

**Exercise as a conservative treatment modality for
shoulder impingement syndrome: a systematic
review**

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Exercise as a conservative treatment modality for shoulder impingement syndrome: a systematic review

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Assistant Supervisor: Dr EJ Bruwer

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It all starts here™

Declaration

The co-authors of the two articles, Prof SJ Moss (supervisor), A/Prof MC Cameron (co-supervisor) and Dr EJ Bruwer (assistant supervisor) hereby give their permission to Miss L Van Zyl to include the two articles as part of the Master's dissertation. The contribution, both advisory and supportive, of the co-authors was within reasonable limits, thereby enabling the candidate to submit her dissertation for examination purposes. The dissertation therefore serves as fulfilment of the requirements for the MSc. Degree in Biokinetics within the research focus area: Physical Activity, Sport and Recreation (PhASRec) in the Faculty of Health Sciences of the North-West University (Potchefstroom Campus). Further to be declared that Miss L Van Zyl had a substantial enough input to be the primary author of the articles. The contribution of each author is presented in the table below.

Author	Contribution	Signature
L van Zyl	As Master's degree student searched the literature, selected the relevant articles for inclusion and exclusion, and drafted the two manuscripts.	
SJ Moss	Contributed to the conceptualisation of the second article, critically reviewed the first article and contributed, read and approved the final version of the manuscripts.	
MC Cameron	Assisted with the writing of the first article (Chapter 3) due to her expert knowledge in systematic reviews. Critically read both manuscripts and approved final version of the manuscripts.	
EJ Bruwer	Contributed significantly in terms of planning and conceptualising of the study and writing of the first manuscript.	

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Ephesians 3:20-21

"Now to Him who is able to do exceedingly abundantly above all that we ask or think, according to the power that works in us, to Him be glory in the church by Christ Jesus to all generations, forever and ever."

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"Family is not an important thing. It's EVERYTHING."

Michael J. Fox

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Abstract

Exercise as a conservative treatment modality for shoulder impingement syndrome: a systematic review

Shoulder impingement syndrome (SIS) is a clinical presentation likely in people who participate in physical activities, sports and occupations involving repeated overhead arm movements. It is one of the most common causes of shoulder pain. Shoulder impingement syndrome can be treated surgically or conservatively, and it is generally asserted that to ensure effective rehabilitation, exercise interventions should be evidence-based with due regard to type, duration, frequency, intensity and supervision of exercise.

In this dissertation, the first aim was to determine whether there is conclusive evidence for home-based or supervised exercise as conservative treatment modality for SIS. Secondly, the study aimed to determine consistencies in the type, duration, frequency and intensity of rehabilitation exercises that can serve as guidelines for rehabilitation of SIS. A systematic review and meta-analysis using data from randomized, controlled intervention studies were conducted to meet these aims. Only English publications meeting the inclusion criteria were included, resulting in six RCTs (n=475; intervention duration, 3 to 12 weeks) meeting the inclusion criteria. Outcomes of interest were pain at rest, pain during movement, as well as shoulder ROM, patient satisfaction and function. Data were summarised and mean differences (MD), standard mean differences (SMD) and an overall effect size of 95% confidence intervals (CI) were extracted using Review Manager 5.3.

Pain at rest was reported by four studies and one study showed statistically significant improvement for exercise (MD -1.90; 95% CI -3.36 to -0.44; $p=0.01$). All six studies reported pain during movement. Only two studies reported significant improvement in pain during movement favouring exercise (compared to no intervention) (SMD -0.81; 95% CI -1.18 to -0.44; $p<0.0001$) while the remaining studies reported no significant improvements between groups. Three studies assessed shoulder range of motion (ROM) and one ROM measurement (medial rotation) from one study reported statistically significant improvement in the exercise group (MD 9.70; 95% CI 2.34 to 17.06; $p=0.010$). Two studies demonstrated no significant improvement in shoulder ROM among groups and were inconclusive. Function was reported by all six studies and two studies demonstrated statistically significant improvements for the exercise groups (SMD -0.66; 95% CI -1.02 to -0.29; $p=0.0004$). Two studies showed improvement in favour of the exercise group, but were not significant. One

study favoured radial extracorporeal shockwave therapy (rESWT) but the results were also not significant and the results for this study were inconclusive. Patient satisfaction was reported by one study and showed statistically significant results in favour of the exercise group.

Some patients in the exercise treatment groups improved significantly on key outcome measurements, but in other studies the improvements did not reach significant or clinically important levels. These results demonstrate a lack of moderate evidence for conservative exercise rehabilitation in the treatment of SIS with regards to frequency, intensity, duration and modality of treatment. Based on the limited evidence, guidelines were compiled for the treatment of SIS with exercise rehabilitation. However, more research is needed to obtain strong evidence for SIS rehabilitation and in order to update the proposed guidelines presented in this dissertation.

Key words: shoulder impingement syndrome, shoulder rehabilitation, conservative treatment for shoulder, exercise modalities in shoulder rehabilitation, exercise therapy

Opsomming

Oefening as konserwatiewe behandelingsmodaliteit vir rotatorkraag beklemming: 'n sistematiese oorsig

Rotatorkraag beklemming (RB) is 'n kliniese kondisie wat algemeen voorkom in persone wat deelneem aan fisieke aktiwiteit, sport of 'n beroep wat herhalende oorhoofse armbewegings vereis. Rotatorkraag beklemming kan chirurgies of konserwatief behandel word. Om effektiewe en suksesvolle rehabilitasie te verseker moet oefenintervensies wetenskaplik gebaseer wees, met behoorlike inagneming van die tipe, duur, frekwensie, intensiteit en toesig tydens die rehabilitasieprogram.

Die eerste doel van die verhandeling was om te bepaal of daar voldoende bewyse is vir oefening as behandelingsmodaliteit vir RB en tweedens, om konsekwentheid in die tipe, duur, frekwensie en intensiteit van oefenintervensies te bepaal, wat as riglyne kan dien vir 'n oefeninggebaseerde rehabilitasieprogram. 'n Sistematiese oorsig en meta-analise is uitgevoer met die gebruik van data uit ewekansige, gekontroleerde intervensie studies om hierdie doelwitte te bereik. Slegs Engelse publikasies wat voldoen het aan die insluitingskriteria is geïdentifiseer en 6 volledige manuskripte is verkry (N = 475; duur van intervensie, 3 tot 12 weke). Uitkomst van belang was pyn met rus, pyn tydens beweging, skouerbewegingsomvang, pasiënt-tevredenheid en funksionaliteit. Data is opgesom en gemiddelde afwyking (GA), standaard gemiddelde afwyking (SGA) en 'n algehele effekgrootte van 95% vertrouwe-interval (VI) is onttrek deur middel van Review Manager 5.3.

Pyn tydens rus is gerapporteer deur vier studies waarvan statisties betekenisvolle verbetering gevind is vir die oefengroep (GA -1,90; 95% VI -3,36 tot -0,44; $p = 0,01$) in een van die studies. Ses studies het pyn tydens beweging gemeet en slegs twee studies het statisties betekenisvolle verlaging in pyn getoon in die oefengroep (SGA -0,81; 95% VI -1,18 tot -0,44; $p < 0,0001$). Die oorblywende studies het geen betekenisvolle verbeterings tussen groepe getoon nie. Drie studies het skouerbewegingsomvang getoets en slegs mediale rotasie van een studie het statisties betekenisvolle verbetering in die oefengroep getoon (GA 9,70; 95% VI 2,34-17,06; $p = 0,010$). Twee studies het geen betekenisvolle verbetering getoon in bewegingsomvang van die skouer tussen groepe nie. Funksionaliteit is gerapporteer deur ses studies en twee studies het statisties betekenisvolle verbeterings getoon ten gunste van die oefengroepe (SGA -0,66; 95% VI -1,02 tot -0,29; $p = 0,0004$). Twee studies het verbetering getoon ten gunste van die oefengroep, maar dit was nie betekenisvol nie. Een studie bevoordeel die radiale buiteliggaamlike skokgolf terapie groep, maar die uitslae was

ook nie statisties betekenisvol nie en die resultate dus onbeslis. Pasiënt-tevredenheid is gerapporteer deur een studie en het statisties beduidende resultate ten gunste van die oefen groep getoon.

Sommige pasiënte in die oefengroepe het betekenisvolle verbetering getoon ten opsigte van die belangrikste uitkomst, maar in ander studies was daar geen statisties- of klinies betekenisvolle verbeterings nie. Hierdie resultate toon 'n gebrek aan 'n redelike bewyse vir konserwatiewe oefening as rehabilitasie in die behandeling van RB met betrekking tot frekwensie, intensiteit, duur en modaliteit van oefening as behandeling. Op grond van die beperkte bewyse en ander konsensus dokumente is riglyne saamgestel vir die behandeling van RB met oefengebasseerde rehabilitasie. Verdere, hoë kwaliteit oefen intervensie studies is nodig om duidelike bewyse vir RB rehabilitasie in te samel en om die huidige riglyne wat in hierdie verhandeling voorgestel is, op te dateer.

Sleutel woorde: rotatorkraag beklemming, skouer rehabilitasie, konserwatiewe behandeling vir skouerpyn, oefening modaliteite vir skouer rehabilitasie, oefeningsterapie

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List of abbreviations

A	AC	acromioclavicular
	AHD	acromiohumeral distance
C	CI	confidence intervals
	CDSR	Cochrane Database of Systematic Reviews
D	DASH	Disabilities of the Arm, Shoulder, and Hand Scale
E	EMG	electromyographic
F	FHP	forward head posture
	FITT	frequency, intensity, time and type
	FST	forward shoulder translation
G	GH	glenohumeral
	GIRD	glenohumeral internal rotation deficit
H	HE	home exercise
I	ITT	intention-to-treat
J	JPS	joint position sense
L	LT	lower trapezius
M	MD	mean difference
	MWM	mobilization with movement
	MRI	magnetic resonance imaging
N	NSAID	nonsteroidal anti-inflammatory drug
P	PNF	proprioceptive neuromuscular facilitation
	PT	physical therapist
	ROM	range of motion
R	RCT	randomised controlled trials
	RevMan	Review Manager
	RM	repetition maximum
	rESWT	radial extracorporeal shockwave therapy
	SAT	scapular assisted test
S	SA	serratus anterior
	SAS	subacromial space
	SC	sternoclavicular
	SD	standard deviations
	SE	supervised exercise

	SF-36	Short Form-36
	SHR	scapulohumeral rhythm
	SIS	shoulder impingement syndrome
	SINS	severity, irritability, nature and stage
	SLAP	superior labral tear from anterior to posterior
	SM	scapular mobilization
	SMD	standard mean difference
	SPADI	Shoulder Pain and Disability Index
	SRQ	self-report questionnaires
	SSM	sham scapular mobilization
	ST	scapulathoracic
T	TENS	transcutaneous electrical nerve stimulation
U	UT	upper trapezius
V	VAS	visual analogue scale

CHAPTER 1

Introduction

1.1 INTRODUCTION

Musculoskeletal disorders in the shoulder girdle, such as shoulder impingement syndrome (SIS), are common in general and athletic populations (Casonato *et al.*, 2003:69; Dahm & Smith, 2003:7). Page (2011:56) asserted that structural or primary impingements sometimes require surgery, whereas functional or secondary impingements and instabilities can be successfully managed with conservative treatments such as exercise intervention to redress the pathomechanics of muscle imbalance. Exercise may be considered the initial treatment modality for these shoulder disorders, and surgery considered only when conservative management has failed (Michener *et al.*, 2004:161; Wright & Matava, 2002:34). Dahm and Smith (2003:5) suggested that surgery could be considered if a three to six month comprehensive exercise intervention program was unsuccessful, and when the surgeon is convinced that the diagnosis is sound.

Michener *et al.* (2004:153) stated that a lack of understanding of the pathomechanics of shoulder impingement syndrome can be clearly seen with some exercise intervention protocols in published literature. A thorough understanding of the normal and abnormal glenohumeral and scapular kinematics, pathophysiology and aetiology of SIS, and the knowledge to perform a comprehensive clinical examination for accurate diagnosis, are important tools for effective rehabilitation. The mechanics and treatment for SIS are thoroughly discussed in a comprehensive literature review in Chapter 2. Given the inconsistency in available literature regarding rehabilitation protocols for SIS, the need to explore the effects of current exercise interventions was identified. A systematic review was conducted to yield information which may guide and increase the knowledge of the exercise therapist. In Chapter 4, evidence-based guidelines for the use of exercise are supplied which can guide clinicians regarding the most effective mode, intensity, frequency, duration and progression of exercise interventions.

1.2 PROBLEM STATEMENT

Shoulder injuries or dysfunctions are prevalent among throwing and non-throwing athletes (Heyworth & Williams, 2009:1029; Liebenson, 2005:190) as well as the general population who are regularly exposed to overhead work (Ludewig & Borstad, 2003:842). Common injuries that occur in the overhead athlete include primary instability, acute traumatic instability, internal impingement, subacromial impingement, overuse tendinitis syndrome (rotator cuff and/or long head of the biceps brachii muscles), posterior rotator cuff musculature tendinitis, SLAP (superior labral tear from anterior to posterior) lesions and Bennett's lesion (Wilk *et al.*, 2002:146). Activities and sports associated with shoulder impingement are tennis, squash, other racquet sports, volleyball, baseball, javelin throwers and other throwing activities (Heyworth & Williams, 2009:1029). Injuries that occur in these overhead athletes are a result of repetitive strain of maximal abduction and external rotation (Heyworth & Williams, 2009:1029; Liebenson, 2005:196).

The shoulder is a ball-and-socket synovial joint, with limited bony stability (Shultz *et al.*, 2009:226). The static stabilizers of the shoulder include the glenohumeral ligaments and glenoid labrum along with the joint capsule, while the rotator cuff muscles as well as other muscular structures surrounding the glenohumeral joint are responsible for dynamic stability (Levine & Flatow, 2000:910; Peat, 1986:1865). Sorensen and Jorgensen (2000:267) defined instability as any discrepancy in the structure or function of the shoulder which leads to abnormal and pathological motion in the glenohumeral joint. Muscular imbalances can lead to changes in the glenohumeral kinematics and these movement impairments are ultimately defined as shoulder instability (Kamkar *et al.*, 1993:218; Voight & Thomson, 2000:371).

Glenohumeral instability leads to secondary shoulder impingement due to a loss of subacromial space secondary to altered shoulder kinematics (Page, 2011:52). The subacromial bursa, supraspinatus tendon, long head of the biceps brachii tendon, joint capsule and labrum are some of the structures that can become stressed or impinged with abnormal shoulder kinematics (Liebenson, 2005:190; Michener *et al.*, 2003:369). Internal impingement can be defined as a pathological condition that occurs when the rotator cuff (posterior fibres of the supraspinatus tendon and anterior fibres of the infraspinatus) becomes impinged between the greater tuberosity of the humerus and the

posterior superior aspect of the glenoid labrum when the arm is in excessive abduction and external rotation (Giaroli *et al.*, 2005:928; Heyworth & Williams, 2009:1024). Subacromial impingement is anterior lateral impingement of the subacromial tissue against the acromion and the coracoacromial ligament with glenohumeral elevation (Michener *et al.*, 2003:369). It has been proposed that changes in the upper body posture such as forward head and rounded shoulders, as well as thoracic kyphosis can cause shoulder impingement symptoms, as these postural adaptations contribute to altered scapular and glenohumeral kinematics (Lewis *et al.*, 2001:466; Michener *et al.*, 2003:370; Thigpen *et al.*, 2010:706).

Conservative treatment aims to regain postural control, correct and improve shoulder muscle imbalance, limit recurrence (Kelly *et al.*, 2010:100) and restore normal neuromuscular function (Page, 2011:53). Conservative treatment precedes surgery in the majority of cases and consists of the following treatment modalities: flexibility exercises for the anterior and posterior shoulder (Hanratty *et al.*, 2012:314), strengthening (Hanratty *et al.*, 2012:314; Wilk *et al.*, 2002:136), motor control techniques, manual therapy, joint mobilization, functional mobility retraining (Michener *et al.*, 2004:163) and scapular stability exercises (Hanratty *et al.*, 2012:314). Buss *et al.* (2004:1433) suggested that conservative treatment seems to be an effective treatment regimen for athletes who wish to return to their activities and be able to perform at or near their previous levels of competition.

Some authors suggest that better results are obtained if exercise is used in combination with other conservative interventions such as physiotherapy treatments (manual therapy, laser therapy, kinesio taping or electrotherapy) (Bang & Deyle, 2000:134; Kaya *et al.*, 2011:203; Kuhn, 2009:148; Moezy *et al.*, 2014:12). There is adequate evidence in the published literature to support the general positive effect of exercise in the rehabilitation of shoulder impingement syndrome (Engebretsen *et al.*, 2009:731, Lombardi *et al.*, 2008:619; Ludewig & Borstad, 2003:847). Consensus is needed on the exercise modalities, duration, repetitions and intensity required to maximize treatment effectiveness (Kelly *et al.*, 2010:107; Michener *et al.*, 2004:160).

The question that needs to be answered is: What is the current evidence on the use of exercise modalities for SIS in relation to the type, duration, frequency and intensity of exercise? Answers to the question would provide evidenced-based information for the compilation of guidelines for future application of exercise rehabilitation as a conservative treatment modality. This information will guide the therapist to develop a well-defined shoulder rehabilitation protocol to successfully treat SIS conservatively. This information will also point out the limitations of current evidence and guide researchers to verify and validate the findings of exercise as treatment modality for SIS.

1.3 OBJECTIVES

The objectives of this study are:

- To determine whether there are conclusive evidence for home-based or supervised exercise as conservative treatment modality for shoulder impingement syndrome.
- To identify consistencies in the type, duration, frequency and intensity of rehabilitation exercises that can serve as guidelines for rehabilitation of shoulder impingement syndrome.

1.4 HYPOTHESES

Since there would be no statistical analyses for the second objective of the study, there is no hypothesis to be formulated in this regard, but the following hypothesis was formulated for the first objective of this research:

- There is conclusive evidence for home-based or supervised exercise as conservative treatment modality for shoulder impingement syndrome.

1.5 STRUCTURE OF THE DISSERTATION

The dissertation is presented in article format consisting of five major parts (Figure 1-1). Chapter 1 is an introduction and provides the problem statement and objectives of this dissertation. To answer the defined research question and problem statement, a narrative review was conducted in Chapter 2: Mechanics and treatment of shoulder impingement syndrome. This chapter critically summarises the current knowledge of the normal and abnormal shoulder anatomy and biomechanics, a broad overview on published and

available articles on SIS and the different treatment modalities regarding this pathology. Chapter 3 is a systematic review entitled: "Exercise as conservative treatment modality for shoulder impingement syndrome: a systematic review". This review systematically searched, identified, appraised and synthesized the trials that have been published regarding exercise as conservative treatment modality for SIS. This article has been prepared for submission to the *Cochrane Database of Systematic Reviews (CDSR)* journal. More information about submissions to the CDSR is presented in Appendix A. Chapter 4 is a guidelines document informed by the literature reviewed in Chapters 2 and 3, entitled "Exercise as conservative treatment modality for shoulder impingement syndrome: evidence-based guidelines". This chapter was prepared in article format for submission to the *Journal of Orthopaedic & Sports Physical Therapy*. The authors' guidelines for this journal are presented in Appendix B. Chapter 5 consists of the summary, conclusions, limitations and recommendations of this dissertation. The references for Chapters 2 and 5 (according to the Harvard style as prescribed by the NWU) are presented at the end of each chapter. The references for the two article-based chapters are also presented at the end of each respective chapter, but in accordance with the journal reference requirements.

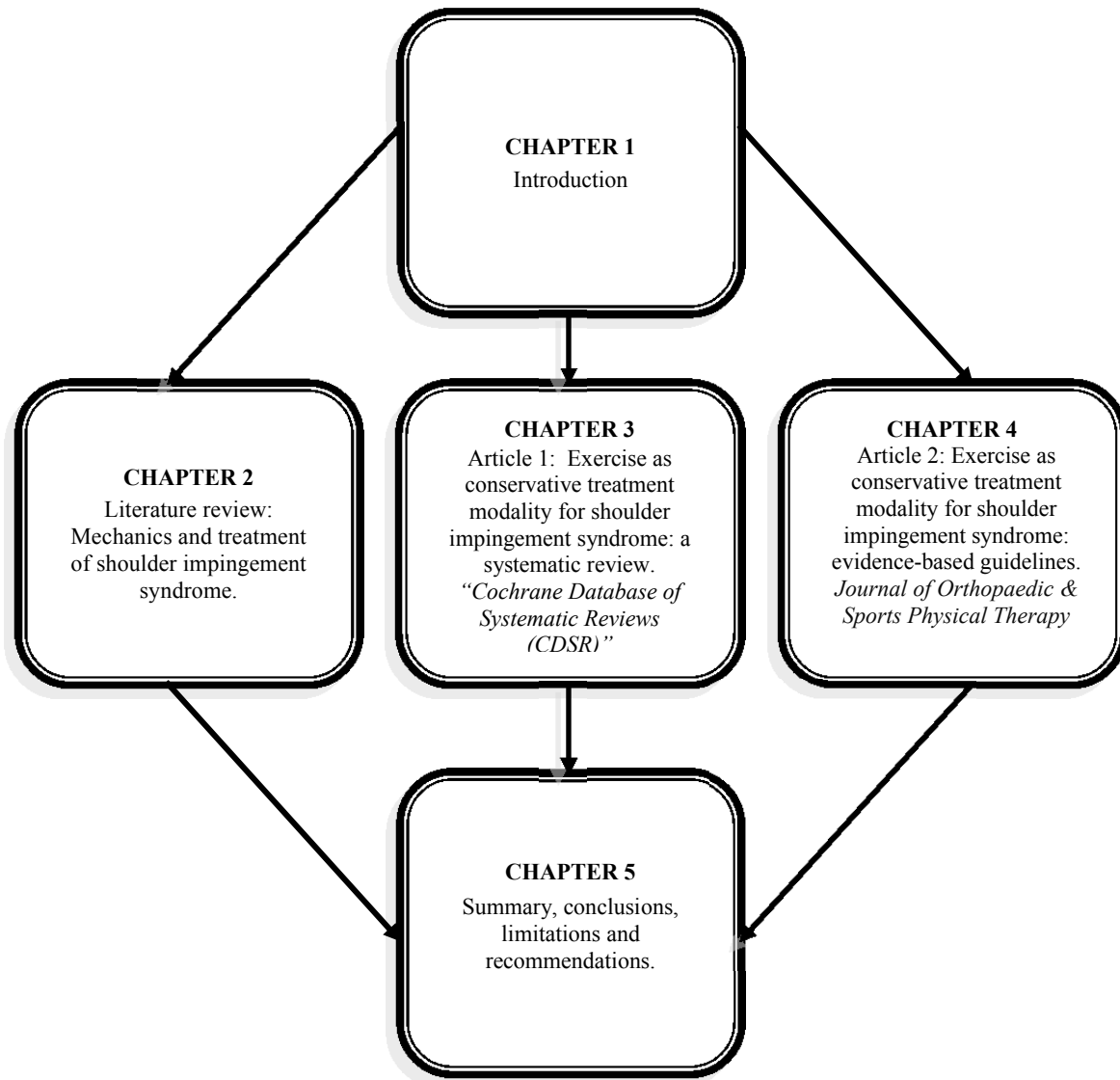


Figure 1-1: Schematic presentation of the structure of this dissertation.

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CHAPTER 2

Literature review: Mechanics and treatment of shoulder impingement syndrome

2.1 INTRODUCTION

The shoulder complex includes the scapula-thoracic and glenohumeral articulations, thus the shoulder is a highly mobile, multi-axial, complex joint, displaying combination movements (Culham & Peat, 1993:349). The high degree of mobility and the repetitive forces on the glenohumeral- and acromioclavicular joints make the shoulder joint vulnerable to instability, dislocations and repetitive stress injuries (Shultz *et al.*, 2010:226). There is no clear consensus in literature of the exact pathophysiology and etiology of shoulder impingement (De Witte *et al.*, 2011:10) and therefore the treatment modalities vary across clinical trials conducted.

Firstly, this chapter presents an approach to improve our understanding of normal and abnormal glenohumeral and scapular kinematics and the numerous factors that cause shoulder impingement syndrome. Secondly, this chapter will provide an overview of the examination and assessment strategies to successfully determine the specific abnormal kinematics and contributing factors of individual patient suffering from this disorder. By determining the severity and factors contributing to the pathology, the clinician can make an informed decision in choosing the appropriate treatment option. Thirdly, surgery and conservative treatment modalities are discussed in this chapter, with emphasis on exercise. This literature overview is concluded with a discussion of the role of the exercise therapist in treating SIS and the results of several outcomes of studies reviewing exercise in the management of this pathology.

2.2 ANATOMY OF THE SHOULDER GIRDLE

2.2.1 Anatomy of the shoulder

The shoulder complex consists of four articulations, namely the glenohumeral (GH) joint, the acromioclavicular (AC) joint, the sternoclavicular (SC) joint and the scapulothoracic

(ST) joint (Loudon *et al.*, 2013:182), which contribute to the incredible range of motion (ROM) of the arm through coordinated joint actions (Hamill & Knutzen, 2009:140). The shoulder complex has limited bony stability and relies on the capsuloligamentous complex and 18 muscles acting on the shoulder joint for stability (Shultz *et al.*, 2010:226). The anterior axio-appendicular muscles consist of the following four muscles: pectoralis major, pectoralis minor, subclavius and serratus anterior and their primary function is to move the pectoral girdle (Moore *et al.*, 2015:414). The posterior axio-appendicular muscles can be divided into three groups: superficial posterior axio-appendicular muscles, deep posterior axio-appendicular muscles and the scapulohumeral muscles (Moore *et al.*, 2015:414). The primary function of the superficial muscles (trapezius and latissimus dorsi) and the deep muscles (levator scapulae and rhomboids) is to attach the superior appendicular skeleton to the axial skeleton (Moore *et al.*, 2015:416). The deltoid, teres major, supraspinatus, infraspinatus, teres minor and subscapularis are the six scapulohumeral muscles and their primary function is to hold the humeral head in the glenoid cavity of the scapula during all movement of the shoulder (Moore *et al.*, 2015:419). The lower, middle and upper trapezius, upper and lower portions of the serratus anterior, levator scapulae, pectoralis minor and rhomboids work in coordinated patterns to control the movement of the scapula (Brukner & Khan, 2012:344).

2.2.2 Applied anatomy of the shoulder girdle

The GH joint is the most mobile joint in the human body and naturally unstable due to the shallowness of the glenoid fossa and disproportionate size of the humeral head (Culham & Peat, 1993:349). Liebenson (2005:190) described this disproportionate relationship of the ball and socket of the shoulder as a ball (humeral head) balancing on a seal's nose (glenoid fossa of the scapula). Simultaneous, synchronized motion of all four joints (GH, AC, SC and ST joints) is the result of static and dynamic stabilizers of the shoulder (Terry & Chopp, 2000:255). Stability of the humeral head on the shallow glenoid fossa, during rest or movement, is dependent on the capsuloligamentous complex (joint capsule, coracohumeral and glenohumeral ligaments) and the glenoid labrum for static stability (Terry & Chopp, 2000:255). The muscular structures (rotator cuff muscles and their respective force-couple antagonist) are responsible for dynamic stability (Culham & Peat, 1993:349; Peat, 1986:1865; Terry & Chopp, 2000:255).

2.2.3 Normal scapulohumeral rhythm

Scapulohumeral rhythm can be defined as the relative motion between the ST and GH joints (DeLee *et al.*, 2010:776) and the coordinated timing of joint and muscular activity during shoulder abduction, flexion and scaption (Liebenson, 2005:192). The main purpose of the scapulohumeral rhythm is to maintain the glenoid fossa in optimal position to receive the head of the humerus (Liebenson, 2005:192). During normal full ROM of 180 degrees of abduction, the humerus, scapula and clavicle must act in a coordinated fashion to provide smooth full shoulder ROM (Culham & Peat, 1993:349, Hamill & Knutzen, 2009:146; Liebenson, 2005:192). Properly coordinated scapula-humeral rhythm consists of an average glenohumeral to scapulothoracic motion ratio of 2:1, thus for every 2° of glenohumeral motion there is 1° of scapulothoracic motion (DeLee *et al.*, 2010:788; Liebenson, 2005:192). During 180° of normal shoulder abduction, the GH joint abducts 120° together with a 60° upward rotation of the ST joint as indicated in Figure 2-1 (Liebenson, 2005:192; Loudon *et al.*, 2013:193). The initial 30° of glenohumeral abduction is only glenohumeral motion and is called the setting phase (DeLee *et al.*, 2010:788; Liebenson, 2005:192). After that, there is an almost equal contribution of abduction between these functional joints (DeLee *et al.*, 2010:788; Liebenson, 2005:192).

Scapular upward rotation, posterior tilt and internal or external rotation are normal scapulothoracic movement that occurs during elevation of the humerus (Ludewig & Braman, 2011:38; Ludewig *et al.*, 1996:64). Ludewig *et al.* (1996:64) investigated scapular electromyographic (EMG) activity during humeral elevation in 25 asymptomatic subjects (11 men and 14 women) with a limited age range between 18-40 years. They found increased humeral elevation with progressively increased activity of the levator scapula, upper trapezius, lower trapezius and serratus anterior. The AC joint (upward rotation of the scapula) and SC joint (elevation of the lateral end of the scapula) also participate in these coupled interactions (Liebenson, 2005:192). Humeral abduction involves 0°-5° elevation of the clavicle in the initial phase, 15° in the second phase and the last phase involves 30°-50° posterior rotation up to 15° elevation (Magee, 2008:249).

