Paramedic University of Applied Sciences

"The effectiveness of eccentric training of the rotator cuff in patients diagnosed with SIS"

A literature review

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Preface

Writing this bachelor thesis is the final chapter of my education at Fontys University of Applied Sciences. It is a culmination of four years of hard work within the English Stream Physiotherapy Program.

Graduation topics were provided by school, but all students were allowed to pick their own topic on request. I choose the latter, knowing that writing a bachelor thesis requires a lot of motivation. What is more motivating and fun than working on a topic that has someone's interest?

The topic I choose is eccentric training as a treatment option for Subacromial Impingement Syndrome (SIS). There were multiple reasons for this choice. Personal motivation was the main one. I have had multiple shoulder injuries myself, already drawing my interest in this topic before I even started studying physiotherapy. Next to that, the shoulder joint(s) is an intriguing joint as it often poses a challenge to physiotherapists to correctly diagnose and treat.

Not much research has been conducted on the effects of eccentric training on SIS, as this paper will show. SIS as a clinical entity remains poorly understood by many. Not surprising when there is not even consensus about what terminology to use when describing SIS. This was a little shocking to find out knowing the prevalence of SIS. Next to that, eccentric training for SIS has become an important and much used treatment intervention, at least in Dutch practice. But where is the evidence in favour of it?

In June 2013 this thesis started when we were asked to either hand in our graduation topics or accept a topic given to us from school. The most difficult and challenging part was to formulate a research question that was narrowed down enough not to drown in work and still broad enough to write a proper thesis. When this was done, the "real" work began and I became more and more familiar with- and interested in the topic. Since then, all work that was put in has lead to this bachelor thesis.

I would like to thank my thesis supervisor Annelies Simons for her advice and constructive feedback during the making of this thesis. Of course there are many other people that deserve a big "thank you" for helping me successfully end this study. I will not name them and take the risk of forgetting someone. If you think you are on that list you probably are, and I am grateful for that.

Hylke Hooghiemstra

Graduation class 2014

Abstract

Background: Eccentric training is an established treatment intervention in the case of Achilles- and patellar tendinopathy. In the last decade, eccentric training as a treatment intervention for SIS has gained attention. The objective of this review was to find out whether the increased use of eccentric training for SIS is justified. This review tried to answer the following research question: "How effective is eccentric training of the rotator cuff in patients diagnosed with SIS?"
Method: A literature search was conducted in April 2014. Search terms, search strategy and in- and exclusion criteria were defined prior to the search process. Online databases PubMed, PEDro, CINAHL, SPORTDiscus and MEDLINE were searched to look for articles with a focus on the effects of eccentric training on pain and function.
Results: Five articles (all published after 2006) with a total of 111 patients of which 74 were assigned to an eccentric training protocol were included. Methodological quality was variable with weak study designs, low participant numbers and no- or short follow-up periods. Training protocols differed from training twice a week for six weeks up to 14 times a week for 12 weeks. The execution of eccentric exercises differed, as there was no consensus over the amount of glenohumeral rotation needed. The only well-designed RCT concluded that eccentric training in combination with traditional rotator cuff training is not better than traditional rotator cuff training alone. The other RCT suggested that eccentric training might be of benefit in the case of SIS. All three non-controlled studies showed significant improvements over time regarding pain and function when using eccentric training as a treatment for SIS.
Conclusion: There is no evidence that proves eccentric training is effective when treating SIS. Eccentric training in combination with traditional rotator cuff training is not better than traditional rotator cuff training alone. The optimal eccentric training protocol has yet to be determined. Large, well-designed, multi-centre studies with long follow-up periods are needed to look at the effects of eccentric training only versus traditional rotator cuff training on SIS in an effort to justify the use of an eccentric training program.

Key words: subacromial impingement syndrome, rotator cuff pathology, eccentric training

Table of Contents

Introduction

Shoulder injuries make up a large part of the patient population in current clinical practice.[1] In a Swedish study done by Tekavec et al.[2], the diagnosis of tendinitis, bursitis or impingement was made in 70% of the cases when patients consulted their general practitioner because of shoulder complaints. Subacromial Impingement Syndrome (SIS) is the diagnose in 48% of patients with shoulder disorders in the Netherlands.[3] The term impingement was first coined by Charles Neer in 1972, describing subacromial impingement.[4] He stated that in most SIS cases the supraspinatus tendon is affected. At times, the tendons of the infraspinatus and the long head of the biceps are affected as well due to their anatomical positions in the subacromial outlet.[4] This review will use the definition of SIS as described by Charles Neer.[4]

There are currently two main theories explaining SIS. One is a degenerative (intrinsic) theory, where symptoms are thought to result from overload on degenerating rotator cuff tendons; the other is a mechanical (extrinsic) theory, where symptoms are caused by compression of the rotator cuff.[5,6]
A study done by Khan et al.[7] on the histopathology of common tendinopathies showed similar collagen fibre degeneration- and disorientation when comparing supraspinatus tendinopathy to Achilles- and patellar tendinopathy.

Shoulder injuries in patients can arise from an array of different underlying pathologies; rotator cuff pathology, scapular dyskinesis, glenohumeral instability, biceps-labrum pathology and glenohumeral internal rotation deficit (GIRD).[8] It is often a challenge for physiotherapists to diagnose the underlying pathology because diagnostic tests for the shoulder are not reliable[9] and pathologies can coexist.[8] SIS due to rotator cuff pathology is considered one of the most common causes for shoulder pain.[6,10]

Conservative treatment of SIS consists of rest, NSAID's and physiotherapy.[11] In physiotherapy, traditional rotator cuff training is a much used conservative treatment for SIS.[12] This conservative treatment is all about strength training of the internal- and external rotators of the shoulder joint with the upper arm adducted against the trunk.[12] The exact role that conservative physiotherapy treatment plays is difficult to assess to date because of lack of uniformity in defining, evaluating and treating SIS.[13]

Since the work of Alfredson et al.[14] on Achilles tendinopathies, the emphasis in physiotherapy treatment is more and more laid on the eccentric phase of muscle contraction when treating and training patients with Achilles- and patellar tendinopathies. Eccentric training has shown to decrease pain and allowing pre-injury activity levels.[14–17] It has shown to repair tendon tissue, but the mechanism behind this repair is still largely unknown.[18] Different explanations for these positive effects exist. One early explanation is that eccentric training lengthens the tendon in combination with hypertrophy and increased tensile strength.[14] A later explanation for the decrease in pain is the decreased vasculo-neural ingrowth resulting from eccentric training.[19,20] Neovascularisation is known to occur in patients with a clinical diagnose of rotator cuff tendinopathy.[21] On a micro level, controlled eccentric training increases collagen production and turn-over, at least in the Achilles tendon.[18] This increased collagen production is also expected to occur in the rotator cuff tendons.[7]

It is of great importance to know whether the increased use of eccentric training in patients suffering from SIS is justified, first of all since SIS may lead to full-thickness rotator cuff tears.[6,15] Secondly, the other main treatment option for SIS next to eccentric training of the rotator cuff, arthroscopic decompression via surgery, has been much debated on recently.[22] A study by Haahr et al.[22] on the effectiveness of arthroscopic decompression surgery could not prove its superiority to physiotherapy treatment.[22] Possible negative side effects of surgery, such as impact on daily life and recovery after surgery, are not even taken into account in their conclusion.[22] This makes physiotherapy a lower threshold treatment option.
This review therefore aims to answer the following research question: "How effective is eccentric training of the rotator cuff in patients diagnosed with SIS?"

This review bundles all relevant literature that looks at the outcome of eccentric training in patients having SIS complaints. It will also give clinicians a better understanding of how the build up of an eccentric training protocol should look like to optimize outcomes.

