

## Introduction

Ever since the Renaissance, the shoulder joint has been paid lots of attention to, not merely because it is one of the human bodies' joint articulations, but also due to its complex structure and build up<sup>(49)</sup>. During the fifth century BC, Hippocrates wrote about joint articulations, and much of his work evolved around the particularities of the shoulder. Galen, a Greco-Roman physician is the father of the study of clinical anatomy, and he has made some useful writings concerning human bodyparts. He discovered that the shoulder has the greatest mobility of any other joint in the body, and is the most predisposed to dislocation<sup>(49)</sup>.

What was discovered in the earlier days, in regards to the shoulder joint, can certainly be applied to today's professional physiotherapists. There has been an enhanced interest to concretise on how to properly establish a proper diagnosis and from there on create a rehabilitation programme that will benefit the injured athlete<sup>(20)</sup>. An extended knowledge concerning the underlying pathophysiology and the mechanism of injury is an additional prerequisite to come to the best solution for the injured athlete<sup>(5)</sup>. Pathology of the shoulder can be divided into two categories, - people under the age of 35 and over. For those under 35 years, pathology is related to the overhead motion where repetitive strain can cause microtrauma. Baseball, tennis, volleyball and swimming are overhead sports that can most probably produce symptoms. This again can lead to secondary complaints that compromise the stability of the shoulder joint. For the population above this age, degenerative factors are most likely to be the underlying cause<sup>(5)</sup>.

Conservative treatment is a common term for physiotherapists involved in the rehabilitation of the injured athletes. Focus is placed on an active treatment approach where the immobilisation period is kept to a minimum. Initially, the goal is to minimise pain, restore range of motion, increase strength, and to restore normal muscle activity so that the athlete can return to the prior level of function<sup>(20)</sup>.

Research done on this subject has not yet established evidence that support the idea of immobilisation of the injured athlete. On the contrary, experimental literature is in favour of early controlled mobilisation that is formed on the basis of basic knowledge of connective tissue healing<sup>(20)</sup>. The intention of this study was to conduct a review to investigate the effect of a physiotherapeutic exercise treatment programme for athletes with shoulder instability and rotator cuff injuries. Also finding out if there existed measurement tools applicable for evaluating if the athlete had gained progress with the treatment. The main question of the project was then: "What is the best evidence based exercise treatment protocol for shoulder instability and rotator cuff injuries in athletes performing overhead activities, and what is the best measurement tool used to determine the athlete's present level after recovery?"

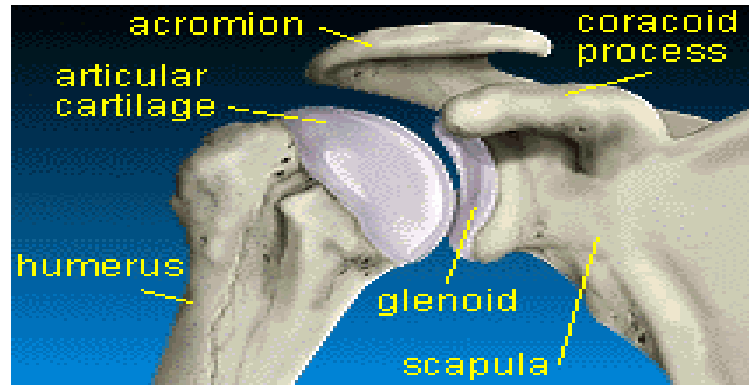
To find answer to the main question, the authors decided to do a systematic review. The method for doing this review was conducted according to The Cochrane Collaboration handbook. These guidelines made the method more reliable, valid and less receivable for systematic errors.

The first chapter will describe the theoretical framework of this subject. Anatomy and pathology of the shoulder will be outlined thoroughly; furthermore will the nervous system be mentioned due to its significant part in integration of movement and sensation. Lastly, exercise therapy and the role of a measurement tool will be underlined to illustrate the interrelation to conservative treatment of the shoulder. The following part will present the methodological approach to this systematic review, describing the procedure used to assess articles obtained. Results regarding the best evidence based exercise protocol for an athlete with shoulder instability and rotator cuff injuries, and the best measurement tool used to determine the athlete's present level after recovery, will be discussed in chapter three. The obtained results will be discussed further in chapter four, and finally a conclusion will be drawn in chapter five along with limitations of the review and implications for further research.

## 1. Theoretical framework

The following chapter gives basic information regarding issues that will be described and used in this report. Theory concerning the topic chosen, namely the shoulder, will be illustrated rather extensively in order for the reader to comprehend the nature of the shoulder joint.

### **1.2 Functional Anatomy of the Shoulder-Girdle Complex: The Glenohumeral joint, Acromioclavicular joint, Sternoclavicular joint and Scapulothoracic articulation**



*Fig. 1 Anatomy of the shoulder joint*

The shoulder joint, figure 1, might seem as though it is comprised of a single joint. However, such a description is inaccurate. From a strictly anatomic standpoint, the shoulder is comprised of five. For practical purposes, however, one may regard the shoulder as having three true joints and one articulation, and that is how this review will continue to describe the anatomy. The shoulder joint, or the shoulder girdle complex as it is typically referred to, consists of the sternoclavicular joint (SC), acromioclavicular joint (AC), the glenohumeral joint, and the scapulothoracic articulation<sup>(13,18,19)</sup>.

The shoulder girdle is a highly specialised structure characterised by great mobility at the expense of stability. Optimal function requires normal anatomic relationships, intact static and dynamic stabilisers, and synchronised activation of balanced muscle force-couples<sup>1</sup>. This applies not only to the arm but to the trunk and lower limbs as well. Frequently, clinicians will focus their attention entirely on the glenohumeral joint and overlook the other joints of the shoulder-girdle complex, especially when motion is restricted. Normal shoulder function requires the delicate interaction of all the shoulder joints as a functional unit<sup>(53, 58)</sup>.

An appreciation of the functional aspects of the shoulder apparatus requires a thorough understanding of its structural design. The elegant anatomic relationships characterising the shoulder emphasise that normally function follows form. Grasping these relationships is critical in comprehending the pathogenesis and rehabilitation of shoulder instability, - and rotator cuff injuries.

The glenohumeral joint is inherently unstable. It is classified as a ball and socket joint, also known as a spheroidal joint, with three degrees of freedom. The relatively large range of motion that it presents, is mainly due to the flat shaped biconcave glenoid fossa, the biconvex humeral head that is much bigger than the glenoid fossa with which it articulates, and its relatively loose articular

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<sup>1</sup> Muscles working together to provide stability of humeral head

capsule. This characterisation of the glenohumeral joint helps explain why the shoulder joint is the most mobile joint in the human body.

The bony anatomy of the glenoid is such that it only covers approximately 25% - 30% of the humeral head. A comparison often given for the mismatch of the humerus on the glenoid is that of a golf ball positioned on the tee <sup>(53)</sup>.

Muscles and their tendon attachments surround the humeral head to help it maintain its position in the glenoid fossa. These attachments are found underneath the coracoacromial arch <sup>(13, 19)</sup>. The coracoid and acromion processes and the connecting coracoacromial ligament, as the name implies, form the coracoacromial arch. Underneath this arch are the subacromial-subdeltoid bursa, the rotator cuff tendons, the long head of the biceps tendon, the glenohumeral joint capsule, and the upper surface of the humeral head. The coracoacromial arch protects the humeral head and the subacromial structures from direct trauma, and further prevents superior dislocation of the humeral head.

The joint is supported by four muscles and their tendons; the subscapularis, infraspinatus, supraspinatus, and teres minor muscles. These muscles are collectively referred to as the rotator cuff. The subscapularis is an internal rotator of the glenohumeral joint, whereas the infraspinatus and teres minor muscles are external rotators. Furthermore, the supraspinatus aids the deltoid in abducting the arm. The rotator cuff as a whole functions to centre the humeral head in the glenoid for stability and to allow maximal leverage during shoulder movements. Together with the deltoid, they place the arm in the overhead position, which is essential in many sports <sup>(62)</sup>. The rotator cuff is surrounded by a bursa that helps the tendons to slide. In addition the labrum, a fibrocartilage tissue, encircles the fossa like a ring to provide more depth for the humeral head to be fixated in.

*The sternoclavicular joint* is the only fixed connection between the shoulder and the thorax. It is classified as a saddle joint, and contributes with 20° of rotation and 40° of elevation of the clavicle. Its role within the shoulder complex is limited to cushioning the shoulder against impacts <sup>(13, 18)</sup>.

*The acromioclavicular joint* is a plane type of synovial joint and is to be found on the outmost part of the clavicle. It is made up of the acromion process of the scapula and the outer part of the clavicle. Movement found is 5° to 8° of rotation on the clavicle, in both anterior and posterior directions. For stability, powerful ligaments are attached on either side, acting as reinforcements <sup>(13, 18)</sup>.

*The scapulothoracic articulation* is a physiological<sup>2</sup> joint situated on the posterior side of the thorax and anterior side of the scapula. This articulation lacks the characteristics of a true joint, having no ligamentous restraints, hence the muscles attached to the scapula and thorax provide for stability. The scapulothoracic articulation plays a significant role in normal arm function, providing dynamic stability, which is crucial for the overhead athlete <sup>(59)</sup>.

The scapulothoracic articulation serves to maintain optimal shoulder muscle length-tension relationships, and stabilises the glenohumeral joint by keeping the glenoid fossa under the humeral head. The articulation facilitates clearance of the humeral head by the acromion during abduction and forward flexion, while affording a greater range of motion than otherwise attainable due to inherent glenohumeral restrictions. Scapular rotation occurs around the thorax by a strut-like mechanism formed by the clavicle, which articulates with the scapula and the axial skeleton by means of the acromioclavicular (AC) and sternoclavicular (SC) joints, respectively.

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<sup>2</sup> Concerning the function of a body part

Synchronous movement of the glenohumeral and scapulothoracic articulation is a kinaesthetic<sup>3</sup> relationship that begins at 30° of humeral abduction and provides 12° of scapular rotation for every 30° of humeral abduction, minor differences in these measurements have been reported. This relationship is termed scapulohumeral rhythm, with the upward scapular rotation dependent upon a force-couple involving the trapezius, levator scapulae, and serratus anterior<sup>(54)</sup>.

### **1.3 Stability of the Shoulder**

#### **1.3.1 Dynamic Stabilisers**

Three muscle groups affect the shoulder movement and serve as dynamic stabilisers.

The first group of the dynamic stabilisers is the scapulohumeral group and consists of the rotator cuff muscles, deltoid, coracobrachialis and teres major, which originates from the scapula and inserts on the humerus. Primarily, the infraspinatus, teres minor, and subscapularis depress and stabilise the humeral head. In their absence, the humeral head would move upward in the glenoid fossa during arm abduction because of the unopposed pull of the deltoid muscle. This movement would result in constant underpinning against the coracoacromial arch<sup>(13,35,62)</sup>. The rotator cuff accomplishes this function through eccentric action, with the muscles maintaining their strength while they lengthen during movement of the joint.

Secondly, the axioscapular group originates from a paraspinal position and inserts on the scapula, and includes the muscles trapezius, serratus anterior, levator scapulae, and rhomboids.

Lastly, the axiohumeral group originates from a similar position, as the axioscapular group in the case of the latissimus dorsi or from parasternal location, as in the case of the pectoralis major and inserts on the humerus. These larger muscles surrounding the shoulder are responsible for controlling scapular stability and the glenoid position for producing the forces necessary for glenohumeral movement.

The dynamic stabilisers of the glenohumeral joint include several force-couples<sup>3</sup>. The first force couple in the transverse plane is the subscapularis, counterbalanced by the infraspinatus/teres minor. The second force couple occurs in the coronal plane between the anterior fibres of the deltoid and the inferior rotator cuff muscles. These force couples establish dynamic equilibrium of the glenohumeral joint in any arm position, and the co-contraction of these force couples compresses the humeral head within the glenoid fossa. When these force couples are not properly balanced or equalised, abnormal glenohumeral mechanics occur. The overhead athlete commonly exhibits posterior shoulder pain and weakness, resulting in shoulder dysfunction secondary to a force couple imbalance. The quality of the glenohumeral motion is directly related to the status of the supraspinatus/infraspinatus muscles. The infraspinatus is directly involved in two critical force couples about the glenohumeral joint<sup>(59)</sup>.

Scapular stability is an important factor in the overall stability of the shoulder, much like the foundation of a building. The long head of the biceps tendon is attached superior on the glenoid labrum, and is also a stabiliser but may not be truly dynamic<sup>(35)</sup>.