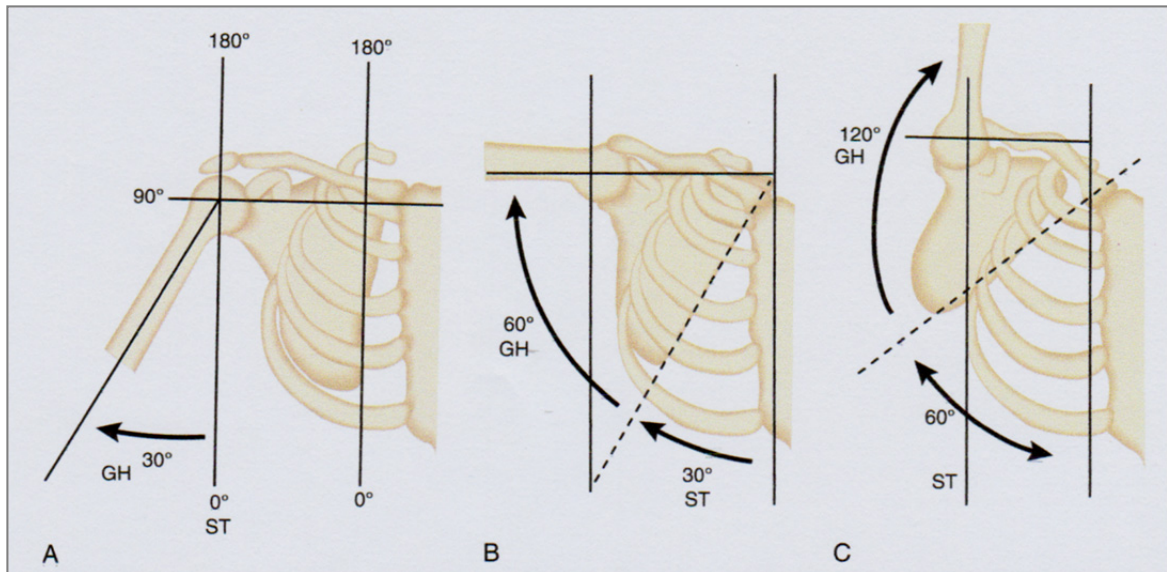


Figure 2-1: Normal scapulohumeral rhythm of the first 30° (A), the next 60° (B) and the final 120° (C) (adapted from: DeLee *et al.*, 2010:788).

2.2.4 Dynamic stabilizers and force couples within scapula and glenohumeral joints

The GH, AC, SC and ST joints must function in coordinated fashion for smooth movement within the shoulder complex (Hess, 2000:66). Jobe and Pink (1993:429) described four types of muscle groups according to their function in the GH joint. Firstly the protectors, which consist of the four rotator cuff muscles, function to externally rotate (infraspinatus and teres minor), internally rotate (subscapularis) and elevate the humerus (supraspinatus). The rotator cuff muscles protect the shoulder joint by fine-tuning the humeral head, directing the motion of the humerus and maintaining the humeral head dynamically in the glenoid fossa (Terry & Chopp, 2000:255).

The scapular pivoters work in close association with the glenohumeral protectors - these scapular muscles function as force couples (Jobe & Pink, 1993:430) and must work synergistically in timing and level of intensity to produce movement around a joint (Houglum, 2010:600). Coordinated outward rotation of the scapula is important during humeral abduction and requires a balance between the scapulothoracic force couple (upper trapezius, lower trapezius, levator scapula and serratus anterior) and the force couple between the deltoid and rotator cuff muscles (Magee, 2008:249). Coupling of deltoid and rotator cuff (subscapularis, infraspinatus, teres minor) force couples permit movement of the humerus with the upward shear forces of the deltoid and stabilize the humerus at the same time with compression and decompression by the rotator cuff muscles as indicated in Figure 2-2 (Hess, 2000:67, Loudon *et al.*, 2013:208).

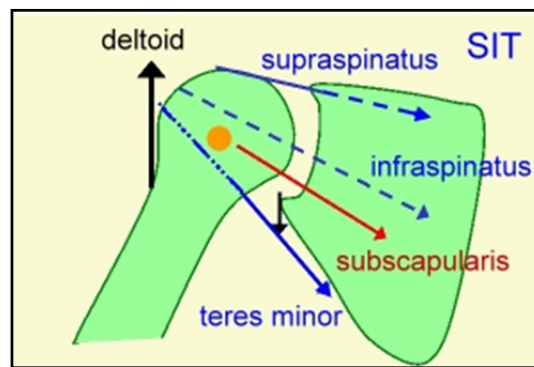


Figure 2-2: The force couple between the deltoid and rotator cuff muscles.

(Adapted from: Chai, H., 2004)

The upper trapezius (UT) counteracts the lateral pull of the deltoid during humerus abduction and the serratus anterior (SA) produces antero-lateral movement of the inferior angle of the scapula (Magee, 2008:249). The lower trapezius (LT) and lower SA work synergistically to provide abduction, elevation and upward rotation of the scapula to shift the glenoid surface in an optimal position to maintain the head of the humerus as indicated in Figure 2-3 (Hamill & Knutzen, 2009:149, Loudon *et al.*, 2013:208).

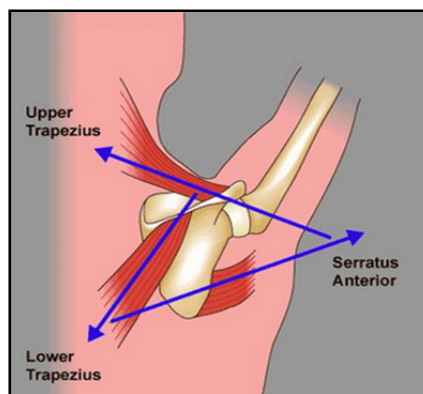


Figure 2-3: A schematic presentation of the scapula force couple.

(Adapted from: Anon., 2010)

The positioners consist of the anterior, middle and posterior deltoid muscles which function to position the humerus in space and the propeller muscles include the pectoralis major and latissimus dorsi (Jobe & Pink 1993:439).

2.3 SHOULDER IMPINGEMENT SYNDROME

2.3.1 Types, definition and etiology

Shoulder impingement syndrome is a commonly diagnosed shoulder pathology and can be classified into two major categories: internal impingement with the glenoid rim and external impingement with the coracoacromial arch (Brukner & Khan, 2007:254; Ludewig & Braman, 2011:38). External impingement can further be divided into two subtypes - primary or structural impingement and secondary or functional impingement (Brukner & Khan, 2007:254; Page, 2011:52). Multiple important structures in the subacromial space (SAS) as indicated in Figure 2-4, that are vulnerable to either impingement or instability, include the subacromial bursa, supraspinatus muscle and tendon, the superior joint capsule and the intra-articular portion of the long head of the biceps brachii (Liebenson, 2005:190; Loudon *et al.*, 2014:191).

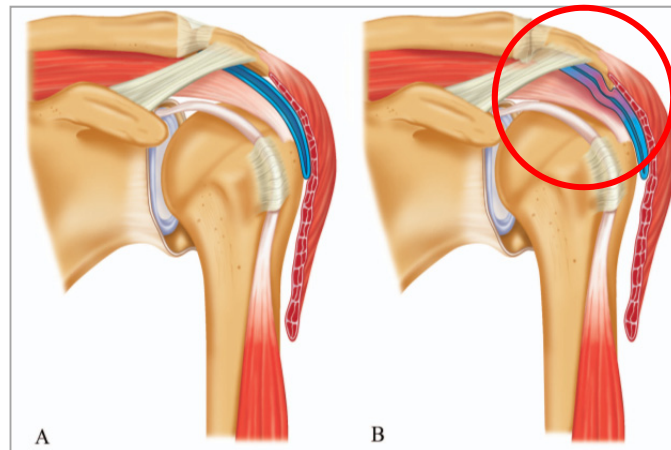


Figure 2-4: A - Anatomy of a healthy shoulder joint and structures of the SAS.

B - Anatomy of a shoulder joint with statically reduced SAS as a result of etiologic mechanisms of SIS (adapted from: De Witte *et al.*, 2011:3).

Sorensen and Jorgensen (2000:267) defined primary or structural impingement as encroachment of the subacromial structures caused by an outlet stenosis of the SAS in a shoulder without instability. The statically reduced SAS can be due to abnormalities of the superior structures. These abnormalities include structural anatomic variations (abnormally beaked, curved or hooked acromion as indicated in Figure 2-5) as a result of congenital abnormality or formation of osteophyte and abnormalities presenting in the older population which include AC joint osteoarthritis, subacromial osteophytes (illustrated in Figure 2-6) and calcifying tendinitis (Brukner & Khan, 2007:254; De Witte *et al.*, 2011:3).



Figure 2-5: Structural anatomic acromion shape variations.

(Adapted from: Anon., 2012)

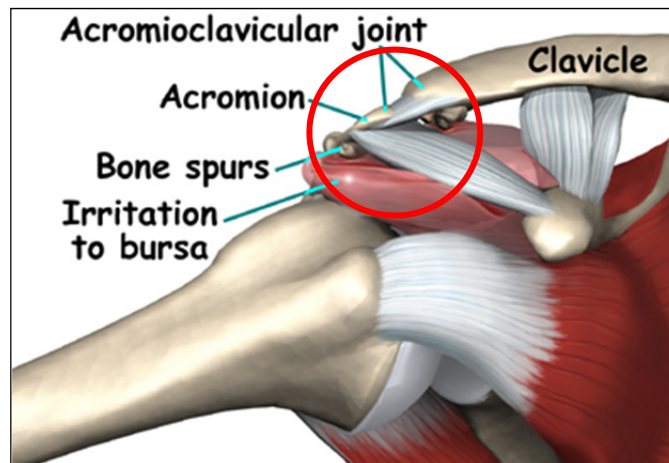


Figure 2-6: Bone spurs (osteophyte formation) of the acromion.

(Source: Anon., 2001)

Secondary or functional impingement can be defined as encroachment secondary to instability in the shoulder (Sorensen & Jorgensen, 2000:267). Secondary impingement is possible with overuse and fatigue of the scapular stabilizers (DeLee *et al.*, 2010:1001), inadequate scapular stabilization or weakness of the scapulothoracic muscles (Brukner & Khan, 2007:254, Kamkar *et al.*, 1993:220). Primary and secondary shoulder impingement contributes to anterior and/or lateral shoulder pain with glenohumeral elevation (Brukner & Khan, 2007:255). Internal or glenoid impingement can be defined as encroachment of the rotator cuff against the posterior-superior surface of the glenoid with the arm in excessive extension, abduction and external rotation (Brukner & Khan, 2007:256; Heyworth & Williams, 2009:1028). Internal impingement occurs mainly in young to middle-aged overhead athletes during the late cocking stage of throwing (Brukner & Khan, 2007:256, Heyworth & Williams, 2009:1028, Jobe & Pink, 1993:431) and usually present with

posterior and/or anterior shoulder pain with abduction or external rotation (Brukner & Khan, 2007:255). De Witte *et al.* (2001:9) suggested that impingement of structures in the SAS can lead to compensation mechanisms during pain-provoking activities to prevent further encroachment.

2.3.2 Causes of secondary shoulder impingement

This pathology occurs when the rotator cuff tendons are impinged as they pass through the SAS (Brukner & Khan, 2007:254). Numerous factors may combine to cause shoulder impingement, such as postural changes associated with forward-head, kyphotic or slouched posture (Bullock *et al.*, 2005:32; Kebaetse *et al.*, 1999:950; Lewis *et al.*, 2005:390), altered glenohumeral and scapular kinematics as a result of muscle imbalance or altered muscle activation (Lucado, 2011:362; Ludewig and Reynolds, 2009:100; Michener *et al.*, 2003:376) and tightness of the pectoralis minor and/or posterior glenohumeral capsule (Lucado, 2011:362).

Correct posture is essential for shoulder balance and normal shoulder kinematics (Houglum, 2010:600). Deviations in posture such as forward-head, thoracic kyphosis or slouched upper body posture are associated with altered scapular kinematics which leads to decreased scapular upward rotation, increased anterior and superior humeral head translation and decreased posterior tilting and external rotation of the scapula (Kebaetse *et al.*, 1999:950, Lewis *et al.*, 2005:390). Bullock *et al.* (2005:32) compared the effect of slouched posture versus erect sitting posture on 28 subjects (14 male and 14 female) with a mean age of 48.2 years, with classic signs and symptoms of shoulder impingement. The maximum active shoulder flexion (measured using video-analysis) and associated pain intensity (measured using the Visual analog scale) were measured in slouched and erect posture. They found that the maximal shoulder ROM increased significantly during the adoption of an erect posture (from 109,7° in the slouched posture to 127,3° in the erect sitting posture). They also found that 19 out of the 28 patients reported less pain when in an erect posture while performing shoulder flexion. It is noted that in the study by Kebaetse *et al.*, (1999:950), muscle force and shoulder abduction ROM was decreased in the slouched posture resulting in altered scapular kinematics. These abnormal glenohumeral and scapular kinematics decreased posterior tilting and increase in superior translation of the humeral head produce increased subacromial pressure as the greater tuberosity approaches the anterior aspect of the acromion (Ludewig *et al.*, 1996:63; Lukasiewicz *et al.*,

1999:576). This prevents full elevation of the shoulder resulting in subacromial impingement (Houglum, 2010:600; Michener *et al.*, 2003:375) of the subacromial bursa, supraspinatus tendon, long head of the biceps brachii tendon, joint capsule and labrum (Liebenson, 2005:190; Michener *et al.*, 2003:369).

Muscle imbalance or altered muscle activation, in particular decreased serratus anterior, increased upper trapezius (Lucado, 2011:362; Ludewig & Reynolds, 2009:100) and decreased activation of the middle/lower trapezius (Cools, 2003:548; Lucado, 2011:362) have been demonstrated to alter the subacromial space dimension as well as the relationship of the subacromial structures (Michener *et al.*, 2003:375). Weakness and fatigue of the muscles that control the scapulothoracic and glenohumeral joint articulations (Michener *et al.*, 2003:376) have been associated with the inability to maintain the scapula in a stable and neutral position (DeLee *et al.*, 2010:239). This scapular dysfunction disturbs the normal scapulohumeral rhythm by reducing or locking the setting phase (Liebenson, 2005:192). Kamkar *et al.* (1993:220) suggested that these muscle imbalances cause altered scapular kinematics which lead to humeral elevation that is not synchronised with upward rotation or adduction of the arm, and which is not synchronised with downward scapular motion. This may predispose an individual to shoulder impingement or aggravate impingement syndrome.

The scapular assisted test (SAT), illustrated in Figure 2-7, can be helpful in identifying individuals with secondary shoulder impingement syndrome, as this manoeuvre provides great relieve by simulating the function of the SA and LT force couple (Rabin *et al.* 2006:654; Seitz *et al.* 2012:639). This clinical examination method test is performed by pushing laterally and upward on the inferior medial border of the scapula and therefore assisting the scapula into upward rotation and posterior tilt (Rabin *et al.* 2006:654; Seitz *et al.* 2012:639). The SAT keeps the subacromial space open or increase the acromiohumeral distance (AHD) during humeral abduction and flexion, thus relieving compression on the rotator cuff muscles and subacromial bursa (Seitz *et al.* 2012:639). Rabin *et al.* (2006:658) concluded that a positive SAT test (reduction in pain during assisted abduction and flexion, compared to a test without assistance) may indicate inadequate function of the SA and LT force couple due to decreased muscle strength and/or activation.

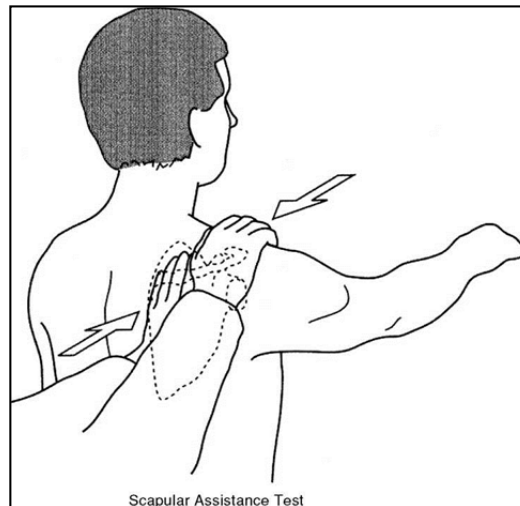


Figure 2-7: Scapular assistance test (SAT)

(Adapted from: *Anon., 2015*)

Restricted joint motion can result from multiple factors and impede the quality and quantity of available joint mobility (Houglum, 2010:94). There is evidence that excessive tightness in the pectoralis minor and/or posterior glenohumeral joint capsule can cause capsular kinematic alterations (Lucado, 2011:362; Ludewig *et al.*, 1996:63; Ludewig & Reynolds, 2009:100). Excess active or passive tension in the pectoralis minor (inserts into the coracoid process of the scapula) can delay normal posterior tipping and excess tension in the rhomboids (inserts into the medial border of the scapula) or levator scapulae (inserts into the superior part of the medial border of the scapula) which may restrict normal upward rotation (Ludewig & Cook, 1996:63). Myers *et al.* (2006:391) found that athletes with internal impingement demonstrated greater glenohumeral internal rotation deficits, which indicates tightness of the posterior capsule and as a result can cause posterior rotator cuff muscles to impinge.

2.3.3 Diagnosis

Examination and assessment are important for clinicians to determine where the deficiencies lie, the degree of the injury as well as information on the severity, irritability, nature and stage (SINS) of a patient's injury (Houglum, 2010:88). The examination is composed of subjective elements which consist of a thorough history of the injury and the patient's report of the injury and the objective assessment which includes observation of postural abnormalities, palpation and measurements of deficiencies in shoulder ROM, muscle strength, special tests and functional tests to understand the mechanism of injury (Houglum, 2010:89). Concerning shoulder clinical assessment, there is no consensus in

current literature to describe the etiologic mechanisms or shoulder movement impairments present in patients with SIS. Understanding these underlying tissue pathologies can assist the clinician to compile a successful treatment regime (Lucado, 2011:362; Ludewig & Reynolds, 2009:98). In order to identify and assess the anatomical and biomechanical deficiencies to design an appropriate therapeutic program, a comprehensive and thorough assessment should be performed for all patients with impingement (Michener *et al.*, 2003:376).

Functional testing plays an integral part in the glenohumeral joint (Shultz *et al.*, 2010:270) and is essential to assess the movement dysfunction and muscle performance for shoulder rehabilitation to be successful (Hess, 2000:67). Seitz *et al.* (2012:634) suggested that static arm positions with scapular observations are insufficient to determine the dynamic scapular alterations present and as a result highlighted the importance of dynamic evaluation of scapular motion. Repetitive concentric and eccentric motion with resistance can assist the clinician to determine scapular motion alterations of the scapular medial border and inferior angle (Ludewig & Reynolds, 2009:97).

Tests for subacromial impingement include the following: active impingement (painful arc), Neer impingement, Hawkins-Kennedy test, Speed's test (biceps, straight arm) and cross-body adduction (Shultz *et al.*, 2010:251). Park *et al.* (2005:1453) evaluated eight physical examination tests to determine the diagnostic value and accuracy and found that a combination of the Hawkins-Kennedy impingement sign, positive painful arc and weakness in external rotation (infraspinatus strength test) are the best predictors for impingement of any degree. Michener *et al.* (2009:1902) also examined the diagnostic ability of five examination tests for subacromial impingement syndrome (Hawkins-Kennedy, Neer, painful arc, empty can (Jobe) and external rotation resistance) and found that the empty can test, painful arc and external resistance test provided the best diagnostic utility and reliability (presented in Table 2-1).

Table 2-1: Diagnostic accuracy for shoulder impingement tests.

TEST	SENSITIVITY	SPECIFICITY
Hawkins-Kennedy	92	25
Neer	88.7	30.5
Painful arc	32.5	80.5
Empty can (Jobe)	62	54
External rotation resistance	25	68.9
Sensitivity: % of time the test yields a + result when condition is truly present (Shultz <i>et al.</i> , 2010:249).		
Specificity: % of time the test yields a – result when the condition was truly absent (Shultz <i>et al.</i> , 2010:249).		
Compiled from: Magee, 2008:358		

These detailed clinical findings should provide adequate information to diagnose the cause of shoulder pain, and sophisticated investigations (X-rays, ultrasound, MRI and arthroscopy) are only an addition to the clinical findings or used when the clinical findings are unclear (Brukner & Khan, 2007:254). X-rays are essential in the diagnosis of different shoulder pathologies and special views have been established to assess shoulder impingement and instability (Brukner & Khan, 2007:253). To evaluate impingement syndrome the supraspinatus outlet views and down-tilt acromial films are obtained (Brukner & Khan, 2007:253). Ultrasound is a reliable non-invasive technique and can detect tendon swelling, abnormal fluid collection or thickening of the bursae and can confirm the presence of impingement while performing active shoulder abduction (Brukner & Khan, 2007:253). Brossmann *et al.* (1996:1515) found that MRI imaging could indicate or display the different forms of shoulder impingement by special positioning of the arm.

De Witte *et al.* (2011:10) found that there are conflicting inclusion and exclusion criteria for SIS patients with the diagnostic label that are used across numerous clinical trials. This finding shows that there is no clear consensus on the combinations of diagnostic criteria which define shoulder impingement. Ludewig and Reynolds (2009:98) suggested that future research should be directed to increase the battery of reliable and valid clinical tools relevant to the evaluation process.

2.4 TREATMENT OF SHOULDER IMPINGEMENT SYNDROME

2.4.1 Surgery

Primary or structural impingement is surgically corrected to alleviate pain (Houglum, 2010:659; Page, 2011:52), however, both primary and secondary problems require exercise therapy whether surgery is performed or not (Houglum, 2010:659). Congenital structural anatomic variations of the acromion or bone spur is the most common cause of primary impingement and can be surgically corrected with removal of the osteophyte (if present) or an anterior acromioplasty (Houglum, 2010:659). Surgical management should be suggested when the pain fails to improve with non-operative or conservative treatment (Brox *et al.*, 1999:110; Dahm & Smith, 2003:5; Gibson *et al.*, 2004:240; Heyworth & Williams, 2009:1033; Wright & Matava, 2002:34). Casonato *et al.* (2003:82) concluded that conservative management can be effective from a minimum of one and a half months and surgery should be considered after a maximum of six months. Dahm and Smith (2003:5) held the opinion that operative management should be considered if the patient fails to improve after a three to six month conservative rehabilitation program. Physical therapy management precedes surgery (Kelly *et al.*, 2010:100) for numerous reasons: physical therapy is more cost-effective and provides statistically and clinically significant improvements in strength, pain and function (Bang & Deyle, 2000:135), patients that undergo surgery have to take more sick leave and days spent off work without long term benefits (Haahr & Anderson, 2006:228) and lastly operative management is avoided because of personal reasons, contraindications and comorbidities (Gibson *et al.*, 2004:240).

Researchers compared the effect of exercise versus arthroscopic decompression in patients with subacromial impingement and found a non-significant difference between the two active treatment groups (Brox *et al.*, 1999:110; Dorrestijn *et al.*, 2009:658; Haahr *et al.*, 2005:763). This provides evidence that similar improvements can be obtained by the two treatment groups for improving pain and dysfunction, but further high quality studies are needed to qualify different treatment choice decisions (Haahr *et al.*, 2005:763).

2.4.2 Different conservative treatment modalities

Conservative management for shoulder impingement syndrome consists of a wide range of treatment modalities: patient education (Conroy & Hayes, 1998:13; Michener *et al.*, 2004:153), exercise therapy which consists of stretching of the anterior and posterior

shoulder girdle (Başkurt *et al.*, 2011:177; Hanratty *et al.*, 2012:314) and strengthening of the rotator cuff and scapular muscles (Başkurt *et al.*, 2011:177; Conroy & Hayes, 1998:13; Hanratty *et al.*, 2012:314; Wilk *et al.*, 2002:136), ice or heat therapy (Conroy & Hayes, 1998; Djordevic *et al.*, 2012:454; Heyworth & Williams, 2009:1033), manual therapy based on massage, manipulation and joint mobilization techniques (Conroy & Hayes, 1998:13; Djordevic *et al.*, 2012:454; Kuhn, 2009:156; Michener *et al.*, 2004:162; Senbursa *et al.*, 2007:920), corticosteroid injection (Djordevic *et al.*, 2012:454; Ginn & Cohen, 2005:121), laser therapy (Michener *et al.*, 2004:162), kinesiotaping, electrotherapy, acupuncture and nonsteroidal anti-inflammatory drug (NSAID) treatment (Devereaux *et al.*, 2016:25; Djordevic *et al.*, 2012:454). The primary goal of conservative treatment is to restore the physiological range of movement and the accessory movements of the glenohumeral and scapulothoracic joints (Casonato *et al.*, 2003:82) and to improve the mobility and dynamic stabilizing function of the shoulder (Conroy & Hayes, 1998:13; Ginn & Cohen, 2005:121) in order to optimize the ability of the dynamic stabilizers to control humeral head translations during functional movements (Dahm & Smith, 2003:4).

Casonato *et al.* (2003:82) suggested that the therapeutic treatment protocol should focus on the following important elements: scapular muscle re-inforcement, a thorough assessment of postural and kinesiological aspects, rotator cuff reinforcement (as well as other shoulder girdle muscles), patient education and manual therapy. A systematic review by Michener *et al.* (2004:162) pointed out the success of combining therapeutic exercises with joint mobilization techniques in the treatment of shoulder impingement. They also indicated that some studies found that laser therapy demonstrated no additional side-effects when combined with therapeutic exercises and should therefore be used for patients who are unable to exercise. Manual therapy is the use of hands-on techniques to treat and improve the status of neuromusculoskeletal pathomechanics and include techniques such as joint mobilization and soft tissue mobilization, massage, trigger point release, myofascial release and neural mobilization (Houglum, 2010:154). According to Senbursa *et al.* (2007:920), manipulative therapy applied by an experienced physical therapist can improve neuromuscular control in the movement patterns of the glenohumeral and scapulothoracic joints through proprioceptive feedback transmitted by deep level receptors. Nagarajana and Vijayakumar (2013:231) indicated that with increasing prevalence and poor outcomes for SIS, it is advised that high quality research is needed for successful alternative modes of conservative treatment. A recent study by Delgado-Gil *et al.* (2015:251) examined the

effectiveness of mobilization with movement (MWM) in 42 patients with unilateral SIS and found that patients who received four treatment sessions demonstrated significant improvement in the intensity of pain with shoulder flexion, maximal shoulder external rotation and maximal shoulder flexion compared to the placebo intervention group.

2.4.3 Exercise as conservative treatment modality

Secondary impingement can be successfully managed by addressing the cause of the problem (Houglum, 2010:659; Page, 2011:56). Available literature strongly support the use of exercise as conservative treatment, aimed at restoring normal scapulohumeral rhythm (Başkurt *et al.*, 2011:178; Kamkar *et al.*, 1993:223), enhancing scapular stabilization (Başkurt *et al.*, 2011:178; DeLee *et al.*, 2010:239; Ludewig & Cook, 2000:287; Moezy *et al.*, 2014:13; Voight & Thomson, 2000:371), correcting posture deviations (Bullock *et al.*, 2005:35; Moezy *et al.*, 2014:12), improving motor control of scapulothoracic and glenohumeral joint and reducing pain with shoulder flexion (Bullock *et al.*, 2005:35; Senbursa *et al.*, 2007:920).

Many of the muscles of the shoulder girdle attach to the lower extremities (such as the pelvis), the cervical spine, thorax and humerus and function as a kinetic chain (Liebenson, 2005:189). Any limitations or disruption in the kinetic chain will alter normal shoulder kinematics and cause compensatory activity (Liebenson, 2005:194). Some studies therefore suggest that a comprehensive shoulder rehabilitation program should consist of activation and joint motion with a proximal-to-distal link model of biomechanics (Kibler *et al.*, 2012:105; McMullen & Uhl, 2000:336). Houglum (2010:600) also highlighted the importance of trunk and lower-extremity stability and strength for normal scapular and glenohumeral function. Shoulder rehabilitation should firstly follow a proximal-to-distal pathway (Kibler *et al.*, 2012:112; McMullen & Uhl, 2000:336).

Shoulder impingement syndrome can be reduced by restoring the scapulohumeral rhythm which synchronizes the motion of the scapulothoracic joint with the glenohumeral joint and by strengthening the rotator cuff muscles to prevent extreme superior translation of the humeral head during elevation (Kamkar *et al.*, 1993:220). Başkurt *et al.* (2011:178) conducted a study to determine the effectiveness of scapular stabilization, strengthening and stretching exercises on several outcome measurements on 40 patients (27 women and 13 men) aged between 24 and 71 years who have been diagnosed with unilateral shoulder

impingement. The results indicated an increase in scapular muscle strength and a decrease in scapular dyskinesis by improving scapulohumeral rhythm.

The rotator cuff muscles originate from the scapula and control the positions and movement patterns of the scapula (Voight & Thomson, 2000:371). The rhomboids, middle trapezius and lower trapezius play a vital role in shoulder function by providing strong retraction and downward rotation force to stabilize the scapula with the arm in space (DeLee *et al.*, 2010:239). Ludewig and Cook (2000:287) stated that a wide variety of exercise programs exist and recommended scapula stabilization, however, rehabilitation programs continue to emphasize the rotator cuff muscle in isolation. DeLee *et al.* (2010:239) highlighted that having a strong rotator cuff without training the scapula to stabilize efficiently is like trying to shoot a cannon from a canoe. Moezy *et al.* (2014:13) verified the effectiveness of a scapular stabilization based exercise program to increase shoulder ROM (abduction and external rotation), improvement of forward shoulder translation and an increase in the flexibility of the pectoralis minor of the involved shoulder.

Hess (2000:68) also stressed the importance of a rehabilitation program to improve the dynamic control of the glenohumeral joint, which can be obtained through isolated control before progressions into resistance, speed and functional rehabilitation are incorporated. The author stressed the importance of centering the humeral head in a sitting or lying down posture to aid in the improvement of joint position sense and thus restoring normal scapulothoracic kinematics. According to the work of Jobe and Pink (1993:430), there are a few principles for progression in the rehabilitation program: the glenohumeral protectors and scapular pivoters should be strengthened first to provide stability, secondly the positioners are incorporated for functional movement such as elevation of the humerus to take place while the propeller muscles (pectorals major and latissimus dorsi) are the last to be incorporated into the shoulder rehabilitation program. The final goal in the shoulder rehabilitation program is to restore the dynamic relationship of bony, static and dynamic stabilizers (Terry & Chopp, 2000:250).