Method

Data Sources

This literature review combined articles from the databases PubMed, PEDro, CINAHL, SPORTDiscus and MEDLINE that investigated the effects of eccentric training on patients suffering from SIS.

A general search string was made for the databases CINAHL, SPORTDiscus and MEDLINE. For the PubMed database a different search string was made to be able to make use of Mesh terms. For the PEDro database a separate search string was constructed, since it was not possible to insert the general search string in the PEDro interface. Table 1 presents an overview of the different search strings used and their corresponding database.

Table 1. *Databases and Corresponding Search Strings*

Database	Search string
PubMed	*"Shoulder impingement syndrome"[Mesh] AND (eccentric training OR exercise)*
PEDro	*"Subacromial impingement syndrome" (*inserted in the "Abstract & Title" box)
CINAHL SPORTDiscus MEDLINE	*(subacromial impingement syndrome OR shoulder impingement syndrome OR rotator cuff tendinopathy OR rotator cuff tendinosis OR rotator cuff tendinitis OR rotator cuff pathology) AND eccentric training*

Study Selection

There was no specific bottom line set for the year in which articles had to be published, since eccentric training for SIS is a relatively new treatment method. References of selected articles were checked for any possible additional relevant articles.

After the results of the initial search a first screening took place based on the inclusion criteria in the article titles- and abstracts. Duplicates were identified during this screening process and the relevant articles remained for full text reading with the exclusion criteria applied. An overview of the in- and exclusion criteria is displayed in table 2.

An overview of the database search is presented in figure 1.

Table 2. *In- and Exclusion Criteria for Studies*

Inclusion criteria
• Studies that did research on patients diagnosed with SIS through a clinical examination and accessory imaging if the SIS diagnosis through clinical examination was doubtful. • Studies that did research on the effects of exercise or training directed to relieve complaints due to SIS. • RCTs[a], CCTs[b], cohort studies, case studies and pilot studies. • articles written in Dutch or English.
Exclusion criteria
• Studies that included patients diagnosed with more than only SIS. • Studies that included patients whose diagnose was established or reassessed through a clinical examination which was not described in the study. • Studies that used more than only eccentric training of the rotator cuff as an intervention. • Studies whose primary outcome measures were not at least pain and shoulder function.

[a]RCTs=Randomized Controlled Trials; [b]CCTs=Clinical Controlled Trials.

Methodological Quality Assessment

The methodological quality of the included studies was assessed by one reviewer (HH).
The PEDro scale (appendix 1), which is considered valid[23] and reliable[24], was used to rate eligible randomized-

and clinical controlled trials (RCTs; CCTs) for methodological quality. It consists of 11 different items of which the first one is not taken into account. For every criterion that can be checked off on the PEDro scale a point is given. The highest score possible on the PEDro scale is 10.

RCTs and CCTs scoring 9-10 on the PEDro scale are considered to be of “excellent” methodological quality. Studies with PEDro scores ranging from 6-8 are considered to be of “good” quality, while studies scoring 4 or 5 are of “fair” quality. Studies that scored below 4 are rated as “poor” quality studies.[25]

Pilot- and case studies were assessed for methodological quality through an 18-criteria modified Delphi checklist developed by Moga et al.[26] (appendix 2). For each criteria 1 point can be earned. A score of over 14 points (>70%) is considered to be of acceptable quality.[26] Any score below 14 points is not labeled.

Data Extraction

Data were extracted from the included studies and were put into separate extraction tables. One extraction table contains outcomes of the intervention(s) and statistical outcomes when available. The methodological quality of the included studies is presented in two combined extraction tables (use is made of two different assessment tools). Patient demographics are summarized in a different extraction table. The last extraction table contains the specific eccentric exercise protocols, and their details, as used by the different studies.

Best Evidence Synthesis

A best evidence synthesis (BES) was done to ensure quality of the results and to assess the statistical significance of this review. This is considered an intelligent alternative to meta-analysis.[27] The synthesis was based on a significance level of $P<0.05$. Analysis of the level of evidence of the included studies was based on Steultjes et al.[28] and took the methodological quality of the included studies into account. This BES consists of five different levels of evidence (table 3). The words "sufficient quality" and "acceptable quality" are considered equal to each other throughout this BES when describing the methodological quality of study designs other than controlled study designs.

Table 3. *Levels of Evidence According to Steultjens et al.[28]*

Level of evidence	***Criteria***
Strong evidence	Provided by consistent, statistically significant findings in outcome measures in at least two high quality RCTs[a]
Moderate evidence	Provided by consistent, statistically significant findings in outcome measures in at least one high quality RCT and at least one low quality RCT or high quality CCT[b]
Limited evidence or:	Provided by statistically significant findings in outcome measures in at least one high quality RCT. Provided by consistent, statistically significant findings in outcome measures in at least two high quality CCTs (in the absence of high quality RCTs)
Indicative findings or:	Provided by statistically significant findings in outcome and/or process measures in at least one high quality CCT or low quality RCT (in the absence of high quality RCTs). Provided by consistent, statistically significant findings in outcome and/or process measures in at least two ODs[c] with sufficient quality (in absence of RCTs and CCTs)
No or insufficient evidence or: or:	In the case that results of eligible studies do not meet the criteria for one of the above stated levels of evidence. In the case of conflicting (statistically significant positive and statistically significant negative) results among RCTs and CCTs. In the case of no eligible studies

[a]RCT=Randomized Controlled Trials; [b]CCT=Clinical Controlled Trials; [c]ODs=Study designs other than controlled designs.

Best Evidence Synthesis: *If the number of studies that show evidence is <50% of the total number of studies found within the same category of methodological quality and study design (RCTs, CCTs or ODs), we will state no evidence.

Results

The online databases PubMed, PEDro, CINAHL, SPORTDiscus and MEDLINE yielded 385 articles for all databases combined. The search strings applied for each online database is presented in Table 1. After screening the articles' title and abstract, and after identifying duplicates, 20 articles remained that used exercises or training for SIS. After full-text review 16 articles were excluded based on the exclusion criteria. One article was added through the snowball method. Ultimately, five studies met the criteria to be included in this literature review. An overview of the results of the database search is presented in figure 1.