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<sup>3</sup> Muscles that work together to provide dynamic stability of humeral head

### 1.3.2 Static Stabilisers

The passive stabilising mechanism of the shoulder includes a combination of osseous and fibrous tissue structures that limit shoulder laxity. Further, protections of these structures is provided by the dynamic stabilisers, proper biomechanics of throwing, and appropriate neuromuscular conditioning

The glenoid labrum and the intact joint capsule serve as the static stabilisers by deepening the glenoid fossa and maintaining negative intra-articular pressure of the joint, which act as suction. The superior, middle and inferior glenohumeral ligaments attach to the labrum, and their function is of substantial significance for glenohumeral static stability. The soft, fibrocartilaginous glenoid labrum contributes to the volume of the fossa and serves as the attachment site for the articular capsule and is a wedge-shaped structure that is attached to the periphery of the glenoid. The labrum is firmly attached to the margin of the glenoid cavity<sup>(13)</sup>. When trauma occurs to the shoulder, and the structure to be injured is the labrum, it is referred to as a Bankart-lesion<sup>4</sup>. The glenohumeral joint capsule has an inferior, or axillary recess, that unfolds to allow shoulder abduction and flexion. Destruction of this fold can be shown by arthrography revealing conditions such as adhesive capsulitis, also referred to as "frozen shoulder"<sup>(1, 38, 54)</sup>. Individual composition and integrity of these static structures create variable effective restraints.

### 1.3.3 Functional Stability and Adaptive Changes

The overhead athlete presents a significant challenge to the clinician. The shoulder joint complex receives repetitively high stress, which may lead to inflammation<sup>5</sup> of the shoulder joint capsule and the rotator cuff musculature. This type of prolonged inflammatory process can eventually result in decreased muscular efficiency, poor dynamic stability, increased humeral head displacement, eventual functional instability, and progressive tissue failure<sup>(59)</sup>.

Overhead athletes repetitively subject their shoulder joints to high microtraumatic stress that, due to accumulative effects, may lead to a variety of shoulder injuries. This type of athletic patient exhibits uniquely specific physical characteristics as a result of adaptation to the overhead motion their sport require, including: hypermobility of the anterior shoulder capsule, excessive external rotation, hypomobility of the posterior joint capsule, limited internal rotation, and generalised laxity of the glenohumeral joint.

The overhead athlete must display functional stability for pain-free sports participation. Functional stability is accomplished through the proficient balance of static<sup>6</sup> and dynamic<sup>7</sup> stabilisers of the shoulder joint complex.

Increased shoulder capsular laxity is necessary to allow the athlete the excessive motion required to cock<sup>8</sup> the arm during the throwing motion or tennis serve. Due to this acquired capsular laxity, the musculature around the shoulder complex must effectively maintain an adequate amount of glenohumeral joint congruency for symptom-free function. Several authors have suggested that functional stability of other joints may be enhanced through improved kinaesthesia skills and proper muscular co-ordination. Whether shoulder joint stability can be enhanced through this type of

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<sup>4</sup> Part of fibrous labrum is pulled off from inferior half of anterior rim of glenoid, caused by traumatic anterior dislocation of the shoulder

<sup>5</sup> The body's response to injury; recognised by redness, swelling, heat, loss of function and pain

<sup>6</sup> Maintenance of a position

<sup>7</sup> Active, moving

<sup>8</sup> 90° abduction and maximal external rotation of the shoulder

rehabilitative training has not yet been documented; however, the clinical approach has scientific basis, and it is believed that it plays a significant role in dynamic glenohumeral joint stability<sup>(59)</sup>.

There are forces contributing to increase the stress on the joint, the force of gravity being one with the arm hanging down for longer periods of time. When throwing a ball at about 80-100 miles per hour (mph), lifting heavy objects or repositioning the arm abruptly, the joint is not surprisingly vulnerable to injury. Rockwood and Matsen states that there are two laws concerning glenohumeral instability that will provide the physician with a basic understanding on how stability of the joint can be comprehended. Briefly summarised, the joint will avoid dislocation when the net reaction force is directed within the glenoid arc. The net reaction force is comprised of ligamentous, muscular and other external forces put on the humeral head (figure 2). Additionally, the congruency of both the humeral head and the glenoid fossa provides the joint with proper stability, preventing the humeral head from dislocation. The direction of the net humeral joint reaction force is controlled actively by the elements of the rotator cuff and other shoulder muscles<sup>(49)</sup>.

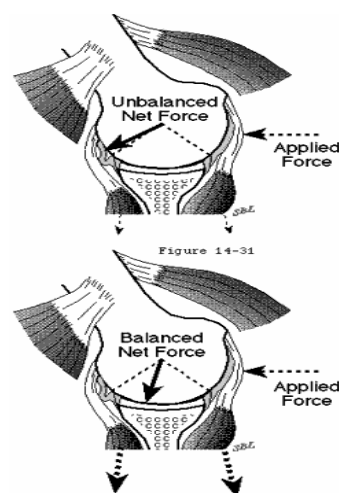


Fig. 2. Stabilisation against an applied translation force by repositioning the glenoid cavity to support the net humeral force

Surrounding and encapsulating the shoulder joint is the capsuloligamentous complex (CLC), which comprises the coracohumeral ligament, and the glenohumeral ligaments: superior, middle and inferior. Ligaments are dense connective tissue connecting joints. They are classified as static stabilisers or restraints that prevent the joint from becoming hypermobile. The shoulder-complex consists, as mentioned, of three parts. The most impressive is the inferior glenohumeral ligament (IGHL) due to its important role in restricting translation, which occurs both inferiorly, anteriorly and posteriorly, all during the movement of abduction<sup>(22,45)</sup>. In the event of excessive movement, the ligaments tighten, thus opposing the abnormal translation.

#### **1.4. Pathology**

Frequently, highly repetitive activity in the population participating on either a high level of sports, on casual or intermittent level, or by poorly conditioned individuals, are prone to develop shoulder injury. Shoulder pain is second only to knee injuries, as a source of significant impairment for performance. Whether pitching a baseball, throwing a football, swinging a racquet, or swimming, the shoulder is at risk to injury due to its biomechanical design<sup>(54)</sup>.

Having the basic knowledge about how the shoulder is built up, it is not difficult to grasp that the joint is rather complex to diagnose and treat once injury has occurred, even for the experienced physiotherapist. The mechanism of injury is often simple of nature, but there are times when there are far more peculiar incidents that need to be examined thoroughly and with a "steady hand". Any of the dynamic or static restraint mechanisms may be damaged by the throwing actions of the athlete, and considerable overlap of injuries might occur. Additionally, an untreated or unrecognised injury may progress to further injuries <sup>(2)</sup>.

Establishing a proper and correct diagnosis based on the information obtained from the patient, and results gained from the examination, is unfortunately not always straightforward. Many underlying structures can from time to time present with similar symptoms, which may create confusion. It is imperative that the physiotherapist knows the basic pathophysiology, anatomy and biomechanics, which is the key to a successful rehabilitation <sup>(22)</sup>.

The two most common pathologies when dealing with the shoulder are glenohumeral instability and rotator cuff tendinopathy, the latter also known as impingement syndrome. They seldom occur alone; on the contrary they follow one another, especially in the overhead athlete. Several different mechanism of rotator cuff injury is presently recognised. These can be divided into acute traumatic<sup>9</sup> injuries and the more common repetitive overuse<sup>10</sup> injuries seen in overhead activities <sup>(54)</sup>.

Acute macrotraumatic rotator cuff injury, although uncommon, can result in partial- and full-thickness tears from a direct contact injury to the shoulder in patients under 40 years of age. In addition, partial and complete tears of the rotator cuff can occur with traumatic anterior instability of the glenohumeral joint in the over 40 population; rupture of the subscapularis should especially be considered among these patients. Non-injurious, repetitive shoulder activity requires proper activation and balance of eccentrically and concentrically contracting agonist<sup>11</sup> "antagonist"<sup>12</sup> muscle groups; the proper athletic technique; the recruitment of muscles of the trunk, abdomen and extremities: and, importantly, appropriate warm-up stretching exercises.

#### 1.4.1 Rotator Cuff Pathology

The rotator cuff is susceptible to many problems that can cause weakness, tenderness and pain. Problems include overuse tendinitis, which can be caused by certain activities, especially overhead activities, such as throwing, swimming, or tennis. If the space between the rotator cuff and the acromion is narrowed, the rotator cuff tendons and the overlaying bursa are prone to become compressed. This can eventually lead to bursitis and/or tendinitis, which is termed impingement. Arm elevation in some component of forward flexion, compressing the supraspinatus, often provokes pain. Not surprisingly, overhead athletes such as swimmers and those participating in racket- and throwing sports may develop shoulder pain that can be attributed most commonly to shoulder impingement. Compression of the infraspinatus, or the long head of the biceps tendon, with the greater tubercle and the anterior third of the acromion, seldom occurs. This also goes for the coracoacromial ligament or other adjacent osseous structures such as the clavicle, coracoid, or acromioclavicular joint <sup>(54)</sup>.

Occasionally, a calcium deposit may be formed in the rotator cuff causing acute inflammation of the tendon and bursa. We call this calcific tendinitis. Rotator cuff tendons are, not to forget, susceptible

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<sup>9</sup> Macrotrauma

<sup>10</sup> Microtrauma

<sup>11</sup> Prime mover of a muscle initiating a specific movement, producing the greatest force

<sup>12</sup> Muscles that reverse or oppose a specific movement



to the process of ageing. As we get older, the tendons degenerate and weaken. Microvascular injection studies of rotator cuff in human cadavers of all ages have demonstrated an undervascularized zone within the supraspinatus tendon just proximal to its humeral insertion. Since most degenerative tears occur in this hypovascular region of the supraspinatus, it is assumed that this localised relative ischemia, combined with ageing, plays a role in the pathogenesis of rotator cuff tears. A rotator cuff tear can occur due to this degeneration alone, or when the weakened tendons are stressed during activities or accidents <sup>(1, 54, 62)</sup>.

The history of rotator cuff lesions is classically described as a progressive, degenerative process ultimately resulting in tissue failure. Without proper intervention, impingement syndrome may progress, resulting in small rotator cuff tears that contribute to reflex inhibition of rotator cuff muscle contraction. This results in an imbalance in the force couple mechanism with the prevailing influence of the contracting deltoid contributing to further impingement <sup>(22)</sup>.

#### 1.4.2 Classification of rotator cuff pathology

There are several different classification schemes of rotator cuff pathologies to find in the literature, which can be applied to the athlete. One macrotraumatic and four microtraumatic mechanisms of rotator cuff injury have been described and several may occur simultaneously in the same patient.

##### Primary impingement or primary compressive

The first is the classic impingement injury, now called primary impingement/primary compressive. A compressive lesion exists when the rotator cuff is truly impinged by the coracoacromial arch. Repetitive overhead activity results in impingement of the supraspinatus against the anterior, inferior aspect of the acromion, and/or the coracoacromial ligament <sup>(22)</sup>.

The shape of the anterior slope of the acromion has been implicated in the development of primary impingement. Three distinct shapes have been described on the basis of a Y view or lateral radiograph of the scapula. As outlined in figure 3, type 1 is a flat acromion, type 2 is curved, and type 3 is hooked. Although the cause-effect relationship between acromial shape and rotator cuff disorders are unclear, the occurrence of a full-thickness tear appears to correlate closely with a type 2 and especially type 3 acromion. With repetitive impingement comes the second stage of fibrosis and tendinitis; the subacromial bursa becomes fibrotic and thickened, and the supraspinatus tendon becomes further inflamed. The third stage can be a partial, usually bursal side, or a complete tear of the rotator cuff, with bony changes like spurring of the anterior acromion.

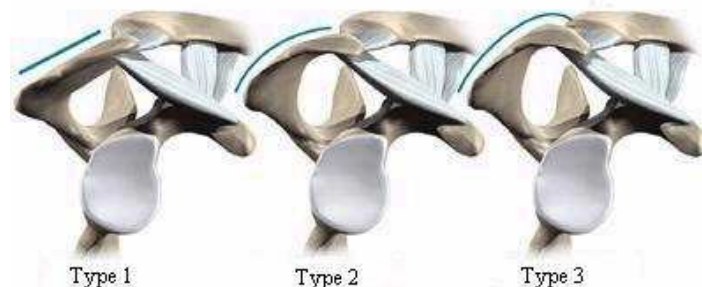


Fig. 3 Three different types of acromion

### Secondary impingement or secondary compressive

The second microtraumatic mechanism is secondary impingement. Individuals who have shoulder instability as a result of congenital laxity, repetitive microtrauma, or macrotrauma, due to participation in overhead sports, place increased demands on the rotator cuff as it attempts to keep the humeral head centred in the glenoid. Fatigue, intrinsic injury such as tendinitis, and a partial undersurface tear of the cuff may ensue. If the rotator cuff continues to fatigue, it may no longer centre the humeral head in the glenoid, and dynamic cephalad<sup>13</sup> migration of the humeral head in the glenoid occurs, resulting in secondary impingement of the rotator cuff under the subacromial arch. Secondary compression results from abnormal humeral head translation due to instability or to glenohumeral or scapulothoracic muscle weakness<sup>(22,62)</sup>.