2.4.4 Outcomes for using exercise as conservative treatment modality

There is expanding evidence through clinical trials and observational studies to support the positive effect of exercise therapy as conservative treatment modality in the successful

management of shoulder impingement syndrome (Engebretsen *et al.*, 2009:4; Lombardi *et al.*, 2008:619; Ludewig & Borstad, 2003:847). Lombardi *et al.* (2008:619) studied 60 patients (46 women and 14 men) diagnosed with shoulder impingement syndrome who participated in a progressive resistance training program twice a week for two months. They concluded that there was a statistically significant improvement in pain and function (Disabilities of the Arm, Shoulder, and Hand - DASH score) and patients exhibited a much higher degree of satisfaction (assessed using the Brazilian version of the Short Form 36). Ludewig and Borstad (2003:847) investigated the effect of a standardized eight week home exercise program which consisted of five shoulder stretching and strengthening exercises in 67 male symptomatic construction workers exposed to routine overhead work. Following the results, the authors asserted the effectiveness of a home exercise program to reduce symptoms and improve function. In another study, 104 patients (52 men and 52 women) aged between 18 and 70 years, with subacromial impingement lasting at least three months, were randomly assigned into two treatment groups: radial extracorporeal shockwave treatment or supervised exercise. A statistically significant better improvement in the shoulder pain and disability index were obtained after the 18 week follow-up in patients who attended two 45 minute sessions of supervised exercise on a weekly basis for 12 weeks compared to those receiving radial extracorporeal shockwave treatment, administered once a week for four to six weeks (Engebretsen *et al.*, 2009:4).

Several researchers found that there is evidence to support the use of exercise in combination with manual therapy to further improve the outcome measures (Bang & Deyle, 2000:134; Conroy & Hayes, 1998:12; Savoie *et al.*, 2015:708; Senbursa *et al.*, 2007:920). Bang & Deyle (2000:134) investigated 30 men and 22 women with diagnosed shoulder impingement syndrome, shoulder tendinitis or rotator cuff tendinitis between 18 and 65 years of age. They stated that supervised exercise with manual physical therapy (aimed to improve glenohumeral joint limitations) are more effective for decreasing pain, increasing strength and improving function compared to supervised shoulder exercise alone. Savoie *et al.* (2015:704) investigated the effectiveness of a six week movement training oriented rehabilitation program on symptoms, functional limitations and acromiohumeral distance (AHD) in twenty five patients (aged between 18-65 years) presenting with subacromial pain. Results indicated that patients who underwent patient education, movement training, strengthening and manual therapy improved statistically and clinically in self-reported outcomes of symptoms and functional limitations. The

researchers also found an increase in AHD in these patients. Senbursa *et al.* (2007:920) compared the effectiveness of joint and soft tissue mobilization techniques with a self-training program in 30 patients aged between 30 and 55 years of age, diagnosed with shoulder impingement syndrome. They concluded that manual physical therapy with exercise have better and earlier results for increasing strength, decreasing pain and improving function. This statement was also confirmed by Conroy and Hayes (1998:12) in a study on eight men and six women with primary SIS, assessing the effect of joint mobilization as a component of comprehensive treatment, and concluded that the additive effect of joint mobilization alleviates pain over a 24-hour period.

Two studies investigated the efficacy of kinesiological taping and exercise in patients with subacromial impingement syndrome (Devereaux *et al.*, 2016:27; Subaşı *et al.*, 2016:745). Devereaux *et al.* (2016:27) investigated the effectiveness of precut kinesiology tape versus NSAID in reducing shoulder pain in 100 patients (mean age: 48 ±12 years). Participants were randomized into one of three groups: precut kinesiology tape and exercise (n=33); NSAID and exercise (n=29) and exercise only (n=38). The results demonstrated a statistically significant decrease in pain by all three treatment groups, but no clinically meaningful difference could be observed between the use of precut kinesiology tape and NSAID (Devereaux *et al.*, 2016:27). In a randomized controlled trial by Subaşı *et al.*, (2016:745), in which 70 patients were randomised in two groups (NSAID injection and exercise n=35 or kinesiological taping and exercise n=35) and assessed after three months. The findings revealed that both groups, in conjunction with an exercise program, improved significantly in visual analogue scale (VAS), shoulder pain and disability index (SPADI) and range of motion measurements.

Several studies have assessed the effectiveness of exercise therapy on other outcome measurements, such as joint position sense (Başkurt *et al.*, 2011:177) and the morphological changes of the subacromial soft tissue structures (Østerås *et al.*, 2010:357). According to Başkurt *et al.* (2011:177) focusing on scapular stabilization exercises in combination with stretching (capsule stretching, forward flexion, abduction and internal rotation stretching with a towel) and strengthening exercises are more effective for increasing the scapular muscle strength, improving joint sense and preventing scapular dyskinesis. A case series on six patients (four men and two women) with unilateral primary SIS investigated the changes in pain, active ROM or morphological changes with MRI

findings after a twelve week high dosage medical exercise therapy program and only found normalization of the subacromial soft tissue structures in one of the six patients (Østerås *et al.*, 2010:357).

At present there are numerous studies available on the effectiveness of exercise in the management of shoulder impingement, but they can only be tentatively accepted because of the low methodological quality regarding the type, duration, frequency and intensity of exercise (Başkurt *et al.*, 2011:177; Gibson *et al.*, 2004:240; Kelly *et al.*, 2010:107; Ludewig & Reynolds 2009:98). This limits the ability to recommend well-defined therapeutic intervention programs. A limitation which also concerns the clinician is the long-term effect of exercise therapy to alleviate pain, improve ROM and decrease altered scapulothoracic kinematics (Roy *et al.*, 2009:187; Michener *et al.*, 2004:162). In order to determine the long-term effect of different exercise intervention programs, further high quality research is needed with a longer follow-up assessment period.

2.5 SUMMARY

The preceding literature overview firstly aimed to describe the scapulothoracic kinematics and muscle function of shoulder impingement syndrome and to explain how postural changes associated with forward-head, kyphotic or slouched posture, altered glenohumeral and scapular kinematics as a result of muscle imbalance or altered muscle activation and tightness of the pectoralis minor and/or posterior glenohumeral capsule can contribute to shoulder impingement. Clinicians must acknowledge these findings because of the vital role a thorough examination and early detection of this altered kinematics play in order to prescribe effective exercise interventions and prevention strategies for shoulder impingement syndrome.

Secondly, the literature overview aimed to describe the different treatment modalities and their efficacy in obtaining successful outcome measures for the underlying pathology. There is, however, no strong evidence of the effectiveness of a specific exercise protocol because of the difference in methodologies used and the variability (regarding the type, duration, frequency and intensity of the exercise program). These methodological flaws complicate the interpretation of findings and the support for exercise can only be tentatively accepted.

In summary, inconsistency in current literature indicate that further research is necessary to produce a level of significant evidence to determine the etiological mechanisms of shoulder impingement syndrome, the combination of reliable and valid diagnostic criteria to define SIS and thirdly finding consensus regarding the type, duration, frequency and intensity most successful in the rehabilitation of SIS. To assist in finding consensus in rehabilitation methods for SIS, a systematic review of randomized controlled trials would assist with obtaining the evidence needed to base rehabilitation techniques on. Therefore, information with regards to evidence-based treatment are of great importance for the clinical practice to develop a guided timeline for a standard rehabilitation program.

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CHAPTER 3

Exercise as conservative treatment modality for shoulder impingement syndrome: a systematic review

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ABSTRACT

Background

Shoulder impingement syndrome (SIS) is characterised by persistent, anterior superior low grade shoulder pain at rest that is worsened by elevation of the humerus from 60° to 120° as well as muscle weakness and loss of mobility. The pain is a result of encroachment of the subacromial structures as it passes through the subacromial space. Treatment for SIS may include conservative modalities such as exercise, manual therapy, joint mobilisation, cryotherapy and transcutaneous electrical nerve stimulation (TENS).

Objectives

The objective of this systematic review is to evaluate the effectiveness of home-based or supervised exercise as treatment modality for SIS.

Search methods

The Cochrane Central Register of Controlled Trials (CENTRAL), EBSCO Host (Academic Search premier, CINAHL, Health Source: Nursing/Academic Edition, Medline and Sport Discus), Science Direct, Scopus, PubMed and Web of Science were searched, using a comprehensive list of search terms (up to June 2015). Reference lists of retrieved articles were screened for eligibility of additional studies. The search was updated again to include material published up to 30 August 2016.

Selection criteria

Randomised controlled trials, involving male and/or female adults over the age of 18 years, with any history of SIS will be included. Studies had to evaluate any mode of exercise as treatment modality (both home-based and supervised sessions) or exercise in combination with other conservative interventions for treating SIS – only if the results of exercise treatment were provided separate from results for other modalities used.

Data collection and analysis

Two review authors independently identified potential trials for inclusion, assessed methodological quality and extracted data. Means, standard deviations (SD) and number of participants for continuous outcomes were extracted. The mean differences (MD), standard mean differences (SMD) and an overall effect size of 95% confidence intervals (CI) were calculated using Review Manager 5.

Main results

Six studies (475 participants with SIS) were identified for inclusion in this review. Exercise treatments lasted between 3 to 12 weeks and used variations of strengthening and stretching exercises. Studies with the same control group treatment were pooled (extracorporeal shockwave therapy (Engebretsen 2009; Engebretsen 2011), no intervention (Lombardi 2008; Ludewig 2003), scapular mobilization (Aytar 2015) and home exercise versus supervised exercise (Granviken 2015). The methodological quality varied among these six studies and the sample sizes were generally small (n=69 Aytar, 2015, n=104 Engebretsen 2009, n=104 Engebretsen 2011, n=60, Granviken 2015, n=46 Lombardi 2008, n=92 Ludewig 2003).

Pain at rest, pain during movement and shoulder range of motion (ROM) were the primary outcomes reported in these reviews. Four studies (Engebretsen 2009; Engebretsen 2011, Lombardi 2008; Aytar 2015) reported pain at rest and only one study (Lombardi 2008) showed statistically significant improvement favouring exercise over no intervention (MD -1.90; 95% CI -3.36 to -0.44; P=0.01) (Analysis 2.1).

Pain during movement was reported in all the included studies, but studies were pooled for re-analysis on the basis of the control groups. In two studies (Lombardi 2008; Ludewig 2003) significant improvements were reported in favour of the exercise group over no intervention (SMD -0.81; 95% CI -1.18 to -0.44; P<0.0001) (Analysis 2.2). In one other study (Aytar 2015) no significant improvements were reported, although there was a little more improvement in the scapular mobilization group (MD 0.20, 95% CI -1.29 to 1.69; P=0.79) (Analysis 3.2). Two studies (Engebretsen 2009; Engebretsen 2011) showed no significant improvements in the exercise group (MD -0.40; 95% CI -1.29 to 0.49; P=0.38) and the control group (MD -0.20; 95% CI -1.13 to 0.73; P=0.6) (Analysis 1.2). Average pain in the past week was reported by Granviken 2015, but no significant improvements were reported (MD -0.20, 95% CI -1.47 to 1.07; P=0.76) (Analysis 4.1).

Shoulder ROM was assessed by three studies (Aytar 2015; Granviken 2015; Lombardi 2008) and one study (Lombardi 2008) reported statistically significant improvement for medial rotation (MD 9.70; 95% CI 2.34 to 17.06; P=0.010) (Analysis 2.4) and the remaining ROM measurements showed no significant difference among groups (Analysis 2.4). The results for Aytar 2015, assessing shoulder ROM (shoulder flexion, shoulder external rotation and shoulder internal rotation) were inconclusive (Analysis 3.3). Granviken 2015 also found no significant difference in

active ROM (flexion, abduction, internal rotation and external rotation) between the home exercise and supervised exercise groups (MD -0.20, 95% CI -1.47 to 1.07; P=0.92) (Analysis 4.2).

Patient satisfaction and function were the two secondary outcomes reported in these reviews. Studies by Lombardi 2008 and Ludewig 2003 showed statistically significant improvement in laborious function, using the Disability of the Arm, Shoulder and Hand questionnaire (DASH 2) (SMD -0.66; 95% CI -1.02 to -0.29; P=0.0004) (Analysis 2.3). Two studies showed improvement in function for patients in the exercise group but were not significant. Engebretsen 2011 favoured the extracorporeal shockwave therapy group but no significant improvement was reported. The results for Aytar 2015 were inconclusive (Analysis 3.4). Patient satisfaction was reported by Ludewig 2003 and showed statistically significant improvement among the participants in the exercise group (MD 1.20; 95% CI 0.24 to 2.16; P=0.01) (Analysis 2.5).

Authors' conclusions

The available evidence was too sparse and the variability of exercise prescription in relation to the frequency, intensity, time and type (FITT principles) too broad to draw conclusions about the effect of specific exercise regimes in treating SIS.

PLAIN LANGUAGE SUMMARY

Non-surgical management for shoulder impingement syndrome

Shoulder impingement syndrome (SIS) is a clinical condition and occurs when the tendons of the rotator cuff muscles and other structures get impinged and irritated as they pass through the gap between the front edge of the acromion (bony process on the shoulder blade) and the head of the humerus (the upper arm). The symptoms of SIS include pain, weakness of the shoulder muscles and loss of movement. This pain is worsened by using the arm in over-head activities. SIS can be diagnosed by a thorough history and physical examination of the patient. Treatment may consist of surgery or conservative (non-surgical) treatment. This review evaluates the effectiveness of exercise to treat this specific shoulder condition.

The current evidence from the included trials is insufficient to support the use of exercise alone to effectively treat SIS. The evidence available provides limited information about the type of exercise, the frequency, intensity and duration of the different exercise treatment regimes. These flaws make it difficult to provide general guidelines for using exercise as treatment modality.

BACKGROUND

Description of the condition

The shoulder is the most mobile of all the joints in the human body (Culham 1993; Shultz 2010) where movement of the shoulder represents a complex relationship between the dynamic and static stabilizers (Terry 2000; Lugo 2008). Overuse (repetitive strain) and fatigue of the stabilizers of the scapula disrupt the intricate interaction between these stabilizing structures and lead to abnormal mechanics of the scapula (DeLee 2010; Liebenson 2005; Lugo 2008). This altered glenohumeral and scapular kinematics can lead to impingement of several anatomic structures including the subacromial bursa, supraspinatus tendon, biceps tendon and the anterior labrum (Liebenson 2005; Loudon 2013). Abnormal movement patterns of the scapulothoracic and glenohumeral joint, such as decreased posterior tipping, external rotation and upward rotation and increased anterior and superior humeral head translation can predispose an individual to impingement (Michener 2003; Lukasiewicz 1999). The subacromial structures compress between the greater tuberosity of the humerus and the anterior aspect of the acromion with humeral abduction (Lukasiewicz 1999). Individuals diagnosed with SIS experience pain at rest that is aggravated with humeral elevation in combination with internal rotation (Başkurt 2011). There are many commonly employed forms of conservative treatment for SIS such as exercise therapy (Conroy 1998; Djordjevic 2012), ice/heat therapy (Conroy 1998; Djordjevic 2012), manual therapy (Conroy 1998; Djordjevic 2012; Kuhn 2009), patient education (Conroy 1998; Senbursa 2007) and kinesiotaping (Djordjevic 2012). A conservative approach in treating shoulder impingement syndrome precedes surgical intervention in the majority of cases (Hanratty 2012; Levine 2000; Michener 2004).

Description of the intervention

Conservative treatment may include the use of a wide range of modalities but this review focuses on exercise therapy as treatment modality for SIS. Thompson 2010 define exercise as "any movement produced by the contraction of skeletal muscles consisting of planned, structured and repetitive bodily movement done to improve or maintain one or more components of physical fitness". The components of an exercise program or prescription, also known as the FITT principle of exercise, consist of the frequency, intensity, time or duration and the type of exercise (Thompson 2010). This review examines, amongst others the effectiveness of exercise interventions as treatment modality for SIS.

The therapeutic exercise protocol for SIS should focus on strengthening, stretching (Başkurt 2011; Conroy 1998; Kamkar 1993; Michener 2004) and active ROM (Bullock 2005; Conroy 1998; Ginn

2005). Muscular strength can be characterized as a muscle or muscle group's relative ability to produce a maximal amount of force against some form of resistance (Houglum 2010; Thompson 2010). Flexibility or ROM describes the full movement potential in which a segment moves in a specific cardinal plane of motion (Houglum 2010; Shultz 2010). These fitness components aim to restore normal glenohumeral biomechanics (Michener 2004; Terry 2000), reduce pain during rest and daily activities (Lombardi 2008, Ludewig 2003), improve proprioception and muscle coordination (Bohnsack 2002) and correct postural and kinesiological pathomechanics (Casonato 2003; Dahm 2003). Restoration of these kinematic alterations will optimise the ability of the static and dynamic stabilizers to control translation of the humeral head (Dahm 2003; Voight 2000).

Why it is important to do this review

SIS is very common among the general and athletic population, but evidence is still lacking on the role of exercise as conservative treatment modality. The effectiveness of exercise can only be tentatively accepted because of the methodological flaws regarding the FITT principles (Başkurt 2011; Gibson 2004; Kelly 2010). Despite the growing expanse of clinically applicable trials, consensus is needed regarding the type of exercise, repetitions, frequency and intensity to develop an appropriate treatment intervention. Questions surround other aspects of exercise as treatment modality such as long term outcomes for different exercise regimes (Ludewig 2009; Roy 2009) and conflicting diagnostic criteria to define SIS (De Witte 2011; Kelly 2010; Ludewig 2009). Consensus on the treatment of SIS by means of exercise is needed in order to implement effective treatment that is not invasive.

OBJECTIVE

The objective of this study was:

- To determine whether convincing evidence exists to support the use of home-based or supervised exercise as treatment modality for SIS.

METHODS

Criteria for considering studies for this review

Types of studies

Full text randomized controlled trials, in English were included in this study.

Types of participants

Participants included male and/or female adults aged 18 years or older, with any history of SIS (see Characteristics of studies). Studies of participants from general as well as athletic populations were included.

Types of interventions

Studies including randomised control trials with exercise as treatment modality for SIS were considered. Randomized control trials with exercise modalities in combination with other conservative interventions for SIS were also eligible, only if the results of the exercise treatment were provided separate from the results for other conservative modalities used. These articles should thoroughly explain the exercise modalities (type, duration, intensity and frequency) used. Trials where exercise treatment was post-surgery, where the shoulder pathology was too broad, where the results of the exercise treatment were not provided separate from the other conservative treatment modalities or where both the control and experimental group had exercise as intervention, were excluded.

Types of outcome measures

The clinically relevant outcomes of interest in SIS were: reduced shoulder pain during rest and activity and improved shoulder ROM (active and passive), improved functional status and quality of life as well as degree of patient satisfaction. If data on more than one pain scale, function scale, quality of life or patient degree of satisfaction scale were provided for a trial, data was extracted according to the hierarchies below for extracted data on the scale that was highest on this list.

Primary outcomes

Pain: measured using any validated scale.

1. Mean or mean change measured by using by visual analogue scale (VAS).
2. Shoulder pain and disability index (SPADI) - pain scale.
3. Numerical or categorical rating scale.

Functional status

1. Disabilities of the arm, shoulder, and hand scale (DASH).
2. SPADI - disability scale.
3. Croft shoulder disability questionnaire.
4. Any other shoulder-specific function scale.

Shoulder ROM:

1. Inclinator.
2. Goniometer.

Secondary outcomes

Quality of life:

1. Components of the Short Form-36 (SF-36).
2. Disease-specific tools.

Degree of patient satisfaction:

1. Self-report questionnaires (SRQ).
2. Other validated questionnaires.

Search methods for identification of studies

Electronic searches

One researcher conducted a computer search using the following databases: Cochrane Central Register of Controlled Trials, EBSCO Host (Academic Search premier, CINAHL, Health Source: Nursing/Academic Edition, Medline and Sport Discus), Science Direct, Scopus, PubMed and Web of Science with a date restriction of articles published from January 1994 up to and including June 2015. The literature search was updated to 30 August 2016. A full search strategy is listed in Appendix A of this article.

Searching other resources

The reference lists of included studies were screened to identify additional published or unpublished data.

Data collection and analysis

Selection of studies

Two authors (LVZ and EJB) identified potential trials for inclusion by assessing the results of the title search and excluded duplicates. One author (LVZ) obtained abstracts for all possible included studies and two authors (LVZ and EJB) assessed these abstracts to identify possible studies to include. The list of included studies was confirmed by a third author (MC), and disagreement was resolved between review authors by consensus.

Data extraction and management

Two authors (LVZ and EJB) independently assessed these included studies for risk of bias with support from the South African Cochrane Centre, which were confirmed by a third author (MC). Disagreements were resolved by discussion with reference to the protocol. Data extraction from included studies was performed independently using a standardised extraction sheet. The mean scores at the end of intervention and end of follow up, the standard deviation (SD) of these values and the number of participants in these analyses were extracted.

To avoid multiple outcomes reporting in the review, the following rules were applied during data extraction:

- Where outcomes were reported at several time points, the measure at the end of the intervention was extracted as the main outcome. Studies of similar duration were analysed using end of intervention data only. Data was extracted at interim time points only if there was an opportunity to pool these data with trials of shorter durations, and these data could clearly be identified as being non-end-point data.
- Where trial authors reported both final values and change from baseline values to end for the same outcome, final values were extracted.
- Where trial authors reported data analysis based on the intention-to-treat (ITT) sample and another sample (e.g. per-protocol, as-treated), ITT data was extracted.
- For crossover trials, data was extracted only up to the point of crossover, given the potential for carry-over effects of interventions to bias results following crossover.

Assessment of risk of bias in included studies

The methodological quality of the included clinical trials was independently assessed by the review authors by using the Cochrane collaboration risk of bias tool (Higgins 2011). How the sequence was generated (selection bias), allocation bias (selection bias), blinding of participants

and personnel (performance bias), blinding of outcome assessment (detection bias), the completeness of outcome data, selective reporting and other potential sources of bias were the features of interest in this risk of bias assessment. The criteria for judging the quality involved assessing the risk of bias as "low risk", "high risk", or "unclear risk". Plots for the "risk of bias" of the included studies were created in Review Manager 5.

Measures of treatment effect

Continuous data

For continuous outcomes, the review authors calculated the mean difference (MD) when the studies used the same measure units. When studies assessed the same outcomes but the results were presented using different instruments to measure, the standardized mean difference (SMD) was used in order to standardize the results to a uniform scale.

Unit of analysis issues

Unit of analysis issues were considered and it was found that results from more than one time point (Engebretsen 2009 - 12 week follow up; Engebretsen 2011 - 1 year follow up) cannot be combined without the possibility of reporting bias. This duplicate data could over-estimate the effect of the treatment. No other unit of analysis was identified in the included studies.

Dealing with missing data

Missing standard deviations were calculated with the Review Manager Calculator tool, which reported the mean, standard error of mean and the number of participants in each group.

Assessment of heterogeneity

It was planned to assess heterogeneity between comparable trials by visual inspection of forest plots, in keeping with the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions (Higgins 2011). A rough guide for interpretation of the I² -statistics was used: 0% to 40% might not be important; 30% to 60% might represent moderate heterogeneity; 50% to 90% might represent substantial heterogeneity; 75% to 100% might represent considerable heterogeneity (Higgins 2011). There were too few trials for this analysis.

Assessment of reporting biases

To assess whether other potential bias could be present it was planned to construct funnel plots, however, an insufficient number of trials for this analysis was identified. It was planned to assess the presence of small study bias in the overall meta-analysis by checking if the random-effects model estimate of the intervention effect was more beneficial than the fixed-effect model estimate, but again there were too few trials for this analysis.

Data synthesis

As far as data extraction was possible, descriptive results are reported for all included studies. Data is pooled from clinically homogenous trials, i.e. with the same interventions, doses, comparators and outcomes. Where data could not be combined, summarised effect estimates and 95% CIs of each trial were used narratively. Meta-analyses are reported for two studies: exercise versus no intervention and extracorporeal shockwave therapy, using the random-effects model, based on the assumption that clinical and methodological heterogeneity was likely.

Subgroup analysis and investigation of heterogeneity

There was insufficient data available to justify subgroup analyses systematic review.

Sensitivity analysis

A sensitivity analysis was planned at protocol stage to investigate the robustness of the treatment effect. It was planned to examine the effects by removing trials at (1) high risk of selection bias from inadequate allocation concealment, or (2) at high risk of detection bias from lack of blinded outcome assessment, (3) loss to follow-up (threshold for compliance – e.g. 80%) and (4) duration and frequency of exercise interventions (e.g. at least 3 days per week). There was, however, insufficient data to perform these analyses.

RESULTS

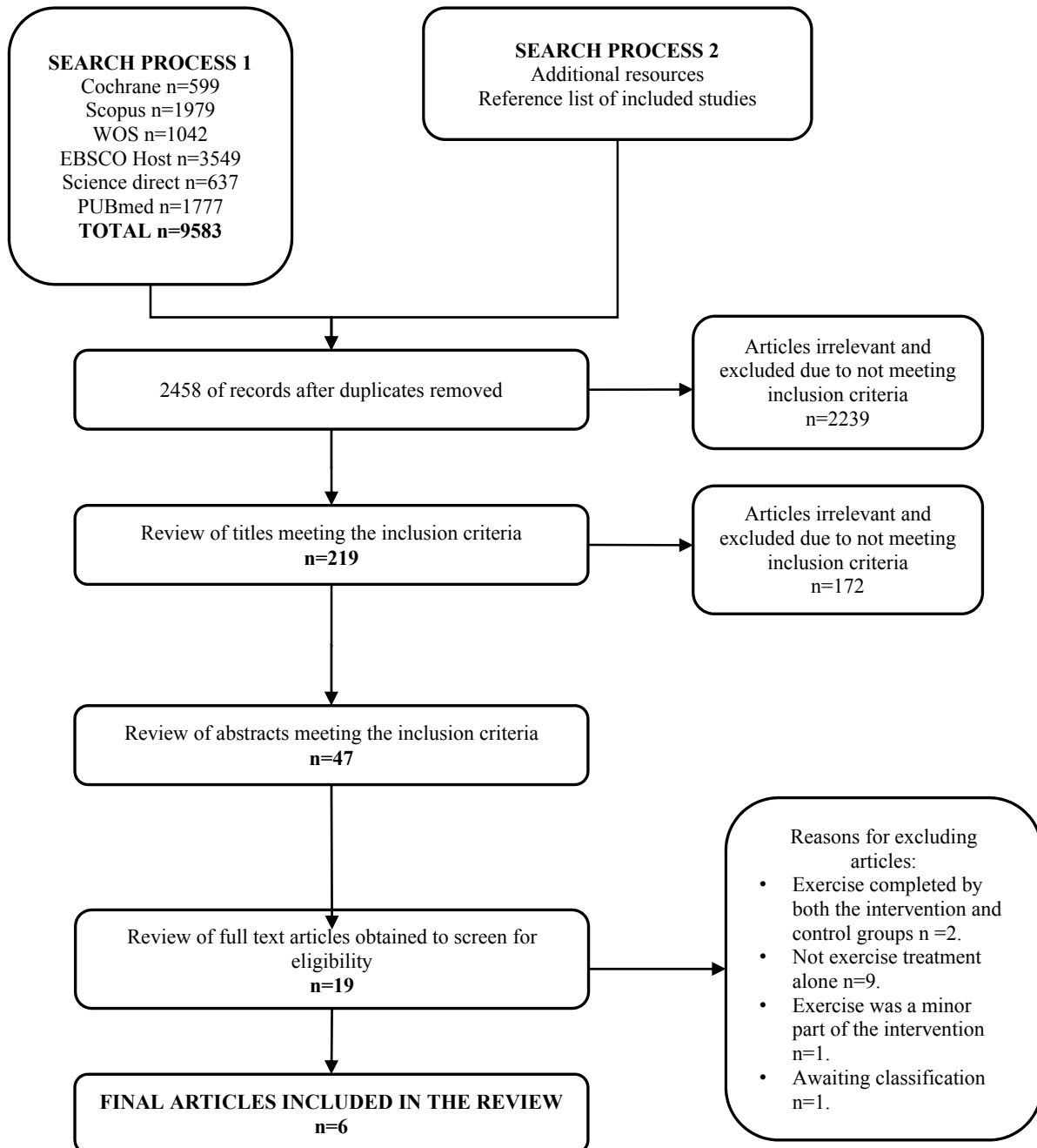
Description of studies

Results of the search

The search was carried out between December 2014 and June 2015 and later updated to include published studies up to 30 August 2016. 9583 unique records were identified from the following databases: Cochrane (599 records), Scopus (1979), Web of Science (1042), EBSCO Host (3549), Science Direct (637), and PubMed (1777). After the duplicates were removed, a total of 2458 titles

were screened for eligibility. A total of 2239 studies were irrelevant and excluded due to not meeting the inclusion criteria. The abstracts of 47 studies were obtained and evaluated for relevance. The remaining 19 records were retrieved and the full text was read (Figure 3-1).

Figure 3-1: PRISMA flow diagram for the study selection process.



Thirteen studies were excluded due to the following reasons:

- Exercise completed by both the intervention and control groups = two studies - Bang 2000; Devereaux 2016.
- Not exercise treatment alone = nine studies - Dilek 2016; Haahr 2005; Kaya 2011; Moezy 2014; Nakra 2013; Ogrodzka 2015; Rhon 2014; Savoie 2015; Struyf 2013.
- Exercise was a minor part of the intervention (soft tissue mobilization and PNF was the main part) = one study - Dajah 2014.
- Awaiting classification = one study - Turner 2001.

A total of six articles were included in this review.

Included studies

In total, six randomised controlled trials written in English were identified for this review (Aytar 2015; Engebretsen 2009; Engebretsen 2011; Granviken 2015; Lombardi 2008; Ludewig 2003) (see Table 3-1 to Table 3-12).

All these studies were described as randomised controlled trials and four of these studies were a two group parallel design (Engebretsen 2009; Engebretsen 2011; Granviken 2015; Lombardi 2008) and two studies included a three group parallel design (Aytar 2015; Ludewig 2003). Engebretsen 2009 and Engebretsen 2011 compared exercise with extracorporeal shockwave treatment while Aytar 2015 compared exercise with scapular mobilization. Two studies evaluated the effect of exercise compared with patients on a waiting list or no intervention (Lombardi 2008, Ludewig 2003), respectively. One study compared supervised exercise with home exercise (Granviken 2015). The sample size in this review ranged from 46 (Granviken 2015) to 104 participants (Engebretsen 2009; Engebretsen 2011). A total of 475 participants were randomly assigned into different treatment groups.