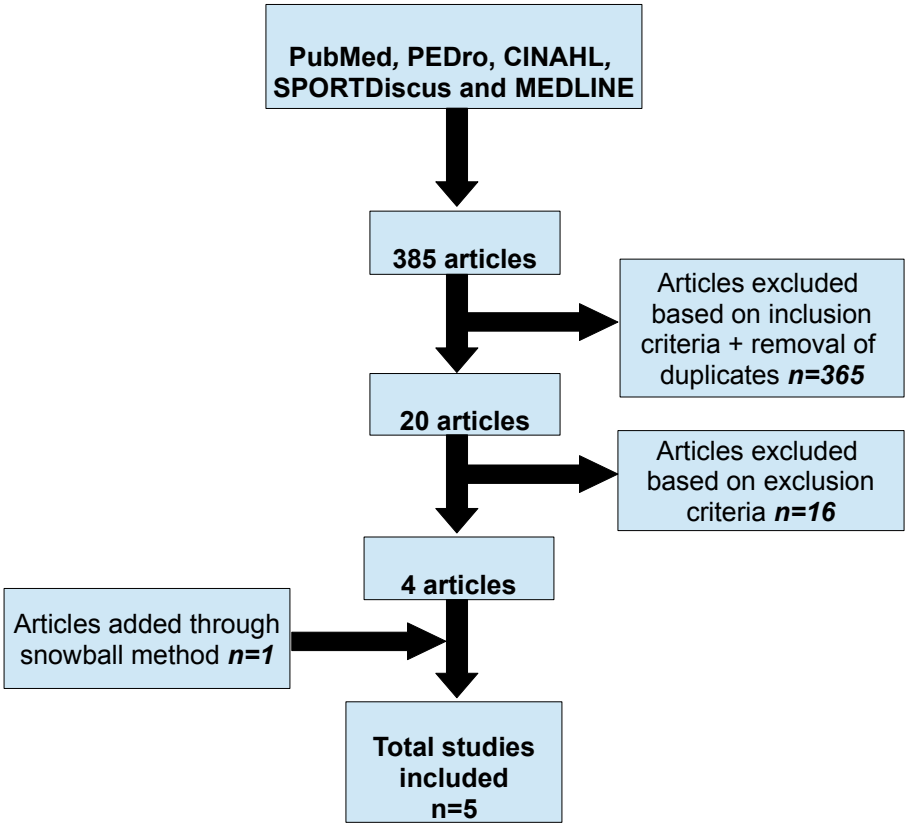

Figure 1. *Selection of Included Studies.*

General Study Characteristics and Outcome Measurements

Study designs were weak in four of the five included studies.[29–32] Only one well-designed RCT with a sample size large enough to draw statistical significant conclusions was included.[12] Follow-up data were recorded in only two studies[31,32], preventing this review from drawing conclusions on the long term effects of eccentric training on SIS. There were no between-group differences reported regarding pain or function in either RCT. Pain and function were clear primary outcome measures in three studies.[29,30,32] No clear difference between pain and function could be made in two studies[12,31] due to measurement tools used.

Three of the five identified studies used the Visual Analog Scale (VAS) as a measurement tool for pain.[29,31,32] With the VAS, patients rate their pain on a 0 – 100 mm scale. Higher scores indicate more pain. It is considered a valid and reliable method.[33]

One study used the Shoulder Pain and Disability Index (SPADI) as a measurement tool for both pain and function.[12] The SPADI consists of 13 items grouped into pain and disability sub-scales. A total SPADI score ranges from 0 – 100 points, with higher scores indicating greater impairment. It is considered a useful measurement tool in clinical practice.[34]

One study used the Oxford shoulder score as a measurement tool for shoulder function.[29] The Oxford shoulder score ranges from 12 – 60 points, with 60 points being the worst outcome. It is a valid and reliable tool.[35]

The study of Bernhardsson et al.[30] used the Patient-Specific Functional Scale (PSFS) to assess shoulder function. Because of its specificity the range of the PSFS varies per study. In this study the range was from 0 - 30 points, 30 points indicating patients can perform on a pre-injury level. The PSFS is considered valid and reliable.[36]

Camargo et al.[31] used the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire to assess both pain and shoulder function. The DASH scale ranges from 0 – 100 points, with 100 points indicating the worst possible condition. The DASH questionnaire has good validity and reliability.[37]

The study by Jonsson et al.[32] used the Constant-Murley score to assess shoulder function. The score ranges from 0 – 100 points, with higher scores indicating higher quality of function. The reliability of the Constant-Murley score is unknown and little validation experiments have been undertaken.[38] An overview of the general study characteristics and outcome measurements is presented in table 4.

Methodological Quality

The PEDro score of the RCTs done by Maenhout et al.[8] and Bateman and Adams[12] was 6 for both studies, indicating good methodological quality.[29] Both studies were incapable of blinding therapists who administered the therapy as well as assessors who measured at least one key outcome. The study of Bernhardsson et al.[30], a single-subject research design, scored 15 points on the Modified Delphi checklist. The case study of Camargo et al.[31] scored 14 points on the Modified Delphi checklist. Both studies were found to be of acceptable methodological quality.[31] The pilot study done by Jonsson et al.[32] scored 11 points on the Modified Delphi checklist and was found to be of the lowest methodological quality. Table 5 provides an overview of the methodological quality rating results by the PEDro scale (RCTs). Table 6 shows the methodological quality rating results by the Modified Delphi checklist (study designs other than controlled designs).

Patient Demographics

A total number of 111 participants with a diagnosis of SIS or rotator cuff tendinopathy were included, of which 74 were assigned to an eccentric training protocol. The study of Camargo et al.[32] had the lowest mean age of participants with 34.2 years (range 20-51). The study of Jonsson et al.[31] had the highest mean age of participants with 54 years (range 35-72). Average age of participants was typical for SIS[39] in all studies except for the study of Camargo et al.[31] Symptom duration was not described in every study. In those who did, the study of Jonsson et al.[32] described the longest average symptom duration of 41 months. Failed previous physiotherapy treatment is described in two of the five included studies.[29,32] All participants can be considered poor cases of SIS. Table 7 provides an overview of the patient demographics of the included studies.

Eccentric Training Regimens

Three studies used a training regimen of exercising in three sets of 15 repetitions twice a day, as described by Alfredson et al.[14] Bernhardsson et al.[30] described two exercises done in three sets of 15 repetitions twice a day. Camargo et al.[31] also deviated from this frequency and used a training frequency of twice a week. The intervention group in the study done by Maenhout et al.[12] was assigned to traditional rotator cuff exercises next to an eccentric exercise. All other interventions were exercises with an eccentric component only. All studies but one[30] used the "empty can", "half full can" or "full can" position as an eccentric exercise (figure 2). This study did not describe its eccentric exercises into detail.[30] In the studies that reported pain levels during exercising subjects were allowed to exercise with some amount of pain.[12,29,30] No pain during the last set of exercises was the basis for progression of those exercises in four of the five studies.[12,29,30,32] An overview of the different eccentric exercise protocols is displayed in table 8.

Additional treatment next to eccentric training was given in two of the five studies.[12,30] In the study of Bernhardsson et al.[30] it consisted of a warm up program of two scapular stabilizing exercises and one stretching exercise for the upper trapezius muscle. The study by Maenhout et al.[12] described a more integrated approach to SIS. Next to a traditional rotator cuff training program it included patient education, glenohumeral mobilisation, scapulothoracic mobilisation, scapula setting exercises and posture correction.

Table 4. *General Study Characteristics and Outcome Measurements*

First author (year), country	**Study design**	**Groups**	**Measurements done at week**	**Primary outcome measures** *(tools used)*	**Outcome**	**Outcome details**	*(Yes/no)* **Statistically significant**	**Follow -up**
Maenhout[31] (2013), Belgium	Randomized clinical trial	Intervention Control	6 and 12	Pain and function (*SPADI*[a]*)*	Significant improvement regarding pain and function for both groups	↓SPADI score of 25.7 (15.8) points for intervention group ↓SPADI score of 27.0 (19.5) points for control group	*(Yes)* P=<0.001	-
Bateman[12] (2014), United Kingdom	Randomized controlled feasibility study	Eccentric Concentric Control	4 and 8	Pain and function *(VAS*[b] and *Oxford Shoulder Score)*	No improvement for any group regarding pain or function	NS[c]	*(no)* NS	-
Bernhardsson[29] (2011), Sweden	Single-subject research design	-	12	Pain and function *(VAS* and *Patient-Specific Functional Scale)*	Significant improvement in 8/10 subjects regarding pain and in 10/10 subjects regarding function	Average ↓[d]VAS score of 30 mm (range 1-58mm) Average function↑[e] of 9 (range 0-15 points)	*(Yes)* P=<0.05	-
Camargo[30] (2012), Brazil	Case series	-	6 and 12	Function and symptoms *(DASH*[f]*)*	Significant improvement regarding pain and function	Decreased DASH score of 5.49 (1.25) points	*(Yes)* P=<0.05	wk[g] 12
Jonsson[31] (2006), Sweden	Pilot study	-	12 and 52	Pain and function *(VAS* and *Constant-Murley score)*	Significant improvement in pain and function in 5/8 patients	For 5/8 satisfied subjects: ↑Constant score of 15 (from 65 to 80). ↓VAS score of 44 mm (from 62 to 18)	*(Yes)* P=<0.05	wk 52

[a]SPADI=Shoulder Pain and Disability Index; [b]VAS=Visual Analog Scale; [c]NS=Not Specified; [d]↓=decrease; [e]↑=increase; [f]DASH=Disabilities of the Arm, Shoulder and Hand; [g]wk=week.

