local injection of corticosteroids. Problems identified (or physical therapy [PT] diagnosis) include range of motion impairments in all planes, deficits in neuromuscular coordination of periscapular musculature and deficits in rotator cuff strength, leading to an inability to tolerate any overhead activity.

Brief introduction: For the purposes of my clinical question, I want to know the efficacy of an eccentric exercise program on patients with subacromial impingement syndrome. The use of eccentrics has been studied and utilized in my current clinical setting for other tendinopathies at the ankle and elbow. However, the introduction of eccentrics is often limited or introduced late in the rehabilitation process for shoulder related tendinopathies. I want to know if emphasizing eccentrics when building therapeutic exercise programs is more effective than traditional exercise programs in the treatment of subacromial impingement syndromes.

My Clinical question: Is the utilization of eccentric therapeutic exercise in the treatment of subacromial impingement syndrome more effective than the use of traditional therapeutic exercise at decreasing symptoms and increasing overall function?

Clinical Question PICO:

Population - Individuals diagnosed with subacromial impingement syndrome [SIS]

Intervention - Eccentric Exercise Program

Comparison - Traditional Therapeutic Exercise

Outcome - Pain Visual Analogue Scale [VAS] scores, Shoulder Pathology and Disability Index [SPADI], Disability of the Arm, Shoulder and Hand [DASH], Self-reported Activities of Daily Living [ADL] abilities, Strength, and Range Of Motion [ROM]

Overall Clinical Bottom Line: Analysis of the findings in these four articles suggests that utilizing an eccentric-based exercise program may provide some additional benefits when compared to more traditional exercise programs. These benefits include improvements in patient function (as measured by the SPADI, DASH, and Constant-Murley Shoulder Assessment), improvement in pain at night, and slight increases in strength at certain positions of shoulder abduction. There appears to be some disagreement as to whether using an eccentric-based exercise program can serve as a viable alternative to surgery. However, the studies with the stronger methods and subject population (Holmgren et al and Maenhout et al) seem to agree that an eccentric program can indeed serve as an alternative to surgical intervention. It is difficult to determine if eccentric-based programs are any more effective as an alternative to surgery than traditional therapeutic exercise programs as only two of the studies compared an eccentric-based program directly to a more traditional program.. Also noteworthy is the fact that all of the exercise programs varied between the studies for both the traditional and eccentric-based groups and this must be taken into consideration when comparing the findings. Neither Jonsson et al nor Camargo et al had particularly strong internal validity making their results even more difficult to apply to the original clinical question. Overall, given that the use of an eccentric-based therapeutic exercise program delivers similar efficacy in most outcome measures but shows some additional improvements in shoulder strength, nighttime pain, and function it is worth considering adding into treatment plans of subacromial impingement syndrome, and may serve as a viable alternative to surgery. This is especially true considering the feasibility and cost of introducing such a program would not be any greater than traditional programs already being utilized. Further considerations and merits are discussed in the synthesis and discussion section.

Search Terms: Eccentrics, Therapeutic Exercise, Physical Therapy, Shoulder, Tendinopathy, Rehabilitation, Rotator Cuff, Impingement

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Rationale for chosen articles

(1) Holmgren T, Hallgren H, Oberg B. Effect of specific exercise strategy on need for surgery in patients with subacromial impingement syndrome: randomised control trial. *British Medical Journal* 2012; pg 344-353.

PEDro Score 7/10 (Evaluated by critically appraised topic [CAT] author Ricky Pitman)

Population: 102 patients recruited through orthopedic specialists with persistent subacromial impingement syndrome and a history of previously failed conservative therapy

Intervention: Eccentric exercises for the rotator cuff, concentric/eccentric exercise program for the scapular stabilizers, and manual mobilization

Comparison: Non-specific movement exercises for the neck and shoulder

Outcome measures: Constant-Murley shoulder assessment scores, (for shoulder function and pain), decision regarding surgery, and global impression of change per patient report

Rationale for article: The investigators specifically analyzed the use of an exercise regimen for treatment of subacromial impingement syndrome which included eccentrics. While the intervention group did not receive specifically an eccentric-only exercise program, the investigators did compare a therapeutic exercise protocol which included eccentric exercises to a protocol that did not utilize eccentrics at all. Further, all of the subjects in this study had received prior conservative treatment which had failed. This means that many of the subjects may have received a generalized therapeutic exercise regimen as a treatment plan previously. Differences found at follow up may present as potential evidence for or against the use of eccentrics in a therapeutic exercise routine for the treatment of SIS. Given that eccentric-heavy therapeutic exercises are not a consensus treatment for SIS, this quality of the patient population is clinically relevant for cases where previous conservative treatment of SIS has proven ineffective. Finally this study included a large enough patient population to protect against type 1 and 2 errors (as determined via a power analysis by the investigators). It had adequate blinding, quality allocation, appropriate statistical analysis, and relevant outcome measures. All of the aforementioned factors provide pertinent information in answering the question regarding the efficacy of eccentric exercises in the treatment of SIS.

(2) Maenhout AG, Mahieu NN, Muynck MD. 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* 2012; pg 1158-1167.

PEDro Score 6/10 (Evaluated by CAT author Ricky Pitman)

Population: 61 patients diagnosed with subacromial impingement

Intervention: Heavy load eccentric training combined with traditional rotator cuff exercise and training

Comparison: Traditional rotator cuff exercises and training only

Outcome measures: Isometric strength at 0, 45, and 90 degrees of abduction; SPADI, and rated perception of improvement

Rationale for article: The investigator question for this article is nearly identical to the original clinical question asked at the beginning of this CAT, specifically comparing eccentric exercise protocols to traditional, non-eccentric heavy treatment protocols for individuals with SIS. Power analysis by the authors determined that sample size was large enough to protect against type 1 & 2 errors, an appropriate statistical analysis was utilized, valid and appropriate outcome measures were used, and adequate methods utilized. While this study design presents with some limitations including the ambiguity about concealed allocation and lack of blinding, the findings of this study will certainly add value to the assessment of the efficacy of eccentric-heavy therapeutic exercise in the treatment of SIS.

(3) Jonsson P, Wahlstrom P, Ohberg L, Alfredson H. Eccentric Training in Chronic Painful Impingement Syndrome of the Shoulder: Results of a Pilot Study. *Knee Surg Sports Traumatol Arthrosc* 2006; pg 76-81.

PEDro Score 1/10 (Evaluated by CAT author Ricky Pitman)

Population: 9 patients diagnosed with subacromial impingement syndrome on a waiting list for surgical intervention (mean 41 months of symptoms, 6 with previously failed exercise treatments)

Intervention: Specifically designed painful eccentric training program for the supraspinatus and deltoid muscles.

Comparison: No comparison group, outcomes of intervention assessed only. However, 6 of 9 patients had previously received a failed non-eccentric exercise training regimen for an unspecified amount of time, 8 of 9 with subacromial cortisone injections with no relief.

Outcome measures: Patient satisfaction, VAS scores, need for surgery

Rationale for article: I first must state that literature is limited regarding the efficacy of eccentric-based therapeutic exercise protocols for treatment of SIS, and even more so for studies which specifically compare an eccentric program to traditional physical therapy. This led me to accept a pilot study, of which the information may be useful but knowingly will not weigh the conclusions beyond their merits. The PEDro score of 1/10 does not paint the entire picture of what these study results may mean for the efficacy of eccentric-based treatment for SIS, but it is important to note the significant limitations of this study design; no comparison group which inevitably leads to no blinding, allocation, or randomness. This pilot study is also limited by a small sample size of 9. Worth noting however is that 6 of the 9 patients in this study had received prior conservative therapy consisting of non-eccentric specific exercise programs and the outcomes of those patients could prove interesting. While it was impossible to tell which patients were the ones which had prior conservative treatment it does add some potential value to the results, albeit with some glaring concerns. From these results, It would not be possible to glean the effectiveness of eccentric-based treatment in comparison to general physical therapy, but rather to determine whether or not eccentric-based treatment is or is not effective in general.

(4) Camargo PR, Avila MA, Alburqueque-Sendin F. Eccentric training for shoulder abductors improves pain, function and isokinetic performance in subjects with shoulder impingement syndrome - a case series. *Revista Brasileira de Fisioterapia* 2012; pg 74-83.

PEDro Score 3/10

Population: Twenty subjects with unilateral subacromial impingement syndrome

Intervention: Eccentric training program for the shoulder in all four planes of movement

Comparison: Baseline scores: two baseline scores were taken 4 weeks apart to assess potential improvement without intervention. Results compared to unaffected side as well

Outcome measures: Disabilities of the Arm, Shoulder, and Hand (DASH) Questionnaire, Peak Torque, Total Work and Acceleration Times in concentric and eccentric phases of motion at 60 and 180 degrees per second angular velocities.