### Tensile failure

A third mechanism of microtrauma to the rotator cuff is tensile failure with throwing. The throwing motion has been divided into five phases: wind-up, early cocking, late cocking, acceleration, and follow-through. The supraspinatus, infraspinatus, and teres minor muscles begin to fire at the end of early cocking phase and become inactive at the end of late cocking as the shoulder has achieved maximum external rotation. The subscapularis subsequently fires in late cocking phase to decelerate the shoulder's external rotation. However, it is during follow-through when all the rotator cuff muscles fire most intensively. As the subscapularis internally rotates the shoulder, the remaining rotator cuff muscles are contracting eccentrically to decelerate the arm. During this repetitive eccentric loading, the rotator cuff is prone to overload, fatigue, tendinitis, and even a partial undersurface tear. Again as the rotator cuff fatigues, dynamic cephalad migration of the humeral head can occur, resulting in secondary impingement of the rotator cuff under the subacromial arch<sup>(62)</sup>.

### Primary tensile/secondary tensile

Tensile lesions are microtraumatic and accumulative in nature. A tensile lesion is essentially a rotator cuff tendon disruption due to overload, most often associated with eccentric activity as found during the deceleration phase of throwing. Literature stresses that the intimate relationship between the capsuloligamentous complex and rotator cuff is not only anatomical but also functional. Balance is necessary for symptom-free overhead motion; therefore compromise to either the static or dynamic components will have a negative impact on the other<sup>(22)</sup>.

### Internal or posterior superior glenoid impingement

The fourth and final mechanism of microtrauma is internal or posterior superior impingement. This occurs with repetitive overhead activities, particularly in throwers, when the arm is abducted 90° and maximally externally rotated. In this position, the posterior inferior aspect of the supraspinatus is impinged between the greater tuberosity of the humeral head and the posterior superior labrum, producing fraying of the posterosuperior labrum and an undersurface tear of the posterior aspect of the supraspinatus. Additionally, in this position increased stress is posed on the anterior inferior capsule that may be associated with internal impingement and glenohumeral instability.

### Macrotraumatic failure

This mechanism of tendon failure results from a single incidence, or, in the young athlete, from repetitive microtrauma displayed by a single event<sup>(22)</sup>.

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<sup>13</sup> Downwards

### 1.4.3 Clinical Presentation

The symptoms of rotator cuff injury caused by both micro- and macrotraumatic mechanisms include pain, weakness, and limitation of active motion. Pain tends to be located to the anterior, superior, and lateral aspects of the shoulder. On the one hand, patients with acute inflammation of the rotator cuff have intermittent mild pain with overhead activities. On the other, those presenting with chronic inflammation of the rotator cuff have persistent, moderate pain with overhead activities; there may be pain at rest, but considerably less than with overhead activities. Patients with partial and full-thickness rotator cuff tears, have persistent pain at rest that is often referred to the deltoid insertion. Those with complete tears typically have night pain. The symptoms of weakness and limitation of active motion may be the result of pain or a rotator cuff tear.

Physical examination will usually demonstrate tenderness in the subacromial space. Atrophy<sup>14</sup> may be apparent in the supraspinatus or infraspinatus fossa of patients with full-thickness tears.<sup>(62)</sup> Patients with secondary impingement often present a history with anterior shoulder pain that increases with progressive activity and is associated with a particular phase of throwing or overhead activity. As the rotator cuff lesion progresses the athlete may also suffer from pain at rest or during the night. According to the progression of symptoms, Jobe (1996, 1997) has defined three stages of glenoid postero-superior impingement, as seen in table 1.

Stage of impingement	Recognised by:
Stage 1	Stiffness and slow warm-up
Stage 2	Posterior pain and positive relocation test
Stage 3	Posterior pain and positive relocation test with additional failure of rehabilitation programme

Table 1. Classification according to Jobe

He states that one should be able to identify and treat patients with glenoid impingement even before the onset of pain<sup>(5)</sup>. This means that the attentive patient should be able to start rehabilitation already at the first stage of the classification.

In addition, Neer<sup>(54)</sup> has classified the impingement syndrome into three stages, but his classification is based on rotator cuff tendon and coracoacromial arch pathology, depicted in table 2.

Stage	Recognised by
Stage 1	Oedema and haemorrhage of the rotator cuff
Stage 2	Reactive hyperaemia <sup>15</sup> and thickening of the subacromial bursa and rotator cuff
Stage 3	Rotator cuff degeneration, with possible presence of tears in the tendon and bony changes involving the acromion

Table 2. Classification according to Neer

### 1.5 Shoulder Instability

Shoulder instability in the competitive athlete is a relatively common problem. The aetiology of glenohumeral instability that can affect the athlete runs a wide spectrum, from an isolated traumatic dislocation to repeated microtrauma or congenital laxity. Although many athletes are able to adapt to a mild laxity that might occasionally develop, repeated dislocation or subluxation episodes can interfere with the process of adaptation, and return to sport can be problematic<sup>(38)</sup>.

<sup>14</sup> Decrease in size of tissue or an organ due to loss of adequate stimulation

<sup>15</sup> Increased blood in an organ or other bodypart

The term shoulder instability constitutes a wide range of disorders that includes dislocation, subluxation, and laxity. Instability can be defined as any structural or functional deficits in the shoulder leading to pathologic motion in the shoulder joint: pathologic translation, also called laxity, hyperangulation, or excessive rotation. Translation, rolling and the rotation of the humeral head determine the motion of the glenohumeral joint <sup>(5)</sup>. Pathological motion is either an increased or decreased movement, where increased translation is called laxity. A combination of increased rotation and rolling is also referred to as hyperangulation.

Functional instability can be defined as activity related symptoms with or without clinically detectable shoulder laxity. Another term used is silent instability, because it is often difficult to detect by ordinary tests. It is now thought that functional instability in the shoulder may lead to a vicious cycle involving micro-trauma and attenuation of the capsular complex, and may eventually lead to shoulder pain. Changes in shoulder proprioception can be related to different pathologic changes in the shoulder, and sensory motor control may be an important factor for functional stability in the shoulder <sup>(5)</sup>.

Most throwers exhibit significant laxity of the glenohumeral joint, which permits excessive range of motion. The hypermobility of the thrower's shoulder has been referred to as "thrower's laxity". The laxity of the anterior and inferior glenohumeral joint capsule may be appreciated by the clinician during the stability assessment of the overhead thrower's shoulder joint. Some clinicians have reported that the excessive laxity exhibited by the thrower, is the result of repetitive throwing and they have referred to this as "acquired laxity", while others have documented that the overhead thrower exhibit congenital laxity <sup>(59)</sup>.

The diagnosis of anterior instability, which also can provoke nerve injury, is the most common form of instability. Along with posterior and multidirectional instability, the underlying pathology can be affirmed on a thorough history and physical examination that includes specific provocative manoeuvres.

Laxity is defined as a partial loss of glenohumeral articulation, and the patients are asymptomatic <sup>(35)</sup>. Subluxation, as with luxation, is defined as partial loss of glenohumeral articulation to the degree that symptoms are produced. It is caused by repetitive trauma. Dislocation is defined as a complete loss of humeral articulation with the glenoid fossa as a result from an acute trauma. Subluxation or dislocation can occur with nearly all sports-activities.

An acute traumatic dislocation to a throwing athlete's dominant shoulder can be devastating. The injury may include a Bankart lesion, rotator cuff muscle tear, labral tear, or even injury to the brachial plexus muscle <sup>(60)</sup>. Typically there are two groups of instability patients, designated by the abbreviations **TUBS** and **AMBRI**:

- |                   |                                   |
|-------------------|-----------------------------------|
| -Traumatic        | -Atraumatic                       |
| -Unilateral       | -Multidirectional                 |
| -Bankart lesion   | -Bilateral                        |
| -Surgery required | -Rehabilitation effective         |
|                   | -Inferior capsular shift required |

Overlaps of these two groups are seen when an individual with generalised ligamentous laxity experiences a traumatic instability episode that results in deformation of the capsuloligamentous complex (CLC) and possibly a labral detachment. Injuries of this type can be very difficult to manage through conservative means due to significant compromise of the static stabilisers. Another group of patients develops instability by repetitive end-range microtraumatic stretching of the CLC,

which eventually results in laxity of the capsule and ligaments as well as labral deterioration. Individuals within this group commonly develop secondary rotator cuff impingement.

### 1.5.1 Primary instability and secondary impingement

The shoulder is subject to great strains during the generation and release of kinetic energy during pitching. In susceptible shoulders, the static stabilisers including the labrum and capsular ligaments struggle to contain the torque placed on the shoulder. As a result, the humeral head translates, stretching the capsule and, frequently abrading the labrum. This process of shearing begins as a subtle microscope measurement and may increase until frank instability occurs. If the static stabilisers are injured, the rotator cuff must use additional tension to control and limit translation. Fatigue due to eccentric overload complicates the thrower's shoulder, resulting in secondary impingement <sup>(1)</sup>.

A relationship exists between shoulder instability and rotator cuff impingement. As the static stabilisers are stretched, increased translation occurs in the glenohumeral joint. The rotator cuff fatigues while attempting to limit translation and tendinitis results <sup>(1)</sup>.

Tensile changes are noted as fibres that fail to function properly underneath the cuff. During arm elevation and rotation, the rotator cuff can no longer control the humeral head, and anterior-superior head migration occurs. Further, breakdown in muscular control reduces scapular rotation, permitting the acromion to limit forward flexion. The impingement syndrome, once believed to be common, is now recognised as a secondary process.

Secondary impingement occurs mostly in athletes under 35 years of age with overhead activity as seen in throwing sports, racket sports, gymnastics, and swimming. The incidence and prevalence seem related to the individual sports, as shown in table 3 <sup>(5,71)</sup>.

Sport	What	Incidence	Type of trauma
Volley ball	Overuse, repetitive movement	8-20%	Microtrauma
Swimming	Long term overuse, repetitive microtrauma	10% in 13-14 year olds 13% in 15-16 year olds 26% in elite swimmers	Microtrauma
Racket sports	Instability, chronic pain with secondary impingement		Traumatic
Baseball	26%: fractures, 37%: contusions and abrasions Remaining percent include strains, sprains, contusions and internal injuries.	9.51 per 1000 slides 4.87 per 1000 game exposures	Traumatic
Sport related injuries are estimated to be 62%			

Table 3. Incidence and prevalence of impingement in different sports.

In general, patients under the age of 25 at the time of the initial episode have a recurrence rate that ranges from 60% to 90%. On the other hand, patients past the age of 45 years old have a recurrence rate of less than 15% <sup>(39)</sup>.

Most skilful throwers show significant hyperelasticity of their anterior glenohumeral joint capsule, which allows excessive external rotation and proper throwing mechanics. Because of the repetitive microtraumatic forces of throwing, the hyperelasticity may progress to primary instability and associated lesions and complaints. In the overhead thrower, this is not uncommon to see. Most athletes with positive signs of anterior impingement were until a few years ago believed to have primary impingement. It is now known that symptomatic throwing athletes often have a primary instability of the shoulder with secondary impingement. Anterior acromiopathy with excision of the coracoacromial ligament in such individuals, which may actually increase shoulder instability and magnify symptoms <sup>(59)</sup>.

Anterior instability may develop after a high-energy trauma. In the throwing athlete however, it often starts as an overuse injury. Chronic overuse can stretch the static stabilisers of the shoulder, which results in instability. The scapular and rotator cuff muscles act out of synchrony with each other posing an increased stress on the rotator cuff to keep the head of the humerus in the centre of the glenoid. As the rotator cuff muscles weaken, the head subluxes anteriorly when the arm is abducted and externally rotated. This anterior subluxation causes a secondary impingement of the rotator cuff on the acromion and the coracoacromial ligaments <sup>(2)</sup>.

In the younger population the patient most prone to injury is the overhead athlete in whom repetitive throwing motions can result in repeated micro-traumata involving the stabilising mechanism of the glenohumeral joint. This minor instability can lead to anterior subluxation of the humeral head. Recurrent subluxation may then result in a secondary impingement phenomenon involving the rotator cuff and the long head of the biceps tendon. This continuum of progressive shoulder pathology has been termed "the instability complex".

### 1.5.2 Classification of shoulder instability

Shoulder instability, which often can be classified into three types, or categories, as explained in table 4.