Table 5. *Methodological Quality Rating by PEDro Scale*

PEDro Item ***Author***	***1[a]***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***Total***	***Quality***
Maenhout et al.[30] (2013)	Y[b]	Y	N[c]	N	Y	N	N	Y	Y	Y	Y	6	Good
Bateman & Adams[31](2014)	Y	Y	Y	Y	Y	N	N	N	Y	Y	N	6	Good

[a]This item is not used to calculate the total PEDro score; [b]Y=Yes; [c]N=No.

Table 6. *Methodological Quality Rating by Modified Delphi Checklist*

MDC[a] Item ***Author***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***	***15***	***16***	***17***	***18***	***Total***	***Quality***
Bernhardsson et al.[29](2011)	Y[b]	Y	Y	Y	Y	Y	N[c]	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	15	Acceptable
Camargo et al.[29] (2012)	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	14	Acceptable
Jonsson et al.[29] (2006)	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	N	11	NS[d]

[a]MDC=Modified Dephi Checklist; [b]Y=Yes; [c]N=No; [d]NS=Not Specified.

Table 7. *Patient Demographics*

First author (year)	**Average age, year**	**Gender**	**Symptom duration**	**Diagnosis**	**How diagnosis made**	**Treatment groups**
Maenhout[12] (2013)	39.8 (13)	25M[a] 36F[b]	At least 3 months	SIS	Specialized shoulder surgeon	*Group 1*: standard RC[c] exercises *Group 2*: standard exercises + eccentric exercise
Bateman[29] (2014)	53	6M 5F	NS[d]	RC tendinopathy	Orthopedic consultant	*Group 1*: concentric exercises *Group 2*: eccentric exercises *Group 3*: control
Bernhardsson[30] (2011)	54 (8.6)	5M 6F	12 (9.1) months	SIS	Physical therapist, radiologist	eccentric exercises
Camargo[31] (2012)	34.2 (10.2)	13M 7F	33.6 (34.8) months	SIS	Physical therapist , orthopedic physician	eccentric exercises
Jonsson[32] (2006)	54	5M 4F	41 months	SIS	Orthopedic surgeon, ultrasound and X-ray	eccentric exercises

[a]=Male; [b]F=Female; [c]RC=Rotator Cuff; [d]NS=Not Specified.

Table 8. *Specific Eccentric Exercise Protocols Used by Included Studies*

First Author (year)	Intervention exercises	Sets	Reps[a]	Trial period *(wk[b])*	Pain level allowed during exercise	Velocity of exercise	Return to start position	Freq[c], times/wk	Basis for progression
Maenhout[12] (2013)	Standard RC[d] exercises + eccentric "full can" exercise in scaption[e]	3	15	12	Pain during exercising may not exceed VAS[f] 50	5"/repetition	Concentric	14	Absence of pain during last set of exercise
Bateman[29] (2014)	Eccentric "full can" exercise in scaption	3	15	8	"some" pain that was not allowed to persist >1 hour after exercising	"Slowly" according to study	Passive	14	No deterioration of symptoms at wk 4
Bernhardsson[30] (2011)	2 eccentric exercises. 1 for the supraspinatus, 1 for the infraspinatus	3	15	12	Patients were allowed to exercise into pain, but not more than 5 on a 0-10 pain scale	NS[g]	NS	14	No or little pain during exercising
Camargo[31] (2012)	Eccentric "half full can" in scaption	3	10	6	NS	NS	NS	2	NS
Jonsson[32] (2006)	Eccentric "empty can" exercise in scaption	3	15	12	NS	"Slowly" according to study	Passive	14	No pain during exercising

[a]Reps=Repetitions; [b]wk=weeks; [c]Freq=Frequency; [d]RC=Rotator Cuff; [e]scaption=shoulder abduction in the plane of the scapula; [f]VAS=Visual Analog Score; [g]NS=Not Specified.

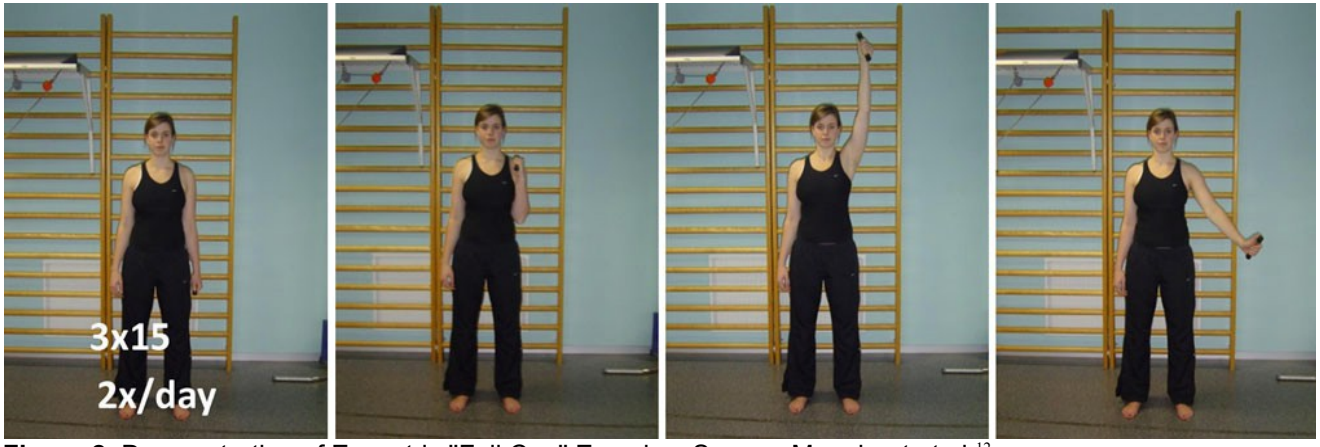

Figure 2. Demonstration of Eccentric "Full Can" Exercise. Source: Maenhout et al.[12]

Best Evidence Synthesis

This BES uses the definitions of levels of evidence according to Steultjens et al.[28] Participants, interventions, outcomes, outcome measurement tools and methodological quality of the included studies are taken into account in this BES.

There is no evidence stating that an eccentric training program for the rotator cuff directed to relieve SIS complaints is effective in decreasing pain and/or increasing shoulder function. Moderate evidence exists stating that eccentric training of the rotator cuff has no influence on the outcomes pain and function when used in combination with a traditional rotator cuff training program directed to relieve SIS complaints. There is no evidence concerning the execution and build-up of an eccentric training program. When ignoring the lack of evidence favouring eccentric training over traditional rotator cuff training for SIS, this review suggests the following eccentric training protocol: the eccentric "full can" exercise in the plane of the scapula done in three sets of 15 repetitions twice a day for 8 to 12 weeks. Patients are allowed to exercise into pain, not more than 5 on a 0 -10 scale. The exercise should be intensified by adding weight or resistance when patients can exercise without any pain.

Discussion

The aim of this review is to assess the effectiveness of eccentric training of the rotator cuff on SIS. It also aims to give clinicians a better understanding of how the build up of an eccentric training protocol should look like to optimize outcomes. This literature review has not succeeded in finding any evidence that proves eccentric training is effective as a treatment option for SIS. There is moderate evidence stating that eccentric training in combination with traditional rotator cuff training is not better than traditional rotator cuff training alone. These findings do not correlate with the positive results of eccentric training in the better studied Achilles- and patellar tendon.[14–17]

Eccentric training as a solitary treatment for SIS is a relatively new approach, with the study of Jonsson et al.[32] (2006) being the first to investigate to the knowledge of the author of this review. Therefore, there has not been much time to conduct large, well-designed studies investigating the effects of eccentric training. This is the main reason why studies with inferior study designs are included in this review, there are just not enough studies done on the topic. It is assumable that more and stronger evidence on eccentric training for SIS will appear in recent time. Maenhout et al.[12] include 61 patients in their RCT and are able to draw statistically significant conclusions. 11 patients are included by Bateman and Adams[29], they are not able to draw any significant conclusions. Their reason for this low participation number is natural fluctuations. Strict inclusion criteria limits the study of Bernhardsson et al.[30] to 10 participants. Despite these low sample sizes studies are still included in this review due to the lack of larger studies investigating the effects of eccentric training on SIS.