Three studies took place in outpatient clinics, two at the Physical Medicine and Rehabilitation Department at Oslo University Hospital, Ullevaal, Norway (Engebretsen 2009; Engebretsen 2011) and one at the Baskent University Physical Medicine and Rehabilitation Outpatient Clinic in Turkey (Aytar 2015). One study recruited from the clinics of the Federal University of São Paulo (Lombardi 2008) and one through local unions and at safety meetings conducted for campus construction employees, University of Minnesota, USA (Ludewig 2003). The last study

(Granviken 2015) recruited patients from the Interdisciplinary Outpatient Clinic of Physical Medicine and Rehabilitation Department at St. Olav's Hospital, Norway.

Women and men were included and the mean ages across studies ranged between 47 and 56.3 years.

The following diagnostic criteria were used among the six studies:

- A positive Neer impingement test (Aytar 2015; Lombardi 2008; Ludewig 2003).
- A positive Kennedy-Hawkins sign (Aytar 2015; Engebretsen 2009; Engebretsen 2011; Granviken 2015; Lombardi 2008; Ludewig 2003).
- A positive painful arc sign (Aytar 2015; Engebretsen 2009; Engebretsen 2011; Granviken 2015; Lombardi 2008; Ludewig 2003).
- A positive Yocom, Jobe and/or Speed test (Ludewig 2003).
- A positive infraspinatus test (Granviken 2015).
- Pain with isometric muscle tests;
 - Abduction at 0° or 30° (Engebretsen 2009; Engebretsen 2011; Ludewig 2003).
 - External and internal rotation (Engebretsen 2009; Engebretsen 2011; Ludewig 2003).
 - Flexion (Ludewig 2003).
- Pain with palpation of the rotator cuff or biceps tendon (Aytar 2015; Ludewig 2003).
- Quick DASH questionnaire >20, pain for ≥6 months and pain with activity between 2 and 8 on a 10 cm visual analog scale (Aytar 2015).
- Normal passive glenohumeral physiological ROM (Granviken 2015).

A variety of different exercise modalities were employed in the six included studies. Three trials (Aytar 2015; Granviken 2015; Ludewig 2003) used stretching exercises and two trials used manual techniques for loosening muscles (Engebretsen 2009; Engebretsen 2011). All six trials employed strengthening exercises and all gradually progressed during the duration of the protocol. Three studies (Engebretsen 2009; Engebretsen 2011; Granviken 2015) relearned normal movement patterns before starting the endurance exercises. Strengthening exercises consisted of scapular stabilising (Granviken 2015), external rotation (Aytar 2015; Lombardi 2008; Ludewig 2003), rotator cuff exercises (Granviken 2015), serratus anterior strengthening (Aytar 2015; Ludewig 2003), flexion, extension and medial rotation (Lombardi 2008), inferior glide (Aytar 2015), closed and open kinetic chain exercise, plyometric exercises and manual resistance exercises for periscapular muscles (Engebretsen 2009; Engebretsen 2011). The exercise therapy regime lasted between 3 and 12 weeks and exercises had to be performed 2-3 times per week. Three studies had

supervision by a physical therapist or physiotherapist (Aytar 2015; Engebretsen 2009; Engebretsen 2011). In one study the home exercise group received one supervised treatment session and the supervised exercise group received 10 supervised treatment sessions (Granviken 2015). Five studies used Thera-Band or thin elastic cords (Aytar 2015; Engebretsen 2009; Engebretsen 2011; Granviken 2015; Ludewig 2003), one study used multi pulley muscle building equipment (Lombardi 2008) and one study used weights (Aytar 2015). Two of the included studies (Engebretsen 2009; Engebretsen 2011) had an additional home programme and two studies just had a home programme during the intervention (Granviken 2015; Ludewig 2003).

The main outcomes were pain at rest and pain during activity measured using 0-10 cm VAS (Aytar 2015; Lombardi 2008), 1-9 Likert scale (Engebretsen 2009; Engebretsen 2011) and the SPADI scale (Ludewig 2003). Granviken 2015 reported average pain in the past week on a numerical rating scale. Three studies measured and reported ROM, two using goniometry (Aytar 2015; Lombardi 2008) and one using a digital inclinometer (Granviken 2015). Three studies did not report ROM (Engebretsen 2009; Engebretsen 2011; Ludewig 2003). All six of the referenced studies measured and reported function using the following measuring scales: Turkish version of the Quick DASH (Aytar 2015), 1-7 Likert scale for the capacity to take down from a shelf (Engebretsen 2009; Engebretsen 2011), DASH 2 and DASH 3 (Lombardi 2008) and SPADI (Ludewig 2003). The Lombardi 2008 study measured quality of life using the Brazilian version of the Short Form 36 (SF-36). Four of the six studies reported patient satisfaction and used different measuring scales. Aytar 2015 used the 7 point Likert scale, Lombardi 2008 used the 5 point Likert scale and another study used two questions in the SRQ. Granviken 2015 reported patient satisfaction as perceived benefit of the treatment (rated as one of seven possibilities) and satisfaction with treatment (rated as one of five possibilities).

Excluded studies

The review excluded twelve studies (Bang 2000; Dajah 2014; Devereaux 2016; Dilek 2016; Haahr 2005; Kaya 2011; Moezy 2014; Nakra 2013; Ogrodzka 2015; Rhon 2014; Savoie 2015; Struyf 2013). Two studies were excluded because exercise was completed by both the intervention and control groups and would therefore not be able to identify the effect of exercise alone (Bang 2000; Devereaux 2016). Nine studies were excluded because exercise treatment was part of a combination treatment and would therefore be unable to identify the effect of exercise alone (Dilek 2016; Haahr 2005; Kaya 2011; Moezy 2014; Nakra 2013; Ogrodzka 2015; Rhon 2014; Savoie 2015; Struyf 2013). One study were excluded because exercise treatment was a minor part of the

intervention (Dajah 2014). One study identified in the search is awaiting classification for possible inclusion, as the abstract or full text could not be sourced (Turner 2001) (See Table 3-13 and Table 3-14).

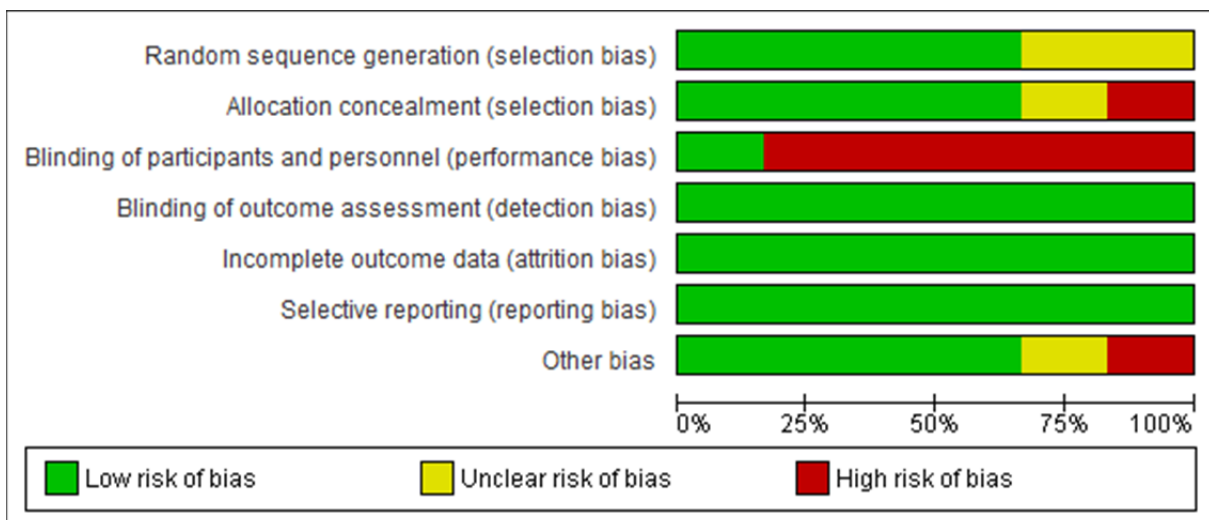
Risk of bias in included studies

Figure 3-2 and Figure 3-3 display the overall risk of bias according to the review authors' judgement across the six included studies.

Figure 3-2: Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

	Ludewig 2003	Lombardi 2008	Granviken 2015	Engelbretsen 2011	Engelbretsen 2009	Ayler 2015	
Random sequence generation (selection bias)	?	+	+	+	?	+	
Allocation concealment (selection bias)	-	+	+	+	+	?	
Blinding of participants and personnel (performance bias)	-	-	-	-	-	+	
Blinding of outcome assessment (detection bias)	+	+	+	+	+	+	
Incomplete outcome data (attrition bias)	+	+	+	+	+	+	
Selective reporting (reporting bias)	+	+	+	+	+	+	
Other bias	-	+	+	+	+	?	

Figure 3-3: Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.



Allocation (selection bias)

All but two studies had adequate sequence generation (Engebretsen 2009; Ludewig 2003). Two trials were judged as unclear, because the sequence generation was identified as quasi-randomised (Ludewig 2003) and the other study was randomised by sex (Engebretsen 2009). Four of the six trials had adequate allocation concealment (Engebretsen 2009; Engebretsen 2011; Granviken 2015; Lombardi 2008). One trial was associated with unclear risk of bias as a result of the method of concealment not described (Aytar 2015). At high risk was Ludewig 2003, because the allocation was not concealed.

Blinding (performance bias and detection bias)

Five of the six studies were judged as high risk for bias, because neither the participants nor personnel delivering the exercise treatment were blinded (Engebretsen 2009; Engebretsen 2011; Granviken 2015; Lombardi 2008; Ludewig 2003). One study showed low risk for bias because the evaluator physical therapist and patients were blinded to the group allocation (Aytar 2015).

Incomplete outcome data (attrition bias)

All of the studies were judged as low risk of bias (Aytar 2015; Engebretsen 2009; Engebretsen 2011; Granviken 2015; Lombardi 2008; Ludewig 2003), because missing data were imputed using appropriate methods (mixed model analysis, intention to treat analysis).

Selective reporting (reporting bias)

All six the included studies were considered as low risk for bias, because all of the primary and secondary outcomes were reported in full (Aytar 2015; Engebretsen 2009; Engebretsen 2011; Granviken 2015; Lombardi 2008; Ludewig 2003).

Other potential sources of bias

Four of the six studies seem to be free for risk of other source of bias (Engebretsen 2009; Engebretsen 2011; Granviken 2015; Lombardi 2008). Aytar 2015 was judged as unclear risk for bias because there might have been interference with the final outcomes when therapeutic modalities and patient education were applied. At high risk was Ludewig 2003, because there was variation in the post-test time between subjects. The majority of subjects discontinued the exercise programme after 8–9 weeks, regardless of the scheduled follow up time.

Effects of interventions

Exercise versus extracorporeal shockwave therapy

Two studies (n=98) compared the effect of exercise versus extracorporeal shockwave therapy. These two studies by Engebretsen 2009 and Engebretsen 2011 are the same study, but the latter study was a one year follow up period.

Pain at rest

Engebretsen 2009 provided data at end of the intervention (12 weeks) and Analysis 1.1 (Figure 3-4) demonstrate that there was no significant effect of exercise on pain at rest (MD -0.40; 95% CI -1.16 to 0.36); P=0.30. At long term follow up (Engebretsen 2011) the data also demonstrates no significant effect on pain at rest (MD -0.50; 95% CI -1.22 to 0.22); P=0.17. The point estimates are all to the left of the vertical axis, indicating that these two studies favoured exercise over shockwave therapy.

Pain during activity

There was not significant effect of exercise on pain during activity for Engebretsen 2009 (MD -0.40; 95% CI -1.29 to 0.49); P=0.38 and Engebretsen 2011 (MD -0.20; 95% CI -1.13 to 0.73), P=0.67 (Analysis 1.2).

Function

At the end of intervention (Engebretsen 2009) participants in the exercise therapy group found little difference but not significant over the radial extracorporeal shockwave therapy (MD -0.40; 95% CI -1.16 to 0.36); P=0.30. At long term follow up (Engebretsen 2011) the study results suggested little but not significant improvement in the function scores among the participants allocated to the radial extracorporeal shockwave therapy (MD 0.30; 95% CI -0.47 to 1.07); P=0.44 (Analysis 1.3).

Exercise versus no intervention

Pain at rest

One study by Lombardi 2008 assessed pain at rest using a visual analog scale and reported significant improvement in pain favouring the experimental (exercise therapy) group (MD -1.90; 95% CI -3.36 to -0.44); P=0.01 (Analysis 2.1).

Pain at movement or work related

Two trials (Lombardi 2008; Ludewig 2003) with a total of 122 participants, suggested that the pain with movement had improved significantly more among the participants in the experimental (exercise) group at the end of the intervention. The pain was measured and reported on different measurement scales (0-10 cm VAS scale and SPADI), therefore these two studies were pooled using an SMD method (SMD -0.81; 95% CI -1.18 to -0.44); $P < 0.0001$ (Analysis 2.2).

Function

Lombardi 2008 assessed laborious function using the DASH 2 questionnaire and Ludewig 2003 used SPADI and reported statistical significant improvement at end of intervention (SMD -0.66; 95% CI -1.02 to -0.29); $P = 0.0004$. Only one study (Lombardi 2008) assessed function and symptoms for activities of daily living using DASH 3. Lombardi 2008 suggested greater improvement in function among participants in the exercise therapy group than the control (no intervention) group, but no significant difference (SMD -0.48; 95% CI -1.00 to 0.030); $P = 0.07$ (Analysis 2.3).

ROM

Goniometric measurements of shoulder ROM were available for one of the include studies (Lombardi 2008). Higher scores mean better or improved ROM. At the end of the intervention participants in the exercise therapy group showed statistically significant results for medial rotation with the arm at 90° abduction (MD 9.70; 95% CI 2.34 to 17.06); $P = 0.010$ (Analysis 2.4), than those allocated in the non-intervention group. No statistically significant differences were reported between groups with flexion ($P = 0.34$), abduction ($P = 0.21$) and lateral rotation with shoulder in 90° abduction ($P = 0.07$). The slight improvement in ROM favoured participants allocated to the exercise therapy group.

Patient satisfaction

One trial (Ludewig 2003) contributed data for patient satisfaction using two questions in the SRQ and showed statistically significant overall effect, favouring exercise over no intervention (MD 1.20; 95% CI 0.24 to 2.16); $P = 0.01$ (Analysis 2.5). Higher scores again indicate increased satisfaction (SRQ).

Exercise versus scapular mobilization

Pain at rest

One study (Aytar 2015) compared exercise versus scapular mobilization. At the end of intervention (three weeks) pain was measured using the 0-10 VAS scale and showed no statistical significant differences, but participants allocated in the exercise group improved a little more than the scapular mobilization group (MD -0.10; 95% CI -1.56 to 1.36); P=0.89 (Analysis 3.1). The wide CI implies that the results were inconclusive.

Pain with activity

Aytar 2015 reported little to no difference between groups, favouring the scapular mobilization group (MD 0.20; 95% CI -1.29 to 1.69); P=0.79 (Analysis 3.2).

ROM

Aytar 2015, assessed shoulder ROM (shoulder flexion, shoulder external rotation and shoulder internal rotation) at the end of intervention and observed a MD of 0.27 (CI -3.54 to 4.08, P=0.49). The wide CI implies that the results were inconclusive (Analysis 3.3).

Function

Function was measured using the Turkish version of the Quick Dash and Analysis 3.4 demonstrates no statistical significant effect on function, but favoured exercise (MD -2.50; 95% CI -12.54 to 7.54); P=0.63. The wide CI implies that the results were inconclusive.

Home exercise versus supervised exercise

Average pain in the past week

One study (Granviken 2015) compared supervised exercise versus home exercise. At the end of intervention (six weeks) average pain in the past week was measured using a numerical rating scale and showed no statistical significant differences, but participants allocated in the supervised exercise group improved a little more than the home exercise group (MD -0.20, 95% CI -1.47 to 1.07); P=0.76 (Analysis 4.1).

Range of motion

Granviken 2015 assessed active shoulder ROM (flexion, abduction, external rotation and internal rotation) at the end of six weeks and reported a MD of (MD 1.70, 95% CI -4.14 to 7.53); P=0.92

(Analysis 4.2). Higher scores demonstrate an improvement in ROM. The slight improvement in active ROM favoured participants allocated to the home exercise group.

DISCUSSION

Summary of main results

Patients with SIS experience pain and weakness of the shoulder muscles with over-head use of the arm. These symptoms are persistent and can affect everyday activities and functional status. It is thought that conservative treatment such as exercise therapy is effective in treating SIS by reducing pain, improving ROM and functional status. This review is therefore important for clinicians to determine which exercise protocol is effective for these patients.

This systematic review on exercise as conservative treatment modality for SIS includes six studies with a total of 475 participants.

When exercise was compared with extracorporeal shockwave therapy, little or no difference was observed with pain at rest (Analysis 1.1), pain during activity (Analysis 1.2) and function (Analysis 1.3). Although all three of the outcomes favoured exercise therapy, the differences between groups were too small to draw any conclusion.

When exercise was compared with no intervention, pain at rest (Analysis 2.1) and pain during movement or work related pain (Analysis 2.2) reduced significantly among the participants in the exercise group. Function also improved significantly among participants in the exercise group (Analysis 2.3). Data on ROM was available from one study, and only medial rotation with the arm at 90° improved significantly during the intervention (Analysis 2.4). For the remaining ROM outcomes, little or no difference was observed between exercise therapy and no intervention. A positive effect of exercise therapy was observed with respect to patient satisfaction (Analysis 2.5).

When exercise was compared with scapular mobilization, little or no difference in pain at rest (Analysis 3.1) and pain with activity (Analysis 3.2) were noted between the two groups. For the remaining outcomes, ROM and function, no conclusion could be drawn because the results were inconclusive (Analysis 3.3; Analysis 3.4).

When supervised exercise was compared to home exercise, no significant difference was observed with average pain in the past week (Analysis 4.1) or active ROM (Analysis 4.2).

Overall completeness and applicability of evidence

Regardless of the comprehensive electronic search, 19 potentially eligible studies were retrieved of which only six were included. One of the six outcomes investigated in this review, were reported in all of the included studies (pain). Patient satisfaction was reported in three studies, ROM in only three studies, functional status in five studies and quality of life in only one of the six included studies. Only one study had a long-term follow up (one year) to determine the effectiveness of the rehabilitation program and recurrence rate. Five studies had a short-term follow up period between 3-12 weeks, but it would be preferable to have longer follow up periods as this would reflect clinical practice.

Quality of the evidence

The risk of bias across the six included studies was relatively low. One limitation is that it was not always possible to blind participants and clinicians to the treatments. Knowledge of group allocation could affect responses to the intervention the participants received and this increases the risk of bias. Functional status, patient satisfaction and quality of life were measured subjectively with different questionnaires which might increase the outcome estimate and influence the true effect. Methodological quality was generally poor across these studies with regard to vaguely described exercise interventions (type of exercise, intensity and the progression) as well as the different exercise protocols used in these studies. The inclusion of studies using different exercise protocols may lead to methodological heterogeneity. All the potential limitations mentioned above are likely to introduce some heterogeneity into the analysis and therefore no firm conclusions can be made.

Potential bias in the review process

The strength of this review lies in its extensive search strategies, refined quality assessment and well-defined data synthesis. Although the search was done as extensively as possible, by excluding non-English publication in this review, the possibility arises that good quality publications could have been excluded. Eligible South-African publications may also have been excluded by not including South-African databases such as Sabinet in the search strategy. Two studies with the same participants could generate a bias by over-estimating the treatment effect.

AUTHORS' CONCLUSIONS

Implications for practice

The available evidence from randomized controlled trials to determine whether convincing evidence exists to support the use of exercise therapy for SIS, is limited. This might be contrary to what happens in common practice, where anecdotal findings from single studies are often implemented in clinical practice without a strong evidence base. It is suggested that future trial authors include follow-up periods relevant to clinical practice and intervention periods longer than six weeks to properly investigate the long term effect of exercise on SIS. There is also not enough high quality, appropriately reported and well defined exercise interventions to draw conclusions in terms of which type, intensity and frequency of exercise is superior to another with regards to outcomes. The data tends to show more positive results for using exercise, but the evidence is not conclusive to indicate a clear direction.

Implications for research

A distinct need remains for high quality randomized controlled trials for exercise therapy interventions in SIS. It is suggested that future trial authors report clinical trials according to CONSORT guidelines. In general there is a lack of good quality trials to inform the choice of specific exercise for rehabilitation. Therefore attention should be given in future studies to use properly defined interventions in future exercise intervention trials. Future research should focus on longer intervention (between eight and twelve weeks) and follow-up periods (ideally longer than one year) to be able to examine whether specific exercise therapy is of benefit in short and long term for treatment of SIS. In order to determine the risks and benefits of certain exercise interventions, trials should use well-defined outcome assessments and include adverse events and patient satisfaction assessment.

DECLARATIONS

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Competing interests

The authors declare that they have no competing interests. No funding has been received for this research.

Contributions of authors

LVZ, EJB and MC designed the research and coordinated the review. LVZ, EJB and MC were responsible for data collection for the review, LVZ and MC analysed and interpreted the data providing a methodological perspective, while LVZ, MC, EJB and SJM provided a clinical and consumer perspective in terms of data management. LVZ prepared the manuscript with revisions from EJB, MC and SJM. All authors read and approved the final manuscript.

Declarations of interest

- Physical activity, Sport and Recreation, North-West University, Potchefstroom, South Africa.
- University of the Sunshine Coast, Queensland, Australia.

CHARACTERISTICS OF STUDIES

Table 3-1: Characteristics of included studies - Aytar 2015

Methods	Randomized, double-blind, placebo-controlled clinical trial (3 group parallel trial).
Participants	<p>Number of participants: Received intervention: <i>randomised</i> n=69, scapular mobilization (SM) n = 23; sham SM (SSM) n = 23; supervised exercise (SE) n= 23; <i>After 3 week intervention:</i> n=66, SM n=22; SSM n=22; SE n=22; <i>First follow up (7 weeks):</i> SM n=8; SSM n=10; SE n=11.</p> <p>Age, mean±SD: SM 52±3,SSM 52±4, SE 51±4.</p> <p>Diagnostic criteria: Study participants were referred from a physician with the diagnosis of SAIS. To confirm this, potential participants demonstrated at least 3 of the following findings: a positive Neer impingement test, a positive Hawkins impingement test, a positive painful arc sign (60–120° of elevation), pain with palpation of the rotator-cuff tendons, pain with isometric resisted abduction, and pain at the shoulder region. On confirmation of these findings, participants were further screened for participation in this study by meeting the following criteria: score of the Disabilities of the Arm, Shoulder and Hand Questionnaire (Quick DASH) >20, pain for ≥ 6 months, and pain with activity between 2 and 8 on a 10 cm visual analogue scale.</p>
Interventions	<p>Frequency and duration: 3 weeks with a total of 9 treatment sessions.</p> <p>Type: Stretching (posterior capsule, external rotation, flexion and abduction stretch, pectoral stretch) - 4 times for 30 seconds. Strengthening (serratus anterior, external rotation, and inferior glide) exercises were performed in front of the mirror with supervision of the PT - 2 sets of 10 repetitions of, holding for 5 seconds at the end of each repetition. Between stretching and strengthening exercises, a 30-second interval was given.</p> <p>Intensity: According to participants' strength, suitable Thera-Band and weight were chosen by PT at the beginning of the treatment. Suitable Thera-Band and weight were determined by participants' performing 10 repetitions of exercises with proper form and without pain or fatigue. Thera-Band or weight was progressed weekly.</p> <p>Home program: The same exercises as done in the SE group were prescribed at the end of the 3 weeks for all groups (SM, SSM, and SE).</p> <p>Follow up: Primary and secondary outcome measurements were taken at baseline (0 weeks), 2 weeks (before the fifth visit), 3 weeks (end of intervention), 7 weeks and 11 weeks.</p> <p>Scapular mobilization (SM)</p> <p>Frequency and duration: Each application was applied 3 times for 10 repetitions and a rate of 1 cycle per 6 seconds, with a 30-second interval between sets.</p> <p>Sham SM (SSM)</p> <p>Hands were randomly put on the scapula, and then just skin was moved in the super inferior, mediolateral, and rotation directions with minimal pressure to make a sham application.</p>
Outcomes	<p>Pain: Pain intensity at rest (0–10 cm VAS), at night (0–10 cm VAS), and during activity (0–10 cm VAS).</p> <p>ROM: Universal goniometer was used to measure active shoulder ROM.</p> <p>Functional status: Turkish version of the Quick DASH.</p> <p>Quality of life: Not reported.</p> <p>Patient satisfaction: 7-point Likert scale.</p>

Notes	<p>The same exercises as done in the SE group were prescribed at the end of the 3 weeks for all groups (SM, SSM, and SE) to be performed at home, therefore only follow up data from week 3 will be used for data analysis (end of treatment).</p> <p>Quick DASH: 11 items to measure physical function and symptoms. Each item has 5 response scores, and the scores for all items are used to calculate a scale score ranging from 0 (<i>no disability</i>) to 100 (<i>most-severe disability</i>).</p> <p>0-10 VAS: On one end <i>no pain</i> and <i>worst pain possible</i> at the other end (as measured from the left-hand side to the point marked).</p> <p>7-point Likert scale: <i>Completely dissatisfied</i> on the left equalling 0 and the right anchor <i>completely satisfied</i> equalling 7.</p>
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Table 3-2: Risk of bias table - Aytar 2015

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"Before the study began randomization procedure was performed using an online random-allocation software program."
Allocation concealment (selection bias)	Unclear risk	The method of concealment is not described.
Blinding of participants and personnel (performance bias)	Low risk	"Evaluator PT and patients were blinded to the group allocations during the course of treatment."
Blinding of outcome assessment (detection bias)	Low risk	"Evaluator PT was blinded to the group allocations during the course of treatment."
Incomplete outcome data (attrition bias)	Low risk	"A mixed model was used, as we had most but not all data points at each time point from all participants."
Selective reporting (reporting bias)	Low risk	All of the study's primary and secondary outcomes that are of interest in the review have been reported.
Other bias	Unclear risk	"Application of therapeutic modalities and patient education may have interfered with the final outcome of this study."

Table 3-3: Characteristics of included studies - Engebretsen 2009

Methods	Single blind randomised study (2 group parallel trial).
Participants	<p>Number of participants: <i>Randomised</i> n=104: supervised exercise n=52; radial extracorporeal shockwave therapy (rESWT) n=52; <i>12 week follow up:</i> supervised exercise n=50; rESWT n=52; <i>18 week follow up:</i> supervised exercise n=50; rESWT n=50.</p> <p>Age, mean±SD: supervised exercise = 49±9.3; rESWT = 47±11.7.</p> <p>Diagnostic criteria: Dysfunction or pain on abduction, normal passive glenohumeral ROM, pain on two of three isometric tests (abduction at 0° or 30°, external or internal rotation), and a positive Kennedy-Hawkins sign. Patients with rotator cuff rupture were included if they met the above criteria.</p>
Interventions	<p>Supervised exercises</p> <p>Frequency and duration: 2 x 45 minute/week (max 12 weeks).</p> <p>Type: Initially, relearning of normal movement patterns to unload the stress on the rotator cuff and subacromial structures. Once normalised, endurance exercises were performed with gradually increasing resistance.</p> <p>Home program: Patients had an adjusted programme, which consisted of correction of alignment during daily living and simple low loaded exercise with a thin elastic cord to provide assistance and resistance to the movement.</p> <p>Follow up: At six weeks the patients completed a postal questionnaire, including the outcome measures, at home. The 12 week and 18 week follow-ups were done at the hospital.</p> <p>rESWT</p> <p>Frequency and duration: 1 x week for 4-6 weeks.</p> <p>Type: 3-5 tender points were treated each time.</p>
Outcomes	<p>Pain: 1-9 Likert scale for pain at rest.</p> <p>ROM: Not reported.</p> <p>Functional status: 1-7 Likert scale for the capacity to take an item down from a shelf.</p> <p>Quality of life: Not reported.</p> <p>Patient satisfaction: Not reported.</p>
Notes	<p>Pain: 1-9 Likert scale (higher scores mean worse pain).</p> <p>Function: 1-7 Likert (higher scores mean worse function).</p>

Table 3-4: Risk of bias table - Engebretsen 2009

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	"A statistician not involved in data collection or analysis randomly allocated patients to treatment groups in blocks of four to six. Randomisation was stratified by sex."
Allocation concealment (selection bias)	Low risk	"A person not involved in the treatments opened the sealed envelopes and assigned appointments according to treatment group."
Blinding of participants and personnel (performance bias)	High risk	Not possible to blind participants or personnel to treatment allocation.
Blinding of outcome assessment (detection bias)	Low risk	"A blinded physiotherapist made the baseline and follow-up measurements. The patients were instructed not to discuss their treatment with the blinded physiotherapist."
Incomplete outcome data (attrition bias)	Low risk	"To evaluate the treatment effect (the mean difference between the groups at six, 12, and 18 weeks), we used the mixed model analysis (repeated measurements). This model includes the interaction between treatment and elapsed time, baseline values are adjusted, and we assume that data are missing at random."
Selective reporting (reporting bias)	Low risk	All the primary outcomes stated under "Methods" are reported in accordance with the protocol.
Other bias	Low risk	We do not suspect other type of bias.