Rationale for article: While the PEDro score is only 3/10 for this article, the results of this study can still potentially give some information about the general efficacy of eccentrics in the treatment of SIS. The PEDro score suffers greatly from the lack of a comparison group. These investigators instead took baseline measurements over time to see how no treatment compared to the use of eccentrics, utilizing subjects as their own control. While the investigation of this study doesn't exactly align with the original clinical question, relevant information is still concluded. The outcome measures for this study are appropriate and detailed, minimal subjects needed was calculated and met, and the statistical measures used to compare to baseline data were appropriate. For the type of study design utilized, I am comfortable accepting the methods used by the investigators in this particular study with the aforementioned caveats and considerations for weighing the results in regards to my clinical question.

Table 0. Comparison of PEDro Scores

	Holmgren et al	Maenhout et al.	Jonsson et al.	Camargo et al
Random	Y	Y	N	N
Concealed allocation	Y	N	N	N
Baseline comparability	Y	Y	N	Y
Blind Subjects	N	N	N	N
Blind Therapists	N	N	N	N
Blind Assessors	Y	N	N	N
Adequate Follow-up	Y	Y	Y	Y
Intention-to-Treat	N	Y	N	N
Between Group	Y	Y	N	N
Point Estimates & Variability	Y	Y	N	Y
Total Score	7/10	6/10	1/10	3/10

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Article: Holmgren T, Hallgren H, Oberg B. Effect of specific exercise strategy on need for surgery in patients with subacromial impingement syndrome: randomised control trial. *British Medical Journal* 2012; pg 344-353

Clinical Bottom Line:

102 patients awaiting surgery with subacromial impingement syndrome randomly received nonspecific active range of motion exercises for the neck and shoulder or a specific eccentric program for the rotator cuff plus concentric/eccentric exercises for the periscapular musculature. The use of the specific exercise protocol was more effective than non-progressive/unloaded active range of motion exercises at relieving nighttime pain (20 [95% CI: 19-28] point mean difference between groups) and improving Constant-Murley shoulder assessment (15 point [95% CI: 8.5-20.6] mean difference between groups) and Disabilities of Shoulder Arm and Hand scores (8 point [95% CI: 2.3-13.7] mean difference between groups) after 3 months of treatment. No significant difference was observed between the treatments for pain at rest or during activity. The MCID was met for the Disabilities of Hand and Shoulder score (Minimal Clinically Important Difference [MCID] 10.2), VAS during activity and VAS at night (MCID 11) after 3 months in the specific exercise group, while the control group failed to meet the MCID in the Disabilities of Hand and Shoulder Assessment. Neither group met the MCID for VAS pain during rest. Further, the eccentric exercise protocol resulted in less need for surgery after three months of treatment. No substantial threats to internal validity were noted, as the assessors recording the outcome measure were blinded to the treatment the subjects received. However, only one physiotherapist conducted the treatment of all patients and was not blinded to the treatment being provided, resulting in a minor threat to both internal and external validity. Further minor threats to consider include the lack of a true control group and lack of subject blinding. This coupled with subjects having control over their outcome is potentially concerning.

Article PICO:

Population: 102 patients recruited through orthopedic specialists with persistent subacromial impingement syndrome and a history of previously failed conservative therapy

Intervention: Eccentric exercises for the rotator cuff, concentric/eccentric exercise program for the scapular stabilizers, and manual mobilization

Comparison: Unspecific movement exercises for the neck and shoulder

Outcome measures: Constant-Murley shoulder assessment scores, (for shoulder function and pain), Disabilities of Hand and Shoulder score, Pain VAS at night and during activity/rest, decision regarding surgery, and global impression of change per patient report

Blinding: It can be difficult to blind subjects to the treatment they receive, and as such the subjects in this study were aware of the treatment they were receiving. Further, the therapists were aware of the treatment they were giving to the subjects. The assessors in this study were blinded however. In this study model, an equal number of each treatment option (unspecific exercises for the neck/shoulder and the specific exercise group) were concealed in envelopes, mixed by hand and then numbered. The orthopedic specialist that measured the outcome variables then paired the measurements to the number and was unaware of which treatment was administered by the physiotherapist. In addition, baseline measurements were taken prior to allocation.

Controls: The control group in this study received unspecific exercises for the neck and shoulder. These exercises included six movement exercises for the neck and shoulder and had no external load. Movements included shoulder abduction, retraction and elevation in combination with neck retraction and stretching of the pectoralis minor and upper trapezius muscles. Each exercise was done in sets of 10 repetitions twice daily, while the stretching was done in sets of 3 repetitions twice daily. Most of these exercises were done as part of an independent home exercise program. However, the control subjects were under supervision of a physiotherapist once every other week. Since these exercises were not loaded, no progression was implemented throughout the study period. Since these exercises were not progressed or prescribed/customized based on the patient's impairments, it seems likely that these exercises would probably have a limited effect on patients with SIS. This may make it a good control when comparing whether or not a specific exercise program is effective in general, but does not align perfectly with my original clinical question which was seeking to compare the use of eccentrics to "traditional therapeutic exercise programs" that already have some baseline efficacy at treating SIS. A typical therapeutic exercise program would include individualization of exercises and ultimately loaded progression via resistance tubing, free weights, or closed chain/body weight. However, I recognize that it would be difficult to create such a control without having other confounds. While the control is appropriate for the specific research question, the alignment with my clinical question is not perfect and this will be taken into account when assessing the findings of this study. It should be noted that all subjects received a subacromial corticosteroid injection and this may have an impact on end-study and follow-up differences.

Randomization: The authors of this study chose to control randomization so that each treatment group would receive an equal number of subjects by preparing sealed envelopes to be given to the physiotherapists to determine which type of treatment to give to the incoming subject. A third person who did not take outcome measurements then recorded the corresponding ID number to the treatment received to allow for blinding of the outcome assessors. There were no differences in the outcome variables at baseline between the groups, and the only difference noted by the authors was the presence of more males in the specific exercise group. Overall, the randomization between the group was successful.

Study: This randomized controlled trial included 102 patients aged 30-65 with a primary diagnosis of SIS, on a waiting list for surgical intervention. Patients were recruited between 2008 and 2010 at a University Hospital in Linkoping, Sweden. Inclusionary criteria consisted of complaints of pain in the proximal lateral aspect of the upper arm, six month duration of symptoms and a lack of response to various (unspecified by the authors) conservative treatment for at least three months. Further, subjects must have tested positive with the Hawkins-Kennedy, lateral Jobe, and Patte's maneuver special tests. In addition, subjects needed to test positive during the Neer's impingement test (1mL injection of 20mg/mL triamcinolon mixed with 6mL of 10 mg/mL mepivacain). Exclusionary criteria included any radiologically verified malignancy, osetoarthritis of the glenerohumeral joint, os acromial bony deformation, acromioclavicular arthritis, history of fracture or surgery in the shoulder, polyarthritis, rhuematiod arthritis, fibromyalgia, shoulder joint instability, adhesive capsulitis, or cervical spine symptoms. Subjects also needed to understand written and spoken Swedish. Subjects were randomly allocated into either a specific or non-specific exercise group. All patients received a subacromial corticosteroid injection prior to further treatment by a physiotherapist. Patients in the non-specific exercise group received movement exercises for the shoulder and neck as described previously in the controls section of this paper. The specific exercise group focused on two eccentric exercises for the rotator cuff, three concentric/eccentrics for periscapular musculature, and a posterior shoulder stretch. All exercises were repeated 15 times in three sets twice daily for eight weeks. The posterior shoulder stretch was performed for 30-60 seconds and repeated three times twice daily. Beyond eight weeks, the exercises and stretch were repeated once daily. The program was individualized with regard to progression of external load under supervision of a physiotherapist, assessed once every other week. Subjects were instructed to not exceed 5/10 pain levels when performing the exercises. In some cases, the therapist would manually stretch the posterior shoulder capsule and pectoralis minor as appropriate. Following the 12 week rehabilitation period, the subjects were instructed to continue independently with the home exercise program for another two months.

Outcome measures: Each measure was taken prior to treatment and at three months (the end of treatment). Of note is that no six month follow up was recorded in this study. This study used the Constant-Murley shoulder assessment score [CMS], which utilizes objective range of motion and strength measurements and subjective pain assessment, work load, and participation in leisurely activities summarized into a score between 0 and 100 (higher scores are more favorable). Another questionnaire, the Disability of the Arm Shoulder and Hand [DASH] questionnaire was used to measure disability and function of the upper extremity, scored between 0 and 100 with lower scores being more favorable. Pain levels were measured using the Visual Analogue Scale [VAS] during activity and rest. Finally, decision regarding surgery was also used as a measure of success for the treatment. All of these outcomes are equally relevant to the original clinical question. While the authors did not cite specific reliabilities for each measure, it is documented in the literature that the DASH ($r = 0.90$ test-retest reliability) and VAS ($r = 0.94$ in literate patients, $r = 0.71$ in illiterate patients) questionnaires are valid and reliable measures for what each measure respectively assesses[1,2]. The

authors reported no validity or reliability data for the Constant-Murley shoulder assessment score. Previous investigation however suggests the reliability of the CMS can be dependent on the experience of the observer and can be improved with further standardization of some of the items[3]. Further, it appears in the current literature that the CMS has a reliability ranging anywhere for poor to excellent.[4] The authors fail to mention MCIDs for any of their outcome measures used. Review of the literature reveals an MCID of 10.2 for the DASH[5], and 11 points for the VAS[4]. No MCID for the CMS could be found with review of current literature.