In every patient there are multiple mechanisms underlying SIS, its aetiology is multi-factorial.[40] It is known that younger people often have SIS complaints secondary to instability, where older people have more SIS complaints due to rotator cuff degeneration.[10] Next to that, younger people are also known to recover faster after injury.[41] These two facts make it very difficult to compare the results of the study done by Camargo et al.[31] with the results of the other studies. The patients in the study by Camargo et al.[31] are on average five years younger than the patients included in the study of Maenhout et al.[12] and a full 20 years younger than the patients included in the other three studies.[29,30,32] The patients included in the study of Camargo et al.[31] do not seem to be typical SIS patients.[39] This is the main reason why the study of Camargo et al.[31] did not weigh heavily in the BES.

Due to the multi-factorial aetiology of SIS, it is difficult to diagnose its underlying causes. This is shown by the study of Jonsson et al.[32] In this study, two patient diagnosed with SIS by a orthopedic surgeon, ultrasound and X-ray were not satisfied with treatment after 12 weeks. When these patients had surgery later, it turned out that the cause of the patients' complaints were a labrum tear and a full-thickness cuff tear. This negatively affects the success rate of eccentric training. By handling strict in- and exclusion criteria regarding the diagnosis of SIS, this review tries to limit this problem as much as possible.

All patients are considered to be in a similar phase of SIS. Four of the five studies only include patients with a symptom duration of 3 months or more, and are all considered to be poor cases.[12,30–32] This makes the total patient population somewhat more homogeneous, but not enough to view them as equal.

The methodological quality of the included studies varies. The two RCTs included in this review are considered to be good methodological quality research.[25] A minor flaw in the study design of the RCTs is the inability to blind assessors that measure at least one key outcome. It is impossible to blind therapists who administer the therapy, they are obviously aware of the potential positive effects of eccentric training. But blinding assessors should have been possible. Two of the three non-controlled studies[30,31] are of acceptable methodological quality.[30,31] This was assessed using a checklist developed by Moga et al.[26] The checklist is used due to its comprehensiveness and usefulness. A proper assessment of reliability and validity when using this checklist is not available. To the knowledge of this author there is no globally accepted tool for rating non-controlled studies that is both reliable and valid. Because of the significant contribution of non-controlled studies to this review the author finds it important to rate the non-controlled studies, their level of evidence being inferior to the two RCTs by study design.

A major flaw in all studies but one[32] is the lack of long term follow-up data. It is known that tendon repair can take over a year before before a tendon regained more or less its original tensile strength.[42] Therefore, only measuring outcomes at the end of the intervention period is not nearly enough. It prevents this review from drawing conclusions on the long term effects of eccentric training on SIS. Next to that, the lack of long term follow-up data masks another problem. The study of Jonsson et al.[32], the only study with long term follow-up data available, includes nine patients in total. In hindsight, two of those nine patients are wrongly diagnosed. Even while use is made of additional imaging techniques when making the diagnosis. The only way wrong diagnoses come up is by following patients for a long period of time after the intervention period. There could have easily been multiple cases similar to these included in other studies. No one will ever know. It can however negatively influence the outcome of eccentric training on SIS.

Questionnaires were used as measurement tools to assess any change in pain or shoulder function. Of particular interest to this review are the SPADI and DASH questionnaires. There is no separation of the outcomes pain and shoulder function when calculating the scores of these questionnaires. The study of Maenhout et al.[12] uses the SPADI as a measurement tool and found statistical significant differences in SPADI scores over time. This review assumes therefore that both outcomes pain and shoulder function are statistical significant different. The same goes for the study of Camargo et al.[31] and their use of the DASH questionnaire. The primary outcomes pain and function are difficult to view separately. But in order to make a better comparison, the primary outcomes pain and function should have been evaluated separately. Bateman and Adams[29] use the Oxford shoulder score as a measurement tool for shoulder function. This assessment tool was originally developed to assess the outcomes of shoulder surgery. Since the patients included in the study by Bateman and Adams[29] did not get surgery, the use of this tool seems inappropriate. It is not a problem when interpreting results of this study since Bateman and Adams[29] were not able to draw any conclusions.

The studies of Maenhout et al.[12] and Bernhardsson et al.[30] use exercise protocols that consist of more than eccentric training only. Because the main focus of these studies is on eccentric training both studies are found valuable enough and are included in this review.

This review compares different eccentric training protocols. Three parameters of these protocols are potentially significantly different: training frequency, duration of the intervention period and execution of the eccentric exercise(s). Four of the five studies included use a similar training frequency as described by Alfredson et al.[14] This training frequency requires two exercises done three times 15 repetitions twice daily for 12 weeks. The study done by Camargo et al.[31] uses a training frequency of only two times a week. During those sessions patients train in sets of three times 10 repetitions, less repetitions than all other studies. The intervention period is only six weeks, shortest of all studies. Interestingly, this study comes to similar conclusions as the studies of Jonsson et al.[32] and Bernhardsson et al.[30] These studies use a higher training frequency, use more repetitions per training and have a longer intervention period. One more reason to believe that the patients included by Camargo et al.[31] are not typical SIS patients. In defense of the study by Camargo et al.[31], in the much better studied Achilles tendon the dosage of eccentric training is also subject of debate.[43] It has been suggested that, in the case of chronic non-insertional Achilles tendinopathy, a lower dosage of eccentric training compared to the protocol of Alfredson et al.[14] gives similar results.[43]

An interesting difference between the included studies is the way subjects executed the eccentric exercise. Three variations have been used: the "empty can"[32], the "full can"[12,29] and the "half-full can".[31] The study of Bernhardsson et al.[30] does not describe their eccentric exercises into detail. Electromyographic analysis of different shoulder positions shows that the "full can" position elicits less deltoid muscle activity than the "empty can" position and therefore better targets supraspinatus muscle activity only.[44] On top of that, exercising in a position of internal rotation and abduction further impinges the rotator cuff tendons by narrowing the subacromial space.[45] These findings seem to make little difference in the outcome of the included studies. When digging deeper, the studies that use the "full can" exercise[12,29] may be more successful in positively altering outcomes than the studies not using this exercise. The study by Maenhout et al.[12] uses the "full can" exercise next to a traditional rotator cuff training program and this successfully decreased shoulder pain and increased shoulder function. Even more interesting, in the study by Bateman and Adams[29] two of three patients assigned to the eccentric "full can" exercise training protocol withdrew from the surgery waiting list at week eight due to improvement in symptoms. Follow-up data in the study of Jonsson et al.[32] shows that five out of seven patients had withdrawn from the waiting list for surgery 52 weeks after the intervention period. That study used the "empty can" position. Therefore, it is suggested that the amount of glenohumeral rotation during the eccentric exercise has only a minor impact on a positive outcome at best.