Table 3-5: Characteristics of included studies - Engebretsen 2011

Method	Randomised controlled trial (2 group parallel trial).
Participants	<p>Number of participants: <i>Randomised</i> n=104: supervised exercise n=52; radial extracorporeal shockwave therapy (rESWT) n=52; <i>12 week follow up:</i> supervised exercise n=50; rESWT n=52; <i>18 week follow up:</i> supervised exercise n=50; rESWT n=50; <i>1 year follow up:</i> n=97: supervised exercise n=48; rESWT n=46.</p> <p>Age, mean±SD: supervised exercise = 49±9.3; rESWT = 47±11.7.</p> <p>Diagnostic criteria: Dysfunction or pain on abduction, normal passive glenohumeral range of motion, pain on 2 of 3 isometric tests (abduction at 0° or 30°, external or internal rotation), and a positive Kennedy-Hawkins sign. Patients with rotator cuff rupture were included if they met these criteria. Previous treatments, including NSAIDs, subacromial injections, and physical therapy, were allowed.</p>
Interventions	<p>Supervised exercises</p> <p>Frequency and duration: 2 x 45 minute/week (max 12 weeks).</p> <p>Type: Initially, relearning of normal movement patterns to unload the stress on the rotator cuff and subacromial structures. In this phase, a mirror for awareness of posture, manual techniques for loosening tense muscles, an elastic rubber band for relaxed repetitive movements, exercises with manual resistance for periscapular muscles, and a sling fixed to the ceiling were used. The focus in the next phase was to increase the eccentric force in the supraspinatus and infraspinatus muscles generated when lowering the arm in a standing position. This training incorporated scapular control and dynamic scapular stability. Once normalised, endurance exercises were performed with gradually increasing resistance. Principles of closed and open kinetic chain and plyometric exercises were incorporated into the next phase of training.</p> <p>Home program: Patients had an adjusted programme at home.</p> <p>Follow up: At 12 months, the participants completed a mailed follow-up questionnaire that included the outcome measures and questions regarding additional treatment in the follow-up period.</p> <p>Radial extracorporeal shock-wave therapy</p> <p>Frequency and duration: 1 x week for 4-6 weeks.</p> <p>Type: 3-5 tender points were treated each time.</p>
Outcomes	<p>Pain: 1-9 Likert scale for pain at rest.</p> <p>ROM: Not reported.</p> <p>Functional status: 1-7 Likert scale for the capacity to take an item down from a shelf.</p> <p>Quality of life: Not reported.</p> <p>Patient satisfaction: Not reported.</p>
Notes	Although the SPADI questionnaire was administered, only the overall SPADI score was reported, which is an aggregate score comprising both pain and functional sub scores. Neither SPADI pain nor disability sub scores were reported independently and have not been extracted here. Although the Hopkins Symptom Checklist was used to collect data on emotional distress, we have not extracted these data here because emotional distress is an incomplete measure of quality of life.

Table 3-6: Risk of bias table - Engebretsen 2011

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"Random allocation in block, stratified according to sex, of 4-6 participants, was performed by a statistician not involved in the data collection or analysis."
Allocation concealment (selection bias)	Low risk	"A person not involved in the treatment opened the seal envelopes and assigned appointments according to treatment group."
Blinding of participants and personnel (performance bias)	High risk	Single blind: participants were not blind to group allocation. Therapists were not blind to group allocation.
Blinding of outcome assessment (detection bias)	Low risk	Single blind: assessors were blind to group allocation.
Incomplete outcome data (attrition bias)	Low risk	Intention to treat analysis. Applied linear model to impute missing data.
Selective reporting (reporting bias)	Low risk	All the primary outcomes stated under "Methods" are reported in accordance with the protocol.
Other bias	Low risk	"The physical therapists providing the treatments completed a checklist to ensure adherence to treatment and to report specific events." "The secondary outcome measures of pain and function were checked for normal distribution, and parametric statistics (mixed models) were appropriate to use."

Table 3-7: Characteristics of included studies - Granviken 2015

Method	Randomised controlled trial (2 group parallel trial).
Participants	<p>Number of participants: <i>Randomised</i> n=46: supervised exercise n=23; home exercise n=23; <i>6 week follow up:</i> supervised exercise n=23; home exercise n=21; <i>26 week follow up:</i> supervised exercise n=21; home exercise n=18.</p> <p>Age, mean (SD): Home exercise = 48.2±9.8; Supervised exercise = 47.6±10.</p> <p>Diagnostic criteria: Aged between 18 and 65 years with unilateral shoulder pain (more than 12 weeks). All three of the following tests had to be positive: the painful arc test, infraspinatus test and the Kennedy-Hawkins test. Participants had to have normal passive glenohumeral physiological ROM.</p>

Interventions	<p>Home exercise group = 1 supervised treatment session with a physiotherapist.</p> <p>Supervised exercise group = 10 supervised treatment sessions with a physiotherapist.</p> <p>Exercises and overall training dose were the same for both groups (established training principles were used).</p> <p>Frequency and duration: Exercises were performed at home with 4-6 exercises twice a day every day. Intervention period was 6 weeks.</p> <p>Type: Exercises to re-establish normal shoulder movement patterns through awareness. Normalise shoulder motion (visual stimulation in front of mirror). Participants started training of correct scapular placement - depressing the shoulder during shoulder flexion and abduction. Focus was on scapular stabilising exercises, rotator cuff exercises, and pain free ROM exercises. Exercises were individually adapted. Stretching exercises, based on individual needs were given later for tight structures. Stretches were held for 30 seconds x 2 for each exercise.</p> <p>Intensity: Participants used 3 sets of 30 repetitions for most exercises. A thin rubber band was used as a training tool - to (1) reduce the arm load, (2) control movement or (3) provide resistance. Exercises and the choice of exercises, starting position and range of motion were decided and performed with as little pain as possible. The home training group was also instructed in the progression opportunities for the appropriate exercises.</p> <p>Home program: Both groups were given written home exercises.</p> <p>Follow up: 6 Weeks</p>
Outcomes	<p>Pain: average pain in the past week - numerical rating scale.</p> <p>ROM: Active ROM - digital inclinometer.</p> <p>Functional status: SPADI</p> <p>Quality of life: Not reported</p> <p>Patient satisfaction: Two separate scales.</p>
Notes	<p>Although the SPADI questionnaire was administered, only the overall SPADI score was reported, which is an aggregate score comprising both pain and functional sub scores. Neither SPADI pain nor disability sub scores were reported independently and have not been extracted here.</p> <p>Numerical rating scale for pain in the past week: 0 (<i>no pain</i>) to 10 (<i>worst possible pain</i>).</p> <p>Patient satisfaction: Perceived benefit of treatment one seven of possibilities: completely recovered, much improved, slightly improved, no change, slightly worsened, much worsened and worse than ever and satisfaction with treatment one of five possibilities: satisfied, somewhat satisfied, mixed (neither satisfied nor dissatisfied), somewhat dissatisfied and dissatisfied.</p>

Table 3-8: Risk of bias table - Granviken 2015

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"Allocation was concealed. The participants were randomised via online access to the randomisation program at the Unit for Applied Clinical Research at Norwegian University of Science and Technology. Randomisation was stratified by gender to obtain gender-balanced groups."
Allocation concealment (selection bias)	Low risk	"Randomisation also used variable block sizes to assign participants to the two treatment groups."
Blinding of participants and personnel (performance bias)	High risk	Not possible to blind physiotherapist or participants to treatment allocation.
Blinding of outcome assessment (detection bias)	Low risk	"Data were obtained before randomisation and at the end of the 6-week intervention period by an examiner blinded to the participants' group assignment. The participants were instructed not to discuss their treatment with the examiner who performed the testing."
Incomplete outcome data (attrition bias)	Low risk	"Data were analysed according to the intention-to-treat principle."
Selective reporting (reporting bias)	Low risk	All the primary outcomes stated under "Methods" are reported in accordance with the protocol.
Other bias	Low risk	We do not suspect other types of bias.

Table 3-9: Characteristics of included studies - Lombardi 2008

Methods	Randomised control trial (2 group parallel trial).
Participants	<p>Number of participants: <i>Randomised</i> n=60: experimental group n=30 (W=21, M= 9); control group (W=25, M=5)</p> <p>Age, mean±SD: Experimental group = 56.3±11.6; Control group = 54.8±9.4</p> <p>Diagnostic criteria: A positive Neer test and Hawkins test for the diagnosis of shoulder impingement syndrome in the previous 2 months and pain between 3 and 8 on the numeric pain scale in the arc of movement that produces the greatest shoulder pain.</p>

Interventions	<p>Experimental group</p> <p>Frequency and duration: Twice a week for a period of 8 weeks.</p> <p>Type: Progressive resistance training: The exercises were flexion, extension, medial rotation, and lateral rotation of the shoulder.</p> <p>Intensity: Once the 6 RM load was determined, training was divided into the following regimen: 2 series of 8 repetitions, the first series with 50% of the 6 RM and the second series with 70% of the 6 RM, respecting the patient's pain threshold. 2 minute rest between the first and second series; the speed of movement was 2 seconds for both the eccentric and concentric phases. The 6 RM load was re-evaluated every 2 weeks.</p> <p>Home program: Not mentioned.</p> <p>Follow up: 2 months (after intervention).</p> <p>Control group</p> <p>On a waiting list and were informed that they would receive physiotherapeutic treatment after 2 months had passed.</p>
Outcomes	<p>Pain: Pain at rest (0–10 cm VAS), pain at movement (0–10 cm VAS).</p> <p>ROM: Active goniometry (flexion, abduction, medial rotation and lateral rotation with shoulder at 90 degrees abduction). (Lateral rotation with arm alongside the body and extension ROM values not used in this SR, as it is highly unlikely that these movements would create any subacromial impingement).</p> <p>Functional status: DASH 2 and the DASH 3.</p> <p>Quality of life: Brazilian version of the Short Form 36 (SF-36).</p> <p>Patient satisfaction: 5 point Likert scale with the following items: much worse, a little worse, unchanged, a little better, and much better.</p>
Notes	<p>"DASH questionnaire, which comprises 30 items that assess function and symptoms; the DASH 2 is used for labourers function and the DASH 3 for activities of daily living."</p> <p>Although patient satisfaction was assessed, the data was not reported - only significant difference indicated by means of a P-value.</p> <p>No long term follow-up (only post-treatment).</p>

Table 3-10: Risk of bias table - Lombardi 2008

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"A computer-generated randomization list was utilized to randomly allocate patients into experimental and control groups."
Allocation concealment (selection bias)	Low risk	"Concealed randomization with an opaque sealed envelope".
Blinding of participants and personnel (performance bias)	High risk	Not possible to blind participants or personnel to treatment allocation: "There was no way for us to prescribe any exercise that would not produce any effect, because even the smallest amount of exercise could have influenced the results."

Bias	Authors' judgement	Support for judgement
Blinding of outcome assessment (detection bias)	Low risk	Single blind: "Evaluations were carried out at the beginning and end of the treatment program by the same blinded examiner for both groups."
Incomplete outcome data (attrition bias)	Low risk	Missing data imputed using last measure carried forward method. "Data from the prior evaluation of the patients from the control group were used for the intent-to-treat analysis."
Selective reporting (reporting bias)	Low risk	All the primary outcomes stated under "Methods" are reported in accordance with the protocol.
Other bias	Low risk	We do not suspect other type of bias.

Table 3-11: Characteristics of included studies - Ludewig 2003

Methods	Randomised controlled trial (3 group parallel trial).
Participants	<p>Number of participants: <i>Randomised</i> n=92: intervention n=34; control n=33; control asymptomatic n=25; 8-12 week treatment follow-up intervention n=30; control symptomatic n=32; control asymptomatic n=23.</p> <p>Age, mean±SD: Intervention 48.0(1.8), control symptomatic = 49.2±1.8, control asymptomatic = 49.4±2.5</p> <p>Diagnostic criteria: Inclusion criteria for symptomatic individuals consisted of a current reported history of shoulder pain localised to the glenohumeral joint region, excluding cervical and periscapular pain, but including the common site of referred pain of the rotator cuff to the C5–6 dermatome above the deltoid insertion. Symptomatic subjects also had to present with at least two positive shoulder impingement tests (Neer, Hawkins/Kennedy, Yocum, Jobe, and/or Speeds tests) and pain reproduction during two of three additional categories of clinical tests. These categories included: (1) a painful arc on active scapular plane abduction of the arm; (2) tenderness to palpation of the biceps or rotator cuff tendons; and (3) pain with one or more resisted glenohumeral joint motions (flexion, abduction, internal rotation or external rotation). Flexion and abduction were resisted at 90° of elevation, and internal and external rotation was resisted both at the subject's side and at 90° of abduction.</p>

Interventions	<p>Intervention</p> <p>Frequency and duration: Strengthening exercises were done 3 days per week for 2 muscle groups and 2 stretches were done for 30 seconds each and repeated 5 times a day.</p> <p>Type:</p> <p>Strengthening</p> <p>Progressive resistance strengthening exercises. For the serratus anterior muscle, strengthening was performed supine by protracting the scapula and raising a hand held weight superiorly. Humeral external rotation was resisted with Thera-Band while subjects were in a standing position. Subjects were instructed to progress from an initial position of the arm close to their side, to a position of abduction of the arm. Performed 3 x 10 repetitions the first week, progress to 3 x 15 repetitions the second week, and 3 x 20 repetitions the third week. Subjects were instructed that exercises may induce muscle fatigue but should not cause increased shoulder pain.</p> <p>Stretching</p> <p>The pectoralis minor stretch was performed by asking the subject to place each hand at shoulder height on adjacent walls of a corner and lean into the corner. The second stretch for the posterior shoulder was performed by reaching towards the opposite scapula and then using the uninvolved hand to further horizontally adduct the humerus until a stretch was achieved. A muscle relaxation exercise for the upper trapezius was performed five times daily by having the subjects raise the arm overhead in the scapular plane without shrugging the shoulder.</p> <p>Intensity: After achieving 3 x 20 repetitions for 3 consecutive sessions, subjects were to further progress their programme by increasing weight resistance or Thera-Band tension (by shortening the band), and repeating the repetition sequence as described.</p> <p>Home program: The whole program was home exercise and not supervised exercise.</p> <p>Follow up: 8-12 weeks.</p> <p>Control: No intervention.</p>
Outcomes	<p>Pain: Work related pain questions from SPADI.</p> <p>ROM: Not reported.</p> <p>Functional status: Work related functional capacity from SPADI.</p> <p>Quality of life: Not reported.</p> <p>Patient satisfaction: Satisfaction score (2 questions in the SRQ - reported separately).</p>
Notes	<p>Asymptomatic control group results will not be used as the aim of the review is to evaluate the effect of exercise on impingement symptoms.</p> <p>No long term follow-up (only post-treatment).</p>

Table 3-12: Risk of bias table - Ludewig 2003

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	"Randomisation was performed by an investigator blindly selecting one of two slips of paper indicating group assignment." We identified this process as quasi-randomised.
Allocation concealment (selection bias)	High risk	Allocation not concealed.
Blinding of participants and personnel (performance bias)	High risk	"The researchers were not blinded to group assignment, but were to baseline measurements at the time of follow up."
Blinding of outcome assessment (detection bias)	Low risk	"Subjects were blinded to their initial scores when completing the post testing, and patients were asked to rate their current status rather than a change in status, so recall bias should not have substantially impacted the results."
Incomplete outcome data (attrition bias)	Low risk	"Missing post-test data were replaced with imputed values based on the average of the observed means from the two symptomatic groups."
Selective reporting (reporting bias)	Low risk	"The initial analysis included all subjects from whom post-test data were obtained, regardless of their level of compliance with the exercise programme. A secondary complete "intention to treat" analysis was also performed where all subjects initially enrolled were analysed."
Other bias	High risk	"Variation in the post-test time between subjects (8–12 weeks). Not surprisingly, it was not always possible for subjects to return for the post-test exactly at the completion of the eight week period. The majority of subjects discontinued the exercise programme after 8–9 weeks, regardless of the scheduled follow up time. Therefore, the apparent effectiveness of the exercises might appear to be less for subjects not seen for follow up until the 12th week." Authors indicated they inspected the data for differences but do not state what they mean by "inspect".

ABBREVIATIONS

CI: Confidence intervals

DASH: Disability of the arm, shoulder and hand questionnaire

FITT: Frequency, intensity, time and type

MD: Mean difference

PNF: proprioceptive neuromuscular facilitation

ROM: Range of motion

SD: Standard deviation

SIS: Shoulder impingement syndrome

SMD: Standard mean difference

SPADI: Shoulder pain and disability index

SRQ: Self-report questionnaires

VAS: Visual analog scale

Table 3-13: Characteristics of excluded studies

Study	Reason for exclusion
Bang 2000	Exercise completed by both the intervention and control groups: unable to identify the effect of exercise alone.
Al Dajah 2014	Exercise treatment was a minor part of the intervention.
Devereaux 2016	Exercise completed by both the intervention and control groups: unable to identify the effect of exercise alone.
Dilek 2016	Not exercise treatment alone: unable to identify the effect of exercise alone.
Haahr 2005	Not exercise treatment alone: unable to identify the effect of exercise alone.
Kaya 2011	Not exercise treatment alone: unable to identify the effect of exercise alone.
Moezy 2014	Not exercise treatment alone: unable to identify the effect of exercise alone.
Nakra 2013	Not exercise treatment alone: unable to identify the effect of exercise alone.
Ogrodzka 2015	Exercise completed by both the intervention and control groups: unable to identify the effect of exercise alone.
Rhon 2014	Not exercise treatment alone: unable to identify the effect of exercise alone.
Savoie 2015	Not exercise treatment alone: unable to identify the effect of exercise alone.
Struyf 2013	Not exercise treatment alone: unable to identify the effect of exercise alone.

Table 3-14: Characteristics of studies awaiting classification - Turner 2001

Methods	-
Participants	-
Interventions	-
Outcomes	-
Notes	Abstract or full text could not be sourced

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DATA AND ANALYSES SUMMARY**Comparison 1: Exercise versus extracorporeal shock wave**

Outcome or Subgroup	Studies	Participants	Statistical Method	Effect Estimate
1.1 Pain at rest 1-9 Likert scale	2	196	Mean Difference (IV, Random, 95% CI [1])	-0.45 [-0.97, 0.07]
1.1.1 End of intervention - 12 weeks	1	102	Mean Difference (IV, Random, 95% CI [1])	-0.40 [-1.16, 0.36]
1.1.2 End of follow up - 1 year	1	94	Mean Difference (IV, Random, 95% CI [1])	-0.50 [-1.22, 0.22]
1.2 Pain during activity - 1-9 Likert scale	2	196	Mean Difference (IV, Fixed, 95% CI)	-0.30 [-0.95, 0.34]
1.2.1 End of intervention - 12 weeks	1	102	Mean Difference (IV, Fixed, 95% CI)	-0.40 [-1.29, 0.49]
1.2.2 End of follow up - 1 year	1	94	Mean Difference (IV, Fixed, 95% CI)	-0.20 [-1.13, 0.73]
1.3 Function (take down) 1-7 Likert scale	2	196	Mean Difference (IV, Random, 95% CI [1])	-0.05 [-0.74, 0.63]
1.3.1 End of intervention - 12 weeks	1	102	Mean Difference (IV, Random, 95% CI [1])	-0.40 [-1.16, 0.36]
1.3.2 End of follow up - 1 year	1	94	Mean Difference (IV, Random, 95% CI [1])	0.30 [-0.47, 1.07]

Comparison 2: Exercise versus no intervention

Outcome or Subgroup	Studies	Participants	Statistical Method	Effect Estimate
2.1 Pain at rest - 0-10cm VAS	1	55	Mean Difference (IV, Fixed, 95% CI)	-1.90 [-3.36, -0.44]
2.1.1 End of intervention	1	55	Mean Difference (IV, Fixed, 95% CI)	-1.90 [-3.36, -0.44]
2.2 Pain at movement or work related	2	122	Std. Mean Difference (IV, Fixed, 95% CI)	-0.81 [-1.18, -0.44]
2.2.1 End of intervention	2	122	Std. Mean Difference (IV, Fixed, 95% CI)	-0.81 [-1.18, -0.44]
2.3 Function DASH questionnaire	2	182	Std. Mean Difference (IV, Fixed, 95% CI)	-0.60 [-0.89, -0.30]
2.3.1 DASH 2 - laborious function	2	122	Std. Mean Difference (IV, Fixed, 95% CI)	-0.66 [-1.02, -0.29]
2.3.2 DASH 3 - activities of daily living	1	60	Std. Mean Difference (IV, Fixed, 95% CI)	-0.48 [-1.00, 0.03]
2.4 Shoulder ROM goniometry	1	300	Mean Difference (IV, Fixed, 95% CI [1])	6.90 [2.39, 11.42]
2.4.1 Flexion	1	60	Mean Difference (IV, Fixed, 95% CI [1])	6.50 [-6.72, 19.72]
2.4.2 Abduction	1	60	Mean Difference (IV, Fixed, 95% CI [1])	9.70 [-5.53, 24.93]
2.4.3 Medial rotation (arm at 90° abduction)	1	60	Mean Difference (IV, Fixed, 95% CI [1])	9.70 [2.34, 17.06]
2.4.4 Lateral rotation (shoulder at 90° abduction)	1	60	Mean Difference (IV, Fixed, 95% CI [1])	12.20 [-0.84, 25.24]
2.4.5 Lateral rotation (arm alongside body)	1	60	Mean Difference (IV, Fixed, 95% CI [1])	0.60 [-7.65, 8.85]

Outcome or Subgroup	Studies	Participants	Statistical Method	Effect Estimate
2.5 Patient satisfaction – SRQ questionnaire	1	62	Mean Difference (IV, Fixed, 95% CI)	1.20 [0.24, 2.16]

Comparison 3: Exercise versus scapular mobilization

Outcome or Subgroup	Studies	Participants	Statistical Method	Effect Estimate
3.1 Pain at rest	1	44	Mean Difference (IV, Fixed, 95% CI)	-0.10 [-1.56, 1.36]
3.2 Pain with activity 0–10 cm VAS scale	1	44	Mean Difference (IV, Fixed, 95% CI [1])	0.20 [-1.29, 1.69]
3.3 Shoulder ROM with universal goniometer	1	132	Mean Difference (IV, Fixed, 95% CI [1])	0.27 [-3.54, 4.08]
3.3.1 Shoulder flexion	1	44	Mean Difference (IV, Fixed, 95% CI [1])	-2.00 [-7.35, 3.35]
3.3.2 Shoulder external rotation	1	44	Mean Difference (IV, Fixed, 95% CI [1])	2.00 [-6.70, 10.70]
3.3.3 Shoulder internal rotation	1	44	Mean Difference (IV, Fixed, 95% CI [1])	3.00 [-3.95, 9.95]
3.4 Shoulder function - Quick DASH 11 item	1	44	Mean Difference (IV, Fixed, 95% CI [1])	-2.50 [-12.54, 7.54]

Comparison 4: Home exercise versus supervised exercise

Outcome or Subgroup	Studies	Participants	Statistical Method	Effect Estimate
5.1 Pain at rest 1-9 Likert scale	2	196	Mean Difference (IV, Random, 95% CI [1])	-0.45 [-0.97, 0.07]
5.1.1 End of intervention - 12 weeks	1	102	Mean Difference (IV, Random, 95% CI [1])	-0.40 [-1.16, 0.36]
5.1.2 End of follow up - 1 year	1	94	Mean Difference (IV, Random, 95% CI [1])	-0.50 [-1.22, 0.22]
5.2 Pain during activity - 1-9 Likert scale	2	196	Mean Difference (IV, Fixed, 95% CI)	-0.30 [-0.95, 0.34]
5.2.1 End of intervention - 12 weeks	1	102	Mean Difference (IV, Fixed, 95% CI)	-0.40 [-1.29, 0.49]
5.2.2 End of follow up - 1 year	1	94	Mean Difference (IV, Fixed, 95% CI)	-0.20 [-1.13, 0.73]
5.3 Function (take down) 1-7 Likert scale	2	196	Mean Difference (IV, Random, 95% CI [1])	-0.05 [-0.74, 0.63]
5.3.1 End of intervention - 12 weeks	1	102	Mean Difference (IV, Random, 95% CI [1])	-0.40 [-1.16, 0.36]
5.3.2 End of follow up - 1 year	1	94	Mean Difference (IV, Random, 95% CI [1])	0.30 [-0.47, 1.07]

Figure 3-4: Analysis 1.1 - Forest plot of comparison 1: Exercise versus extracorporeal shock wave, outcome: 1.1 Pain at rest 1-9 Likert scale.

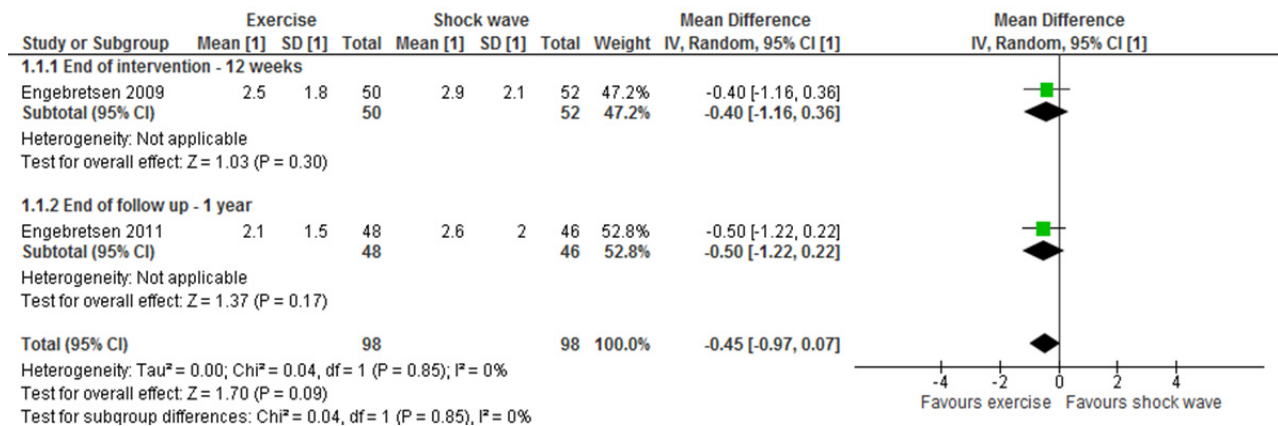


Figure 3-5: Analysis 1.2 - Forest plot of comparison 1: Exercise versus extracorporeal shock wave, outcome: 1.2 Pain during activity - 1-9 Likert scale.

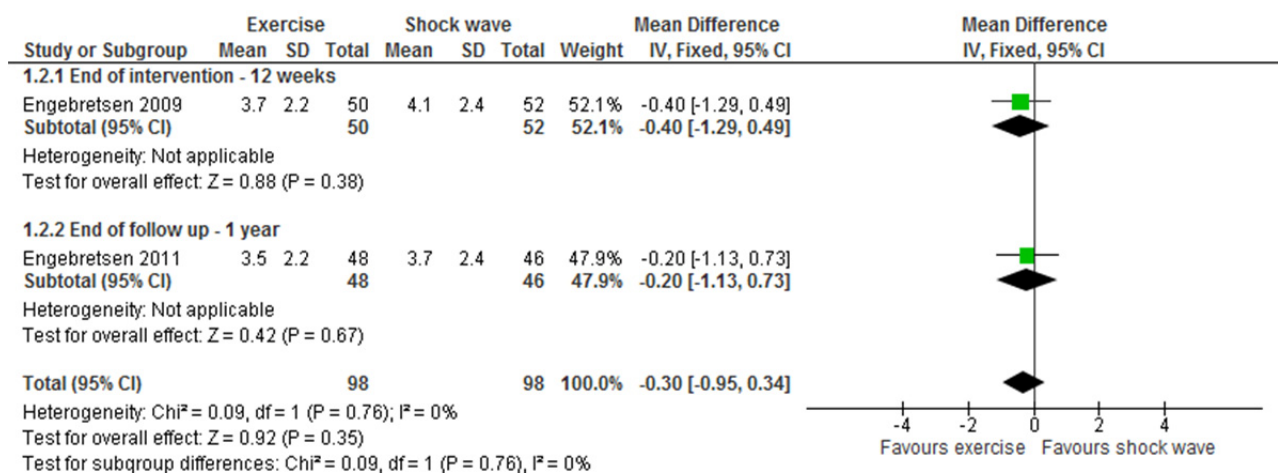


Figure 3-6: Analysis 1.3 - Forest plot of comparison 1: Exercise versus extracorporeal shock wave, outcome: 1.3 Function (take down) 1-7 Likert scale.

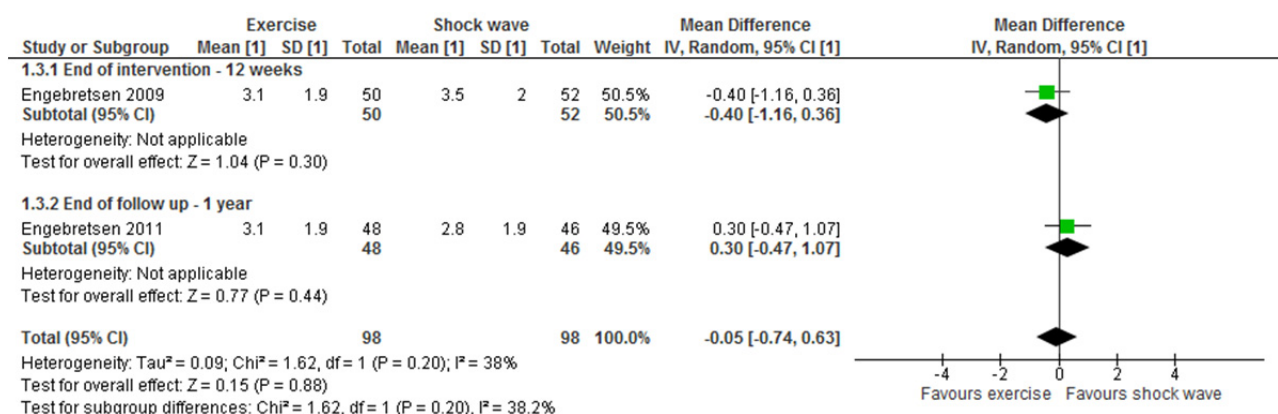


Figure 3-7: Analysis 2.1 - Forest plot of comparison 2: Exercise versus no intervention, outcome: 2.1 Pain at rest - 0-10cm VAS.