Study losses: 102 patients were eligible for inclusion in this study. Of these 102 subjects, 97 completed the entire 3 month rehabilitation protocols (95.1%). All 5 of these lost subjects were excluded by three weeks; two developed adhesive capsulitis and three patients changed their mind about participating in the study. It is doubtful that either intervention led to the development of adhesive capsulitis (1 subject developed the condition in each group). Further, the other 3 patients opted out of the study at the first physiotherapy visit. No Intention to treat analysis was done, and all subjects were measured in the group they were randomly assigned to.

Summary of internal validity: The overall internal validity of this study is good. The investigators utilized an effective randomization protocol that was successful (no differences between the groups at baseline). Further, the investigators implemented blinding for the assessors. Appropriate outcome measures were used, several of which are valid and reliable according to current literature, and others are potentially useful from a clinical standpoint (e.g. decision for surgery). While the authors were unable to blind the patients and physiotherapists to the treatment they were receiving or administering, this is a minor threat to internal validity since the individuals measuring the outcomes were blinded to treatment.

Evidence: Table 1 below illustrates the relevant outcome measures at baseline and 3 month follow up.

Table 1. Outcome measure data

	Baseline		3 Month Follow-Up	
	Specific Exercise (SD)	Control(SD)	Specific Exercise (SD)	Control (SD)
CMS*	48.5 (15)	43.5 (15)	72.5 (19)	52.5 (23)
DASH**	30.0 (14)	35.0 (19)	16.0 (15)	29.0 (19)
VAS Rest**	15.0 (19)	20.0 (21)	10.0 (14)	20.0 (25)
VAS Activity**	61.0 (22)	66.0 (20)	25.0 (26)	41.0 (27)
VAS Night**	46.0 (28)	40.0 (30)	15.0 (22)	27.0 (27)

Table 1. Showing the Constant-Murley Score [CMS], Disability of Arm and Shoulder Score [DASH], and Visual Analogue Scale for pain [VAS] at rest, during activity, and at night. Note:* denotes higher scores are desirable; ** denotes lower scores are desirable. CMS and DASH are in point values defined on the respective questionnaires while VAS is measured in millimeters.

The specific exercise group demonstrated a statistically significant improvement in the CMS while the control group did not. DASH scores were significantly improved in the specific exercise group and also met the aforementioned MCID of 10.2 points while DASH score changes in the control group were not significant nor met the MCID. MCID values for the VAS scores were met in both the control and specific exercise group for pain during activity and at night while the MCID was not met for pain at rest.

Table 2 below illustrates the mean change from baseline to the 3 month follow up for the specific exercise group and control group. Further, this table displays the differences in mean change between the groups.

Table 2. Mean change and difference between groups for outcome measures

	Mean Change		Difference between Groups
	Specific Exercise	Control	
CMS	24.0	9.0	15.0
DASH	14.0	6.0	8.0
VAS Rest	4.1	-5.0	-5.4
VAS Activity	36.0	25.0	-10.6
VAS Night	32.0	12.0	-20.0

Table 2. Showing the mean change and difference between groups for the Constant-Murley Score [CMS], Disability of Arm and Shoulder Score [DASH], and Visual Analogue Scale for pain [VAS] at rest, during activity, and at night. CMS and DASH are in point values defined on the respective questionnaires while VAS is measured in millimeters.

These data were calculated by the investigators. Of note is a discrepancy in VAS at rest, with the author reporting the mean VAS at rest to be 20 at baseline and 20 at 3 month following up in the control groups, and then subsequently reporting a mean change of -5.

In summary, the authors concluded the specific exercise group to have significant improvements in the mean score compared to the control group in CMS, DASH, and VAS at night. No significant differences were found in mean changes from baseline to 3 month follow up between the specific exercise and control group in VAS at rest and during activity.

Applicability of study results:

Benefits vs. Costs: Implementing this specific exercise protocol would not take any more resources than the control group, as the supervision of a physiotherapist was required with both methods. No extra equipment is necessary to implement the more effective exercise group, and thus the benefits obtained from utilizing this specific protocol with similar cost conclude the cost/benefit to be favorable.

Feasibility of treatment: This specific protocol used in the study could be implemented in a therapy setting. The procedures within the specific exercise group were described well enough to reproduce in the clinic. All equipment and expertise necessary to implement the treatment would be found in a traditional physical therapy clinic, and the treatment does not take any more time than traditional interventions for SIS. Treatment session times utilized in the specific exercise protocol were similar to traditional treatment session lengths and within normal allowable periods for insurance reimbursement. Finally, with only 5 dropouts, it can be concluded that the specific exercise protocol does not seem to present a concern for adherence, despite the dependence of the treatment on home exercise program compliance. No pain levels were reported during treatment, however and the patient's tolerance for treatment needs to be considered when selecting an appropriate intervention.

Summary of external validity: Overall the external validity of this study is fair. One physiotherapist implemented the treatments, and concern exists that the significant changes may have resulted from the skills of the therapist and not the protocol itself. In a real-world setting, multiple therapists would be implementing the exercise protocol, and this protocol is dependent on therapist judgment for progression. I would have liked to see a 6 month follow-up, as in a real-world setting physical therapists aim to have improvements of impairments and symptoms retained beyond 3 months. Finally, all patients received a subacromial corticosteroid injection and this may not be the case with all patients that come into the clinic presenting with SIS symptoms. Further, it has also been documented that corticosteroid injections can show symptoms relief at 3 months, and some concern exists that the results hinge on the use of a subacromial corticosteroid injection and not upon the treatment protocol itself.

Article: Maenhout AG, Mahieu NN, Muynck MD. 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* 2012; pg 1158-1167.

Clinical Bottom Line: Results of this study which includes 61 subjects with unilateral SIS revealed a similar level of efficacy when comparing a traditional exercise program consisting of elastic band-resisted internal and external rotation to a free weight eccentric shoulder range of motion exercise program with regard to SPADI scores and isometric strength. The evidence in this study suggests that adding eccentrics with free weights can improve isometric shoulder flexion strength at 90 degrees of abduction, but isometric strength in every other position did not improve. Further, the evidence presented in this study suggests that utilizing the exercise programs for 6 weeks provides the most benefit. No benefit in any of the outcome measures (isometric shoulder flexion strength at 0, 45, and 90 degrees of abduction and the SPADI questionnaire) was observed in the final 6 weeks of treatment, except for the eccentric-heavy group showing some improvement in SPADI scores. Over the 12 week intervention period, adding eccentric exercises to the traditional protocol resulted in an increase of about 10 N of isometric force production in 90 degrees of shoulder abduction and showed further improvements in isometric strength in 0 or 45 degrees of abduction, or SPADI scores. Implementing the protocol would be feasible, and the added costs would be minimal. However, it seems that using the traditional exercise protocol would be the most beneficial option for most patients considering the additional time commitment associated with adding eccentric exercises that result in minimal improvement.

Article PICO:

Population: 61 patients diagnosed with subacromial impingement

Intervention: Heavy load eccentric training combined with traditional rotator cuff exercise and training

Comparison: Traditional rotator cuff exercises and training only

Outcome measures: Isometric strength at 0, 45, and 90 degrees of abduction; SPADI, and rated perception of improvement

Blinding: The authors of this study mentioned that the investigators were unable to be blinded to the treatment received by the subject for outcome measurement. The subjects were not blinded to the treatment they received, nor were the therapists giving the treatment blind to the treatment they were using. The overall lack of blinding, specifically the lack of blinding of the investigator, is a potentially significant threat to the internal validity of the study.

Controls: The control group is this study was referred to as a "traditional rotator cuff strength training" group. The subjects in this group performed internal and external rotation resisted with an elastic band daily, for 3 sets of 10 repetitions. Patients were instructed to perform the exercise on a 6 count, with 2 seconds of concentric phase, 2 seconds of isometric phase, and 2 seconds of eccentric phase. Resistance magnitude (denoted by color) of the band was determined by subjective questioning of the subjects regarding pain difference during exercise and at rest. Once pain during activity was not significantly greater than at rest, the resistance was progressed. This program was done for 12 weeks.