This review did not find any evidence stating that eccentric training has a positive effect on SIS. This is not a shocking conclusion, if SIS is to be viewed as an insertional tendinopathy of the rotator cuff tendons. In most SIS cases the suprapinatus musculotendinous unit is involved.[4] A well described portion of the supraspinatus musculotendinous unit is the so called "critical zone".[46,47] It is thought to be the place where most problems occur.[4,47] The critical zone is in close proximity to the insertion of the supraspinatus tendon onto the greater tubercle of the humerus.[46,47] A plausible explanation for the lack of convincing evidence regarding eccentric training as a treatment option for SIS maybe can be found in studies investigating eccentric training in patients with insertional Achilles tendinopathies. In insertional Achilles tendinopathy, the problem site is also around the insertion of the Achilles tendon onto the calcaneus (comparable to SIS). There is also little evidence supporting the use of eccentric training in insertional Achilles tendinoapthy, in line with the evidence that this review found. It is not a very plausible explanation, but it is worth a consideration.

There are few limitations to this review. First of all, this review was conducted and written by one person. The studies included were compared and criticized by one person. That may give this review a narrow view on the topic. Secondly, the amount of studies included is small with most studies having a small number of subjects. This, and the weak study designs, limits the power of conclusions drawn. If this review was to be repeated, it would be highly interesting to conduct a systematic review of all treatments available targeting SIS. In this way, the question of whether eccentric training only is better than any other treatment option can be answered more clearly.

There is a need of large, multi-centre well-designed RCTs with uniform eccentric training exercises that address the effects of eccentric training only over other types of treatments, traditional rotator cuff training being the most important one. In addition to this, studies should distinguish further between sub-populations, age and activity level being two interesting factors. More long term follow-up data should be recorded to draw conclusions on the long term effect of eccentric training on SIS. As of yet, eccentric training seems to be no better than traditional rotator cuff training.

What is already known about this topic
• Eccentric training has become a popular treatment option for patients with SIS.
What this review adds
• It is not proven that eccentric training only is better than traditional rotator cuff training. • The studies included suggest exercising in scaption, focusing on eccentric lowering of the arm. • There is a lack of large, well-designed studies investigating the effects of eccentric training on SIS

Conclusion

There is no evidence that proves eccentric training of the rotator cuff is effective in decreasing pain or increasing shoulder function in patients suffering from SIS. Moderate evidence exists stating that three months of eccentric training of the rotator cuff in combination with traditional rotator cuff training does not lead to a decrease in pain or an increase in shoulder function when compared to three months of traditional rotator cuff training alone. There is no consensus among authors over how an eccentric training program for SIS should look like. Large, well-designed, multi-centre studies with long follow-up periods are needed to look at the effects of eccentric training only versus traditional rotator cuff training on SIS in an effort to justify the use of an eccentric training program.

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Appendices

Appendix I: PEDro – Quality rating scale: protocol sheet

Appendix II: Modified Delphi checklist: protocol sheet

Appendix III: PEDro score: Bateman and Adams

Appendix IV: PEDro score: Maenhout et al.

Appendix V: Modified Delphi checklist score: Bernhardsson et al.

Appendix VI: Modified Delphi checklist score: Camargo et al.

Appendix VII: Modified Delphi checklist score: Jonsson et al.

APPENDIX I

PEDro scale

1.	eligibility criteria were specified	no ❑ yes ❑ where:
2.	subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	no ❑ yes ❑ where:
3.	allocation was concealed	no ❑ yes ❑ where:
4.	the groups were similar at baseline regarding the most important prognostic indicators	no ❑ yes ❑ where:
5.	there was blinding of all subjects	no ❑ yes ❑ where:
6.	there was blinding of all therapists who administered the therapy	no ❑ yes ❑ where:
7.	there was blinding of all assessors who measured at least one key outcome	no ❑ yes ❑ where:
8.	measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	no ❑ yes ❑ where:
9.	all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"	no ❑ yes ❑ where:
10.	the results of between-group statistical comparisons are reported for at least one key outcome	no ❑ yes ❑ where:
11.	the study provides both point measures and measures of variability for at least one key outcome	no ❑ yes ❑ where:

The PEDro scale is based on the Delphi list developed by Verhagen and colleagues at the Department of Epidemiology, University of Maastricht (*Verhagen AP et al (1998). The Delphi list: a criteria list for quality assessment of randomised clinical trials for conducting systematic reviews developed by Delphi consensus. Journal of Clinical Epidemiology, 51(12):1235-41*).The list is based on "expert consensus" not, for the most part, on empirical data. Two additional items not on the Delphi list (PEDro scale items 8 and 10) have been included in the PEDro scale. As more empirical data comes to hand it may become possible to "weight" scale items so that the PEDro score reflects the importance of individual scale items.

The purpose of the PEDro scale is to help the users of the PEDro database rapidly identify which of the known or suspected randomized clinical trials (ie RCTs or CCTs) archived on the PEDro database are likely to be internally valid (criteria 2-9), and could have sufficient statistical information to make their results interpretable (criteria 10-11). An additional criterion (criterion 1) that relates to the external validity (or "generalisability" or "applicability" of the trial) has been retained so that the Delphi list is complete, but this criterion will not be used to calculate the PEDro score reported on the PEDro web site.

The PEDro scale should not be used as a measure of the "validity" of a study's conclusions. In particular, we caution users of the PEDro scale that studies which show significant treatment effects and which score highly on the PEDro scale do not necessarily provide evidence that the treatment is clinically useful. Additional considerations include whether the treatment effect was big enough to be clinically worthwhile, whether the positive effects of the treatment outweigh its negative effects, and the cost-effectiveness of the treatment. The scale should not be used to compare the "quality" of trials performed in different areas of therapy, primarily because it is not possible to satisfy all scale items in some areas of physiotherapy practice.

Last amended June 21st, 1999

Notes on administration of the PEDro scale:

All criteria **Points are only awarded when a criterion is clearly satisfied**. If on a literal reading of the trial report it is possible that a criterion was not satisfied, a point should not be awarded for that criterion.

Criterion 1 This criterion is satisfied if the report describes the source of subjects and a list of criteria used to determine who was eligible to participate in the study.

Criterion 2 A study is considered to have used random allocation if the report states that allocation was random. The precise method of randomization need not be specified. Procedures such as coin-tossing and dice-rolling should be considered random. Quasi-randomization allocation procedures such as allocation by hospital record number or birth date, or alternation, do not satisfy this criterion.

Criterion 3 *Concealed allocation* means that the person who determined if a subject was eligible for inclusion in the trial was unaware, when this decision was made, of which group the subject would be allocated to. A point is awarded for this criteria, even if it is not stated that allocation was concealed, when the report states that allocation was by sealed opaque envelopes or that allocation involved contacting the holder of the allocation schedule who was "off-site".

Criterion 4 At a minimum, in studies of therapeutic interventions, the report must describe at least one measure of the severity of the condition being treated and at least one (different) key outcome measure at baseline. The rater must be satisfied that the groups' outcomes would not be expected to differ, on the basis of baseline differences in prognostic variables alone, by a clinically significant amount. This criterion is satisfied even if only baseline data of study completers are presented.

Criteria 4, 7-11 *Key outcomes* are those outcomes which provide the primary measure of the effectiveness (or lack of effectiveness) of the therapy. In most studies, more than one variable is used as an outcome measure.

Criterion 5-7 *Blinding* means the person in question (subject, therapist or assessor) did not know which group the subject had been allocated to. In addition, subjects and therapists are only considered to be "blind" if it could be expected that they would have been unable to distinguish between the treatments applied to different groups. In trials in which key outcomes are self-reported (e.g., visual analogue scale, pain diary), the assessor is considered to be blind if the subject was blind.

Criterion 8 This criterion is only satisfied if the report explicitly states *both* the number of subjects initially allocated to groups *and* the number of subjects from whom key outcome measures were obtained. In trials in which outcomes are measured at several points in time, a key outcome must have been measured in more than 85% of subjects at one of those points in time.

Criterion 9 An *intention to treat* analysis means that, where subjects did not receive treatment (or the control condition) as allocated, and where measures of outcomes were available, the analysis was performed as if subjects received the treatment (or control condition) they were allocated to. This criterion is satisfied, even if there is no mention of analysis by intention to treat, if the report explicitly states that all subjects received treatment or control conditions as allocated.