Type of shoulder instability	History	Findings on physical examination
Anterior instability	<ul style="list-style-type: none"> <li>Usually occur in men in their early 20s</li> <li>Most common type of glenohumeral instability (85%-95% of all cases)</li> <li>Direction of force anterior on arm or posterior on shoulder</li> <li>"Dead arm" syndrome common (transient loss of sensation, a numbness and tingling in involved extremity)</li> <li>Often associated with acute injury but can be from overuse, such as baseball pitchers</li> </ul>	<ul style="list-style-type: none"> <li>Patient presents acutely with arm in abduction and internal rotation, perhaps palpable anterior mass</li> <li>Axillary nerve injuries can occur</li> <li>Drawer and load-and-shift tests result in anterior displacement and popping</li> <li>Apprehension and relocation tests positive</li> </ul>
Posterior instability	<ul style="list-style-type: none"> <li>More commonly associated with seizure or severe electrical shock</li> <li>Offensive linemen vulnerable to repetitive subluxation</li> <li>Subluxation occurs when arm is in a forward-flexed, adducted and internally rotated position</li> <li>Posterior shoulder pain with activity</li> </ul>	<ul style="list-style-type: none"> <li>Patient presents with arm externally rotated and a prominent humeral head on the posterior shoulder</li> <li>Missed clinically in 50% of cases (standard shoulder radiographs do not demonstrate posterior displacement)</li> <li>Posterior joint line tenderness on palpation</li> <li>Posterior rotator cuff weakness</li> <li>Drawer and load-and-shift tests result in posterior displacement and popping</li> <li>Apprehension and relocation tests negative</li> </ul>
Multidirectional instability	<ul style="list-style-type: none"> <li>Most commonly occurs in athletes with congenital hyperlaxity of multiple joints in sports requiring overhead arm motions</li> <li>Usually vague symptoms with activity</li> <li>Can result from pre-existing shoulder injury, and may predispose to impingement</li> </ul>	<ul style="list-style-type: none"> <li>Evidence of generalized ligamentous laxity</li> <li>Usually rotator cuff weakness is present</li> <li>Drawer and load-and-shift tests result in anterior and posterior planes of displacement without popping</li> <li>Positive sulcus test is pathognomonic</li> </ul>

Table 4. Types of instability related to the shoulder joint.

### 1.6 Biomechanical factors

The shoulder joint is often injured in the throwing athlete due to its greater range of movement than any other joint in the body, and because its stability depends upon intact muscles and ligaments rather than supporting bony structures. Static limits of glenohumeral motion for all activities are imposed by the geometry of the articular components of the cavity as well as the soft tissue envelope. The extremes of motion achieved during the normal throwing motion put all of these structures at risk. Additionally, the speed with which the action occurs, results in the extreme use of the dynamic stabilising structures, increasing the vulnerability to injury <sup>(2)</sup>.

The overhead throwing motion is an extremely skilful and intricate movement on the shoulder joint complex. With the overhead throw placing extraordinary demands on the shoulder complex, there is required a precise and co-ordinated effort to create velocity and accuracy. In this event, excessively

high stress is applied to the shoulder joint because of the tremendous forces generated by the thrower<sup>(1, 59)</sup>.

The thrower's shoulder must be lax enough to allow excessive external rotation, but stable enough to prevent symptomatic humeral head subluxations, thus requiring a delicate balance between mobility and functional stability. This is referred to as "the thrower's paradox"<sup>(59)</sup>.

Muscles used and the movements performed are similar in both overarm throw and striking skills. When these skills are repeated forcefully a number of times, such as in baseball pitching or serve in tennis, the stress that these muscles undergo, frequently result in overuse-type injuries. Recent research in anatomy and kinesiology has greatly influenced the general understanding of shoulder injuries. Problems in throwers include rotator cuff tendinitis due to overuse and eccentric overload, subtle instabilities, labral degenerative changes and tears, and secondary subacromial and parascapular problems<sup>(1, 22)</sup>.

Although overuse of the throwing shoulder might contribute significantly to injury, many difficulties begin with improper mechanism and poor conditioning. Coaches, trainers, and physicians have attempted to identify potential problems in throwers to avoid or delay career-ending injuries. Pitchers are made aware of strain and overuse to avoid serious injury. Pitching mechanism can lead to injury, the starting point being the foot plant. Hyperextension of the knee whilst planting the striding leg by landing on the heel, may cause a sudden deceleration of the body, which results in undue counter-force on the throwing arm. Such a manoeuvre is often seen in pitchers who are "overthrowing", hence trying to get more velocity on their fastballs. The planted foot should always point toward home plate; placing the striding foot outside the target and wide to the torso results in "opening up too soon". In this instance, pelvic rotation occurs too early, creating increased stress across the anterior shoulder and elbow. Planting the foot toward the third-base side of home plate slows down rotation of the torso, taking from the body's momentum and forcing the throw to be delivered entirely by the arm. The throwing motion should be a smooth acceleration and deceleration of the centre of gravity toward the target. This fluid motion should be maintained regardless of the type and velocity of pitch being thrown<sup>(1, 2)</sup>.

### 1.6.1 Throwing Motion

Throwing with improper or faulty mechanics can lead to shoulder pain or injury, or both, caused by abnormal stresses that are applied across various tissues. To determine whether the thrower exhibits improper throwing mechanics, the clinician should carefully observe how the athlete is throwing. When evaluating an athlete's throwing mechanics, one commonly looks at several different aspects of the movement. The baseball pitch has been studied extensively, both in the clinical setting and in the laboratory. The clinician can use a video recorder to film the thrower and analyse the biomechanics during slow-motion playback to pinpoint improper mechanics. Filming should be performed from multiple angles, including lateral, posterior, and anterior views, to accurately assess the athlete. Normally, analysis of several aspects of the throwing motion is done in sequential order to detect subtle pathomechanical deviations through the phases of throwing<sup>(40, 59)</sup>.



### 1.6.2 Analysis of Sport Skills using the Kinetic Link Principle

To propel a ball with velocity and accuracy, the thrower must generate kinetic energy. Utilising muscles in the lower extremities and torso, energy can be generated and released through the throwing motion. After the ball is released, the retained energy must be dissipated. Improper transfer of energy can lead to injury in the shoulder. If the generation of kinetic energy is done improperly, the muscular source will be highly exposed, and the final outcome will most probably end in fatigue overuse injuries. Following ball release, if the energy is not properly dissipated, tissue injury can result. The biomechanics of a correctly thrown ball protect the thrower from injury<sup>(40)</sup>. The kinetic link principle applies to numerous skills. An application of the kinetic link concept may serve the following purposes for the teacher or coach:

- Understand and analyse a particular skill.
- Help recognise performance ability levels.
- Help gain a basic understanding of the similarities and differences of skills that use the same general movement pattern.
- Gain a better understanding of the developmental patterns that are used by children as they progress through stages of learning to a mature form of a movement pattern.

Six phases are differentiated in the overhead throwing motion. Delineation between the phases is determined by changes in forces and muscle firing that occurs during the cycle. From a mechanical perspective, the goal of the motion is to sequentially develop a package of potential energy that is further converted to kinetic energy that can be imparted to the ball in an efficient and fluid manner. Rotational energy is created by a combination of upper extremity motion with the body turn and thrust forward motion of the torso. As the body assumes a greater role in generating rotational energy, the more susceptible structures can be reserved, increasing the longevity of the thrower's career. The phases of throwing have been described to help coaches and physicians communicate about different aspect of the mechanics of throwing<sup>(40)</sup>.

#### Phase 1

The wind-up, or preparatory phase, is the preparing phase during which the body's overall centre of gravity is raised with minimal stress transmitted to the shoulder. By drawing back on one leg and turning sideways, the pitcher creates potential energy with the highest possible centre of gravity. At the end of this phase, the shoulder is in minimal internal rotation and slight abduction, with minimal muscular activity<sup>(1, 40)</sup>.

#### Phase 2

Early cocking, which is a phase with minimal load, moves the shoulder into 90° of abduction and 15° of horizontal abduction. Cocking permits proper body and arm positioning. By positioning the contralateral arm and leg up and out, the lower body turn can begin to generate momentum. Early activation of the deltoid muscle and late activation of the muscles supraspinatus, infraspinatus, and teres minor, mark the initiation of this phase<sup>(1, 40)</sup>.

#### Phase 3

Late cocking begins with the planting of the striding length and ends with the shoulder in a position of maximal external rotation, 170°-180°. Once the forward leg strikes the ground, the hips are planted, and the remaining turn and acceleration occur in the upper part of the body<sup>(1, 40)</sup>. The scapula retracts to facilitate this position and form a stable base for the humeral head, from which the next phase can begin. Shoulder abduction is maintained at 90° to 100°, and horizontal positioning moves to 15° of adduction. The combination of abduction and external rotation results in obligatory posterior translation of the humeral head on the glenoid. Deltoid muscle firing decreases,

and infraspinatus, supraspinatus, and teres minor muscle activity reaches its peak in the mid-portion of this phase. In the terminal part, subscapularis muscle firing is initiated as the torso begins to open up as it rotates forward. Biceps muscle activity is moderate, and increased firing of the pectoralis major, latissimus dorsi, and serratus anterior muscles mark the end of the phase. This creates a maximal horizontal adduction of 100 N·m and internal rotation torque of 70 N·m. Rotation of the torso results in a shear force across the anterior shoulder of 400 N, with the rotator cuff muscles firing generating a compressive force of 650 N.

#### Phase 4

Acceleration, the shoulder is rotated to the ball release point of 90° rotation, maintaining the shoulder abduction. The scapula begins to protract, maintaining a stable base for the humeral head as the body moves forward, allowing for the conversion of muscle function from eccentric to concentric anteriorly and from concentric to eccentric posteriorly. Quite remarkably, shoulder loads are minimal as the arm rotates internally at velocities greater than 7000 deg/sec. The body's momentum energy is converted into arm rotation. Ligamentous structures in the shoulder and elbow are placed under a great deal of stress as this energy transfer is completed. The triceps muscle has marked activity early and the pectoralis major, latissimus dorsi, and serratus anterior muscles have marked activity late. With horizontal adduction occurring to the neutral position, minimal posterior shear stresses (50 N) extend across the back of the shoulder. The humeral head re-centres as the capsule unwinds <sup>(1, 40)</sup>.

#### Phase 5

Deceleration, which is recognised as the most violent phase of the throwing cycle, is responsible for the dissipation of the remaining energy that is not imparted to the ball. Deceleration is an essential reversal of the first three phases of the throwing cycle. This phase begins at ball release and ends with the cessation of humeral rotation to 0°. Shoulder abduction is again maintained at 100° and horizontal adduction increases to 35°. A violent contraction of all muscle groups occurs, with eccentric contraction necessary to slow down arm rotation. Joint loads are at their greatest in this phase, with recorded posterior shear forces of 400 N, and compressive forces of greater than 1000 N. Adduction torque of greater than 80 N·m and horizontal abduction torque of nearly 100 N·m are generated.

#### Phase 6

The follow through-phase is a re-balancing phase where the body moves forward with the arms until motion stops. This phase has great potential for cumulative injury. In this phase energy must dissipate as the body weight continues to transfer into contralateral leg. Rapid internal rotation and abduction of the shoulder must be reduced to decelerate the arm. The rotator cuff and shoulder adductors are relied upon here <sup>(1,40)</sup>. Shoulder rotation drops to 30° as horizontal adduction increases to 60°, and abduction is maintained at a constant of 100°. Muscle firing returns to resting levels, and joint load decrease, but compressive forces can still be calculated at approximately 400 N, inferior shear at approximately 200 N, and anterior shear at approximately 75 N.

The entire throwing motion takes less than two seconds. The wind-up and cocking phases require approximately 1.5 seconds. The acceleration phase takes approximately 0.05 seconds and the deceleration and follow-through phases takes approximately 0.35 seconds. The thrower depends on the torso and lower extremities for appropriate transfer and absorption of energy <sup>(1, 40)</sup>.

The throwing motion involves a series of phases, where the dynamic and static restraints of the glenohumeral and scapulothoracic joints are stressed to their limits. Therefore, maintaining a balance of proper biomechanical forces is essential to avoiding injury. A basic understanding of the

phases and forces applied during each portion at the throwing cycle allows for an improved understanding of the mechanisms that result in the common profiles of injury. Few biomechanical differences do exist between the different types of pitches thrown. Increase in adduction strength and possible decrease in strength of external rotation may exist in the dominant arm of the thrower. These differences in strength characterise the alteration in strength ratios between the dominant and non-dominant arms.

Strengthening solely the muscles involved in the concentric portions of an overarm throw or strike will result in overuse-type injuries to the other surrounding structures. These considerations should be applied not only to baseball pitching but also to tennis, volleyball, badminton, weight throwing, swimming, and other sports involving other overhead activities <sup>(40)</sup>.

## 1.7 Nervous system

The nervous system is a fine, delicate system that provides the human being with the ability to manage communication and controlling systems. The central nervous system (CNS) and the peripheral nervous system (PNS) make up the nervous system. Both consist of neurones that react to electrical signals causing immediate response <sup>(56)</sup>. What is sensed and perceived by sensory receptors convey afferent impulses towards the integration centre of the brain, which in turn provides motor output, efferent signals, to the periphery (figure 4).

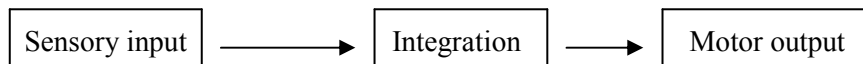


Fig. 4 Function of the nervous system adapted from Lephart <sup>(30)</sup>

The CNS and the PNS are closely related; the one can not function properly without the other. Afferent impulses are conveyed according to what is sensed in the periphery towards the higher level of the CNS, and efferent impulses are mediated from the CNS after having interpreted and integrated incoming information (figure 5) <sup>(56)</sup>.