Randomization: The authors mention that subjects were randomly allocated into each treatment group, but the specific methods were not described. Sixty six patients met eligibility with 5 declining to participate. The 61 remaining patients were allocated randomly into the eccentric heavy (31 subjects) or traditional group (30 subjects). The authors reported no difference in anthropometric data between the groups at baseline. The authors failed to mention if outcome measurements at baseline were similar or different between the groups. Using the authors data, it was concluded that there was no significant difference between the groups in the outcome measures at baseline. Overall randomization was successful, but the lack of listed methodology for each subject's allocation is a potential minor threat to internal validity.

Study: This randomized control trial included 61 patients which were divided randomly into a traditional exercise group (30 subjects) or eccentric heavy group (31 patients). Patients were eligible for the study if they met the following criteria: > 18 years of age, unilateral shoulder pain for at least 3 months, pain through range of motion, 2 positive impingement tests (Hawkins-Kennedy, Jobe, or Neer), 2 of 4 resistance tests were painful (thumb up abduction at 90 degrees, resisted abduction at 0 degrees, resisted internal and external rotation with shoulder abducted), and pain with palpation of the supraspinatus or infraspinatus tendon insertion. Subjects were excluded from this study if they presented with a partial or full tear of the rotator cuff tendon, previous history of shoulder surgery/fracture/dislocation, had a traumatic onset of pain, osteoarthritis, adhesive capsulitis, traumatic glenerohumaral joint instability, shoulder nerve injury, or concomitant cervical pathology or systemic musculoskeletal disease. Further, no subject could have a history of physical therapy or corticosteroid injection to treat this shoulder pain.

Subjects in the traditional exercise group performed internal and external rotation with a resistance band and were instructed to complete each repetition on a 6 seconds count, with 2 seconds for each phase (concentric, eccentric, and isometric). Subjects completed 3 sets of 10 repetitions daily, with level of resistance tubing being selected based on no increase of pain during repetitions. Subjects in the eccentric heavy group performed the same traditional exercises as the control group, with the addition of free weight eccentric exercises. Free weight exercises included shoulder abduction in scaption at 3 sets of 15 repetitions, and each repetition was instructed to take 5 seconds during the lowering phase. Resistance from the free weight exercise was dependent on pain during repetitions and after exercise (never to exceed 5/10) and no

pain increase the following day. When no pain was present during the final set of 15 repetitions, dumbbell weight was increased.

Patients in both groups completed a daily log book to record pain during the exercises and the occurrence of adverse events. All subjects performed the exercises at home for 12 weeks and attended one physiotherapy session per week during the first period of 6 weeks, reducing to bi-weekly during the final 6 weeks. During these treatment sessions, patients were instructed on good form for the exercises and progressed according to the aforementioned protocol.

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Outcome measures: Relevant outcome measures recorded by the investigators included the Shoulder Pain and Disability Index (SPADI), isometric strength at 0, 45, and 90 degrees abduction and isometric strength in internally and externally rotated positions. Isometric strength was measured with a handheld dynamometer with patients seated, feet touching the floor, and no back support with contralateral limb grasping the chair for support. Current literature suggests that the MCID for isometric strength gains is a 10 percent increase in force output.[8] The authors cited the reliability for handheld dynamometry to have an Inter-Class Correlation [ICC] ranging from 0.78 to 0.85.[6,7] The SPADI was used to measure changes in shoulder function and pain and was cited by the authors to have a high test-retest reliability as a subjective self-exam (ICC=0.95).[7.9] The authors cited no MCID for the SPADI questionnaire, but review of the literature suggests the MCID to be 18.[5]

Study losses: Of the 61 subjects that met eligibility and agreed to participate in the study, 50 completed the study from baseline to 12 weeks (82.0%). At six weeks 3 patients were lost within the eccentric-heavy group; 1 due to lack of time and 2 were excluded because they received additional treatment. Within the traditional exercise group, 3 subjects were lost during the six week follow-up due to self reports of no improvement in condition. At twelve weeks, no subjects were lost in the eccentric-heavy group while 1 subject was lost in the traditional exercise group due to the subject being on a holiday. The authors state that all subjects were analyzed in the group they were originally assigned to and that the intention to treat principle was respected but provided no objective results reflecting overall intention to treat. It was not clear what the author's threshold for intention to treat calculation was, but given that 82% of the subjects completed the study from baseline to 12 weeks it is likely that 80% was used as a threshold.

Summary of internal validity: The overall internal validity of this study was good. The most significant threat to internal validity is the fact that the assessor who measured the outcome variables was not blinded to the treatment the specific subject received. The detailed and specific inclusionary/exclusionary criteria as well as the decision to exclude subjects who received other treatment is a further strength of the internal validity. However, losing two patients to follow up at the six week mark due to no perceived improvement within the traditional exercise group, and further, not including them in the end data analysis is worth noting when analyzing potential differences between the groups, as this reason for leaving is clinically relevant to the original clinical question.

Evidence:
In addition to the SPADI questionnaire, isometric strength was measured in 0, 45, and 90 degrees of abduction as well as in internal and external rotation at the 90/90 position at baseline, 6 weeks, and 12 weeks. Table 3 below illustrates the values at baseline and at the 12 week end of study values with mean differences.

Table 3. Scores for each outcome measure at baseline and 12 weeks with mean changes and significance

	Baseline		Week 12		Mean Change	
	Eccentric	Traditional	Eccentric	Traditional	Eccentric	Traditional
SPADI	42.0 (11.0)	44.3 (11.5)	17.0 (11.4)	14.5 (11.7)	25.7 (P<.01)	27.0 (P<.01)
ISO 0	127.9 (27.6)	123.2 (28.0)	154.3 (27.6)	147.1 (27.2)	31.5 (P<.01)	17.3 (P<.01)
ISO 45	71.2 (12.3)	68.2 (12.3)	81.6 (12.2)	83.5 (11.8)	12.8 (P<.01)	12.5 (P<.01)
ISO 90	64.7 (12.6)	63.0 (12.7)	78.0 (12.5)	70.0 (12.2)	14.7 (P<.01)	5.1 (P>.05)
ISO ER	82.9 (12.5)	83.4 (12.9)	96.0 (12.4)	92.7 (12.3)	13.2 (P<.01)	10.2 (P<.01)
ISO IR	121.7 (17.9)	119.0 (18.2)	129.0 (17.9)	125.0 (17.2)	18.1 (P=.04)	7.3 (P<.01)

SPADI values are in percent disability with lower scores being more favorable. Isometric force output is measured in Newtons and depicted as "ISO" followed by degrees of shoulder abduction. All isometric testing done for shoulder flexion. Parentheses denote standard deviation or P-value. Data derived from the authors and not calculated.

Worth noting from table 3 is that all outcomes improved significantly from baseline to 12 weeks in both intervention groups with the exception of isometric flexion strength in 90 degrees of abduction, which did not significantly change in the traditional exercise group. From this table is it not possible to conclude if there was a greater change in the first or final six weeks of this intervention, and this information could prove valuable clinically. In some clinical settings (and for insurances purposes), duration of care exceeding six weeks may not be feasible. Table 4 below illustrates values at baseline and six weeks with mean differences in order to address this question.

Table 4. Scores for each outcome measure at baseline and 6 weeks with mean changes and significance

	Baseline		Week 6		Mean Change	
	Eccentric	Traditional	Eccentric	Traditional	Eccentric	Traditional
SPADI	42.0 (11.0)	44.3 (11.5)	25.4 (11.9)	17.7 (12.0)	17.1 (P<.01)	24.1 (P<.01)
ISO 0	127.9 (27.6)	123.2 (28.0)	150.8 (27.6)	142.7 (27.5)	26.3 (P=.016)	19.5 (P<.01)
ISO 45	71.2 (12.3)	68.2 (12.3)	79.7 (12.0)	81.7 (12.0)	11.1 (P=.013)	12.1 (P<.01)
ISO 90	64.7 (12.6)	63.0 (12.7)	74.8 (12.3)	72.5 (12.3)	11.6 (P<.01)	9.5 (P<.01)
ISO ER	82.9 (12.5)	83.4 (12.9)	94.3 (12.2)	90.5 (12.5)	12.1 (P<.01)	8.6 (P=.02)
ISO IR	121.7 (17.9)	119.0 (18.2)	126.5 (17.6)	123.2 (17.5)	12.2 (P>.05)	5.6 (P>.05)

SPADI values are in percent disability with lower scores being more favorable. Isometric force output is measured in Newtons and depicted as "ISO" followed by degrees of shoulder abduction. All isometric testing was done for shoulder flexion. Parentheses denote standard deviation or P-value. Data derived from authors and not calculated.

When analyzing the mean changes over the first six weeks of treatment, it is observed that both the eccentric-heavy and traditional exercise group resulted in significant improvements with all outcomes except isometric flexion strength in an internally rotated position. This is evidence that both treatments appear to be effective in the six week window with the exception of gaining isometric flexion strength in an internally rotated position. Considering that this outcome was significant at the 12 week mark, some benefits can be seen from continuing treatment beyond six weeks in both the eccentric-heavy and traditional exercise group. Worth noting is that while isometric flexion strength in a 90 degree abducted position significantly improved from baseline to six weeks in the traditional exercise group, over a 12 week treatment duration the significance disappeared. This may be some evidence that the traditional exercise intervention may actually be worse over a 12 week treatment duration for isometric flexion strength in a 90 degree abduction position. Assessing the data from the week 6 mark to week 12 could help lend more insight into the effects beyond 6 weeks. Table 5 below Illustrates this data.