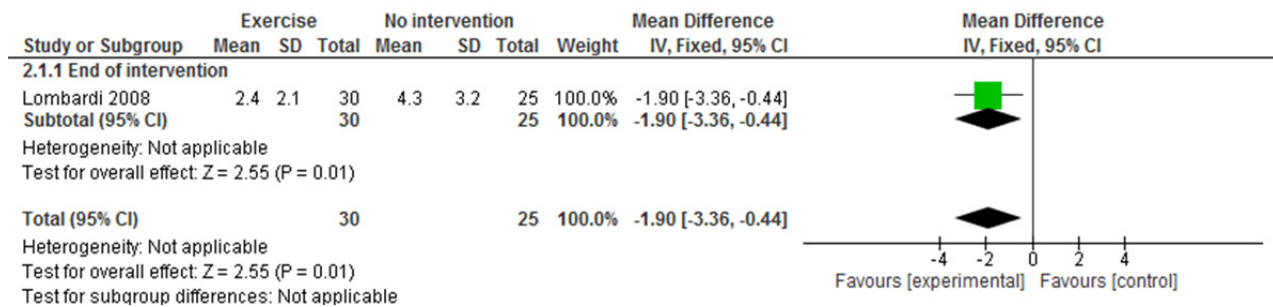


Figure 3-8: Analysis 2.2 - Forest plot of comparison 2: Exercise versus no intervention, outcome: 2.2 Pain at movement or work related.

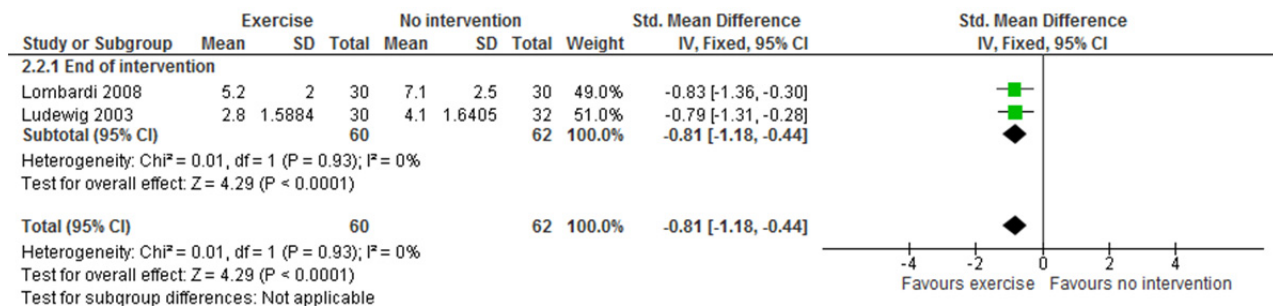


Figure 3-9: Analysis 2.3 - Forest plot of comparison 2: Exercise versus no intervention, outcome: 2.3 Function DASH questionnaire.

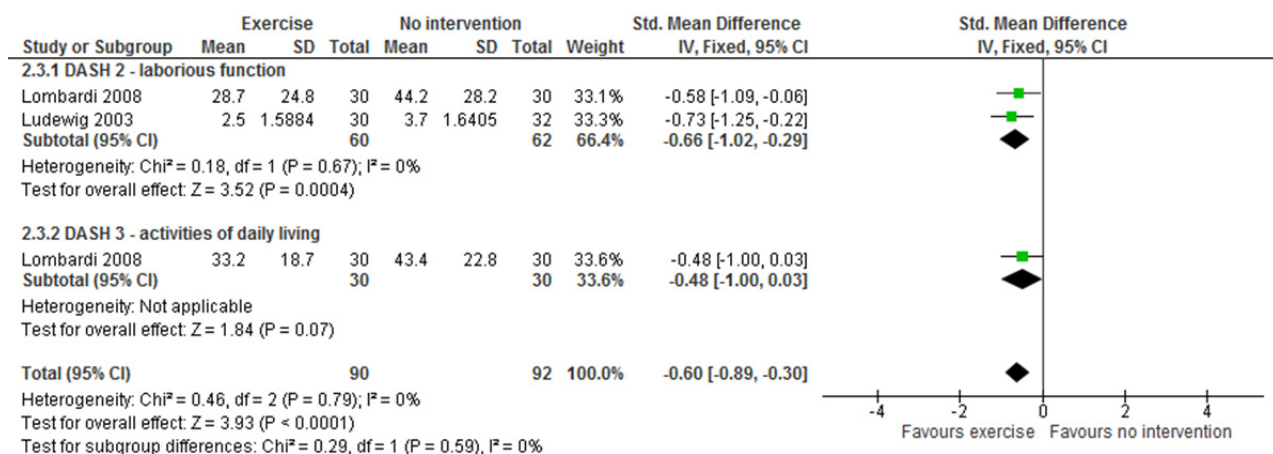


Figure 3-10: Analysis 2.4 - Forest plot of comparison 2: Exercise versus no intervention, outcome: 2.4 Shoulder ROM goniometry.

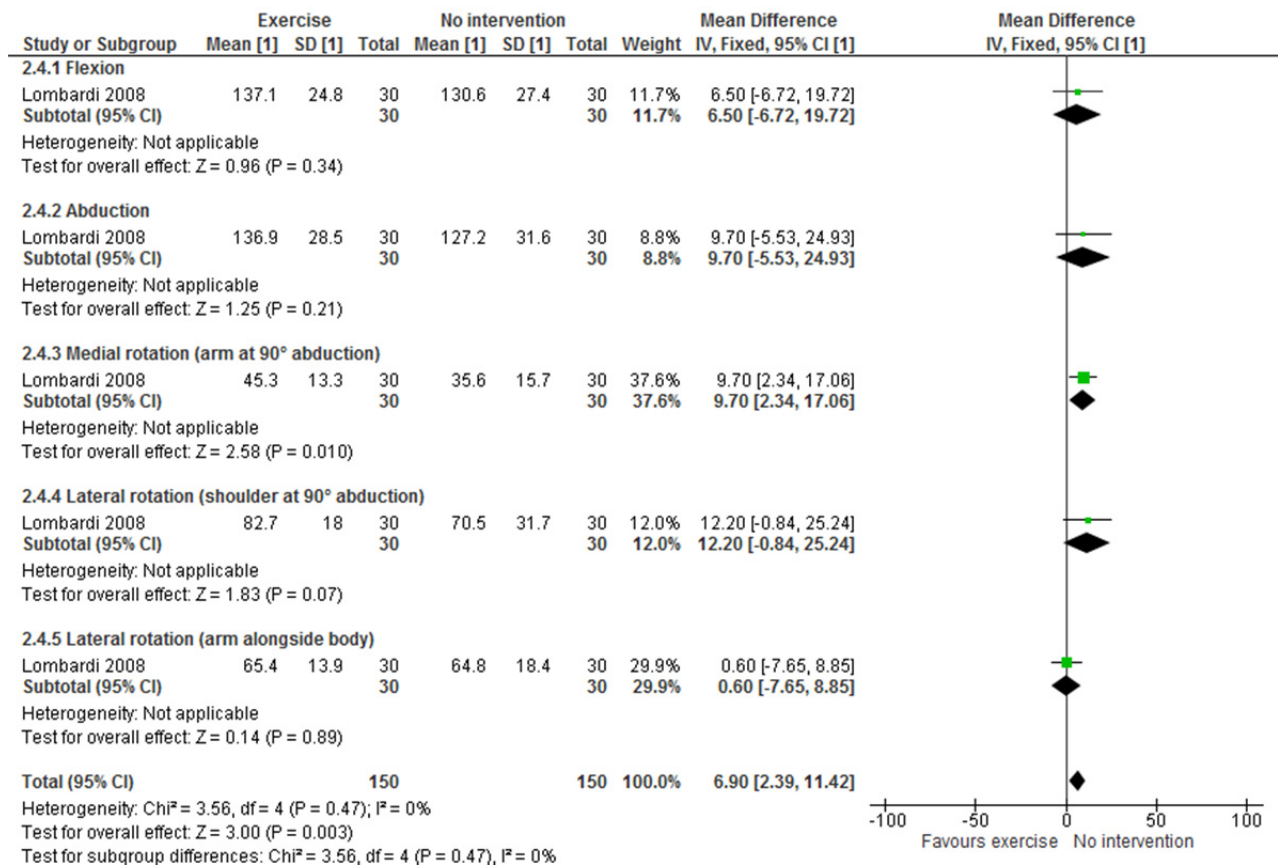


Figure 3-11: Analysis 2.5 - Forest plot of comparison 2: Exercise versus no intervention, outcome: 2.5 Patient satisfaction - SRQ questionnaire.

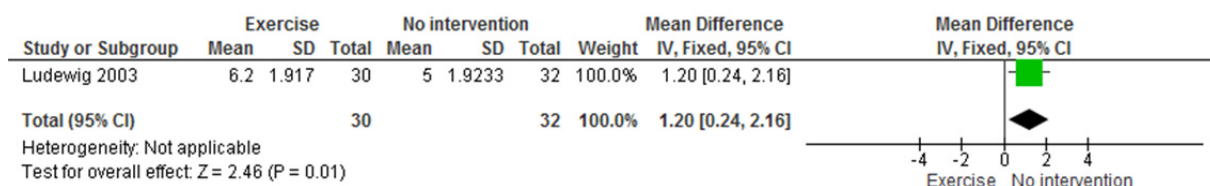


Figure 3-12: Analysis 3.1 - Forest plot of comparison 3: Exercise versus scapular mobilization, outcome: 3.1 Pain at rest.

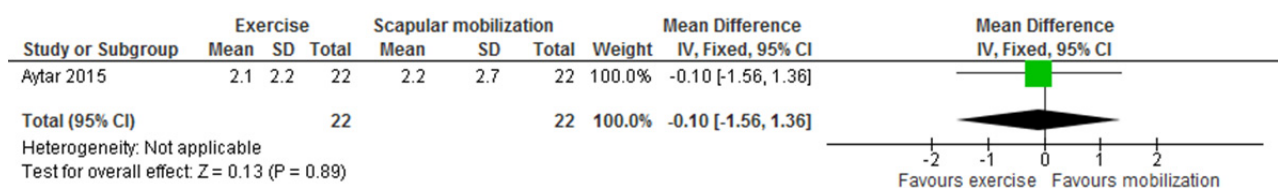


Figure 3-13: Analysis 3.2 - Forest plot of comparison 3: Exercise versus scapular mobilization, outcome: 3.2 Pain with activity 0–10 cm VAS scale.

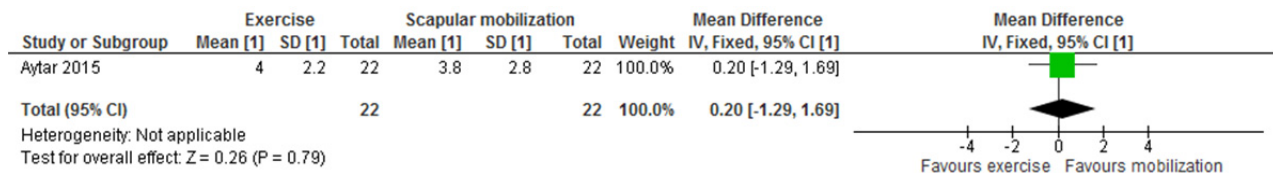


Figure 3-14: Analysis 3.3 - Forest plot of comparison 3: Exercise versus scapular mobilization, outcome: 3.3 Shoulder ROM with universal goniometer].

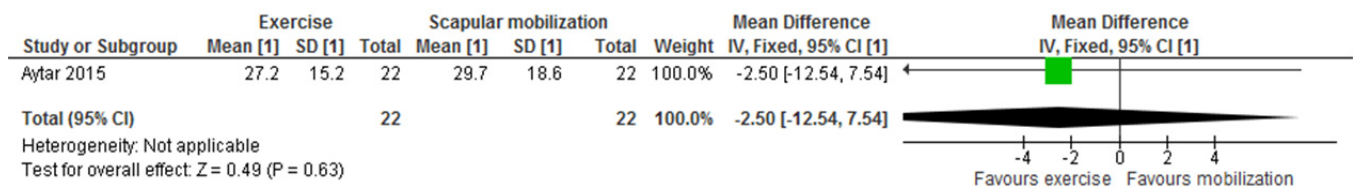


Figure 3-15: Analysis 3.4 - Forest plot of comparison 3: Exercise versus scapular mobilization, outcome: 3.4 Shoulder function - Quick DASH 11 item.

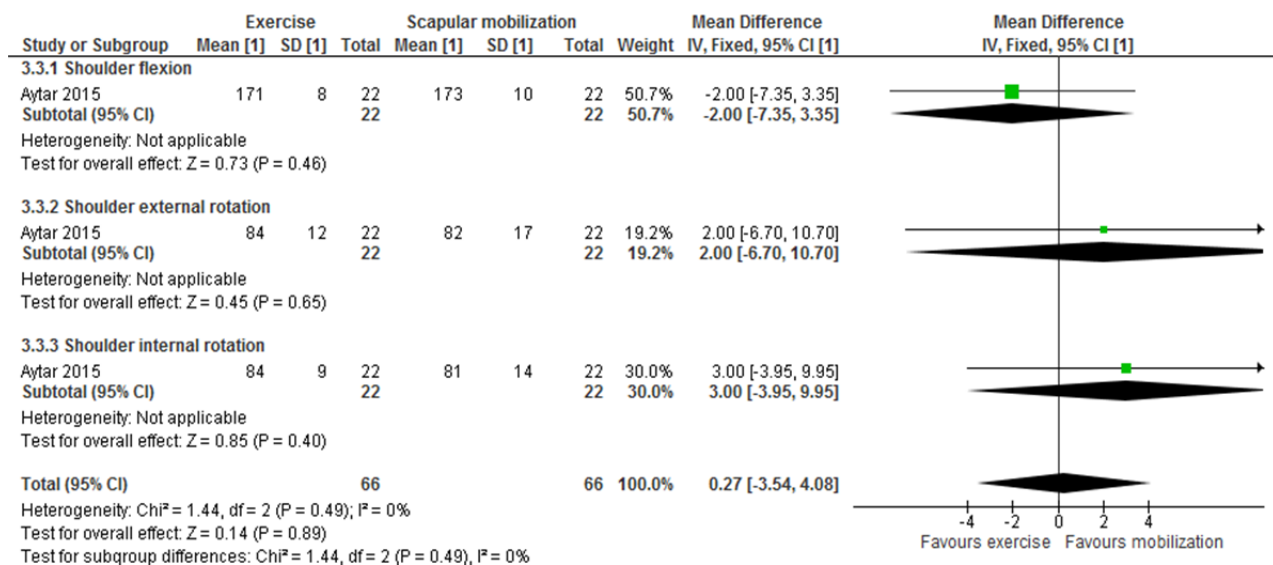


Figure 3-16: Analysis 4.1 - Forest plot of comparison 4: Home exercise versus supervised exercise, outcome: 4.1 Average pain in the past week - numerical rating scale.

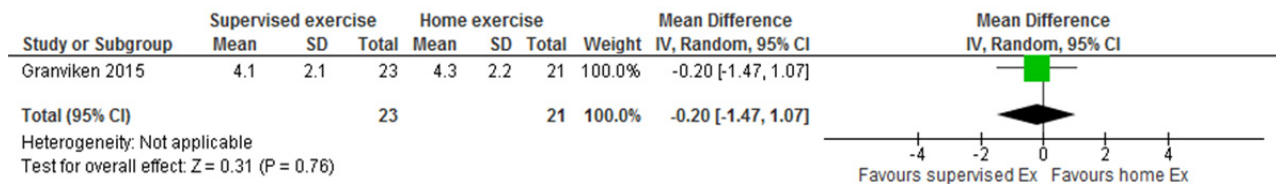
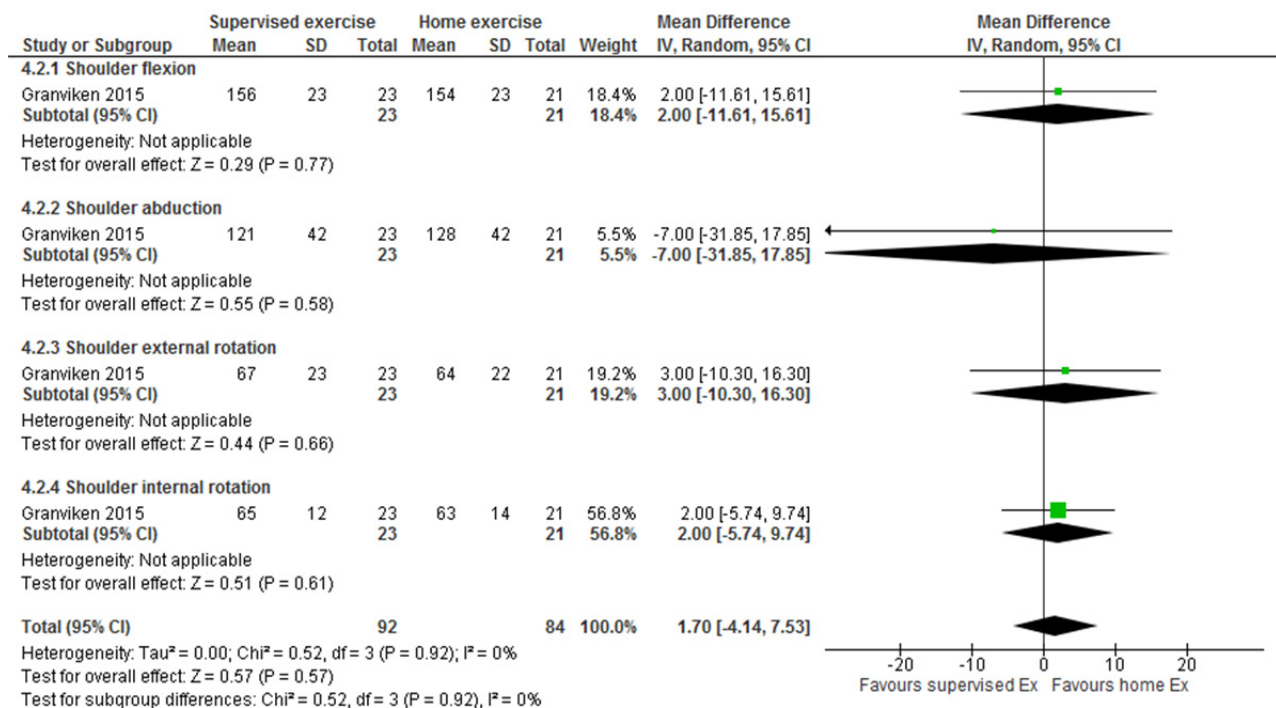


Figure 3-17: Analysis 4.2 - Forest plot of comparison 4: Home exercise versus supervised exercise, outcome: 4.2 Shoulder active ROM - digital inclinometer.



APPENDIX A TO CHAPTER 3

1 Search strategy: search words and phrases included

- 1) "shoulder impingement syndrome" and "rehab*"
- 2) "shoulder impingement syndrome" and "exercise"
- 3) "shoulder impingement syndrome" and "exercise modalities"
- 4) "shoulder impingement syndrome" and "treatment modalities"
- 5) "shoulder impingement syndrome" and "conservative treatment"
- 6) "shoulder impingement syndrome" and "exercise intervention"

- 7) "shoulder impingement syndrome" and "shoulder rehab*"
- 8) "shoulder impingement syndrome" and "exercise therapy"
- 9) "shoulder impingement syndrome" and "physical therapy"
- 10) "shoulder impingement syndrome" and "home-based exercise"
- 11) "shoulder impingement syndrome" and "home-based rehab*"
- 12) "shoulder impingement syndrome" and "supervised exercise"
- 13) "shoulder impingement syndrome" and "supervised rehab*"
- 14) "subacromial impingement" and "rehab*"
- 15) "subacromial impingement" and "exercise"
- 16) "subacromial impingement" and "exercise modalities"
- 17) "subacromial impingement" and "treatment modalities"
- 18) "subacromial impingement" and "conservative treatment"
- 19) "subacromial impingement" and "exercise intervention"
- 20) "subacromial impingement" and "shoulder rehab*"
- 21) "subacromial impingement" and "exercise therapy"
- 22) "subacromial impingement" and "physical therapy"
- 23) "subacromial impingement" and "home-based exercise"
- 24) "subacromial impingement" and "home-based rehab*"
- 25) "subacromial impingement" and "supervised exercise"
- 26) "subacromial impingement" and "supervised rehab*"
- 27) "internal impingement" and "rehab*"
- 28) "internal impingement" and "exercise"
- 29) "internal impingement" and "treatment modalities"
- 30) "internal impingement" and "exercise modalities"
- 31) "internal impingement" and "conservative treatment"
- 32) "internal impingement" and "exercise intervention"
- 33) "internal impingement" and "shoulder rehab*"
- 34) "internal impingement" and "exercise therapy"
- 35) "internal impingement" and "physical therapy"
- 36) "internal impingement" and "home-based exercise"
- 37) "internal impingement" and "home-based rehab*"
- 38) "internal impingement" and "supervised exercise"
- 39) "internal impingement" and "supervised rehab*"
- 40) "posterior impingement" and "rehab*"

- 41) "posterior impingement" and "exercise"
- 42) "posterior impingement" and "treatment modalities"
- 43) "posterior impingement" and "exercise modalities"
- 44) "posterior impingement" and "conservative treatment"
- 45) "posterior impingement" and "exercise intervention"
- 46) "posterior impingement" and "shoulder rehab*"
- 47) "posterior impingement" and "exercise therapy"
- 48) "posterior impingement" and "physical therapy"
- 49) "posterior impingement" and "home-based exercise"
- 50) "posterior impingement" and "home-based rehab*"
- 51) "posterior impingement" and "supervised exercise"
- 52) "posterior impingement" and "supervised rehab*"

CHAPTER 4

Exercise as conservative treatment modality for shoulder impingement syndrome: evidence-based guidelines

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Synopsis:

This manuscript presents rehabilitation guidelines based on results from a highly rigorous systematic review and meta-analyses of existing literature. The purpose of this guideline is to provide evidence-based exercise rehabilitation as treatment modality for shoulder impingement syndrome to therapists involved in the rehabilitation process. The lack of evidence in all aspects of shoulder rehabilitation necessitated the integration of existing consensus information in the guidelines. This guideline focuses on scapula stabilizing and strengthening, strengthening of weak shoulder muscles and stretching tight structures, the principle of gradual progression and incorporating a proximal-to-distal kinetic chain approach to rehabilitation.

Key words: therapeutic exercise, rehabilitation guidelines, rotator cuff strengthening, painful arc syndrome

INTRODUCTION

The glenohumeral joint relies on both the static and dynamic stabilisers for stability.^{37,27,55} The rotator cuff muscles provide an intricate stabilising force at the joint by centralising and maintaining the humeral head in the glenoid fossa.^{11,21,18} Should the humeral head not be centralized in the glenoid fossa, shoulder pain will eventually present. Shoulder impingement syndrome (SIS) is one of the most prevalent causes of shoulder pain.^{9,42} Shoulder impingement can result from multiple factors such as postural changes or deviations,^{7,23,28} altered shoulder kinematics and muscular imbalance^{31,36,42} and tightness of shoulder structures³¹. These muscular imbalances and altered kinematics may cause the subacromial structures to become sporadically trapped and compressed during shoulder movements.^{5,33} A consequence of structures impinging in the subacromial space, is the presentation of compensation mechanisms that result in altered joint position and movement dysfunction²⁸, pain at rest and during movement^{2,26,28,42} as well as joint and tissue swelling and inflammation²⁶. Long-term dysfunction may result in subsequent loss of function in the shoulder joint.

Haahr and Andersen¹⁶ evaluated the prognosis between four to eight years follow-up of 84 adults with subacromial impingement symptoms lasting for six months to three years. Income transfer, sick leave and disability pension were the main outcomes evaluated in the study. The study indicated that patients who had surgery spent more time off work and reported higher total income transfers during the first year of follow-up than the patients treated conservatively with exercise. It has become very important for patients to evaluate ways to make the most beneficial use of their medical schemes by comparing the outcomes of health care interventions and associated costs. By comparing the costs associated with conservative and surgical treatment, it is clear that conservative treatment such as exercise rehabilitation is a cost-effective means of treating secondary shoulder impingement. In spite of the fact that exercise is considered a relatively cost-effective and conservative modality for treating SIS, evidence-based guidelines for exercise rehabilitation as treatment of SIS are not currently available. Guidelines have been published for treatment of following thermal-assisted capsulorrhaphy⁵⁹, open shoulder stabilisation³ and arthroscopic anterior capsulolabral repair¹⁴. The limited evidence on exercise as rehabilitation modality for treating SIS conservatively⁵⁶ may be the reason for a lack of guidelines published for SIS treatment. Therefore, the focus of this article is to provide clinical guidelines for physical therapists to compile an individualised exercise rehabilitation program for conservatively treating SIS.

AIM OF THE GUIDELINE

Evidence-based guidelines for the conservative treatment of SIS was compiled for the use by exercise therapists/clinical exercise physiologists/physiotherapists/athletic trainers to use while treating patients diagnosed with SIS. This guideline is not intended for labrum pathology, rotator cuff pathology or ruptures, glenohumeral osteoarthritis, rheumatoid arthritis or patients who had undergone surgical procedures. The information contained and presented in this evidence-based guideline is not intended to serve as the standard of medical care for SIS. This document should serve as a guideline and should therefore be used in conjunction with a thorough assessment of the patient such as taking a medical history and conducting a thorough physical examination of the patient. It is not intended to replace the independent judgment for medical advice of a qualified practitioner, clinician or other qualified health care provider. The authors take no responsibility and are also not liable for persons following this guideline or use it inappropriately.

METHODS OF DEVELOPMENT

This guideline was developed from a systematic review presenting evidence on the effectiveness of exercise as conservative treatment modality for SIS. Clinical trials were searched for by conducting a comprehensive literature search on research published from January 1994 to August 2016. The following databases were used: Cochrane Central Register of Controlled Trials (CENTRAL), EBSCO Host (Academic Search premier, CINAHL, Health Source: Nursing/Academic Edition, Medline and Sport Discus), Science Direct, Scopus, PubMed and Web of Science. Reference lists of included trials were also searched to identify additional trials for eligibility. Two independent reviewers critically appraised the titles and abstracts and full text of the literature search to identify possible studies for inclusion. Appraised studies and those where conflict was present between the two reviewers, were resolved and confirmed by a third reviewer. Studies were eligible if they were in English and comprised randomised control trials with exercise as treatment modality for SIS or exercise in combination with other conservative interventions (only if separate results were given for exercise treatment and the other conservative modalities used). Data were analysed using Review Manager (RevMan 5.3) and the outcomes of interest were pain during rest and movement, functional status, shoulder range of motion (ROM) (primary outcomes), quality of life and patient satisfaction (secondary outcomes). Because of insufficient randomised controlled trials using exercise for the rehabilitation of SIS, consensus statements in the peer reviewed published literature were also included to develop these rehabilitation guidelines.

REHABILITATION GUIDELINE PRINCIPLES

The foremost priority in formulating an exercise program is to determine the cause of the patient's discomfort and/or limitation. The physical therapist's evaluation must include patient history^{20,26}, posture screenings²⁰, ROM, shoulder muscle strength^{20,58}, special shoulder tests and measures, and finally functional testing^{20,54} to provide important information on the possible contributing factors of the resulting impingement.

The initial impression of the SINS (severity, irritability, nature and stage) of the condition can be established through a logical and thorough system of sequential questions to obtain a clear description of the associated signs and symptoms and to get more information about the direction of the objective assessment.^{20,54} Optimum upper quarter muscle function is dependent on adequate lower quarter muscle function and spinal posture³⁹ and therefore postural observation of the whole body plays an essential role in posture observation in the presence of shoulder impingement.^{25,39} Deviations in posture can either contribute to injury or result from an injury⁵⁴ and for that reason it is vital to identify deviations from a normal ideal posture in the postural assessment and observation.²⁸ Ludewig et al.³⁵ suggested that an objective assessment of the scapula alone does not provide sufficient information related to the mechanisms of abnormal scapulothoracic kinematics and muscle function of the underlying pathology, and consequently requires a comprehensive kinematic assessment. Range of motion of the shoulder joint should be performed actively and passively and should consist of glenohumeral motion, scapular motion as well as combined movements (for instance Apley's scratch test).⁵⁴ Muscle strength assessment allows the clinician to identify underlying deficiencies to prevent injuries and to determine muscle weakness, dysfunction and performance⁵⁴ by comparing the muscle strength results of the affected side with the unaffected side.⁵ To adequately compile a rehabilitation program a thorough examination is needed to determine which muscles appear tight or overactive and which muscles are lengthened and underactive as a result of altered joint kinematics.³⁹ Lucado³¹ also highlighted the importance of including scapulothoracic muscle strength and length in the examination process.

The next step in the evaluation focuses on the special tests for the shoulder joint to confirm the severity and nature of the suspected shoulder impingement.⁵⁴ According to Park et al.⁵¹ a combination of the Hawkins-Kennedy impingement sign (sensitivity 92%; specificity 25%)⁴⁰, infraspinatus strength test (sensitivity 25%; specificity 68.9%)⁴⁰ and the positive painful arc (sensitivity 32.5; specificity 80.5%)⁴⁰ provide the best diagnostic reliability. The Hawkins-Kennedy test identifies impingement of the supraspinatus tendon between the greater tuberosity of

the humerus and the coracoacromial ligament. The test is considered positive if the patient reports pain when the shoulder is forcefully moved into medial rotation with the arm flexed to 90 degrees^{40,51,54} as indicated in Figure 4-1.