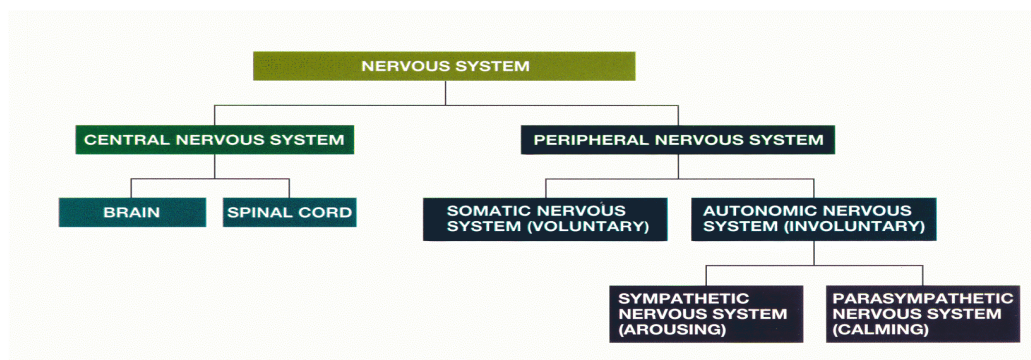


Fig.5 Structure of the nervous system <sup>(13)</sup>

Signals that are transferred by mechanoreceptors ascend through afferent tracts located dorsally within the spinal cord. There are mainly three tracts that are of importance, namely the posterior spinocerebellar tract, dorsal column pathway, and the anterolateral spinothalamic tract. The two latter provides the somatosensory cortex with information obtained from the mechanoreceptors and proprioceptors, while the spinocerebellar tract transmit impulses from the trunk and limb proprioceptors to the cerebellum. <sup>(56)</sup>.

How a sensory signal is interpreted and in which manner a motor response occurs, depends on the level in which the signal has been delivered. Roughly speaking there are three levels of importance when talking about motor response: the spinal level (segmental level), the brain stem level (projection level), and the cortical level (precommand level). They are arranged hierarchically, and interconnect with each other in a way that all sensory and motor modalities are maintained.

The spinal level is where spinal reflexes are produced. Unconsciously it activates muscles through the reflex pathway and the fine network of the many existing neurones.

The brain stem level regulates the spinal cord and integrates vestibular, visual, and somatosensory inputs. Due to its location, between the spinal and cortical level, modification of motor commands is one of its tasks. Processing information is done unconsciously<sup>(31)</sup>.

The cortical level consists of the motor cortex, basal ganglia and cerebellum. This is where commands for voluntary movements are issued, and it is where direct and indirect cortical control occurs<sup>(31)</sup>.

All movements that are carried out, thoughts and actions, reflect the nervous system's function and activity<sup>(13)</sup>. Normal shoulder function is dependent on an intact nervous system that receives and interprets signals properly to be able to detect changes that can be disruptive for adequate performance and functioning. The sensory information conveyed from the periphery originates through activity of mechanoreceptors, visual and vestibular<sup>16</sup> receptors. Inputs are conducted to the central nervous system (CNS) for appropriate perception in order to propagate motor responses allowing the shoulder to move or maintain its position.

### 1.7.1 Proprioception

When a person is standing on a balance board or performing push ups on an irregular surface, a number of sensory receptors are working hard to inform the brain about pressure, touch, and whereabouts in the environment. In this manner the integration centre in the brain is able to interpret what is going on, and at the same time keep the body stable at one place. Proprioception has been defined in various ways, and in 1906 Sherrington first described it to be "related to the senses of position and movement of limbs"<sup>(31)</sup>. It is a sensory modality that is sensing and interpreting changes in joint position and joint movement, involving afferent input from the skin, muscles and joints. Information obtained is conducted through the sensory motor system towards higher levels of the nervous system where it is processed to the three motor control areas; the spinal level, brain stem level, and cerebral cortex. Additionally, the associated areas, the cerebellum and basal ganglia, are alerted so that motor commands can be properly regulated<sup>(30,31)</sup>.

Proprioception is a collective term for four important mechanoreceptors, namely the Ruffini endings, Pacinian corpuscles, muscle spindles, and Golgi tendon organs. The Pacinian corpuscles react quickly to stimuli posed on them. Their discharge rate is decreased within milliseconds, transmitting sensation about joint motion. On the other side, Ruffini ending, Ruffini corpuscles and the Golgi tendon-like organs keep on firing, and their discharge rate does not decrease. They are known to notice stimuli at specific joint angles. Furthermore, there are muscle spindles that react to stimuli when a muscle is stretched. It responds by initiating a stretch reflex, and accompanies the other mechanoreceptors in providing afferent input about joint and limb position.

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<sup>16</sup> Source of information in preserving equilibrium

Any changes in the environment, internally or externally, the mechanoreceptors send off signals for the brain to interpret, and further convey output to the muscles. This is known as the neuromuscular control pathway (figure 6) <sup>(31)</sup>.

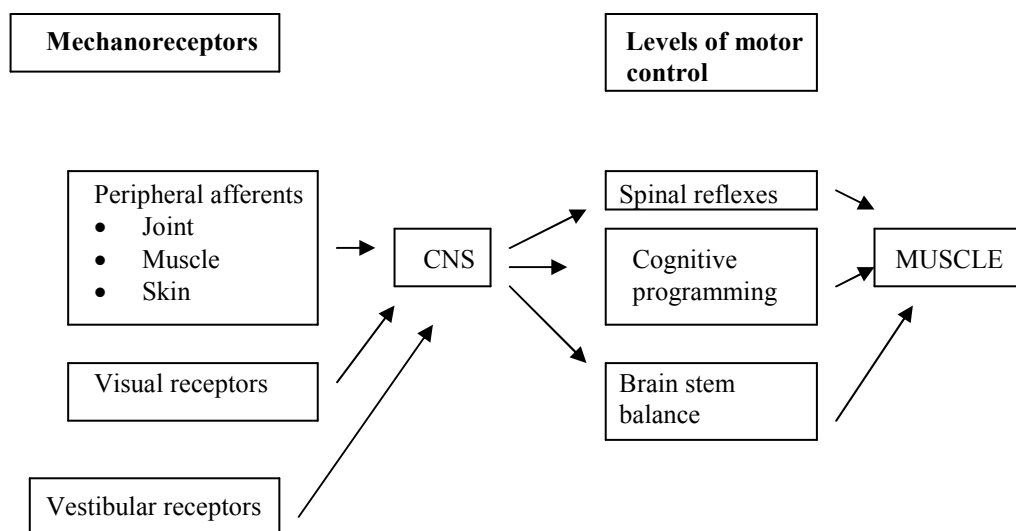


Fig. 6 Neuromuscular control pathway adapted from Lephart <sup>(30)</sup>

In a situation where the shoulder or another joint is injured, the role of proprioception is being compromised. There has been questioned whether proprioceptive deficits lead to injury, or if injury cause proprioceptive deficits. Nevertheless, when dynamic stability is challenged, position sense is altered and the risk of re-injury to occur becomes considerably higher. Mechanoreceptors are then inhibited and can not perform sufficiently, neuromuscular control decreases with the possible outcome of re-injury. Figure 7 shows how a vicious circle occurs if injury is not treated appropriately <sup>(14, 31)</sup>.

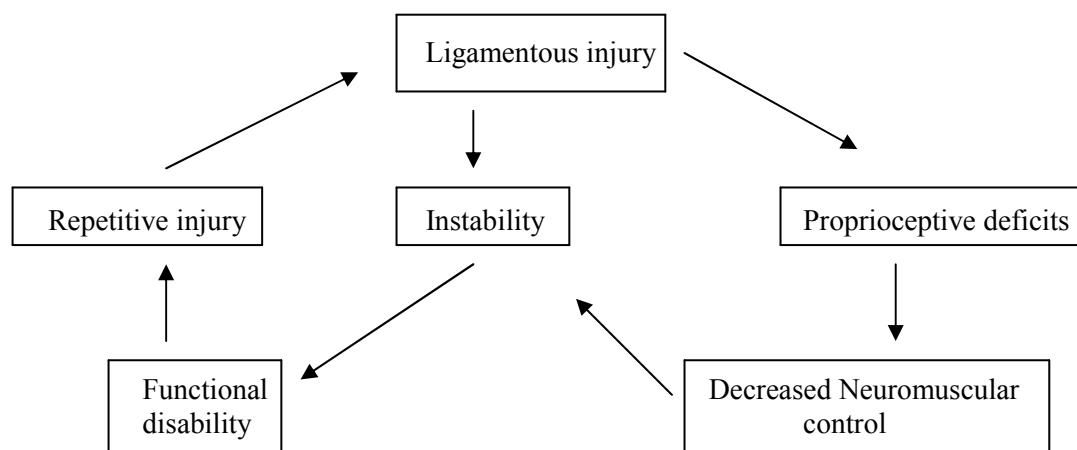


Fig. 7 Interaction between mechanical instability and decreased neuromuscular control; vicious circle of functional instability, adapted from Lephart MS <sup>(30)</sup>

It is easy, speaking of static stabilisers only as ligaments when addressing proprioception. Not to forget are the muscles surrounding the joint; they too are in possession of mechanoreceptors providing the neuromuscular system with important sensory information. Muscles have the ability to

fatigue, and when they do, the level of threshold to maintain muscular balance is decreased; thus the athlete is yet again predisposed to injury. Especially, in the overhead athlete, external and internal rotators are most susceptible to be damaged. This is reflected by the fact that sports involving the overhead motion requires extensively movement in external rotation to achieve high velocities enabling them to perform their utmost <sup>(14)</sup>.

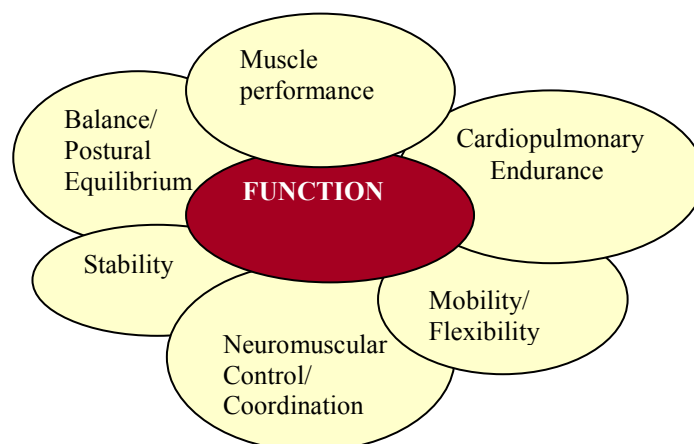
In a study done on female softball athletes, assessment and testing of proprioception was carried out to establish whether female softball athletes had decreased joint position sense in the dominant shoulder as opposed to the non-dominant one. They concluded that external rotation joint position sense was reduced in the overhand throwing athlete and that shoulder laxity and altered joint position-sense occur bilaterally <sup>(14)</sup>.

Rehabilitation of the injured shoulder involves a substantial re-training of proprioception and neuromuscular function. Sensation of joint movement needs to be addressed, re-establishing the altered afferent pathways. Additionally, the three levels of motor control previously mentioned, have to be carefully integrated with the aim to facilitate and obtain a greater neuromuscular control.

### **1.8 Exercise Therapy**

Exercise therapy is a frequently used intervention in the physiotherapeutic setting. Exercise in it self can be interpreted as exertion of the body for the purpose of developing and maintaining physical fitness by regularly or repeatedly use of a body part <sup>(63)</sup>. Exercise therapy or therapeutic exercise is characterised by movements performed by the patient or the physiotherapist, with an underlying medical purpose. Deliberate and planned execution of physical movements, postures or activities aim at preventing impairments, improve and re-establish function, thus reducing the health risk factors and optimise a long term sense of well being <sup>(53)</sup>.

Physical function is a wide aspect that needs to be appreciated for the individual patient. The ability to perform and function in daily life depends on several factors that interact with each other (figure 8). Should one of these factors be impaired, in one way or another, it is likely that the degree of function will subside and initiate a negative response on the person's level of performance <sup>(28)</sup>.



*Fig.8 Interaction of factors important for performance and daily living <sup>(28)</sup>*

Interventions that are used in a therapeutic setting are applied with the ultimate goal of reducing and correcting functional impairments. Modalities such as mobility, strength, stability, range of motion, co-ordination, and neuromuscular function are frequently applied and evaluated for their significance in the treatment programme. Furthermore, performing activity specific tasks in the patient's functional environment should be encouraged. A combination of the two aforementioned assignments could reinforce the effect and outcome of treatment, and all together achieve an overall higher quality<sup>(28)</sup>.