Table 5. Scores for each outcome measure at week 6 and week 12 with mean changes and significance

	Week 6		Week 12		Mean Change	
	Eccentric	Traditional	Eccentric	Traditional	Eccentric	Traditional
SPADI	25.4 (11.9)	17.7 (12.0)	17.0 (11.4)	14.5 (11.7)	7.5 (P<.01)	1.6 (P>.05)
ISO 0	150.8 (27.6)	142.7 (27.5)	154.3 (27.6)	147.1 (27.2)	9.7 (P>.05)	-0.2 (P>.05)
ISO 45	79.7 (12.0)	81.7 (12.0)	81.6 (12.2)	83.5 (11.8)	3.8 (P>.05)	-0.1 (P>.05)
ISO 90	74.8 (12.3)	72.5 (12.3)	78.0 (12.5)	70.0 (12.2)	4.5 (P>.05)	-4.1 (P>.05)
ISO ER	94.3 (12.2)	90.5 (12.5)	96.0 (12.4)	92.7 (12.3)	1.8 (P>.05)	2.5 (P>.05)
ISO IR	126.5 (17.6)	123.2 (17.5)	129.0 (17.9)	125.0 (17.2)	8.1 (P>.05)	3.4 (P>.05)

SPADI values are in percent disability with lower scores being more favorable. Isometric force output is measured in Newtons and depicted as "ISO" followed by degrees of shoulder abduction. All isometric testing was done via shoulder flexion. Parentheses denote standard deviation or P-value. Data was derived from authors and not calculated.

As can be seen from table 5, SPADI score did improve significantly from the final six weeks of treatment in the eccentric-heavy group, but no other outcome measure demonstrated significant improvement in either intervention group. This suggests some potential increase in patient function can be gained from six additional weeks of treatment. However, isometric strength does not seem to have continued improvement beyond six weeks of treatment.

Of greatest interest with regard to the original clinical question is the difference of improvement between the two intervention groups. Table 6 displays the relevant data.

Table 6. Showing the mean differences between the intervention groups and significance

	12 Week Mean Difference (SD)	P-Value
SPADI	1.3 (-7.0-9.70)	>.05
ISO 0	14.2 (-8.8-37.1)	>.05
ISO 45	0.4 (-9.7-10.4)	>.05
ISO 90	9.6 (-0.7-19.9)	0.033
ISO ER	3.0 (-6.7-12.6)	>.05
ISO IR	10.7 (-4.1-25.6)	>.05

Mean difference was not calculated and provided by the authors. Mean difference was calculated by subtracting the mean of the eccentric-heavy group and traditional group with standard deviations denoted in parentheses

When analyzing the mean differences between the groups, it can be observed that the traditional exercise group and eccentric-heavy group were equally effective at improving the SPADI questionnaire scores. With regard to isometric shoulder flexion strength, the traditional exercise group was equally effective as the eccentric-heavy group with the exception of the 90 degree abducted position, where the eccentric-heavy exercise group produced a greater increase in force production.

Applicability of study results:

Benefits vs. Costs: Utilizing the eccentric-based protocol does not require more equipment to complete and is not more expensive to utilize within the clinic. However, when considering the level of commitment for the patient, the eccentric-heavy protocol is more time consuming, which could be an issue within treatment sessions as often other manual therapy is used in conjunction with exercise programs. Further, the extra time commitment associated with the eccentric-heavy protocol could be detrimental to overall compliance as a home exercise program. This extra time commitment needs to be taken into account with patients to determine if the commitment is worth the increase in isometric strength in a 90 degrees abducted position. Considering no difference between the intervention groups in with the SPADI questionnaire, it is unlikely that adding the eccentrics will result in an increase in function or subjective perception of improvement.

Feasibility of treatment: Overall, implementing this eccentric-heavy exercise protocol is feasible. All exercises were described well enough in the study to be reproduced in the clinic, including dosing. The main concern would be the aforementioned time commitment increase with the eccentric-heavy exercise protocol. With minimal benefits resulting from the eccentric-heavy protocol, it is difficult to justify its use in the clinic over the traditional exercise protocol in the study. Further, adhering to the 12 weeks of treatment for both protocols may be time consuming and potentially exceed insurance reimbursement. Considering that the data in the study showed improvement in only one of the isometric strength outcome measures, and not in the SPADI, between week 6 and week 12 the eccentric exercise protocol may prove equally effective for patients over a 6 week period as over a 12 week period.

Summary of external validity: Overall the external validity of this study is good. The patients used in this study are typical of those who would come in for treatment, experiencing unilateral shoulder pain and testing positive on a number of diagnostic tests for SIS. Further, the facilitation of treatment is reasonable in a typical therapy setting, with a therapist using judgment similar or identical to the protocol guidelines for progression of exercises.

Article: Jonsson P, Wahlstrom P, Ohberg L, Alfredson H. Eccentric Training in Chronic Painful Impingement Syndrome of the Shoulder: Results of a Pilot Study. *Knee Surg Sports Traumatol Arthrosc* 2006; pg 76-81

Clinical Bottom Line: Based on the investigation of 9 patients diagnosed with subacromial impingement syndrome (4 with image-confirmed supraspinatus muscle tears) by Jonsson et al, the use of an eccentric-only training regimen can lead to improvements in pain VAS and Constant-Murley Shoulder assessment score. Given the study's methods, it is impossible to conclude if the eccentric regimen described and used in this pilot study is more effective than a typical exercise regimen, or even if it is more effective than no treatment at all. However, utilizing the author's protocol resulted in a significant mean improvement of 11.1 points for the Constant-Murley Shoulder assessment score and 30.78mm on the pain VAS at 12 weeks of treatment. This met the MCID for pain VAS of 18[1][8], while the MCID for the Constant-Murely Shoulder is unknown. These improvements were retained at 1-year follow-up. However, only 5 of the 9 patients reported being satisfied with the outcome at the 12 week period, and at the 1-year follow-up 2 of the 9 patients opted for surgery. Considering the numerous threats to internal validity consisting of the lack of a comparison group, low number of subjects, specific subject population, and lack of blinding the overall internal and external validity of these findings are guarded at best.

Article PICO:

Population - 9 patients diagnosed with subacromial impingement syndrome on a waiting list for surgical intervention (mean 41 months of symptoms, 6 with previously failed exercise treatments, and 4 with confirmed supraspinatous rupture)

Intervention - Specifically designed painful eccentric training program for the supraspinatus and deltoid muscles.

Comparison - Outcomes of intervention were not compared to a control group. However, 6 of 9 patients had previously received a failed non-eccentric exercise training regimen for an unspecified amount of time and 8 of 9 subjects with subacromial cortisone injections had no relief.

Outcomes - Patient satisfaction, VAS scores, status on waiting list for surgery, and Constant Murley Shoulder Assessment Score [CMS]

Blinding: This was an observational pilot study that did not compare two separate interventions. Therefore, all subjects within the study received the same treatment and blinding was not utilized due to the study model.

Controls: Since this was an observational pilot study and all subjects received the same treatment, no control or comparison group was utilized. Only the baseline scores and end-of-study outcomes were compared.

Randomization: The study model did not include randomization due to the fact that there was no comparison group. No allocation was necessary given that there was only one intervention group

Study: Nine patients with an age range of 35 to 72 years of age (mean 54) experiencing chronic painful impingement syndrome were included in this observational study. Patients experienced these symptoms for at least 23 months, with one patient experiencing symptoms as long as 72 months (mean, 41 months) and were on the waiting list for surgical intervention. All patients had tried rest for greater than 3 months, while 8 tried subacromical cortisone injections and 6 had participated in a shoulder rehabilitation program previously. Diagnosis was concluded via positive Neer's or Hawkins-Kennedy impingement test, or via ultrasound and x-ray. Worth noting is that 4 of the 9 subjects were confirmed to have a supraspinatus rupture. All patients received the eccentric training regimen. The regimen utilized a sling tool called the Ulla-sling, which was attached to a door and used to elevate the arm into a starting position of 90 degrees of abduction in the coronal plane. Patients were instructed to slowly lower their arms, and use the sling system to bring their arms back into the starting position. These were done in 3 sets of 15 repetitions, twice daily for all days of the week for a total of 12 weeks. Noteworthy is that the patients were instructed to keep their thumbs pointed toward the floor (and thus effectively reducing the subacromial space).