Criterion 10 A *between-group* statistical comparison involves statistical comparison of one group with another. Depending on the design of the study, this may involve comparison of two or more treatments, or comparison of treatment with a control condition. The analysis may be a simple comparison of outcomes measured after the treatment was administered, or a comparison of the change in one group with the change in another (when a factorial analysis of variance has been used to analyze the data, the latter is often reported as a group × time interaction). The comparison may be in the form hypothesis testing (which provides a "p" value, describing the probability that the groups differed only by chance) or in the form of an estimate (for example, the mean or median difference, or a difference in proportions, or number needed to treat, or a relative risk or hazard ratio) and its confidence interval.

Criterion 11 A *point measure* is a measure of the size of the treatment effect. The treatment effect may be described as a difference in group outcomes, or as the outcome in (each of) all groups.

Measures of variability include standard deviations, standard errors, confidence intervals, interquartile ranges (or other quintile ranges), and ranges. Point measures and/or measures of variability may be provided graphically (for example, SDs may be given as error bars in a Figure) as long as it is clear what is being graphed (for example, as long as It is clear whether error bars represent SDs or SEs). Where outcomes are categorical, this criterion is considered to have been met if the number of subjects in each category is given for each group.

APPENDIX II

Modified Delphi checklist:

Nr.	Criteria	Rating: Yes = 1 point No = 0 points
1	Is the hypothesis/aim/objective of the study clearly stated in the abstract, introduction or methods section?	
2	Are the characteristics of the participants included in the study described?	
3	Were the cases collected in more than one centre?	
4	Are the eligibility criteria (inclusion and exclusion criteria) to entry the study explicit and appropriate?	
5	Were participants recruited consecutively?	
6	Did participants enter the study at a similar point in the disease?	
7	Was the intervention clearly described in the study?	
8	Were additional interventions (co-interventions) clearly reported in the study?	
9	Are the outcome measures clearly defined in the introduction or methods section?	
10	Were relevant outcomes appropriately measured with objective and/or subjective methods?	
11	Were outcome measured before and after interventions?	
12	Were the statistical tests used to assess the relevant outcomes appropriate?	
13	Was the length of follow-up reported?	
14	Was the loss of follow-up reported?	
15	Does the study provide estimates of the random variability in the data analysis of relevant outcomes?	
16	Are adverse events reported?	
17	Are the conclusions of the study supported by results?	
18	Are both competing interest and source of support for the study reported?	

Criteria and draft dictionary for the quality assessment checklist:

1. **Is the hypothesis/aim/objective of the study clearly stated in the abstract, introduction, or methods section?**
   Yes: The hypothesis/aim/objective of the study is clearly stated in the abstract, introduction, or methods section.
   No: The hypothesis/aim/objective is not provided in the abstract, introduction, or methods section.

Study population

2. **Are the characteristics of the participants included in the study described?**

Yes: The most relevant characteristics are presented. The authors should report the total number, age, and gender distribution of the participants. Ethnicity, severity of disease/condition, comorbidity, or etiology should also be included, if relevant.

No: The most relevant characteristics of the participants are not reported. If only the number of participants was reported or any of the relevant characteristics is missing, the question should be answered no. *Note: Assessor(s) should decide which aspects are important before using the checklist.*

3. Were the cases collected in more than one centre?

Yes: Cases are collected in more than one centre (multicentre study).

No: Cases are collected from one centre, or it is unclear where patients came from.

4. Are the eligibility criteria (inclusion and exclusion criteria) to entry the study explicit and appropriate?

Yes: The eligibility criteria are clearly stated and replicable, and match the objective of the study.

No: The eligibility criteria are not clearly stated. *Note: Assessor(s) should decide which aspects are important before using the checklist.*

5. Were participants recruited consecutively?

Yes: There is a clear statement that the participants are recruited consecutively.

No: The participants were recruited based on other criteria, such as access to intervention determined by the distance or availability of resources. The method used to recruit participants is not clearly stated.

6. Did participants enter the study at a similar point in the disease?

Yes: There is a clear description about the clinical status of participants, duration of condition (exposure) before the intervention, comorbidity, severity, or complications of all participants in the study.

No: There is no description about whether participants entered the study at a similar point in the disease. Participants did not enter the study at a similar point in the disease, as revealed by a wide range of disease duration before entering the study or different comorbidities or complications due to progression of their condition/disease. *Note: Assessor(s) should decide which aspects are important before using the checklist.*

Intervention and co-intervention

7. Was the intervention clearly described in the study?

Yes: There is a detailed description about the characteristics of the intervention (e.g. dosage, frequency of administration, duration, permanent or temporary intervention, and technical parameters/characteristics of a device).

No: The intervention is only mentioned by name without any details, the information provided is unclear, or important parameters of the intervention are missing from the presentation. *Note: Assessor(s) should decide which aspects are important before using the checklist.*

8. Were additional interventions (co-interventions) clearly reported in the study?

Yes: The name or type of co-intervention is acknowledged in the study. The question should be answered yes if it is obvious (based on study context) that co-interventions were unnecessary. Quality Appraisal Tool for Case Series 47

No: Co-intervention(s) are not reported, or the name(s) or type(s) of co-intervention(s) are unclear. *Note: Assessor(s) should decide which aspects are important before using the checklist.*

Outcome measures

9. Are the outcome measures clearly defined in the introduction or methods section?

Yes: All relevant (primary and secondary) outcomes that match the objective(s) of the study are described in the introduction or methods section (e.g. accomplished, measurable improvements or effects, symptoms relieved, improved function, improved test scores, and quality of life measures).

No: The outcomes are reported for the first time in the results or conclusion section of the study. The relevant outcomes are briefly mentioned without any details in the results, discussion, or conclusion section(s)**.** The outcomes reported are not relevant to study objective(s). *Note: Assessor(s) should decide which aspects are important before using the checklist.*

10. Were relevant outcomes appropriately measured with objective and/or subjective methods?

Yes: Appropriate methods used to measure the outcomes are described in the methods section. These measures might be objective (e.g. gold standard tests or standardized clinical tests), and/or subjective (e.g. self-administered questionnaires, standardized forms, or patient symptoms interview forms).

No: No details are provided on the objective or subjective methods used to measure study's outcomes.

11. Were outcomes measured before and after intervention?

Yes: The relevant outcomes are measured before and after applying the intervention.

No: The outcomes are measured only after applying the intervention.

Statistical analysis

12. Were the statistical tests used to assess the relevant outcomes appropriate?

Yes: The statistical tests are clearly described in the methods section and are used appropriately (e.g. parametric test for normally distributed population vs. nonparametric test for non-Gaussian population).

No: The statistical tests used to assess the relevant outcomes are inappropriate. From the information available it is unclear the distribution of the population from which the participants at the study were selected.

Results and conclusions

13. Was the length of follow-up reported?

Yes: The length of follow-up is clearly reported.

No: The length of follow-up is not reported, or the duration of the study is unclear.

14. Was the loss to follow-up reported?

Yes: The number or proportion of patients lost to follow-up is reported.

No: The number or proportion of patients lost to follow-up is not reported.

15. Does the study provide estimates of the random variability in the data analysis of relevant outcomes?

Yes: The study reports estimates of the random variability (e.g. standard error, standard deviation, confidence intervals) for all relevant primary and secondary outcomes.

No: Estimates of the random variability are not reported for all relevant outcomes. The presentation of the random variability is unclear (e.g. measure of dispersion reported without indicating if it is standard deviation or standard error).

16. Are adverse events reported?

Yes: The undesirable or unwanted consequences of the intervention during the study period or within a prespecified time period are reported. Absence of any adverse event(s) is acknowledged in the study.