Within the field of therapeutic exercise, the physiotherapist will most likely be able to achieve positive progression if therapeutic variables are applied. Variables are means that are employed to modify and adjust type of exercises done in order to vary the manner of performing the activity. Additionally, the form in which the type exercises are done present the performer with challenging assignments which demands a great deal from the patient. A list of variables and forms of performance is shown in table 5<sup>(53)</sup>.

Variable	Form
Extremity chain	Open/closed chain
Load	Little/much support
Tempo changes	Low/high
Stabilisation form	Static/dynamic
Attention	Large, low, stable/small, high, moving
Visual control	Conscious/unconscious
Resistance level	Eyes open/eyes closed
Resistance type	Close to joint/far from joint
Direction	Firm/light
	Acceleration/deceleration
Initial position	
Motion direction	
Motion velocity	
Duration of maintaining final position	
Number of repetitions	
Grip	

Table 5. Therapeutic variables for stability and mobility<sup>(53)</sup>

Treatment outcome is mostly based on the intervention strategies chosen for the individual patient. Setting accurate parameters such as intensity, frequency, and duration depends on at which stage the treatment is and how the patient copes with the adjustments. Evaluating the patient's response to change of interventions is a way to keep an overview if progress is made or not, and implement changes if necessary to obtain desired results<sup>(28, 57)</sup>. Measuring the postulated outcomes is another part of the evaluating process to gain information concerning progression of the treatment. In other words, the composition of the plan need to be measurable and the changes in patient status over time has to be noted for the treatment to be as effective as possible.

Movements within the exercise therapy setting are done either actively, actively assisted, or passively, and there is a clear distinction between the three. Active movements are undertaken solely by the patient, active assisted movements are accomplished both by the patient and the therapist together as the therapist is guiding the movement through its path, while passive are brought about by the therapist without having the patient doing any movement. Depending on the patient's complaint(s), degree of function, and amount of pain, the physiotherapist determines what type of intervention is the best to apply in the given situation<sup>(53)</sup>.

## **1.9 Physical examination and testing**

Examination is a necessary measure to perform in the event of being able to detect the underlying mechanism of injury and structures involved. Being able to establish an accurate diagnosis is the foundation for successful treatment. When examining the overhead athlete, past history of treatment or prior shoulder problems are of importance. These points of attention can provide the physician with useful information and ease the framework on which steps to take during the examination. This report will not go in depth of each step of the examination process, but will provide basic insight into some special tests that are found to be of value when examining the injured shoulder in the overhead athlete <sup>(41, 34)</sup>.

### **Tests performed for laxity**

**Drawer test:** Patient is sitting while the physiotherapist pushes the humeral head against the glenoid fossa, and then moving it anteriorly and posteriorly. Positive if an anterior displacement of the joint occurs.

**Sulcus test:** Patient is sitting while the physiotherapist performs caudal traction to the humerus, attempting to displace it inferiorly. Observe and feel for a sulcus to appear. If positive, multidirectional instability is present.

Grading of the test by measuring the distance from the inferior margin of the acromion to the humeral head. Distance less than 1cm is graded 1+, 1-2cm is graded 2+, and greater than 2cm are graded 3+.

**Push-pull test:** Patient is lying supine with the arm 90° abducted and elbow flexed at 90°. The physiotherapist applies posterior pressure to the proximal humerus causing the humeral head to translate posteriorly from within the glenoid fossa. The test is positive for posterior laxity if humerus translates more than one centimetre.

### **Tests performed for stability**

**Fulcrum test:** Patient is lying supine with the arm 90° abducted. The physiotherapist places one hand under the glenohumeral joint while carefully extending and externally rotates the patient's arm. The arm is held in this position about one minute, which will fatigue the subscapularis. The test is positive for anterior instability if the patient becomes apprehensive which is a normal reaction.

**Crank/Apprehension test:** Patient is sitting with the arm held in 90° of abduction and external rotation. Using one hand, the physiotherapist pulls back the patient's arm by the wrist, while with the other fixating the back of the shoulder. During this test the patient presenting with anterior instability will become apprehensive. Sensitivity is measured to be high with 91% and specificity measures to 93% <sup>(15)</sup>.

**Jerk test:** Patient is sitting with the arm in internal rotation and forward flexion to 90°. The physiotherapist holds at the patient's elbow and axially loads the humerus in proximal rotation. At the same time, the arm is moved horizontally across the body. The test is positive if a sudden jerk occurs as the humeral head slides off the back of the glenoid.



### Tests performed for impingement

Neer's sign: Patient is standing, actively pronating the arm. The physiotherapist passively places the arm in forced flexion while fixating the scapula to prevent scapulothoracic motion. If pain occurs, it is positive for subacromial impingement.

Hawkins test: Patients is standing. The physiotherapist elevates the arm to 90°, then internally rotates the shoulder. Subacromial impingement or rotator cuff tendinitis is likely to cause the pain experienced with this manoeuvre.

### Tests for impingement

Neer Impingement test: Patient is sitting and the physiotherapist passively elevates the arm at an angle between flexion and abduction. Overpressure is applied while the glenohumeral joint is in a position of neutral, internal rotation and then external rotation. According to the literature, the sensitivity of the test is presumed to be of 93% in confirming impingement <sup>(15)</sup>.

Hawkins-Kennedy Impingement test: Patient is sitting with the physiotherapist passively flexing the arm up to 90°. With the elbow stabilised, the arm is forced into internal rotation. There exists a slight inconsistency between literature when measuring sensitivity of the test. The range is from 62%-78% when testing for impingement. <sup>(15)</sup>

## **1.10 Measurement Tool**

As the athletic population is placing increased demands on effectiveness and efficiency of tailored made treatment programs when recovering from injuries, healthcare providers need to be able to measure and make adjustments to preserve the efficiency of the interventions at hand. The degree of disability should be quantified using functional assessment scales, to identify and evaluate the condition of the patient, which is in the interest of both the athlete and the professional in order to achieve pre-morbid level <sup>(44)</sup>.

A measurement tool is a diagnostic tool or device used to assess or measure performance, ability or the function of individual patients. It is important for the healthcare provider in identifying, quantifying standardising and judging the results attained through treatment <sup>(44)</sup>. Selecting a measurement tool will depend on the patient's complaints; not every device is appropriate in every clinical situation. Issues that need to be considered when choosing one device over another is whether it measures what it is intended to do. If there is evidence of validity, reliability, responsiveness of the tool, and finally, if there is a need for additional recourses to be able to assess it appropriately.

As mentioned previously, there are requirements that need to be paid attention to. Validity, reliability, and responsiveness are three qualities ensuring the physiotherapist about the nature of the tool. Additionally reproducibility and interpretability are also points that should be emphasised. Validity verifies that the test is measuring what it is supposed to measure. Reliability refers to what extent a measure is consistent and free from error, responsiveness describes an instrument's ability to detect useful change over time and reproducibility defines to what extent the tool is free from error. Finally, interpretability is defining how a person can assign qualitative meaning to quantitative scores <sup>(7, 23, 46)</sup>.

Functional outcome measures are not limited to only one device. Scales, questionnaires, and manual instruments are some examples of tools that can provide the clinician with important information. The patient's own perception of function can contribute to the clinical assessment that creates a broader spectre for the clinician to work with. An open dialogue between patient and practitioner is important if the already set goals are to be achieved, not merely based on the outcome of the measures done, but also how the patient feels regarding his/hers own health. Individual considerations have to be taken into account when evaluating the level of impairment and disability. One person may become frustrated when performance can not be reached, whilst others react more subtle. In this event, outcome measures will give valuable information regarding physical limitations and disabilities, which can contribute to the predictions concerning the progression of treatment. Literature mentions several tests used for measuring shoulder function. The most represented and discussed measurement tools are questionnaires appraising various issues. After evaluating and exploring outcomes of previous studies, there is a consensus that the general questionnaires have an important function in the overall evaluation of the shoulder in the average population. Specific outcome measures for the overhead athlete is not well defined, thus it is advisable to create a specific, functional measurement tool enabling the athlete, coach and therapist to measure functional status whenever needed <sup>(7, 23, 44)</sup>.

Not to forget is that every overhead sport has its own characteristics. On the one hand, playing baseball challenges the motion of abduction and external rotation of the shoulder with the following deceleration phase. On the other, a swimmer's shoulder is most vulnerable during the initiation phase of arm stroke when performing breaststroke.

Analysing the problematic movement(s), and identifying the functional problem(s) the athlete is presenting with, should be carried out at an early stage after injury has occurred. Choosing the proper measurement tool must be done with careful consideration due to the different tools that exists. Identifying the challenges at hand, the objectives and priorities pertaining to the injured athlete need to be identified in order to proceed easier with an established treatment strategy <sup>(17)</sup>.

In the actual event of measuring it is substantial to decide on how frequently there is a need to measure. Next, one should decide at what times it should be done, e.g. before, during or after competition. The intention is to provide the athlete, health care provider, and coach with meaningful and informative results that need to be processed and interpreted. Interpretation should consider measures done previously in order to understand the progression or decline in performance. Finally, long term re-measurements should be performed. Results obtained identify the changes achieved and reflect the outcome of the treatment.

There is no obvious answer to which tool to apply in the different sports. There exist several tools that include some of the same measurable items; hence focus should be on determining if the items are of relevancy for the particular person presenting with shoulder problems.

## 2. Method

### **2.1 Introduction**

This chapter describes the entire research process, in order to provide an answer to the main question of this systematic review.

To be able to answer this question, the following steps were done:

- 2.2 Developed a project plan
- 2.3 Formulated the main question
- 2.4 Locating and selecting studies
- 2.5 Collecting data
- 2.6 Quality assessment of the studies
- 2.7 Analysing presenting the results
- 2.8 Interpreting the results

### **2.2 Developing a project plan**

After having received the project proposal from our commissioner, consisting of a problem description and general administrative information (Appendix I), the development of the project plan (Appendix II) was the next step in the process. The plan describes the way in which this systematic review was to be carried out, by whom, the reason why it ought to be made, when it was going to be performed, what the end product would look like, and the estimated costs of the total project.

### **2.3 Formulating the main question**

The main question, □What is the best evidence based exercise treatment protocol for shoulder instability and rotator cuff injuries in athletes performing overhead activities, and what are the best measurement tool used to determine the athlete's present level? □In order to be able to answer this specifically, sub-questions were developed as follows:

- What can the systematic reviews tell us about the effect of a physiotherapeutic exercise treatment for athletes, with rotator cuff injuries and/or shoulder instability, performing overhead activities?
- Which treatment exercises have the best effect when choosing a treatment programme for athletes, with shoulder instability and rotator cuff injuries, performing overhead activities?
- What is the content of the evidence based exercise treatment protocol regarding therapeutic rationale, outcomes, progress build-up, and time lines for athletes, with shoulder instability and rotator cuff injuries, performing overhead activities?
- Which measurement tools are the most reliable and valid to determine the recovery of athletes with shoulder instability and rotator cuff injuries, performing overhead activities?

### **2.3.1 Type of design**

The types of studies of interest were systematic reviews, clinical controlled trials, and randomised controlled trials, and narrative reviews. According to the Cochrane handbook, systematic reviews, followed by randomised controlled trials, are the best type of studies to evaluate the therapeutic effects obtained in individuals. Succeeding are clinical control trials, then non-experimental studies, and lastly are expert opinions or ideas inferred from basic science. Narrative reviews, which are of non-experimental type of studies, were included in this systematic review as sources of information to the theoretical background if they met the inclusion criteria.

### **2.3.2 Types of participants**

Participants of interest were defined as athletes performing overhead activity, suffering from shoulder instability and/or rotator cuff injuries. They were not differentiated on the basis of age or gender, but they had to be participating in sports on an active level. Additionally, they could not have undergone surgery previous to the conservative treatment they were about to receive.

### **2.3.3 Types of interventions**

Interventions of interest were conservative treatment. Studies reporting e.g. electrotherapy, massage, ice, heat, ultrasound, and surgery were included if they were compared to a non-operative treatment group. Focus was placed on exercises as mobility, strength, range of motion, stability, stretching, pain, flexibility, and neuromuscular training, - done both actively and passively.

### **2.3.4 Type of outcome measures**

In order to be able to answer the main- and sub questions, it was necessary to define the specific outcomes. Relevant for this review was the following outcomes: strength, mobility, stability, co-ordination, throwing distance, power, retaining competition level, recurrence rate, recovery time, endurance, speed. These should be mentioned in a treatment protocol.

## **2.4 Locating and selecting studies**

### **2.4.1 Data base search**

To achieve an adequate overview over research previously done, and be able to obtain as many articles as possible covering the subject at hand, thorough searches were done in several databases. The ones of value for our study were Cochrane<sup>(67)</sup>, Medline<sup>(68)</sup>, PubMed<sup>(69)</sup>, and Cinahl<sup>(70)</sup>. These databases all cover a great deal of information, and to be able to make the search as precise as possible, specific key words were utilised.