Outcome measures: Outcome measures included Constant-Murley score, isometric muscle strength at 30 degrees of horizontal abduction (measured via Isobex isometric dynamometer) and pain VAS. The Isobex dynamometer has a good reliability for measuring isomteric strength as cited by the authors.[10] No threshold for MCID was discussed by the authors. However, as mentioned previously, review of the literature reveals a change of 10 percent is considered to be clinically significant in isometric strength, with a change of 18 being considered clinically significant for pain VAS.[1][8]

Study losses: All subjects that began the study also finished the study. Since all subjects received the same intervention, each subject was analyzed within the same parameters at the end of the study as at baseline. However, two subjects elected to get surgery after the 12 week follow-up but before the 52 week follow-up, one with a confirmed supraspinatus rupture and one without. Thus, no data was recorded for those subjects at 52 weeks.

Summary of internal validity: Overall the internal validity of this study is poor. This study model had a low sample size which likely would not have the power to show a significance against a comparison intervention. Further, there is no comparison intervention to draw a conclusion from regarding the effectiveness of the intervention compared to conventional interventions. Further, the assessor was completely aware of the treatment received as no blinding was utilized. The lack of a control group and thus blinding and randomization is an overall major threat to internal validity. Due to the aforementioned factors it is only possible to determine if the intervention generated significant changes and not possible to determine if the use of eccentrics is more effective than another intervention, or even rest.

Evidence: Values for the Constant-Murley shoulder assessment score, pain VAS, and isometric strength were measured at baseline, 12 weeks, and 52 weeks. Table 7

illustrates the means in Constant-Murley score and Pain VAS over the study period. Note that these values were derived from the authors.

Table 7. Constant-Murley Shoulder Assessment Score and pain VAS at baseline, 12 weeks, and 52 weeks.

Outcome Measure	Means		
	Baseline	Week 12	Week 52
Constant Murley Score (SD)	55.44 (16.52)	66.56 (19.39)	63.43 (24.97)
Pain VAS (SD)	70.67 (20.51)	39.89 (29.70)	38.86 (23.26)

As depicted in table 7 above, the Constant-Murley Score seemingly improved from baseline at the 12 week mark while slightly regressing at the 1-year follow-up. A similar trend can be noted when observing the Pain VAS, although continued improvement seemed to have occurred after the intervention period at the 1-year follow-up. To know whether these trends are clinically meaningful, it is important to look at the mean differences. Table 8 below illustrates this data

Table 8. Mean differences for Constant-Murley shoulder assessment score and Pain VAS

Outcome Measure	Mean Change	
	Baseline to 12 Weeks	12 weeks to 52 weeks
Constant Murley Score	11.10 ($P < .05$)	-3.12 ($P > .05$)
Pain VAS	30.78 ($P < .05$)	1.03 ($P > .05$)

The Constant-Murley shoulder assessment score improved 11.1 points over the 12 week intervention period and this change was statistically significant. Measuring the Constant-Murley score at the 1-year follow up revealed no significant change, suggesting retention of the favorable result. Regarding pain levels, subjects reported a mean improvement of 30.78mm that was statistically significant, while the 1 year follow-up revealed no significant change from the 12 week mark also suggesting retention of the favorable result.

Subjectively, only 5 of the 9 patients reported that they were satisfied with their outcomes at 12 weeks. Regarding the decision for surgery, 2 of the patients ended up opting for surgery when surveyed at the 1-year follow-up.

Applicability of study results:

Benefits vs. Costs: Implementation of this eccentric training program should not be any more costly than traditionally utilized exercise programs, as no additional special equipment would be required. This eccentric training regimen could easily be integrated into a regular 30 or 45 minute physical therapy session and would not take any more

time than an otherwise prescribed home exercise. A minor concern is the fact that most soft tissue injuries typically occur during the eccentric phases of movement, and emphasizing this phase of movement could pose as an increased risk to adverse events. However, given that this exercise is unloaded and is controlled by the patient with a potential ability to provide assistance with the opposite limb, this is a minor risk consideration.

Feasibility of treatment: The eccentric exercise assigned to the subjects in this study were described well enough within the publication to be fully reproduced in the clinic. The 12 week treatment period for the subjects in this study is reasonable and could align with insurance reimbursement depending on how clinic visits were allocated. This intervention could be heavily home exercise based, meaning the frequency of visits could be relatively low. However, efficacy of this intervention could likely be very dependent on patient compliance at home, as is the case with almost all home exercise programs. The last consideration is that this treatment was indeed painful, which could threaten patient compliance.

Summary of external validity: The numerous threats to internal validity result in some concerns when applying the results of this study to the greater population. These results may be able to be applied to patients who still present with subacromial impingement symptoms despite attempted corticosteroid injection. While it is difficult to determine based on the study methods whether or not this treatment is more effective than traditional treatment (or even no treatment at all), the significant improvements in pain and CMS score mean that the use of an eccentric regimen may be beneficial for patients who present with SIS symptoms and have failed to respond to subacromial corticosteroid injection. Regardless, the patient population is small and very specific, leading to the overall external validity to be poor.

Article: Camargo PR, Avila MA, Alburqueque-Sendin F. Eccentric training for shoulder abductors improves pain, function and isokinetic performance in subjects with shoulder impingement syndrome - a case series. *Revista Brasileira de Fisioterapia* 2012; pg 74-83.

Clinical Bottom Line: This investigation featured 20 subjects recruited from Universidade Federal de São Carlos (UFSCar), São Carlos, SP, in Brazil who were confirmed to have unilateral subacromial impingement syndrome via physiotherapist and orthopedic surgeon evaluation and had no presence of a supraspinatus tear (confirmed via ultrasonography). Subjects served as their own controls with measurements being taken at baseline and then 4 weeks later before beginning treatment, which consisted of eccentric-based exercises performed on an isokinetic exercise machine at two fixed angular velocities of 60 and 180 degrees per second. All patients received the same treatment for the same treatment period. Overall, subjects failed to meet the MCID of 10.2[1] for the DASH questionnaire except when comparing the initial baseline measurement to the post-intervention measurement. The isokinetic variables assessed included peak torque and work production at the aforementioned angular velocities and these outcome measures do not have accompanying MCIDs. Statistically significant improvements were reported for work production in concentric and eccentric phases of motion at an angular velocity of 180 degrees per second, and concentric phases of motion at an angular velocity of 60 degrees per second. Peak torque showed significant improvements in the concentric phase of movement at 180 degrees per second angular velocity only. These results are difficult to translate into improvements in function. Additionally, their clinical significance is also difficult to interpret with no published MCID for these variables, and only an Minimally Detectable Change [MDC] published for isokinetic torque production (ranging from 21% to 43%[13]) which the improvements failed to meet. Due to the study design, this investigation had some threats to overall internal validity including a lack of blinding, lack of randomization/allocation and potential maturation effects leading to an overall fair internal validity. While these results could be applied to many patients experiencing subacromial impingement syndrome, this patient population consisted of patients with a more chronic condition (average duration of symptoms = 3 years; maximum 10 years) and thus it may be difficult to apply to more acute cases. Given the limited and somewhat inconclusive benefits and costs associated with the treatment (isokinetic machine) this treatment does not seem cost effective, even if it is feasible to utilize in a physical therapy clinic.

Article PICO:

Population: Twenty subjects with unilateral subacromial impingement syndrome

Intervention: Eccentric training program for the shoulder in all four planes of movement

Comparison: Baseline scores: two baseline scores were taken 4 weeks apart to assess potential improvement without intervention. Results were compared to the unaffected side as well.

Outcome measures: Disabilities of the Arm, Shoulder, and Hand (DASH) Questionnaire, Peak Torque, Total Work and Acceleration Times in concentric and eccentric phases of motion at 60 and 180 degrees per second angular velocities

Blinding: Neither subjects nor assessors were blinded to the only treatment provided. No blinding was utilized within this study's methods.

Controls: Subjects were utilized as their own controls. Each subject was measured at baseline and then 4 weeks following with no intervention and these results were compared to the outcomes at the end of the investigation period. While this can create a threat to internal validity, this method does provide a sense of the expected outcome within a specific patient, given a scenario with no treatment compared to one with treatment. It is often difficult to have a true control in medicine due to ethical concerns, and this is one way to attempt to compare to a "true control" at the cost of an introduction of a threat to internal validity.

Randomization: Randomization was not possible since all patients received the same treatment, meaning there were no groups to be assigned to. The study design prevented the possibility of randomization for group allocation. However, the authors did randomize which arm would be measured first when collecting outcome measure data.