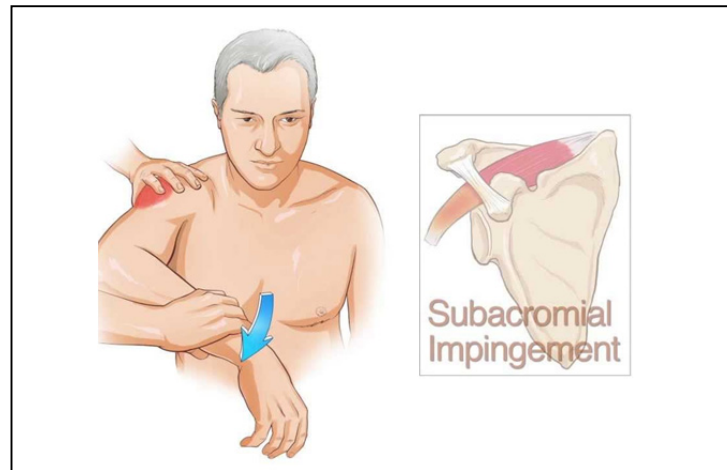


Figure 4-1: The Hawkins-Kennedy test

(Source: <https://i.ytimg.com/vi/hzgQcLuaFLw/maxresdefault.jpg>)

The infraspinatus muscle strength test evaluates rotator cuff integrity and tests for subacromial impingement⁵⁴. The test is performed with the patient's arm in a neutral position with 90 degrees elbow flexion and the physical therapist will apply an internal rotation force that the patient resists (illustrated in Figure 4-2). A positive test occurs when the patient reports pain or is unable to resist the internal rotation force.^{40,51,54}

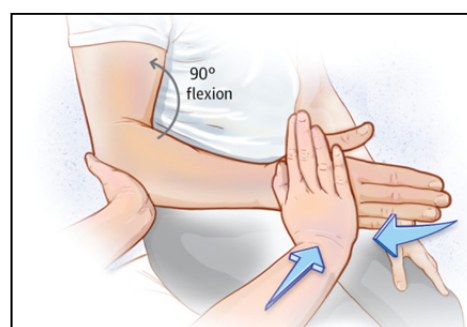


Figure 4-2: The infraspinatus muscle strength test

(Source: http://static.wixstatic.com/media/eeb56a_281a4130c3d54325947c43cef3421a60.png)

The final test in this combined cluster is the painful arc test where the patient actively abducts the shoulder until full abduction is reached and in the same arc of motion brings the arm down (illustrated in Figure 4-3). If the patient reports pain between 60 and 120 degrees of abduction the test is considered positive.⁵⁴

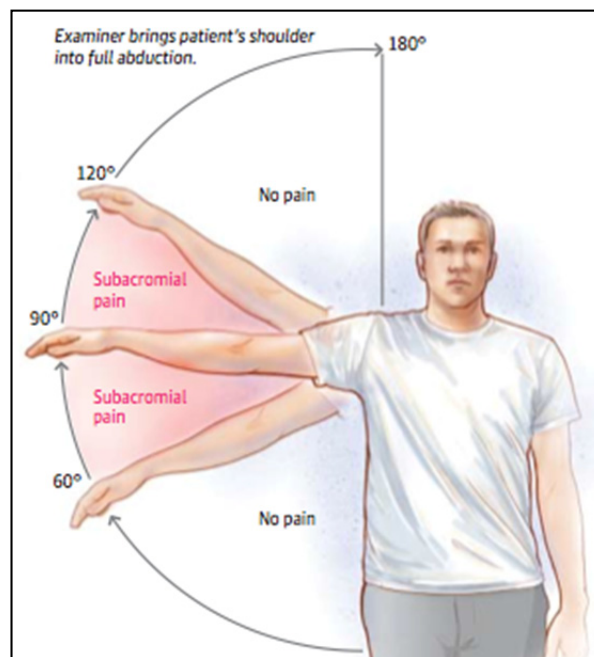


Figure 4-3: The painful arc test.

(Source: <https://jcphysiotherapy.files.wordpress.com/2015/02/screen-shot-2014-05-07-at-2-27-45-pm.png>)

In another study, the empty can test (Jobe test) (sensitivity 62%; specificity 54%)⁴⁰, painful arc and external resistance test (infraspinatus strength test) were found to be the best predictors for shoulder impingement syndrome.⁴⁴ The empty can test is performed with the shoulder abducted to 90 degrees in scapular plane (illustrated in Figure 4-4), while the patient tries to resist a downward force. An inability to resist the downward force indicates a positive result.^{40,54}

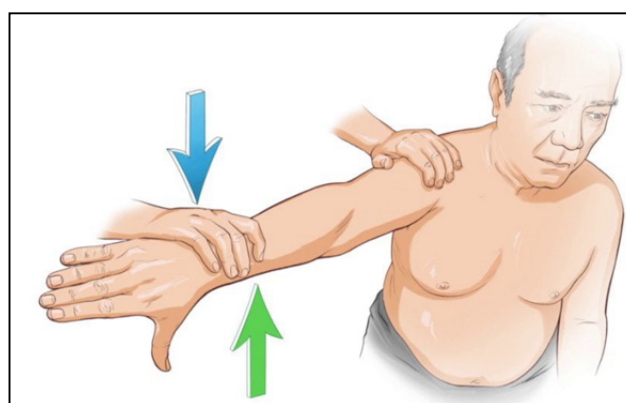


Figure 4-4: The empty can test (Jobe test)

(Source: http://i.vimeocdn.com/video/441881972_1280x720.jpg)

The systematic overview of the clinical evaluations presented is necessary for identifying pathology correctly and to obtain a thorough and more detailed understanding of the SINS

(severity, irritability, nature and stage) of the injury. Once the evaluation process is complete, the clinician will be able to compile a well-designed individualised rehabilitation program according to the information obtained and documented through the systematic procedure.

REHABILITATION GUIDELINES

The major rehabilitation goals for SIS include improving faulty thoracic posture,^{7,10,45} stabilization of the scapula to restore normal scapulohumeral rhythm,^{22,34} improving strength and function of the rotator cuff and scapulothoracic muscles,^{22,46,49,57} establishing normal ROM by stretching tight structures of the anterior and posterior shoulder⁴³ and reducing pain and inflammation^{48,26}.

The initial rehabilitation goal in treating shoulder impingement is correction of faulty posture.^{7,10,45} Postural deviations such as slouched posture has been associated with decreased posterior scapular tilting and upward rotation and increased superior translation of the humerus. These deviations may cause a reduction in glenohumeral movement and an imbalance of the muscle articular systems.^{23,28} It is essential to correct faulty posture and scapular control prior to an aggressive strengthening program to prevent reinforcement of poor shoulder kinematics³⁶. Bullock et al.⁷ evaluated the effect of slouched posture compared to erect sitting posture on two outcomes (shoulder flexion and pain) in 28 subjects with shoulder impingement. They found immediate improvement in upper limb function and reduction in pain with shoulder flexion, following posture correction and re-education. Another investigation by Moezy et al.⁴⁵ demonstrated a decrease in forward head posture (FHP), forward shoulder translation (FST) and mid-thoracic curve in the exercise therapy and physical therapy groups. In this clinical trial, 68 participants between the ages of 18 to 75 years, with unilateral SIS, participated in a six-week program (exercising three times per week, which consisted of flexibility, strengthening, scapular stabilization and postural exercises).⁴⁵

The next goal in the rehabilitation process is scapular stabilisation to improve and restore the normal scapulohumeral rhythm (SHR).^{22,34} Shoulder impingement can be associated with an altered SHR, where the scapula setting phase (first 60 degrees of SHR) is reduced or absent.²⁹ Emphasis should be placed on restoring normal SHR and decreasing scapular dyskinesia, by incorporating scapular stabilisation exercises in the rehabilitation program.² Başkurt et al.² found positive effects on 40 patients with unilateral shoulder impingement in improving scapular muscle strength, joint position sense (JPS) and scapular dyskinesia when scapular stabilisation exercises were added to a strengthening and stretching program. Scapular stabilisation exercises lessen the

scapular dyskinesis by synchronizing scapulothoracic motion with glenohumeral motion²² and improving the controlling and stabilising ability of the scapula.²

A third goal in the rehabilitation process is to restore flexibility and ROM of tight structures such as posterior shoulder tightness^{31,47} and the pectoralis minor^{31,35,38}. Tightness in these structures can alter scapular kinematics by causing excessive anterior tilting of the scapula resulting in excessive compression of the structures in the subacromial space.^{31,35} Myers et al.⁴⁷ investigated posterior shoulder tightness as well as bilateral external and internal humeral rotation in 22 male competitive baseball players, 11 with internal impingement and 11 control throwers. The results obtained from the study indicated that throwers with internal impingement have significantly increased posterior shoulder tightness and glenohumeral internal rotation deficit (GIRD) compared to normal throwers. Research done by Lukasiewicz et al.³⁸ compared three-dimensional scapular position and orientation during rest, elevation to horizontal and maximal elevation between 20 non-impaired subjects and 17 patients with SIS. They reported a lack of posterior tilting and excessive superior translation in subjects with impingement compared to the non-impaired subjects. Ludewig and Cook³⁵ suggested that the lack of posterior tipping can be caused as a result of excess active or passive tension in the pectoralis minor. Incorporating stretching and flexibility exercises in the rehabilitation program will therefore restore the balance of the scapular stabilisers and mobilisers.³¹

The final goal is to strengthen the weak rotator cuff and scapulothoracic muscles and improve static and dynamic function of the upper extremity.^{48,49,57} Adequate strength between the agonist/antagonist muscle groups can decrease impingement by improving the stabilising ability of the scapula², providing dynamic stabilisation^{52,58}, increasing the subacromial space by depressing the humeral head and preventing excessive humeral superior translation during functional activities^{2,10,22} resulting in a decrease in pain and inflammation^{2,46}.

In conjunction with the limited number of good quality trials to support the use of exercise for treating SIS conservatively, the type of interventions reported vary considerably with regards to the rehabilitation programs.^{12,13,30,32} In a study by Ludewig and Borstad³² on 67 male construction workers with shoulder pain, the effect of an eight week home exercise program consisted of two stretches (pectoralis minor and posterior shoulder stretch) and a progressive resistance strengthening program for two muscle groups (serratus anterior and humeral external rotators). The construction workers performed the stretches every day and the strengthening program was

performed three times a week. The findings demonstrated that the construction workers showed significant improvements for shoulder function and reducing symptoms of SIS. A study by Lombardi et al.³⁰ investigated the effect of a progressive resistance training program twice a week for two months, which involved sixty patients with SIS. The program elicited improvements in function in favor of the patients that underwent progressive resistance training. The effect of a 12-week supervised exercise program, of two 45 minute sessions per week, was studied by Engebretsen et al.¹² in 52 patients with subacromial shoulder pain compared to shockwave treatment. Compared with the radial extracorporeal shockwave treatment, the supervised exercise group demonstrated improved results regarding shoulder pain and disability index and work status. After a 1-year follow-up the findings demonstrated that the benefit of supervised exercise was not maintained, however, more patients in the supervised exercise group returned to work and they required less additional treatment.¹³

These high-quality trials display evidence to support the use of exercise to successfully treat SIS, but it is still unclear which muscles to target, the duration of the intervention, intensity, frequency and the mode of exercise to use in the program prescription.¹⁷ The exercise programming components and the recommended FITT (frequency, intensity, time and type) principles adapted by the few trials that used exercise therapy as treatment modality are summarised in Table 4-1 and Table 4-2 respectively. Most of the reviewed trials proposed strengthening and stretching exercises in the rehabilitation programs. All the authors subjected their patients to gradual progression in strength training by increasing the weights or tension of the resistance bands.¹ In another study the progression was negotiated by increasing the total repetitions by five weekly.³² One group suggested that improvement in pain may have occurred due to strengthening of the rotator cuff muscles which resulted in improved joint stability.³⁰ Various forms of strengthening exercises were employed but the most important exercises included strengthening of the serratus anterior, external rotators, internal rotator as well as flexion and extension exercises.

Among these reviewed articles it seems important to stretch the posterior capsule, pectoralis minor, external rotators, shoulder flexors and shoulder abductors^{1,32} or to use manual techniques to loosen tight muscles^{12,13}. It seems important to stretch the tight structures, as it is thought that a tight pectoralis minor and/or posterior glenohumeral capsule leads to decreased posterior tilting (which results in impingement)^{31,38,47}.

Table 4-1: Summary of exercise programming components of the six reviewed articles

	Stretching	Strengthening	Home Program	Supervision
Aytar et al. ¹	Participants performed the following stretches; posterior capsule, external rotation, flexion and abduction stretch and the pectoral stretch	Serratus anterior, external rotation and inferior glide	-	Supervision of PT
Engebretsen et al. ¹²	Manual techniques to loosen tight muscles	Once normalized, endurance exercises were performed. Principles of closed and open kinetic chain and plyometric exercises were incorporated in the next phase of training.	Daily correction of alignment and low loaded exercises with elastic cord (thin).	Feedback and correction by physiotherapist
Engebretsen et al. ¹³	Manual techniques to loosen tight muscles	Exercises with manual resistance for open scapular muscles. Once normalized, endurance exercises were performed. Principles of closed and open kinetic chain and plyometric exercises were incorporated in the next phase of training	Daily activities: correction of alignment. Low loaded exercises with elastic cord (thin).	Feedback and correction by physiotherapist
Lombardi et al. ³⁰	-	Progressive resistance training: Flexion, extension, medial rotation and lateral rotation of the shoulder	-	-
Ludewig & Borstad ³²	Pectoralis minor, posterior shoulder. Muscle relaxation exercise for upper trapezius	Two muscle groups. Progressive resistance: serratus anterior and humeral external rotation	Entire program was a home program	-
Granviken & Vasseljen ¹⁵	Stretching exercises for tight structures Pain free ROM exercises	Training of correct scapular placement, scapular stabilizing, rotator cuff	Home exercise group (HE) and supervised exercise (SE)group were given home exercises	SE group = 10 supervised sessions HE group = 1 supervised session

Table 4-2: Summary of the FITT principles of the six reviewed articles

	Frequency	Intensity	Session duration	Intervention duration	Progression
Aytar et al. ¹	3 times a week (in total 9 sessions)	Thera-Band and weights (the progression was determined the participants performing 10 repetitions of exercises - without fatigue or pain)	-	3 weeks	Thera-Band or weights was progressed weekly.
Engebretsen et al. ¹²	Twice a week	Gradually increasing resistance	45 minutes per session	12 weeks	Increased the resistance gradually
Engebretsen et al. ¹³	Twice a week	Gradually increasing resistance	45 minutes per session	12 weeks	
Lombardi et al. ³⁰	2 x week	First series: 50% of the 6RM Second series: 70% of the 6RM (within patient's pain threshold) Two minute rest. Speed: Two seconds for eccentric and concentric movement. Multi-pulley muscle-building system	-	8 weeks	6 RM load was reevaluated every 2 weeks
Ludewig & Borstad ³²	3 x a week	Thera-Band	-	8-12 weeks	Initial position of the arm close to the side – to abduction of the arm Week 1: 3 x 10 Week 2: 3 x 15 Week 3: 3 x 20 After achieving 3 sets of 20 repetitions for 3 successive sessions – progress was increased by weight resistance or thera-band tension (Shortening the band)
Granviken & Vasseljen ¹⁵	Twice a day, everyday	Three sets of 30 repetitions – 4-6 exercises Thera-band (tool to reduce arm load/control movement/provide resistance)	-	6 weeks	Exercises were individually adapted Progression opportunities for the appropriate exercises

The following general indications and suggestions can be given to help prescribe an exercise rehabilitation program for SIS based on consensus presented in the literature:

1. Various researchers have suggested implementing the kinetic chain approach, which follows a proximal-to-distal pathway^{25,41,53}. This approach emphasises integrated sequencing of the lower extremities such as the hip and trunk to facilitate scapular motion⁵³. Altered kinematics in the lower extremity should be addressed early in the physical therapy program to ensure successful rehabilitation outcomes.
2. A gradual and sequential progressive plan should be implemented, in a multiphase approach, to gradually increase the stresses applied to the glenohumeral joint⁵².
3. All the contributing factors should be considered when planning the intervention program to help restore and improve the specific movement deviations³³.

Table 4-3 summarises the key points of the exercise guidelines for SIS addressed in this section.

Table 4-3: Exercise guidelines for SIS: Summary of key points.

Rehabilitation goals	<ul style="list-style-type: none"> • Reducing pain. • Correction of faulty and abnormal posture. • Improving normal scapulohumeral rhythm with scapular stabilization. • Restoring flexibility and full ROM of the shoulder joint. • Improving muscle imbalance by strengthening weak scapulothoracic and glenohumeral muscles. • Returning to daily activities, work and recreational activities.
Suggested patient education	<ul style="list-style-type: none"> • Postural re-education: <ul style="list-style-type: none"> ○ Correction of postural alignment with daily activities. ○ Adoption of an erect posture during daily activities. ○ Training of correct scapular placement.
Suggested therapeutic stretching	<ul style="list-style-type: none"> • Stretching of tight structures: <ul style="list-style-type: none"> ○ Posterior capsule/shoulder. ○ Pectoralis minor. ○ External rotators. ○ Flexion stretch. ○ Abduction stretch.
Suggested therapeutic strengthening	<ul style="list-style-type: none"> • Strengthening of the weak muscles: <ul style="list-style-type: none"> ○ Serratus anterior. ○ Lateral or external rotators. ○ Medial or internal rotators. ○ Flexion. ○ Extension.
Suggested frequency	<ul style="list-style-type: none"> • At least two to three times per week.

Suggested intensity	<ul style="list-style-type: none">• Intensity should be within the patient's pain threshold:• Suggested intensity:<ul style="list-style-type: none">○ 50% of 6 RM (repetition maximum) – first phase• Gradually increase intensity after re-evaluation.
Suggested progression criteria	<ul style="list-style-type: none">• Either by gradually increasing the repetitions or resistance.• How to increase repetitions:<ul style="list-style-type: none">○ Not more than five repetitions per week.• How to increase resistance:<ul style="list-style-type: none">○ Start with manual resistance.○ Thin elastic cord/thera-band.○ Increasing thera-band tension (shortening the band).○ Weights according to patient's ability and progress.
Intervention duration	<ul style="list-style-type: none">• Until the patient is able to:<ul style="list-style-type: none">○ Return to full daily activities.○ Work.○ Participate in recreational activities.• Without:<ul style="list-style-type: none">○ Pain.○ Discomfort.○ Limitation.

CONCLUSION

In general, functional or secondary impingement requires the implementation of a well-designed exercise program, whereas surgical intervention may be beneficial for patients with structural or primary impingement^{20,50}. Surgery for secondary impingement should be considered when an exercise regimen fails to alleviate pain and improve functionality during daily activities^{4,19,60}. The precise interventions that are used in current literature vary considerably in the type, intensity, frequency and duration. There is a need for more, well-designed research to give clarification on the type, duration, frequency, intensity and follow-up time for comprehensive conservative treatment for SIS. In addition the effect of home-based or supervised rehabilitation should be clarified, as well as the most important markers for determining an effective rehabilitation program.

Physical rehabilitation remains a cornerstone for treating SIS conservatively and therefore results obtained from high quality randomized controlled trials will assist in the update of rehabilitation guidelines for the treatment of persons with SIS.

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CHAPTER 5

Summary, conclusions, limitations and recommendations

5.1 SUMMARY

The shoulder joint, considered the most complex joint in the human body, also allows for a tremendous range of motion. This combination of complexity and large range of motion increase the need for stability in the joint to prevent and manage injuries. Exercise has been applied as a modality to achieve prevention and treatment/rehabilitation of shoulder injuries. This chapter summarises the most important findings from this study and will draw conclusions from the results obtained. It is, however, important to recognise that there were limitations against which the findings have to be interpreted. This chapter will also present these limitations and proposed recommendations for future investigations.

Exercise in the published literature exists on the outcomes of exercise rehabilitation for shoulder pain. In order to treat based on evidence, the effect of exercise in isolation needs to be determined and not in combination with other conservative modalities. Consensus is needed on the intensity, frequency, duration and progression of the exercise intervention. Answers to these questions will help and guide the therapist/clinical exercise physiologist/physiotherapist/athletic trainer to compile the best evidence-based rehabilitation program to successfully treat patients presenting with SIS. Therefore, the aim of this study was twofold – firstly to determine whether conclusive evidence for home-based or supervised exercise as conservative treatment modality for SIS exists, by investigating and identifying existing evidence in literature by means of a thorough systematic review. The second aim of the study was to determine consistencies in the type, duration, frequency and intensity of rehabilitation exercises that can serve as guidelines for rehabilitation of SIS, by summarising all empirical evidence included in the systematic review. The problem statement, aim/objectives, hypotheses and the structure of the dissertation were presented in Chapter 1.

In a review of the current literature in Chapter 2, titled: "Mechanics and treatment of shoulder impingement syndrome" the unique anatomy of the shoulder joint, the etiology,

causes and diagnosis of SIS and the treatment approaches available in literature were presented. From the literature review it was evident that the extensive mobility of the shoulder joint is at the expense of stability. Therefore the joint relies on the integrated stabilising mechanisms of the rotator cuff muscles surrounding the shoulder, the glenoid labrum and the ligaments for stabilisation. Efficiency of shoulder movement results in the coordinated movement of the four shoulder joints (GH, AC, SC and ST joints) through synchronised dynamic stability of the rotator cuff muscles and force couples (scapulothoracic force couples and the force couples between the deltoid and rotator cuff muscles). This efficient and properly coordinated glenohumeral and scapulothoracic movement plays a vital role in maintaining posture, controlling movements and holding the humeral head in the glenoid cavity of the scapula. Imbalance or deviations of the muscles can lead to abnormal stress on the shoulder joint and the scapulothoracic muscle's dynamic instability, loss of proprioception and kinaesthetic control and can ultimately result in progressive injury if this cycle continues.

Shoulder impingement syndrome (SIS) is a very common cause of shoulder pain or pathology among both general and athletic populations as a result of their occupation (repetitive overhead activity or incorrect sitting posture) and athletic activity (eccentric muscle overload). Individuals with SIS present with pain during rest or activity over the lateral superior anterior shoulder (that aggravates with overhead activities), inflammation as well as weakness of the shoulder muscles. Encroachment of the subacromial structures can be caused by numerous factors or a combination of these factors: postural deviations, muscle weakness or fatigue that lead to altered glenohumeral and scapular kinematics and posterior capsule and/or pectoralis minor tightness.

Diagnosis of impingement starts with a comprehensive medical history, postural observations, shoulder ROM measurements, manual muscle strength tests, special tests and functional tests. The following special tests are indicated as the best predictors for SIS and should be performed during the clinical examination: painful arc, Neer impingement, empty can, Hawkins-Kennedy, cross body adduction, Speed's test, infraspinatus strength test and the scapular assisted test. To rule out pathology or when clinical findings are unclear, other comprehensive clinical tests such as X-rays, ultra-sound, MRI and arthroscopy can be performed to confirm findings or obtain a clear diagnosis.

When exploring the literature regarding different treatment approaches it is evident that SIS can be treated conservatively or surgically. The goal of operative management such as arthroscopic decompression is to create more space for the subacromial structures to pass through the subacromial space. General consensus in literature is that operative management should only be considered if a three to six month conservative approach fails to improve symptoms or if other etiologies are present. Literature findings further indicated that there are a few conservative treatment approaches that can be used to relieve pain and inflammation. These strategies include increasing the scapulothoracic and rotator cuff muscle strength, re-establishing ROM and improving deviations in thoracic posture. These conservative treatment approaches include cryotherapy, ultrasound, manual therapy, TENS, corticosteroid injection, acupuncture, kinesiotaping and exercise therapy. In several outcome studies reviewing the results of exercise in the management of SIS, exercise seems to be effective but the most effective mode, frequency, duration, intensity and progression of exercise interventions are still unclear. As a result of these gaps in literature with regard to exercise as treatment modality for SIS, a systematic review was conducted.

Chapter 3 presents the systematic review of existing literature to address and answer the defined research questions concerning the effectiveness of home-based or supervised exercise for treating SIS. The chapter was compiled as an article entitled: "Exercise as treatment modality for SIS: a systematic review" and prepared in accordance with the requirements of the *Cochrane Database of Systematic Reviews (CDSR)* journal. The aims of the review was to provide a complete, extensive summary of evidence available to determine the effectiveness of exercise therapy for SIS by examining the following outcomes of interest: pain at rest and during movement, shoulder ROM, functional status, quality of life and the degree of patient satisfaction. Only six studies (475 participants with SIS) met the inclusion criteria and were included in the review.

Exercise was compared with extracorporeal shockwave therapy in two studies (where one study was a longer follow up period), no intervention, scapular mobilization and finally supervised exercise was compared with home exercise. The benefits of supervised exercise over extracorporeal shockwave therapy on pain during rest and during movement were maintained at long term follow up (one year). Improvements in function, however, were not maintained and also demonstrated not to be statistically significant. In two studies, results showed significant positive improvements in pain at rest, pain with movement, function and patient satisfaction in participants who received a home exercise program

consisting of five shoulder stretching and strengthening exercises and progressive resistance training, over no intervention. These results therefore may suggest that exercise can be an effective treatment approach for treating SIS. All the remaining outcomes and studies showed no statistically significant improvement in favour of exercise. From the results obtained with the systematic review we can summarise that data tend to show more positive results for using exercise as treatment modality than extracorporeal shockwave therapy, no intervention and scapular mobilisation. However, the evidence is not conclusive and statistically significant enough to give a clear direction. The available evidence in literature to determine the effectiveness for the use of exercise rehabilitation to treat SIS is sparse, and should therefore serve as a guide for future research opportunities.

Chapter 4, presenting the guidelines for treatment of SIS, was prepared in article format according to the guidelines for the *Journal of Orthopaedic and Sports Therapy* and provides evidence-based exercise guidelines for treating SIS, as indicated by the sparse evidence from the systematic review. The purpose of this article was to compile consensus rehabilitation guidelines to facilitate clinicians in the rehabilitation process. Through the systematic review conducted in Chapter 3, it is evident that there is a lack in high quality trials for exercise therapy in available literature and current evidence fails to provide sufficient and thorough description of the exercise treatment interventions used, in order to draw any conclusions regarding the FITT principle.

The guidelines proposed (Chapter 4) mainly represent key points on SIS rehabilitation according to available evidence. The review articles suggest that patient education consisting of postural re-education (correct posture during daily activities) plays an integral role in the first phase of rehabilitation. Most authors suggested strengthening of the weak muscles (serratus anterior, internal and external rotators, flexors and extensors) and stretching of the tight shoulder structures (posterior capsule, pectoralis minor, abductors, external rotators and flexors). These exercises and stretches should be performed at least two to three times per week and the intensity should be determined according to the patient's pain threshold. As muscles adapt to these exercises, progression can be performed in several ways according to the patient's ability and progress; gradually increasing resistance (manual resistance, thin thera-band, increasing thera-band tension and weights) or gradually increasing the repetitions. The intervention duration should last until the patients are able to return to full daily activities, work or recreational activities without pain, discomfort or limitation.

5.2 CONCLUSIONS

The conclusions drawn for this study, is based on the hypothesis and objectives presented in Chapter 1:

"There is conclusive evidence for home-based or supervised exercise as conservative treatment modality for shoulder impingement syndrome."

Study results showed little or no difference favouring exercise therapy over extracorporeal shockwave therapy with the following outcomes: pain at rest (MD -0.45, 95% CI -0.97 to 0.07; $p=0.17$), pain during activity (MD -0.30, 95% CI -0.95 to 0.34; $p=0.35$) and function (MD -0.05, 95% CI -0.74 to 0.63; $P=0.88$).

Compared to no intervention, the exercise group showed statistically significant reduction in pain at rest (MD -1.90, 95% CI -3.36 to -0.44; $p=0.01$) and pain at movement or work related pain (SMD -0.81, 95% CI -1.18 to -0.44; $p<0.0001$). The exercise group also demonstrated statistically significant improvement in function among participants in the exercise group (SMD -0.60, 95% CI -0.89 to -0.30; $p<0.0001$). The results also indicated little or no difference observed between the exercise therapy and no intervention for overall shoulder ROM measurements (flexion, abduction, medial rotation with the arm at 90°, lateral rotation with the arm at 90° and lateral rotation with the arm alongside the body) (MD 6.90, 95% CI 2.39 to 11.42; $p=0.003$). The results showed a positive effect for patient satisfaction in the exercise therapy group (MD 1.20, 95% CI 0.24 to 2.16; $p=0.01$).

Pain at rest (MD -0.10, 95% CI -1.56 to 1.36; $p=0.89$) and pain with activity (MD 0.20, 95% CI -1.29 to 1.69; $p=0.79$), demonstrated little or no difference between the supervised exercise and scapular mobilization group. Shoulder ROM (shoulder flexion, shoulder external rotation and shoulder internal rotation) (MD 0.27, 95% CI -3.54 to 4.08; $p=0.89$) and function (MD -2.50, 95% CI -12.54 to 7.54; $p=63$), the results were inconclusive and therefore we are not able to draw any conclusion.

Average pain in the past week (MD -0.20, 95% CI -1.47 to 1.07; $p=0.76$) and active shoulder ROM (shoulder flexion, shoulder abduction, shoulder external rotation and shoulder internal rotation) (MD 1.70, 95% CI -4.14 to 7.53; $p=0.57$), demonstrated no statistically significant difference between supervised exercise and participants in the home exercise group.

This hypothesis is therefore rejected due to the fact that the evidence for home-based or supervised exercise as treatment modality for SIS is inconclusive and sparse at present time. The evidence available regarding the effectiveness of exercise (home-based or supervised) by means of a systematic review has been clearly captured and explained from the data extraction. All the data collected in the study from the six included studies were taken into consideration with regard to this aim/objective and it can be concluded that the differences between the exercise groups and control groups were too small to draw any conclusion, even though the data tend to show more positive results for exercise. More research is needed to verify and validate the findings of this study and to determine the effectiveness of exercise.

To achieve the second objective: *"To determine consistencies in the type, duration, frequency and intensity of rehabilitation exercises that can serve as guidelines for rehabilitation of shoulder impingement syndrome"* no statistical analyses were conducted, therefore no hypothesis was set for this objective.

Evidence obtained from the systematic review consisting of well-defined, good quality randomised controlled trials, formed the basis for this objective. There are many aspects and components in an exercise rehabilitation program (such as the type, intensity, frequency, duration and progression) that should be addressed in an effective rehabilitation approach for SIS. Since the systematic review indicated a lack of good quality randomised controlled trials as well as inconsistency in available evidence regarding the FITT principles, guidelines for therapists/clinical exercise physiologists/physiotherapists/athletic trainers were compiled in accordance with the current evidence-based exercise rehabilitation information available and consensus statements published. It can be concluded that the current guidelines proposed for conservative treatment of SIS are based on the limited evidence available and should be updated when more proper, high quality randomised controlled trails are available.