No: There is no statement about the presence or absence of adverse events.

17. Are the conclusions of the study supported by results?

Yes: The main conclusions of the study are supported by the evidence presented in the results section.

No: The conclusions are not supported by the evidence presented in the results section.

Competing interest and source of support

18. Are both competing interest and source of support for the study reported?

Yes: Both competing interest and source of support (financial or other) received for the study are reported, or the absence of any competing interest and source of support is acknowledged.

No: Either there is no information available about competing interests and sources of support, or only one of these elements is reported.

APPENDIX III

PEDro score for:
Bateman M., Adams N. A randomised controlled feasibility study investigating the use of eccentric and concentric strengthening exercises in the treatment of rotator cuff tendinopathy. SAGE Open Medicine. 2014;2(3):1-7.

Score: 6/10

Nr.	Criteria	Rating Yes = 1 point No = 0 points
1	Eligibility criteria were specified	**Yes** / ~~No~~ Where: Method
2	Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	**Yes** / ~~No~~ Where: Method
3	Allocation was concealed	**Yes** / ~~No~~ Where: Method
4	The groups were similar regarding the most important prognostic indicators	**Yes** / ~~No~~ Where: Results
5	There was blinding of all subjects	**Yes** / ~~No~~ Where: Method
6	There was blinding of all therapists who administered the therapy	~~Yes~~ / **No** Where: N.A.*
7	There was blinding of all assessors who measured at least one key outcome	~~Yes~~ / **No** Where: N.A.
8	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	~~Yes~~ / **No** Where: Results
9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by "intention to treat"	**Yes** / ~~No~~ Where: Results
10	The results of between-group statistical comparisons are reported for at least one key outcome	**Yes** / ~~No~~ Where: Results
11	The study provides both point measures and measures of variability for at least one key outcome	~~Yes~~ / **No** Where: N.A.

N.A.= Not Applicable

APPENDIX IV

PEDro score for:
Maenhout A., Mahieu N., Muynck de M., Wilde de L., Cools A. 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. 2013;21(5):1158-1167.

Score: 6/10

Nr.	Criteria	Rating Yes = 1 point No = 0 points
1	Eligibility criteria were specified	**Yes** / ~~No~~ Where: Method
2	Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	**Yes** / ~~No~~ Where: Method
3	Allocation was concealed	~~Yes~~ / **No** Where: Method
4	The groups were similar regarding the most important prognostic indicators	~~Yes~~ / **No** Where: Results
5	There was blinding of all subjects	**Yes** / ~~No~~ Where: Method
6	There was blinding of all therapists who administered the therapy	~~Yes~~ / **No** Where: N.A.*
7	There was blinding of all assessors who measured at least one key outcome	~~Yes~~ / **No** Where: N.A.
8	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	**Yes** / ~~No~~ Where: Results
9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by "intention to treat"	**Yes** / ~~No~~ Where: Results
10	The results of between-group statistical comparisons are reported for at least one key outcome	**Yes** / ~~No~~ Where: Results
11	The study provides both point measures and measures of variability for at least one key outcome	**Yes** / ~~No~~ Where: N.A.

N.A.= Not Applicable

APPENDIX V

Modified Delphi checklist score for:

Bernhardsson S., Hultenheim Klintberg I., Kjellby Wendt G. Evaluation of an exercise concept focusing on eccentric strength training of the rotator cuff for patients with subacromial impingement syndrome. Clincal rehabilitation. 2011;25(1):69-78.

Score: 15/18

Nr.	Criteria	Rating: Yes = 1 point No = 0 points
1	Is the hypothesis/aim/objective of the study clearly stated in the abstract, introduction or methods section?	**Yes**
2	Are the characteristics of the participants included in the study described?	**Yes**
3	Were the cases collected in more than one centre?	**Yes**
4	Are the eligibility criteria (inclusion and exclusion criteria) to entry the study explicit and appropriate?	**Yes**
5	Were participants recruited consecutively?	**Yes**
6	Did participants enter the study at a similar point in the disease?	**Yes**
7	Was the intervention clearly described in the study?	**No**
8	Were additional interventions (co-interventions) clearly reported in the study?	**Yes**
9	Are the outcome measures clearly defined in the introduction or methods section?	**Yes**
10	Were relevant outcomes appropriately measured with objective and/or subjective methods?	**Yes**
11	Were outcome measured before and after interventions?	**Yes**
12	Were the statistical tests used to assess the relevant outcomes appropriate?	**Yes**
13	Was the length of follow-up reported?	**Yes**
14	Was the loss of follow-up reported?	**Yes**
15	Does the study provide estimates of the random variability in the data analysis of relevant outcomes?	**No**
16	Are adverse events reported?	**No**
17	Are the conclusions of the study supported by results?	**Yes**
18	Are both competing interest and source of support for the study reported?	**Yes**

APPENDIX VI

Modified Delphi checklist score for:
Camargo PR., Avila MA., Alburquerque-Sendin F., Asso NA., Hashimoto LH., Salvini TF. 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;16(1):74-83.

Score: 14/18

Nr.	Criteria	Rating: Yes = 1 point No = 0 points
1	Is the hypothesis/aim/objective of the study clearly stated in the abstract, introduction or methods section?	**Yes**
2	Are the characteristics of the participants included in the study described?	**Yes**
3	Were the cases collected in more than one centre?	**No**
4	Are the eligibility criteria (inclusion and exclusion criteria) to entry the study explicit and appropriate?	**Yes**
5	Were participants recruited consecutively?	**No**
6	Did participants enter the study at a similar point in the disease?	**Yes**
7	Was the intervention clearly described in the study?	**Yes**
8	Were additional interventions (co-interventions) clearly reported in the study?	**Yes**
9	Are the outcome measures clearly defined in the introduction or methods section?	**Yes**
10	Were relevant outcomes appropriately measured with objective and/or subjective methods?	**Yes**
11	Were outcome measured before and after interventions?	**Yes**
12	Were the statistical tests used to assess the relevant outcomes appropriate?	**Yes**
13	Was the length of follow-up reported?	**Yes**
14	Was the loss of follow-up reported?	**Yes**
15	Does the study provide estimates of the random variability in the data analysis of relevant outcomes?	**Yes**
16	Are adverse events reported?	**No**
17	Are the conclusions of the study supported by results?	**Yes**
18	Are both competing interest and source of support for the study reported?	**No**

APPENDIX VII

Modified Delphi checklist score for:
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;14(1):76-81.

Score: 11/18

Nr.	Criteria	Rating: Yes = 1 point No = 0 points
1	Is the hypothesis/aim/objective of the study clearly stated in the abstract, introduction or methods section?	**Yes**
2	Are the characteristics of the participants included in the study described?	**Yes**
3	Were the cases collected in more than one centre?	**No**
4	Are the eligibility criteria (inclusion and exclusion criteria) to entry the study explicit and appropriate?	**No**
5	Were participants recruited consecutively?	**No**
6	Did participants enter the study at a similar point in the disease?	**Yes**
7	Was the intervention clearly described in the study?	**Yes**
8	Were additional interventions (co-interventions) clearly reported in the study?	**Yes**
9	Are the outcome measures clearly defined in the introduction or methods section?	**Yes**
10	Were relevant outcomes appropriately measured with objective and/or subjective methods?	**Yes**
11	Were outcome measured before and after interventions?	**Yes**
12	Were the statistical tests used to assess the relevant outcomes appropriate?	**No**
13	Was the length of follow-up reported?	**Yes**
14	Was the loss of follow-up reported?	**Yes**
15	Does the study provide estimates of the random variability in the data analysis of relevant outcomes?	**No**
16	Are adverse events reported?	**No**
17	Are the conclusions of the study supported by results?	**Yes**
18	Are both competing interest and source of support for the study reported?	**No**