Study: Thirty seven subjects with the diagnosis of subacromial impingement syndrome via physical therapist, orthopedic surgeon, and radiologist were recruited to participate in this study from a physical therapy waiting list at Universidade Federal de São Carlos (UFSCar), São Carlos, Brazil. All patients were screened for supraspinatus or long head biceps brachii tendon tears via ultrasonography, which is shown to be highly sensitive in the diagnosis of such conditions[11]. Further exclusionary criteria included a positive sulcus sign, pregnancy, positive apprehension test, history of shoulder or neck surgery, systemic illness, subacromial corticosteroid injection within the previous 3 months, and previous physical therapy treatment within 6 months of the start of the investigation period. For strength and torque measurements, all subjects performed a warm-up routine involving upper trapezius stretching and shoulder movements in all four planes. The subjects were instructed to be in a seated position, with the trunk

stabilized via chest and pelvic straps, and perform the exercises in an isokinetic exercise machine (Biodex Multi-Joint System 3, Biodex Medical System Inc., NY, USA). In neutral rotation, the arm was placed in 20 degrees abduction and the elbow fully extended. The machine axis was set at the subject's acromioclavicular joint. The subjects performed eccentric exercises from 80 degrees of abduction to the starting position of 20 degrees abduction at 60 and 180 degrees per second. The subjects performed both the concentric and eccentric phases of motion, and were given a familiarization period consisting of 3 submaximal effort repetitions followed by 5 maximal effort repetitions with a 2 minute rest period between familiarization and measurement. A 2 minute rest period was also utilized between the 60 degrees per second and 180 degrees per second trials. The eccentric program utilized the aforementioned positioning, with subjects performing the maximal contraction phases twice a week with at least one rest day in between for six weeks. These exercises were performed bilaterally, and dosing consisted of 3 sets of 10 repetitions, with 3 minutes rest between each set. Only the eccentric phase was performed, from 80 degrees of abduction to 20 degrees of abduction in the scapular plane.

Outcome measures: Outcomes were measured at baseline, four weeks following with no treatment, six weeks after the introduction of the intervention period, and six weeks after the end of the intervention period. Outcomes included the DASH questionnaire, peak torque production, total work and acceleration times in the concentric and eccentric phases of motion (measured via isokinetic dynamometer) at two different angular velocities of 60 and 180 degrees per second. The authors did not cite the reliability of their isokinetic dynamometer, but a review of the literature reveals low to moderate relative reliability (ICC 0.25-0.81) for detecting isokinetic strength imbalances both unilaterally and bilaterally, while having a high reliability when measuring peak torque[12]. Further review reveals that at an angular velocity of 60 degree per second, reliability ranges from good to excellent (ICC 0.69-0.92) in measuring peak torque and the minimal clinically detectable change ranged from 21% to 43%[13]. A review of the literature revealed no MCID available for measuring isokinetic strength with an isokinetic dynamometer. Regarding the DASH, as mentioned previously it is documented to have high test-retest reliability (r=0.90)[1] and an MCID of 10.2[5].

Study losses: While thirty seven subjects volunteered to participate in the study, only 25 met the inclusionary criteria and were measured at baseline. Of this initial 25, 20 subjects completed the study from start to finish. The authors reported that the five subjects lost were due to personal or work-related schedule conflicts and not related to adverse events during the investigation period. No intention to treat analysis was done by the authors. However this poses little threat considering the reasons for leaving the study and 80% retention. Twenty patients (7 female, 13 male) with shoulder pain ranging in duration from 5 to 120 months were able to complete the study from start to finish.

Summary of internal validity: Overall the internal validity of this study is fair. While the study methods did utilize a type of control group for comparison, used valid and reliable outcome measures and compared the groups appropriately at baseline, a few

significant threats exist. First is the lack of blinding of the subjects and assessors, which, given the study methods, was not possible as all the subjects received the treatment. It would have been possible to have the treatment done by a separate therapist not affiliated with the investigators or have an outside group measure the outcomes in order to defend against this threat given the study methods, but this was not done. Second is the potential for a maturation effect. Given the way the comparison was made, subjects were measured at baseline and then 4 weeks following without any treatment before participating in the intervention program. It is possible that some effects could be explained by the extent of time, however this seems unlikely given the mean duration of symptoms for the population was about 3 years. Third, no randomization was utilized due to the study methods, however this threat is considered minor since all subjects were essentially in both the comparison and treatment group.

Evidence: Main outcome measures that will be discussed in this section include the DASH questionnaire, Peak Torque, and Isokinetic Force production at 60 and 180 degrees per second angular velocity.

Table 9 shows the DASH questionnaire scores throughout the investigation period.

Table 9. Showing the score of the DASH questionnaire at baseline, 4 weeks without treatment, 6 weeks into the intervention and 6 weeks post-intervention

	Baselines (±95% CI)		Intervention	Post-Intervention
	0 weeks	4 weeks	6 weeks	6 weeks
DASH Score	18.78±3.06	14.28±3.24	9.70±2.09	5.49±1.25

Note: Lower DASH scores are more desirable

These scores show that on average the subjects started at a base DASH score of roughly 19 and improved to roughly 14 when measuring 4 weeks later, suggesting a potential for the aforementioned concern of a maturation effect. However, the authors report that there was no statistically significant difference between those two values at baseline, and it failed to be a difference larger than the previously mentioned MCID of the DASH questionnaire. By the end of the intervention period, the subjects improved to roughly 10 on average. The subjects further posted an improved average of roughly 5.5 six weeks following the intervention, suggesting not only retention but continued improvement. Table 10 below further illustrates the differences between each evaluation period for the DASH questionnaire.

Table 10. The mean differences in DASH scores at different time intervals

Comparison	Difference (95% CI)	p-value
Baseline 1 & Intervention	9.08 95% CI (3.04 - 15.12)	<.05
Baseline 2 & Intervention	4.58 95% CI (-0.74 - 9.91)	>.05
Intervention & Post Intervention	4.20 95% CI (0.23 - 8.18)	<.05

As displayed in the table on the previous page, whether or not the intervention period was proven to be statistically significant depends on which baseline score it was compared to. This is further evidence for a potential maturation effect during the 4 week period of no intervention. The authors did not do a direct comparison between baseline scores, nor a comparison between either baseline and the post-intervention score. Since the raw data isn't available, there is no way to calculate significance or 95% confidence interval for these comparisons, only mean difference. The authors do however state that the post intervention mean score is significantly different from both baseline scores, and that the two baseline scores themselves do not have a statistically significant difference. When assessing mean differences only, noteworthy is the fact that the mean difference of 4.5 between the baseline scores is below the DASH MCID previously mentioned. Although the mean difference of 9.08 between the first baseline measurement and the intervention is statistically significant, it falls short of the DASH MCID. However, at the post-intervention period, this difference grows to 13.29 which does meet the MCID for the DASH questionnaire. The mean difference of the second baseline measurement of 8.79 falls short of this MCID, however.

The impact of the intervention on peak torque production and total work were also documented by the authors and are worth discussing, as often strength goals are incorporated into a patient's plan of care. Table 11 illustrates this data for both angular velocities of 60 and 180 degrees per second and for the concentric and eccentric phases of motion.

Table 11. The means of peak torques and total work for concentric and eccentric phases of shoulder abduction at a fixed angular velocity of 60 and 180 degrees per second

	Peak Torque (Newton-meters)			
	Baseline 1	Baseline 2	Intervention	Post-Intervention
Concentric (60 deg/sec)	52.7±4.2 (44.0 - 61.4)	52.2±4.4 (43.2 - 61.2)	54.7±4.2 (46.0 - 63.4)	54.4±4.3 (45.6 - 63.3)
Concentric (180 deg/sec)	58.7±4.6 (49.3 - 68.0)	58.0±4.7 (48.4 - 67.6)	63.0±4.7 (53.7 - 72.2)	62.0±4.5 (52.5 - 71.5)
Eccentric (60 deg/sec)	49.8±3.7 (41.9 - 57.7)	47.9±4.0 (39.5 - 56.2)	51.0±4.4 (42.0 - 60.1)	50.3±4.5 (40.8 - 59.7)
Eccentric (180 deg/sec)	55.0±4.8 (45.2 - 64.7)	52.3±4.7 (42.7 - 62.2)	55.1±5.3 (44.8 - 65.4)	54.9±5.2 (44.3 - 65.5)
	Total Work (Joules)			
	Baseline 1	Baseline 2	Intervention	Post-Intervention
Concentric (60 deg/sec)	212.7±19.8 (172.3 - 253.2)	220.4±20.6 (179.6 - 261.2)	228.6±18.3 (192.8 - 264.3)	230.0±19.7 (190.9 - 269.1)
Concentric (180 deg/sec)	191.6±15.9 (159.6 - 223.7)	192.3±15.9 (159.5 - 225.2)	207.2±15.8 (175.8 - 238.6)	200.7±17.3 (165.6 - 235.7)
Eccentric (60 deg/sec)	83.3±14.7 (54.3 - 112.3)	88.4±16.1 (56.2 - 120.7)	116.5±18.3 (81.1 - 152.0)	113.1±16.6 (76.0 - 150.2)
Eccentric (180 deg/sec)	103.2±11.8 (77.9 - 128.4)	113.1±15.8 (82.4 - 143.7)	131.2±18.6 (94.3 - 168.0)	137.1±17.8 (101.6 - 172.6)

Parentheses in column and row headers denote units. Parentheses within data denote 95% confidence intervals.