Key words: athlete, overhead sports, rotator cuff, shoulder instability, treatment, effects, best evidence, treatment protocol, measurement tool, outcome measures, questionnaire.

As stated in the sub-question, a measurement tool was to be identified and assessed for its reliability and validity in order to determine the recovery process of the athlete. This question was dealt with separately from the other sub-question; that is, the articles obtained were reviewed as an independent matter. However, the same databases were used in the search process, and keywords such as overhead sports, athlete, best evidence, measurement tool, outcome measure and questionnaire were applied. Moreover, the inclusion and exclusion criteria were the same as for the other studies retrieved.

Inclusion criteria, (table 6):

- Types of studies: Systematic reviews, Randomised Clinical Trials, Controlled Clinical Trials, Narrative reviews
- Language: In order to assess the methodological quality appropriately, articles written in English would be the first priority, although Norwegian, Swedish and Danish articles will be considered if they had any value.
- Measurement tool(s): Currently available tool(s) that can be assessed and also used as an intervention for measuring results obtained with the athlete.

Patients/Problem:	Interventions:	Outcome measures:
<ul style="list-style-type: none"> <li>- Athletes performing overhead activities</li> <li>- Injury limited to the shoulder joint and the rotator cuff</li> </ul>	Conservative treatment: <ul style="list-style-type: none"> <li>- Patients have undergone exercise therapy after injury occurred</li> <li>- Patients have undergone mobilisation therapy after injury occurred</li> <li>- Exercises that have previously been used in a rehabilitation programme</li> </ul>	<ul style="list-style-type: none"> <li>- Studies using relevant outcomes with minimum of one of these subjects: Strength, mobility, stability, co-ordination, throwing distance, power, retaining competition level, recurrence rate, recovery time, endurance, speed. These should be mentioned in a treatment protocol.</li> </ul>

Table 6. Inclusion criteria

Exclusion criteria:

Studies that:

- does not mention any of the relevant outcomes
- include other illnesses
- include other injuries
- has no relevant connection with evidence based articles
- does not mention any form of treatment
- has no relevant connection with clinical studies
- articles completed more than 15 years ago

For the articles obtained in the databases, the related article's link was explored to establish whether there were other relevant studies that needed to be evaluated. The same procedure was followed in the same way as the original studies.

## 2.4.2 Reference checking

Proper reference check was carried out from the included articles, in order to see if other studies could be of interest for this systematic review. They were assessed according to title, key words, and abstract.

## 2.4.3 Personal communication with experts

Early in the process, Knut Jæger Hansen, a physiotherapist at a private practice, NIMI, who has had lectures- and has published at least one folder concerning the shoulder, was contacted. Due to his busy time schedule there was only a limited amount of information he was able to provide the group with. During the process of developing the project plan, assistance was received from Maarten Hulshof, a physiotherapist specialised in the science of movement.

## 2.5 Collecting data

A broad primary search was carried out which involved at least one of the above mentioned keywords that gave an outcome of 117 articles. Secondly, a narrow search was performed using more specifically the inclusion- and the exclusion criteria. As a result two folders were made by two of the authors. Folder 1 contained articles that almost fulfilled the inclusion- and exclusion criteria. This folder consisted of 19 articles. The second folder consisted of articles that were relevant according to the criteria's set, but they did not completely fulfil them. 21 articles were put in this folder which would be used as lower evidence based sources if needed.

Further on, a table was made to give an overview of which articles consisted of the keywords mentioned earlier. As soon as this was done, the articles were placed in a second table indicating where they were located and could be collected. Four articles from folder 1 were found at Fontys Mediatheek Eindhoven TF, and one was printed from the Internet. Articles of interest were picked up at the Vrije Universiteit Amsterdam. Five out of nineteen articles from folder 1 and three additional articles of interest found at the Vrije Universiteit Amsterdam were accepted for further research. The study of Ubinger *et al* was among the three. Nine articles from folder 1 were not available and were therefore ordered through the Fontys Mediatheek Eindhoven TF. In the progress, one article was excluded, because of its similarity to other abstracts and in addition it had to be ordered from Cologne in Germany. Furthermore, the nineteen articles were roughly read through by using the data extraction list (table 7). Ten articles were excluded since they did not fulfil the criteria's in the list. Five articles were found using the references to already collected articles, and they were ordered from Fontys Mediatheek Eindhoven TF. A second thorough search was applied in the same manner as the first search. No additional articles were found.

The search done was also aimed at acquiring reviews concerning measurement tools. All in all, three articles were obtained; two RCT's and one systematic review. One was available on the Internet, one had to be retrieved from Vrije Universiteit Amsterdam, and the last was later on ordered from the Fontys Mediatheek Eindhoven TF.

Method/design	2 Participants	3 Interventions	4 Outcomes	5 Result
Systematic review RCT CCT	Athletes with shoulder (glenohumeral) instability and/or rotator cuff injury Age group	Type of exercise therapy: conservative treatment - frequency - duration - number of sessions - intensity Type of interventions: - active - passive - closed/open kinetic chain	Pain ROM Stability Coordination Strength Function Quality of life	-The effect of a conservative treatment programme -Best evidence based treatment program -The best measurement tool for evaluating the athlete if recovery has been successful.

Table 7. Data extraction list

## **2.6 Quality assessment of studies**

The PEDro scale is a methodological quality assessment tool that evaluates clinical trials. It contains 11 items and ranks the article from 1-10 as to how good the quality is. The PEDro scale is described in appendix III.

A certain amount of the articles retrieved and included in this review were narrative reviews attained from medical journals. Most of the articles retrieved and included in this review were narrative reviews attained from medical journals. The PEDro scale is not a tool to be used to evaluate narrative reviews and guidelines, hence it was necessary to develop a checklist to be able to assess the quality of the specific narrative reviews. A self-made checklist, appendix V, was developed to be able to assess the quality of the narrative reviews.

One of the articles obtained was a systematic review. When appraising the methodological quality of the systematic review, nine questions were used<sup>(73)</sup>. Appraising a systematic review is described in appendix IV.

## **2.7 Analysing and presenting results**

The results obtained after using the data extraction list were analysed in a systematic order. To ensure that this process was done properly, the principles of the Cochrane handbook analysis was used. The analysis consists of five steps:

- What comparisons should be made?
- What study results should be used in each comparison?
- Are the results of studies similar within each comparison?
- What is the best summary of effect for each comparison?
- How reliable are the summaries?

The first step in addressing these questions was to compare participants, interventions and outcomes. Alongside this were reviews concerning measurement tools compared according to which items they were dealing with. This process should be as close as possible to the main question. The next step was to make summaries of the characteristics, and results of the included studies. Finally, it was considered whether the results were comparable in the different studies. Before a comparison could be made, it was necessary to rank the methodological quality of the included studies in order to give some studies more weight.

## **2.8 Interpreting data**

The results from the studies were interpreted in relation to the methodological quality of the studies. Due to the separate sub-questions that were developed, it was decided to distinguish the sub-question regarding measurement tool from the others when interpreting and analysing the data obtained. Thus in the section concerning results and discussion, findings relative to measurement tools were described with an additional sentence.

The following elements are discussed in chapter four:

- Study selection
- Internal validity of included trials
- External validity of included studies
- Methodological quality of included narrative reviews
- Interpretation of results

## 3. Results

### 3.1 Introduction

When the search for studies were retrieved, and a data extraction from these studies were done, comparisons of the different studies were initiated in order to analyse the information needed to answer the main and sub-questions of this systematic review.

This chapter consists of:

- An introduction part presenting the studies retrieved, with a description of the participants, interventions, and outcome measures that are used.
- Quality of the included studies
- Effect on outcome measures in regard to exercise rehabilitation
  - Comparison of recurrence rate
  - Comparison of immobilisation time
  - Comparison of rehabilitation program (exercise therapy)
  - Comparison of age of the participants
  - Comparison of returning to sport vs. not returning to sport
  - Comparison of measurement tools used to determine when the athlete can return to sport
- Analysing the statistical- and clinical significance

#### 3.1.1 Description of studies found

In all, a total of nineteen studies were retrieved. From these nineteen studies only seven were eligible to fulfil the inclusion criteria for this systematic review. The other twelve studies were excluded due to their lack of clinical/controlled trials thus they were not applicable to answer the main question in this systematic review.

The remaining seven studies meeting the eligibility criteria are displayed and described in appendix VI. Of the included studies, five are randomised-controlled trials, one is a controlled clinical trial, and one is a case study. One of the studies included is making a comparison between isokinetic resistance exercises and electromyographic biofeedback in athletes with anterior shoulder instability, another is investigating the effect of closed kinetic chain training on neuromuscular control in the upper extremity. The athletes receiving the non-operative treatments in four of the included trials belong to a control group, while the main focus is on the athletes receiving arthroscopic surgery. Although sufficient amount of clinical trials were obtained, systematic reviews, table 11, and narrative reviews, table 8, were included as a supplement to the theoretical background, not for clinical relevancy. Year of publishing ranged from 1990 to 2005. All included studies are published in English.

In regards to the measurement tool, a total of three articles fulfilled the inclusion criteria. Two of the articles are randomised clinical trials, whereas the third is a systematic review. The latter describes the evaluation of a quality of life questionnaire in which it also compares other commonly used measurement tools for the overhead athlete. The two RCTs both evaluate the effect and clinical relevance of the outcome measures used, and are displayed in appendix VII. Articles retrieved had a publishing range from 1990-2005, and all were published in English.



Study	Number of authors	Number of references	Outcome
Irrgang 1992 (10)	3	41	Rehab., TP, DRTP, MT
Pezzullo 1995 (11)	3	19	Rehab.
Wilk 2002 (12)	3	99	Rehab., TP, DRTP, MT
Litchfield 1993 (13)	5	23	Rehab., DRTP, MT
Khan 2001 (14)	3	42	Rehab., MT
Richards 1997 (15)	2	29	Rehab., I, DRTP, MT
Altchek 2000 (16)	2	31	Rehab., DRTP
Pepe 2001 (17)	2	35	Rehab., DRTP

Table 8. Data characteristics of the included articles assessed with the Narrative Review scale.

#### Abbreviations:

**DRTP** = Discussing return to play

**I** = Immobilisation

**Rehab.** = Rehabilitation by means of exercise therapy

**TP** = Treatment protocol

**MT** = Measurement tool (used to determine when the athletes/patients can return to sport/previous activity)

### 3.1.2 Description of participants

The participants in the seven clinical trials were assessed with the PEDro scale.

- Patient population sizes ranges from 20 to 40 participants.
- Mean age of the participants range from 17 to 24 years.
- In total, the seven studies investigate the effect of exercise therapy on 130 patients.

Further results are described in appendix VI.

### 3.1.3 Description of intervention

The six clinical trials along with the one case study included, have all described the interventions for the control groups, depicted in appendix VI. The narrative review articles and the systematic review article do not use any specific control intervention, nor does the RCT [3] concerning the measurement tool (8,9).

### 3.1.4 Description of outcome measures

Of the seven clinical trials, several were measuring more than one outcome.

- 5 studies measured recurrence rate (1,2,3,4,7)
- 5 studies measured amount of athletes returning to sport (or previous activity) (1,2,3,4,7)
- studies measured recovery time (1,2,3)
- studies made use of measurement tools to determine when the athletes/patients could return to sport (or previous activity) (1,4,5)
- 1 study compared isokinetic resistance exercises versus electromyographic biofeedback (5) in function and strength
- 1 study the effect of a 4-week closed kinetic chain (CKC) training (6) programme on the neuromuscular control of the upper extremity and to determine whether there was a significant difference between skill-dominant limb and non-dominant limb stability indices

Further details regarding the outcomes are illustrated in appendix VI where specific data characteristics are described thoroughly.

In regards to the measurement tool, the study of Placzek *et al* measures individual differences between scales (appendix VII) while Kirkley invented a tool, the WOSI (appendix IX) that was considered to be the best to apply in a clinical setting.

### 3.2 Quality of included studies

#### 3.2.1 The PEDro scale

Of the studies retrieved, seven were assessed for its methodological quality by the PEDro scale. Of the additional three articles retrieved for the review of measurement tools, two were assessed using the PEDro scale (Kirkley 1998, Placzek 2004). The score ranges from 4 to 9 out of a maximum score of 10 points.

The PEDro score obtained by the seven studies, with the additional two from the measurement tool analysis, are displayed in table 9. For further information concerning the PEDro scale, see appendix III. Results regarding the measurement tools will only be discussed briefly where it is relevant because the steps to be described further, is not relevant for these RCT's.