The results obtained in this investigation show moderate evidence for exercise in reducing pain at rest and pain during movement in patients presenting with SIS. Reasons for the reduction in pain may be as a result of postural re-education and strengthening exercises performed in the interventions. Multiple types of strengthening exercises were employed, but most of the reviewed studies targeted the serratus anterior, lateral or external rotators, medial or internal rotators, flexors and extensors. Strengthening these muscles was thought

to be effective in reducing pain by stabilising the scapula, centering the humeral head and preventing extreme superior translation and ultimately restoring normal scapulohumeral rhythm. By centering the humeral head and preventing excessive superior migration of the humerus, the space between the acromion and rotator cuff (subacromial space) increases and can therefore reduce impingement of the subacromial structures. Exercise also produced positive evidence for improving function in persons with SIS. These results may suggest that pain has an influence on functional status in patients with SIS. By reducing pain at rest and pain during movement, pain-related functional limitation can be reduced and therefore increasing and improving patients' functional status during daily activities. The evidence for shoulder ROM, however, is limited and inconclusive. Shoulder ROM exercises mostly targeted the posterior capsule/shoulder, pectoralis minor, external rotators, flexors, extensors and abductors. The lack of improvement in shoulder ROM could be due to the compensation patterns noticeable in patients suffering from SIS. These compensation patterns can be present until the patient is completely pain-free and normal neuromuscular facilitation is restored allowing muscles to become more efficient in their movements. We can speculate that shoulder ROM may require longer intervention periods to demonstrate significant improvements. Current evidence on the use of exercise modalities for SIS on the type, duration, frequency and intensity of exercise has shown that exercise as conservative treatment modality for SIS is effective to some degree, because most of the studies reported improvements in outcomes after completion of the various exercises intervention programs. This should only be tentatively accepted as a result of the methodological flaws regarding the type, duration, frequency and intensity of exercise, lack of good quality trials and the short intervention periods and follow-up periods.

Most of these studies failed to provide sufficient and detailed descriptions of the interventions followed and therefore also reduces the confidence in the results obtained. Firstly, vague description and poorly defined FITT protocols make evaluation of the true effects of specific exercises challenging and almost impossible to replicate. Secondly, the lack of specificity and variety in interventions hamper interpretation of which type, intensity, frequency, duration, and progression may be superior to another to gain optimum strength, shoulder ROM and return to normal function. These flaws also limit the therapist/clinical exercise physiologist/physiotherapist/athletic trainer to extract the specific FITT parameters and therefore the author was only able to synthesise a guideline according to current available evidence and existing consensus statements.

Longer follow-up evaluation periods that are more relevant to clinical practice should be considered for future trials. This can provide the therapist/clinical exercise physiologist/physiotherapist/athletic trainer with more information on the long-term outcomes, benefits and recurrence rate for using exercise as treatment modality. Exercise interventions lasted between three and 12 weeks which can be considered as a short period relative to clinical practice. Interventions should replicate clinical practice and should therefore consist of the four rehabilitation stages. This will provide adequate information regarding the optimal intervention duration to further enhance and prolong the positive effect of exercise treatment and reduce recurrent impingement symptoms.

This comprehensive review raises a number of considerations for future research about the value of exercise as conservative treatment but is more useful to direct future studies than in helping us to compile conclusive evidence-based guidelines to manage our patients.

5.3 LIMITATIONS AND RECOMMENDATIONS

The findings of this study should be interpreted against the background of some limitations that could be identified:

- (a) A limitation of this study was the fact that although various search engines were used, no South African databases were consulted. This could be considered a limitation, as relevant high quality South African trials may have been missed. Consequently, researchers should include South African databases to ensure that an extensive and rigorous search strategy is implemented to identify all available evidence.
- (b) The current study limited the literature search to the English language, because funding for translation services was sparse. This could be considered as a limitation, as potentially good quality non-English studies were excluded, which might have strengthened the recommendations. Future trials should aim to include studies in all languages to limit the potential of excluding good quality trials in other languages.
- (c) Only electronic databases were used in the search strategy. This can be seen as a limitation, as relevant data may have been missed. To ensure that a comprehensive search is conducted, it is suggested that future trials should include multiple sources, such as grey literature to get more published and relevant studies.

5.4 FUTURE RESEARCH

- (a) Different interventions were identified through the reviewed trials, but the intervention duration and follow up period of these trials are relatively short in terms of clinical practice. We suggest that future research should focus on longer intervention duration and a long-term follow up period to be able to examine whether specific exercise therapy is of benefit in both the short and long term for SIS treatment.
- (b) Research is available on exercise for treating SIS, but the intervention regarding the frequency, intensity, duration and type of exercise is not sufficiently described to draw any conclusion or use as a guide to facilitate clinicians. Future research should therefore aim to thoroughly describe future exercise intervention according to the FITT principle.

Appendix A: Contributions to The Cochrane Collaboration

Contributions to The Cochrane Collaboration by means of Review Manager

Review Manager 5 (RevMan 5) is the software used for preparing and maintaining Cochrane Reviews.

RevMan 5 can be used for protocols and full reviews. It is most useful when the question for the review has been formulated, and it allows for text preparation, building the tables showing the characteristics of studies and the comparisons in the review, and addition of study data. It can perform meta-analyses and present the results graphically.



<http://tech.cochrane.org/revman/download>

Appendix B: JOSPT Information for authors

INFORMATION FOR AUTHORS

The *Journal of Orthopaedic & Sports Physical Therapy*[®] (*JOSPT*[®]) publishes scientifically rigorous, clinically relevant content in print and online for physical therapists and others in the health care community to advance musculoskeletal and sports-related rehabilitation practice globally.

JOSPT accepts manuscripts for review from any discipline that addresses orthopaedic or sports physical therapy from any relevant perspective, including clinical practice and outcomes, kinesiology, motor behavior, fitness, gerontology, neuroscience, or epidemiology. While clinical implications should be discussed in all manuscripts submitted for review, *JOSPT* recognizes the importance of all research types in advancing musculoskeletal and sports-related practice and so publishes research spanning the entire spectrum of clinical, basic, and translational science.

MANUSCRIPT REVIEW TIME

JOSPT makes every effort to provide a rapid and efficient review process. In 2014, new manuscript submissions were reviewed in 79 days on average, and revised and resubmitted manuscripts were reviewed in an average of 40 days.

Submitted work (randomized controlled trials, systematic literature reviews, and mechanistic studies) that is considered by the editor-in-chief to be of exceptionally high significance to the literature will be fast-tracked, with an effort to complete the initial review process within 30 days.

For the past 2 years, half of the accepted papers *JOSPT* publishes come from authors located outside the United States.

IMPACT FACTOR AND USEFULNESS

Based on the 2014 *Journal Citation Reports, Science Edition*, published in June 2015, *JOSPT*'s current impact factor is 3.011. *JOSPT*'s 5-year impact factor is 3.627. Based on the current impact factor, *JOSPT* is ranked 4th of 134 journals in Rehabilitation, 8th of 72 journals in Orthopedics, and 10th of 81 journals in Sport Sciences. *JOSPT*'s readers regularly rank it first in usefulness to them in their

work, scoring *JOSPT* a 4.29 on a scale of 5, when comparing it to 14 other journals in the field.

DISTRIBUTION

JOSPT is distributed monthly in print and/or online to more than 35 000 individual and institutional subscribers located in 60 countries around the world.

JOSPT is available online through its website, www.jospt.org, which enables content delivery not only to desktop computers, but also to mobile devices. Website traffic is approximately 100 000 visitors each month, 71 000 of whom are unique.

JOSPT is the official journal of the American Physical Therapy Association's Orthopaedic Section and Sports Physical Therapy Section. It is also a recognized journal of 35 professional organizations in 27 countries. (See *JOSPT*'s masthead at the front of this issue for complete partner listing.)

DIGITAL ACCESS

JOSPT's online article archives are complete and include issues and articles from summer 1979, when *JOSPT* was first published, to date. All articles are available in PDF format and many in PDF Plus, which includes available reference and other links. All articles published from January 2010 to date, all musculoskeletal imaging articles, and all clinical practice guidelines are also available in full-text HTML for easy display on mobile devices.

All material from *JOSPT*'s launch to within 3 years of the current issue is publicly available, or open access. In addition, articles published in the last 3 years that are clinical practice guidelines, that are the basis for current Read for Credit continuing education exams, and that rely on publicly funded research are also open. Accepted manuscripts that report

on publicly funded research are made available in digital form to their authors to provide to central databases such as NIH's PubMed Central for public access.

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Authors also have permission, with no fee, to reproduce material they have created for *JOSPT* for use in books, book chapters, or articles for other journals, so long as copyright credit is given to *JOSPT*. Uploading articles to public-access websites (eg, ResearchGate) is not allowed.

INDEXING

Several well-known services—in particular, Index Medicus (PubMed/MEDLINE), Excerpta Medica (Embase), and Cumulative Index to Nursing and Allied Health Literature (CINAHL)—index *JOSPT*.

KUDOS FOR JOSPT AUTHORS

To ensure that the high-quality work of authors reaches the widest possible audience, *JOSPT* partners with Kudos, a service that provides tools for authors to maximize the visibility and reach of published journal articles.

Authors who have previously published in *JOSPT* can sign up for Kudos and begin using the service immediately, at no charge. The link to Kudos is <https://www.growkudos.com/sessions/register>.

RESEARCH AND CLINICAL PUBLICATION AWARDS

JOSPT bestows 2 annual publication awards: the *JOSPT* Excellence in Research Award and the George J. Davies – James A. Gould Excellence in Clinical Inquiry Award.

Complete Instructions for Authors and other tools can be found at <http://www.jospt.org/page/authors>. ●

INSTRUCTIONS TO AUTHORS

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MANUSCRIPT SUBMISSION

All manuscripts must be submitted online at <http://mc.manuscriptcentral.com/JOSPT>, which either can be accessed directly or through the JOSPT website at www.jospt.org. Please direct questions about online submission to the JOSPT office at 1-877-766-3450.

General Requirements

All manuscripts must meet the following basic requirements to be eligible for review by JOSPT:

- Written in English
- Include a cover letter
- Present findings or data that have not been previously published either in print or electronic (online) format or widely disclosed in a form other than published abstracts of oral presentations at scientific conferences and meetings
- Undergoing exclusive review by JOSPT
- Address scientific, clinical, or professional issues relevant to musculoskeletal or sports-related physical therapy practice
- Written in accordance with the "Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals" by the International Committee of Medical Journal Editors, December 2013 (<http://www.icmje.org/> and http://www.icmje.org/urm_main.html)
- Formatted according to AMA style guidelines (*American Medical Association Manual of Style, 9th Edition*), except for the references, which should be numbered consecutively in alphabetical order.

Submissions that do not meet the above essential requirements will be returned to the author without review. In the peer-review process, JOSPT reviewers are unaware of the author's identity and institutional affiliation. Associate editors are not blinded to author identity and vice versa.

Author/Reviewer Tools and Resources

Authors are required and reviewers invited to take advantage of the author and reviewer tools and resources section of the JOSPT website (www.jospt.org), which provides useful links related to writing and reviewing manuscripts. These materials were created to assist authors in ensuring that key methodological information relevant to the conduct of their study is included in the manuscript. This section specifically provides a link to the EQUATOR Network website (<http://www.equator-network.org>), an excellent resource designed to help authors report on health research that includes links to resources such as the CONSORT, PRISMA, STROBE, and STARD statements, among others.

Revised Manuscripts

When the editors suggest that a manuscript be revised and resubmitted, the same guidelines outlined for the preparation of the original manuscript apply. All resubmitted manuscripts must be accompanied by a cover letter. The cover letter must include a list of all revisions with regard to suggestions in the review materials provided by the editorial office. Changes made

to the text and tables must be highlighted in the manuscript.

Protection of Human Subjects

The name of the Institutional Review Board that approved the research protocol involving human subjects must be included on the title page and in the Methods section. The Methods section must also contain a statement that informed consent was obtained and that the rights of the subjects were protected.

It is mandatory that clinical trials initiated on or after January 1, 2013 be prospectively registered in a public trials registry. In these cases, authors should provide the name of the registry and the registration number on the title page. For clinical trials initiated prior to January 1, 2013, prospective clinical trial registration is desirable but not mandatory.

Case reports should include, when required by the appropriate Institutional Review Board, a statement that each subject was informed that data concerning the case would be submitted for publication or a statement indicating approval by the Board. In all cases, patient confidentiality must be protected.

Use of Animals

Manuscripts with experimental results in animals must include a statement on the title page and in the Methods section that an animal utilization study committee approved the study.

Use of Cadavers

When applicable, manuscripts with experimental results on cadavers must include a statement on the title page and in the Methods section that a relevant utilization study committee approved the study.

MANUSCRIPT CATEGORIES

Research Report

A full-length report of an original clinical, basic, or translational research investigation that advances the clinical science of musculoskeletal and sports-related physical therapy. This category also includes sys-

tematic literature reviews with or without meta-analysis.

Authors submitting a randomized controlled trial must consult the CONSORT statement (revised in 2010) and its related extension for trials of nonpharmacological treatments, checklist, and flow diagram (<http://www.consort-statement.org/> and <http://www.consort-statement.org/consort-statement>). *JOSPT* further requires that a flow diagram illustrating the progress of patients throughout the trial be included as a figure in the manuscript. In addition, authors must include a copy of the completed CONSORT checklist appended to the manuscript, with the understanding that the checklist will not appear with any published paper.

Authors submitting manuscripts for observational studies (cohort, case-control, cross-sectional studies) should comply with the STROBE statement (<http://www.strobe-statement.org/index.php?id=strobe-home>) and should submit a completed STROBE checklist together with the manuscript. The checklist is used to facilitate the peer-review process but is not published with studies accepted for publication.

Large therapy or prevention studies that use a case series design should also be submitted as research reports and be submitted with an accompanying STROBE checklist.

Similarly, preparation of studies investigating the diagnostic accuracy of clinical tests will benefit from consulting the STARD statement, checklist, and flow diagram (<http://www.stard-statement.org>). *JOSPT* requires that a flow diagram illustrating the progress of patients throughout the study be included as a figure in the manuscript. Authors must include a copy of the completed STARD checklist appended to the manuscript, with the understanding that the checklist will not appear with any published paper.

Systematic reviews of the literature, with or without a meta-analysis, addressing a topic of interest and relevance to musculoskeletal, sports, and manual physi-

cal therapists are also considered research reports. Accordingly, systematic literature reviews must have a structured abstract and include a Methods section detailing the search strategy, inclusion/exclusion criteria, evaluation of the quality of the articles, etc. The editor-in-chief must invite manuscripts submitted in this category; however, self-nominations for an invitation to submit a systematic literature review are welcome. Self-nominations, which must include a cover letter addressed to the editor-in-chief and a current curriculum vitae, should be sent electronically to jospt@jospt.org.

Authors submitting a systematic literature review of randomized controlled trials should consult the PRISMA statement and related checklist and flow diagram for quality reporting of systematic reviews and meta-analyses (<http://www.prisma-statement.org>). *JOSPT* requires that a flow diagram illustrating the progress of study selection and exclusion (as well as reasons for exclusion) be included as a figure in the manuscript. Authors must include a copy of the completed PRISMA checklist appended to the manuscript, with the understanding that the checklist will not appear with any published paper. Prospective registration of systematic reviews protocol information in a database such as PROSPERO (www.crd.york.ac.uk/PROSPERO/) is recommended but not required.

The above is not a full list of study designs and the authors are required to use the appropriate checklist for their study design as available on the EQUATOR Network website (<http://www.equator-network.org>).

Case Report

A detailed description of the management of a unique clinical case. Case reports must include the following 4 sections: Background, Case Description, Outcomes, and Discussion. The description of the case includes the relevant patient characteristics, examination/evaluation, diagnosis, and a description of the interventions that were provided. Manuscripts describing the management of a small group of

similar patients are also considered in this category and should be formatted accordingly.

Resident's Case Problem

A report on the process and logic associated with differential diagnosis (ie, clinical decision making). The Background section includes general clinical or research information pertinent to the case. The Diagnosis section provides patient characteristics and history. It then details the examination and evaluation process leading to the working diagnosis and the rationale for that diagnosis, including a presentation of medical imaging studies and the results of other clinical tests. Interventions used to treat the patient's condition and the outcome of treatment may also be briefly described at the end of the Diagnosis section; however, the focus of the resident's case problem should be on the diagnostic process. The Discussion section offers a scholarly, critical, and referenced analysis of how the diagnosis guided the care of the patient.

Clinical Commentary

A scholarly paper containing opinion or perspectives having relevance to musculoskeletal and sports physical therapy. Clinical commentaries submitted for review require an abstract that is not structured. The editor-in-chief must invite clinical commentaries. Self-nominations for an invitation to submit a clinical commentary are welcome. Self-nominations, along with a cover letter addressed to the editor-in-chief and current curriculum vitae, should be sent electronically to jospt@jospt.org.

Narrative Literature Review

Literature reviews on topics that are not conducive to a formal systematic review but are relevant to musculoskeletal and sports physical therapy may be considered for publication. The editor-in-chief must invite narrative literature reviews. Self-nominations, which must include a cover letter addressed to the editor-in-chief and

INSTRUCTIONS TO AUTHORS (CONTINUED)

current curriculum vitae, are welcome and should be sent electronically to jospt@jospt.org.

Brief Report

Suitable for high-quality, high-impact research reports that are less than 2000 words (excluding references) and have no more than a total of 4 tables or figures. The number of references should be 20 or less. Potential exists for additional supporting material (ie, tables, figures) to be included as appendices online if needed. This category of papers can be used for all types of research reports, including the description of a new instrument, technology, or methods relevant to musculoskeletal physical therapy practice or clinical research. Follow the instructions for research reports, using the additional information provided above to prepare the manuscript.

MANUSCRIPT PREPARATION

All manuscripts submitted to *JOSPT* should be double-spaced and have 2.54-cm (1-in) margins on all sides of the page. Pages should be consecutively numbered, starting with the title page. Pages should be continuously line numbered, with line numbers starting at 1 on the abstract. The font should be 12-point Arial, Times New Roman, or Courier. All measurements in the manuscript should be presented in SI units, except for those of angular measures, which should be presented in degrees rather than radians. The manuscript should be arranged as follows:

Title Page (separate page)

- Title of the manuscript
- Names of each author with their highest academic credential (ie, PhD), or most relevant professional designation (eg, PT), or both (eg, PT, PhD). Limit credentials to these 2 items only
- Institution, city, state/country for each author
- Statement of the sources of grant support (if any)
- Statement of Institutional Review Board approval of the study protocol

- Name of the public trials registry and the registration number
- Corresponding author's name, address, and e-mail address
- Word count of the text portion of the manuscript

Anonymous Title Page (separate page)

- Title of the manuscript
- Statement of financial disclosure and conflict of interest (see item 6 of the Author Agreement and Publication Rights Form)
- Acknowledgements (on a separate page)

Abstract

- Structured Abstract: Research reports (including systematic literature reviews) and brief reports require an abstract containing a maximum of 250 words, divided into 6 sections with the following headings (in this order): Study Design, Objectives, Background, Methods, Results, Conclusion. The abstract for case reports should have 5 sections with the following headings: Study Design, Background, Case Description, Outcomes, and Discussion. The abstract for resident's case problems should have 4 sections with the following headings: Study Design, Background, Diagnosis, and Discussion.
- Unstructured Abstract: Clinical commentaries and narrative literature reviews require an abstract (called synopsis) that is not structured and that contains a maximum of 250 words.
- All abstracts should include, when appropriate, a line item called "Level of Evidence," which indicates the study type and level of evidence, according to the classification system listed at the Oxford Centre for Evidence-Based Medicine website (<http://www.cebm.net>). This final line in the abstract should be in the following format example: "Level of Evidence: Therapy, level 2a." When the study does not fit any of the study type and level of evidence descriptors included in the above classification system, this line may be omitted.

- A list of suggested study design names and the Oxford Centre for Evidence-Based Medicine levels of evidence table are provided for reference in the Authors section of the *JOSPT* website.
- All abstracts should end with a Key Words section, containing 3 to 5 key words that do not appear in the manuscript title.

Text

- Research reports, systematic literature reviews, and brief reports require the body of the manuscript to be divided into 5 sections: Introduction, Methods, Results, Discussion, and Conclusion.
 - Case reports require the body of the manuscript to be divided into 4 sections: Background, Case Description, Outcomes, and Discussion.
 - Resident's case problems require the body of the manuscript to be divided into 3 sections: Background, Diagnosis, and Discussion.
 - Clinical commentaries and narrative literature reviews do not have specific mandatory subdivisions or sections.
- For all manuscripts, the text should be less than 4000 words and be supplemented by a reasonable number of figures and tables.

Key Points

- The brief Key Points section of the manuscript (needed for research reports only, including systematic literature reviews) should be provided at the end of the text, prior to the references. These points should be written in a user-friendly language, consist of brief sentences, and summarize the most important information related to the findings, implications, and caution directly resulting from the work. These 3 subheadings should be used:
- Findings: One or 2 statements on what the study adds to current knowledge.
 - Implications: A statement on how the results impact clinical practice or research on this topic.
 - Caution: A statement on the most important limitations of the study, es-

pecially external validity (what may prevent wide utilization of the results).

References

- References should be numbered consecutively in alphabetical order, according to author last name and initials, title, and year. Where the first-author names are identical, references with 1 author precede those with multiple authors. Where all the author names are identical, the title is the next ordering component, followed by the year.
- All references in the References section must be cited in the text.
- References must be cited in the text by using the reference number in superscript at the end of the sentence or the referenced portion of the sentence. The reference goes after the author's name when the author's name is listed (eg, Davies¹). If there are only 2 authors in the reference, then the text should include both authors (eg, Davies and Ellenbecker¹). If the reference has more than 2 authors, the text should include "et al" after the first author's name (eg, Davies et al¹).
- In the Reference section, when a reference has 7 or more authors, list the first 3 authors, followed by "et al."
- References must include only material that is retrievable through standard literature searches. References to papers accepted but not published or published ahead of print should be designated "in press" or use the PubMed/MEDLINE [Epub ahead of print] status until an updated citation is available. Doctoral and master's theses are considered published material. Information from manuscripts not yet accepted for publication and personal communications will not be accepted. The use of abstracts and proceedings should be avoided unless they are very recent and the sole source of the information.
- Abbreviations for the journals in references must conform to those of the National Library of Medicine in Index Medicus (<http://www.ncbi.nlm.nih.gov/journals>).

- References that have CrossRef Digital Object Identifiers (doi) should include them at the end of the citation.
- References must be verified by the author(s) against the original documents. Reference style and punctuation should conform to the examples that follow:

Journals

Wilson T. The measurement of patellar alignment in patellofemoral pain syndrome: are we confusing assumptions with evidence? *J Orthop Sports Phys Ther.* 2007;37:330-341. <http://dx.doi.org/10.2519/jospt.2007.2281>

Books

Portney LG, Watkins MP. *Foundations of Clinical Research: Applications to Practice.* 3rd ed. Upper Saddle River, NJ: Prentice Hall Health; 2009.

Organization as Author and Publisher

US Food and Drug Administration. Guidance for industry: patient-reported outcome measures: use in medical product development to support labeling claims. Rockville, MD: FDA; 2006.

Chapter in a Book

Jones MA, Rivett DA. Introduction to clinical reasoning. In: Jones MA, Rivett DA, eds. *Clinical Reasoning for Manual Therapists.* Edinburgh, UK: Butterworth-Heinemann; 2004:3-24.

Master's or Doctoral Thesis

Langshaw M. *Cervical Spine Mobilisation: The Effect of Experience and Subject on Dose* [thesis]. NSW, Australia: The University of Sydney; 2001.

Published Abstract of a Paper Presented at a Conference

Chen YJ, Powers CM. The dynamic Q-angle: a comparison of persons with and without patellofemoral pain [abstract]. Proceedings of the North American Congress on Biomechanics. Ann Arbor, MI: 2008.

Universal Resource Locator (URL)

NFHS Associations. 2007-2008 National Federation of State High School Associations Participation Survey. Available at: <http://www.nfhs.org>. Accessed May 17, 2010.

Paper Presented at a Symposium

Nelson-Wong E, Gregory DE, Winter DA, Callaghan JP. Postural control strategies during prolonged standing: is there a relationship with low back discomfort? American Society of Biomechanics Annual Conference. Palo Alto, CA: American Society of Biomechanics; 2007.

Tables

- Each table must be self-contained and provide standalone information independent of the text.
- See *AMA Manual of Style*, section 2.13, to organize and format tables.
- Table titles should list the table number in uppercase bold (eg, "TABLE 1"), followed by a period, then the title of the table in sentence case.
- Abbreviations used in each table must be spelled out below the table.
- Footnotes must be listed below the table, after the abbreviations, in order of occurrence in the table (left to right, row to row). According to AMA style, footnotes are cited with the following superscript symbols (in this order): *, †, ‡, §, ||, ¶, #, **, ††, ‡‡. Where these symbols are unavailable, superscript numbers may be used.
- All tables must be referred to somewhere in the text.
- All tables go after the reference list.

Figures

- Figure captions should list the figure number in uppercase bold (eg, "FIGURE 1") followed by a period, and continue with the text of the caption in sentence case.
- All abbreviations appearing in the figures should be defined in the caption for each respective figure, and abbreviations appearing only in the figure caption must be defined at first use.
- Digital figures must be at least 350 dpi (dots per inch).
- Charts and graphs generated from spreadsheet programs must accompany, or allow access to, the data
- Photographs must be in JPEG file for-

INSTRUCTIONS TO AUTHORS (CONTINUED)

mat (JPG) and graphic art in GIF file format and at a resolution of at least 350 dpi.

- All figures must be referred to in the text.
- Each view (eg, A, B, C) within the figure must be defined in the figure caption.
- Color figures and graphics are welcome.
- All figures go after the tables at the end of the manuscript.

Videos

Authors may wish to consider including supplemental videos to be published online with their manuscript. These videos can describe intervention or examination techniques as well as surgical procedures or other material pertinent to the manuscript. Intent to include videos may be mentioned in the cover letter with the initial manuscript submission or may be discussed with the editor-in-chief once the manuscript is accepted. Videos should be:

- MPEG-1, MPEG-2, or AVI files.
- No longer than 2.5 minutes.
- Introduced with a title screen and include audio narration.
- There is no limit on the number of videos that may be submitted.

ADDITIONAL REQUIRED DOCUMENTS

For submissions to qualify for review, the following documents must either be e-mailed (manuscripts@jospt.org), mailed (JOSPT, 1033 N Fairfax St, Ste 304, Alexandria, VA 22314-1540), or faxed (1-703-891-9065) to the JOSPT office.

Author Agreement and Publication Rights Form

This document must have original signatures of all authors. Author signatures may be on separate copies or 1 copy of the form. The form is at the end of these instructions. Please submit the form when you are submitting the manuscript on the manuscript submission website at <http://mc.manuscriptcentral.com/jospt>. Please contact the JOSPT office with any questions.

Photograph/Video Release Statement

Signed photograph/video release forms should accompany photographs/videos of patients and subjects. A photograph/video release statement should contain the following: (1) manuscript title; (2) names of all authors; (3) statement placed below the manuscript title and author names as follows: "I hereby grant to the *Journal of Orthopaedic & Sports Physical Therapy* the royalty-free right to publish photographs and/or videos of me for the stated journal and the above manuscript in which I appear as subject, patient, or model, and for the stated *Journal's* website (www.jospt.org). I understand that any figure in which I appear may be modified."; and (4) the original signature and date signed from each subject who appears in the figures. This original signed statement must be submitted to the JOSPT office with the manuscript.

OTHER CONTRIBUTIONS

Musculoskeletal Imaging

This feature focuses on the use and interpretation of medical imaging related to a case scenario relevant to musculoskeletal or sports physical therapy practice. In most instances, these cases will emphasize how information from imaging can affect physical therapy management of the patient. In some instances, however, this feature may be used to share information on unusual medical conditions, or to simply illustrate commonly used imaging techniques and their interpretation. Contributions should include no more than 3 authors, 250 words, 3 figures, and 3 references (if any). Submissions, including text and images, must be submitted online at <http://mc.manuscriptcentral.com/jospt>, which can be accessed either directly or through the JOSPT website at www.jospt.org. Please direct questions about online submission to the JOSPT office at 1-877-766-3450. See the Figures section of the instructions to authors for technical specifications for the figures.

Letter to the Editor-in-Chief

A letter related to professional issues or

articles published in the *Journal*. Letters will be reviewed and selected for publication by the editor-in-chief based on the relevance, importance, appropriateness, and timeliness of the topic. Letters to the editor-in-chief are copy edited and the correspondent is not typically sent a version to approve. Letters to the editor-in-chief should include a summary statement of any conflict of interest, including financial support related to the issue addressed. Letters should be sent electronically to jospt@jospt.org. Authors of the relevant manuscript are given the opportunity to respond to the content of the letter.

Invited Commentary

An expert's point of view concerning an article published in the *Journal*. Commentaries are invited by the editor-in-chief and immediately follow the article discussed. Authors of the manuscript under commentary are given the opportunity to respond to the expert's point of view.

JOSPT'S EDITORIAL POLICIES

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seek information intended to enhance the review.

6. Authors are not permitted to make changes during the proof stage of publication except to correct inaccuracies.
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8. The editors may solicit additional reviews to supplement the opinion of the assigned associate editor and reviewers.
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- Name of the Institutional Review Board that approved the protocol for the study on the title page.
- Name of the public trials registry and the registration number on the title page, if applicable.
- Statement in the Methods section that informed consent was obtained and the rights of subjects were protected.
- Properly structured abstract.
- Continuous line numbering throughout the entire manuscript.
- References listed and numbered in alphabetical order and cited with superscripts in the text.
- Inclusion of the appropriate checklist (eg, CONSORT, STARD, PRISMA), if applicable.

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Original signature of each author:

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Name	Date	Name	Date
Name	Date	Name	Date

Appendix C: Confirmation of language editing

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24 November 2016

To whom it may concern:

DECLARATION: LANGUAGE EDITING

This letter serves as proof that the following document was submitted to the undersigned for language editing in October 2016:

Author: Leanri van Zyl

Document type: Dissertation: M.Sc (Biokinetics), NWU

Title: *Exercise as a conservative treatment modality for shoulder impingement syndrome: a systematic review*

Review comments and recommendations were communicated to the author during the course of October and November 2016.

Applying changes in order to arrive at a final approved document remains the responsibility of the document author.

Yours sincerely



CHRISTEL EASTES
Potchefstroom