For the sake of the clinical question, only the data for the involved side is shown above. The authors additionally provided data and comparison to the uninvolved side and averaged the two in order to compare the effect of maturation throughout the investigation period. For a fixed angular velocity of 60 degrees per second, the authors did show a statistical difference in the eccentric phase for total work production. At a fixed angular velocity of 180 degrees per second, statistical differences were shown in the concentric and eccentric phases of movement in total work production and in the concentric phase of motion for peak torque. In other words, the authors did notice an effect of maturation throughout the investigation period in the aforementioned categories, although this seems like a questionable method to assess maturation. If improvement were being achieved due to the intervention on the effected side and not on the uninvolved side, it is still possible to show a statistically significant change over time. This is especially relevant in this case, as the authors reported significant differences in the same categories when assessing the involved side only.

Table 12 illustrates the mean differences and confidence intervals at each time interval for total work and peak torque. Please note that only the differences for those variables concluded to be statistically significant by the authors are included within table 12, with the exception of the comparison of intervention and post-intervention.

Table 12. Showing the mean differences for isokinetic variables statistically different from baseline measurements. Differences for Intervention and Post-Intervention are for comparison purposes only

Peak Torque (Newton-meters) at 180 deg/sec; Concentric Phase	
	Mean Difference
Baseline 1 & Intervention	3.75 (0.27 - 7.24)
Baseline 2 & Intervention	4.58 (1.03 - 8.13)
Intervention & Post-Intervention	-0.52 (-2.39 - 1.35)
Total Work (Joules) at 60 deg/sec; Eccentric Phase	
Baseline 1 & Intervention	29.89 (13.14 - 46.63)
Baseline 2 & Intervention	27.18 (8.42 - 45.93)
Intervention & Post-Intervention	5.65 (-5.07 - 16.37)
Total Work (Joules) at 180 deg/sec; Concentric Phase	
Baseline 1 & Intervention	13.75 (0.62 - 26.89)
Baseline 2 & Intervention	16.00 (1.72 - 30.28)
Intervention & Post-Intervention	-2.07 (-15.98 - 11.82)
Total Work (Joules) at 180 deg/sec; Eccentric Phase	
Baseline 1 & Intervention	29.03 (11.40 - 46.66)
Baseline 2 & Intervention	20.85 (2.68 - 39.01)
Intervention & Post-Intervention	4.65 (-4.45 - 13.76)

Parentheses in column and row headers denote units. Parentheses within data denote 95% confidence intervals.

Interpreting these results is somewhat difficult due to the fact that no published MCIDs exist for these outcome measures. While the MCID for isometric strength was mentioned previously, no MCID exists for assessment of isokinetic strength. Further, translating total work into strength capability is unclear and no MCID exists for this variable. The data does suggest that the subjects were able to produce more energy during both phases of movement with a fixed angular velocity of 180 degrees per second, as well as during the eccentric phases at a fixed angular velocity of 60 degrees per second. It also appears that the capabilities improve more in the eccentric phases of movement compared to the concentric phase of movement, which should be no surprise given that the intervention is itself an eccentric training program. It is unclear how these gains in total work capability translate into improved function. Regarding peak torque, the aforementioned 21% to 43% MDC for isokinetic peak torque was not met in any of the categories and it is thus difficult to conclude that these differences were meaningful, despite the author's report of statistical significance.

Applicability of study results:

Benefits vs. Costs: Considering how unclear the results of the intervention were in producing favorable outcomes in the isokinetic variables, and how those results translate into increased function, it is difficult to conclude that there is any significant benefit to this treatment. Further, most comparisons suggested that the subjects in this investigation failed to meet the MCID in the DASH questionnaire, only making this mark when comparing the first baseline to the post-intervention, and this result could be explained by a potential maturation effect. It would be difficult to justify this treatment even if it was free and it most definitely isn't. This program would require the use of an expensive isokinetic machine. However, assuming this program was effective, treatment sessions could be much shorter than conventional treatments as it only involves 3 sets of 10 repetitions with a few minutes rest and done bilaterally. Further, the necessity of having a physical therapist present to facilitate the exercise may not be necessary and other, cheaper personnel may be able to supervise these exercises. Compliance with the treatment may be higher than other more traditional treatment, as all treatment is done in the clinic supervised by a therapist and not part of a home exercise program. Despite all of this, the efficacy of the treatment is questionable and the machine is expensive--likely not outweighing the cost savings of shorter treatment sessions and less expensive personnel. Therefore, the use of this protocol by the investigators has a seemingly unfavorable cost to benefit ratio.

Feasibility of treatment: While this treatment may not be worth the costs for the results it provides, it would be feasible to implement into a physical therapy clinic, assuming you had access to an isokinetic machine. The study procedures were described well enough to reproduce in the clinic, the time frame for which the treatment sessions take place are relatively short and the treatment period does not extend beyond what most insurance companies are willing to allow. It may be feasible for patients as well, considering they would not need to enter the clinic any more frequently than some traditional treatments and it requires no independent home exercise program. Overall this protocol would be feasible to implement in a clinical setting, despite the questionable benefits and unfavorable cost to benefit ratio.

Summary of external validity: The scope of the patient population is equivalent and inclusive of patients that could be seen in a physical therapy clinic, as patients had a ranging duration of symptoms and tested positive for subacromial impingement syndrome, which is often treated conservatively by physical therapists. Given the inclusion and exclusion criteria, it may be more difficult to translate the results into more acute impingement cases as the patient population had an average duration of symptoms of 3 years, with the maximum being 10 years. Overall it appears that the results of this investigation could be applied to many patients with subacromial impingement syndrome seen in the physical therapy clinic if this study's internal validity was stronger.

Synthesis & Discussion: Based on the results from Holmgren et al, Maenhout et al, Jonsson et al, and Camargo et al, utilizing an eccentric-based therapeutic exercise program may lead to some improvements in self-reported function (as determined by the DASH, Constant-Murley Shoulder Assessment Score, and SPADI), pain, and strength. Findings in the Holmgren et al study support the use of an eccentric exercise program, showing greater improvement than a ROM exercise program in function as demonstrated by Constant-Murley Shoulder Assessment score and DASH questionnaire. Holmgren and colleagues did however conclude that their eccentrically based exercise protocol was not significantly more effective at reducing pain during rest or activity than the use of traditional ROM exercises (however both groups improved beyond the MCID). Further, it should be taken into consideration that the subjects in Holmgren et al study were aware of the treatment they were receiving, and this coupled with the ability to control their own outcomes (ex applying more or less effort) may have influenced the results. As shown by Maenhout et al, when comparing an eccentric-heavy exercise program to a more traditional exercise program over a six week period, strength gains appear to be similar with some indication that shoulder flexion at 90 degrees of abduction may improve further with the use of eccentric exercises. Also reflected from the Maenhout study: improvement in SPADI scores were similar between the groups for the first six weeks, but in the final six weeks the eccentric-heavy exercise group showed continued significant improvements. Regarding pain, it seems the utilization of eccentrics improves nighttime pain more effectively than traditional programs. However, Maenhout et al shows similar levels of efficacy between the groups for pain during activity or rest (agreeing with Holmgren and colleagues). There seems to be some disagreement between investigators (Jonsson et al, Camargo et al, Holmgren et al) regarding the effectiveness of an eccentric-based program as an alternative to surgery. However, the studies with the stronger design and larger patient populations (Camargo et al and Holmgren et al) concluded that the introduction of eccentric exercises into a treatment program for subacromial impingement syndrome was more effective when compared to a more traditional program as an alternative to surgery. This disagreement could have resulted from differences in sample size and exercise protocol. Findings within the Jonsson et al study agree with the findings of Holmgren et al and Maenhout et al with regard to improvements in Constant-Murley Shoulder Assessment score and pain VAS. However, these results within the Jonsson et al investigation were not compared directly to a traditional exercise group. Camargo et al found eccentric-based exercises to improve some isokinetic kinematic variables (work and peak torque production) at specific fixed angular velocities, but these results are ultimately difficult to translate into patient function. The Camargo et al investigation found improvements in DASH questionnaire scores, but these differences fell short of the published MCID values. This was not the case in the Holmgren et al investigation as the change in DASH scores met the MCID, and this may have been due to the difference in the use of a control group and the exercise protocol. Overall when considering the merits and shortcomings of these investigations, it can be determined that with patients who are diagnosed with

SIS, eccentric-based exercise programs can be more effective than traditional programs at generating improvements in self-reported function, and to a lesser extent, strength in specific shoulder positions. With regard to pain management, an eccentric-based exercise program seems to be equally effective when compared to a more traditional program. Some of the similarities in outcome measures between the groups may be due to the fact that SIS can have a number of underlying causes outside of a tendinopathy. Additionally, with these results in mind, it is important to note the variations in eccentric protocols and the utilization and definition of control groups amongst the investigators. These variations may impact the findings discussed in this analysis.

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