Study (Publication year)	1	2	3	4	5	6	7	8	9	10	11	Sum
Arciero (1994)	Y	0	0	1	0	0	0	1	1	1	0	4/10
Kirkley (1999)	Y	1	1	1	0	1	1	1	1	1	1	9/10
Bottoni (2002)	Y	1	0	1	0	0	0	1	1	1	1	6/10
Wintzell (1999)	Y	1	1	1	0	0	1	1	1	1	1	8/10
Reid (1996)	Y	1	0	1	0	0	0	0	1	1	1	5/10
Ubinger (1999)	Y	1	0	1	0	0	0	1	1	1	1	6/10
Buss (2004)	Y	0	0	1	0	0	0	1	1	0	1	4/10
Kirkley (1998)	Y	1	0	1	0	0	0	1	1	1	1	6/10
Placzek (2004)	Y	1	1	0	0	0	1	0	1	1	1	6/10

Table 9. Methodological quality measured with the PEDro scale. Articles are listed according to their score on the scale.

Items on the PEDro scale:

1. Eligibility criteria were specified
2. Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received).
3. Allocation was concealed.
4. The groups were similar at baseline regarding the most important prognostic indicators.
5. There was blinding of all subjects.
6. There was blinding of all therapists who administered the therapy.
7. There was blinding of all assessors who measured at least one key outcome.
8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups.
9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat".
10. The results of between-group statistical comparisons are reported for at least one key outcome.
11. The study provides both point measures and measures of variability for at least one key outcome.

### 3.2.2 Appraising a Systematic Review scale

Of the studies retrieved, two were assessed for their methodological quality by the Appraising a Systematic Review scale. The articles scored very high on the scale by achieving an 8 and a 7, out of a maximum score of 9 points. The Appraising a Systematic Review score obtained by this study, along with an additional review concerning measurement tool, are displayed in table 11. For further information concerning the Appraising a Systematic Review scale, see appendix IV.

Study (Publication year)	1	2	3	4	5	6	7	8	9	Sum
Gibson (2004)	1	1	1	1	1	0	1	1	1	8/9
Bot (2004)	1	1	1	1	0	0	1	1	1	7/9

Table 11. Methodological quality measured with the Appraising a Systematic Review scale

Items on the Appraising a Systematic Review scale:

1. Is the topic well defined?
2. Was the search for papers thorough?
3. Were the criteria for inclusion of studies clearly described and fairly applied?
4. Was study quality assessed by blinded or independent reviewers?
5. Was missing information sought from the original study investigators?
6. Do the included studies seem to indicate similar effect?
7. Were the overall findings assessed for their robustness?
8. Was the play of chance assessed?
9. Are the recommendations based firmly on the quality of the evidence presented?

### 3.2.3 The Narrative Review scale

Of the studies retrieved, eight were assessed for the quality by the self-made narrative review scale. Most of the articles score very high on the scale. The scores range from 5 to 8, out of a maximum score of 8 points. The Narrative Review scores obtained by the eight studies are displayed in table 10. For further information concerning the Narrative review scale, see appendix V.

Study (Publication year)	1	2	3	4	5	6	7	8	Sum
Irrgang (1992)	1	1	1	1	1	1	1	1	8/8
Pezzullo (1995)	1	1	0	1	0	1	1	1	6/8
Wilk (2002)	1	1	1	1	1	1	1	1	8/8
Litchfield (1993)	1	1	1	1	0	1	1	1	7/8
Khan (2001)	1	1	0	0	1	1	1	0	5/8
Richards (1997)	1	1	0	0	1	1	1	1	6/8
Altchek (2000)	1	1	0	0	1	1	1	0	5/8
Pepe (2001)	1	1	1	0	1	1	1	0	6/8

Table 10. Quality assessment of the Narrative Reviews, studies are listed according to their score on the review scale.

Items on the Narrative Review scale:

1. Does the topic correlate with the content of the study?
2. Is the content clearly described?
3. Are the exercise suggestions or exercise protocols for either shoulder instability or rotator cuff injuries for athletes performing overhead activities?
4. Is the outcome reproducible/applicable?
5. Are the references fairly applied?
6. Is the article published between 1990-2005?
7. Is the publisher an adequate organisation/magazine?
8. Does the author have a history in writing medical reviews?

### 3.2.4 Internal validity

Validity is the degree to which a result (of a measurement or study) is likely to be true and free of bias (systematic errors). This is also referred to as methodological quality. The expression "internal validity" is sometimes used to distinguish validity, which describes the extent to which the observed effects are true for the people in a study.

There were certain methodological characteristics that could be derived from the results after assessing the studies with the PEDro scale. This applies both to the trials pertaining to the findings of effects of exercise treatment (seven articles) and those belonging to the measurement tool (two articles) as shown in table 12. All studies fulfilled the eligibility criteria<sup>3</sup>.

	Reviews concerning effects of exercise and treatment protocol, number of articles	Reviews concerning measurement tool
Studies specified with eligibility criteria	All	All
Studies randomly recruited subjects	Five	All
Studies with concealed allocation.	Two	One
Similarity at baseline regarding the most important prognostic indicators	All	All
Blinding of all subjects	None	None
Blinding of all therapists who administered the therapy.	One	All
Blinding of all assessors who measured at least one key outcome	Two	One
Studies measuring at least one key outcome obtained from more than 85% of the subjects initially allocated to groups.	Six	One
Studies, in which subjects for whom outcome measures were available, received the treatment or control condition as allocated.	All	All
Studies containing statistical between-group comparisons for at least one key outcome.	Six	All
Studies providing both point measure and measures of variability for at least one key outcome.	Six	All

Table 12. Outcome of reviews assessed with the PEDro scale

Of the included studies, five are randomised-controlled trials, one is a controlled clinical trial, and one is a case study. Studies had a variety of number of subjects, ranging from twenty (5) to forty (2). The study of Arciero *et al* (1) was prospective, but there was no treatment randomisation. Athletes chose their treatments. In the study of Buss *et al* (7) there was no control group, but 30 in-season athletes with anterior shoulder instability were treated with physical therapy and fitted, if appropriate, with a brace. These athletes were followed over a 2-year period for the number of recurrent instability episodes, additional injuries, subjective ability to compete, and ability to complete their season or seasons of choice.

In two of the studies allocation was concealed (2,4). There was no blinding of subjects and only two of the studies had blinding of assessor (2,4). Blinding of the therapist was reported in one study (2).

The measurement in a study should include more than 85% of the subjects initially allocated to the groups to avoid potential bias. In six of the studies (1,2,3,4,6,7) the number of dropouts do not exceed this level.

All studies scored positively on question nine on the PEDro scale, which concerns intention to treat analysis.

Six of the studies measured the change in one group with change in another and a simple comparison of outcomes measured after the treatment was administered. One example: five studies compared the outcomes in recurrence rate and athletes able to return to their previous sport/activity (1,2,3,4,7).

Six studies (2,3,4,5,6,7) provided both point measures and measures of variability for at least one key outcome described as size of the treatment effect, difference in group outcomes or as the outcome in all groups. The outcomes in these studies are categorical, and the number of subjects in each category is given for each group.

### 3.2.5 External validity

When evaluating the methodological quality an important aspect to take into consideration is the applicability, which is also called external validity, relevance, transferability or generalizability. External validity is the degree to which the result of an observation holds true in another setting<sup>(63)</sup>. When discussing the result in relation to methodological quality, it is important to not be blinded by the summarised score on the methodological quality assessment scale. While it is possible to apply basic principles of measurement to the development of a scale for assessing the validity of RCTs, the relationship between such a score and the degree to which a study is free from bias is not obvious<sup>(63)</sup>.

There were 130 participants in four of the studies (1,2,3,4). Of these, 64 were subscribed to the non-operative group, while the remaining 66 patients were placed in the operated group. The number of participants in the non-operative groups of the mentioned studies ranges from fourteen to twenty. It is not clear whether or not 64 participants are enough to give the right impression of the treatment effect.

Among the seven clinical trials, four of them include females in their studies (2,4,6,7). Out of the 130 participants mentioned above, only 11,5% of them are female. None of these studies made differences in treatment outcomes between males and females. It is believed that

Five of the studies divide the participants into different age groups, and report the recurrence rate of the respective groups. The study of Arciero *et al* (1) has one group with an average age of 19,5 years. The study of Kirkley *et al* (2) has got one group as well, but it is stated in the study that: □ In any clinical trial with small numbers of patients, it is important to stratify the randomisation for potential major cofounders to avoid inequities between groups. Patient age correlates very closely with the rate of re-dislocation even within the younger-than-30-years age group itself. Therefore it was decided to stratify the randomisation based on age: 1. 22 years and younger and 2. 23 to 30 years of age. The randomisation was also stratified for surgeon to overcome the bias that may be introduced by small differences in surgical technique□(2). The study of Bottoni *et al* (3) has one group with an average age of 23 years receiving non-operative treatment. The study of Wintzell *et al*

(4) has one group with an average age of 24 years. The study of Buss *et al* (7) has one group with an average age of 17 years. There is a variety in average age from the different studies, but all of them keep the age under 30 years. However, most of the studies concentrate their studies around young participants, with an age mean of 21,3 years among these studies (1,2,3,4,7), which is reported to be the most difficult age group to rehabilitate from, due to the high level of activity.

### **3.3 Effect on outcome measures in regard to exercise rehabilitation**

Next, a description of outcome measures will be presented. Each section will outline the results obtained in the clinical trials. However, the results achieved relating to the measurement tool, will only be presented in point 3.3.6 due to lack of information concerning recurrence rate, immobilisation time, rehabilitation programme, age of participants, and returning to sport vs. not returning to sport.

#### **3.3.1 Recurrence rate**

Of the included studies, there are only five (1,2,3,4,7), indicating recurrence rate of the injured overhead athlete after completion of a rehabilitation programme. Rates ranged from 41% to 80% in the athletes who received non-surgical treatment while in the group undergoing surgical intervention, the percentage was between 11,1% and 20%.

#### **3.3.2 Immobilisation time**

Since only one of the narrative reviews mentioned any immobilisation length (15), this systematic review decided to concentrate on the five studies (1, 2,3,4,7) in which it was possible to compare the various immobilisation time periods with the recurrence rate in the different studies.

The five mentioned studies (1,2,3,4,7) reported various length of immobilisation, ranging from no period of immobilisation to four weeks of immobilisation. The results in recurrence rate ranges from 41% (7) to 80% (1). The immobilisation length that gave the best result according to the recurrence rate, was no period of immobilisation (7). The worst outcome was an immobilisation length of four weeks (1).

The five RCT's (1,2,3,4,7), provided information regarding immobilisation as an addition to active rehabilitation. Distinctions are made between the two groups receiving non-surgical treatment and those undergoing surgery. In the non-surgical group, the immobilisation period is mostly set between three and four weeks followed by an extensive rehabilitation programme. Three and four weeks immobilisation also applies to the surgical group right after arthroscopic repair had been performed.

#### **3.3.3 Rehabilitation program (exercise therapy)**

##### **Studies concerning the RCT's**

Four of the studies (1,2,3,4) provide the non-operative control group with exercise therapy, although with some differences in type of means applied. A general impression is that all rehabilitation time ranged from one to three months, with or without mobilisation. Three of the clinical trials (1,3,4) did not administer any solid rehabilitation programme although one or two modalities were indicated. Only the study of Kirkley *et al* (2) presented an exercise treatment program. The study introduced a program of immobilisation for three weeks followed by a twelve-week program of ROM, glenohumeral and scapular stabilisation exercises, divided into three phases.

One RCT (5) illustrated that visual and auditory electromyography (EMG) feedback of rotator cuff muscle contraction is twice more effective to decrease pain at rest and with activity, than an isokinetic resistance exercise programme when performed twice a week. This is compared at baseline scores. Using a verbal response scale, significant results were obtained at 26 and 52 weeks follow-up. However, during follow-up, the isokinetic exercise group did not display substantial change.

#### Studies concerning the narrative reviews

Of the eight narrative reviews, four mention a comprehensive rehabilitation programme, which is divided into different treatment phases. Wilk(12) and Irrgang(10) are in favour of four phases while Richards(15), and Pepe(17) offer three. Additionally, one RCT, Bottoni (3) mentions a rehabilitation programme, but not as extensively. Simultaneously they provide recommendations as to what sort of exercises should be employed in the various phases, with emphasis on the fact that the athlete has to recover fully from one phase before entering the following.

Pezzulo (11), Khan (14) and Altchek (16) display guidelines and principles on how to achieve a successful rehabilitation. Included are a number of exercises, in which there can be drawn parallels with the other narrative reviews. Of the interventions described

- five (10,12,14,15,17) propose the use of isokinetic exercises
- six (10,12,14,15,16,17) the use of sensomotoric exercises
- eight (10,11,12,13,14,15,16,17,) emphasises training stability
- five (10,11,12,16,17) display the use of concentric movement
- six (11,12,13,14,16,17) the use of eccentric movement
- five (10,14,15,16,17) promoted isometric exercises
- five (10,14,15,16,17) promoted the application of plyometrics
- Four (10,12,13,17) are in favour of stretching,
- four (10,12,14,17) mentions mobilisation
- five (10,11,12,16,17) described pain inhibition

#### **3.3.4 Age of the participants**

Of all articles obtained, only the RCT's mention specific age groups.

In group 1 (aged 22 and younger) there is a high mean percentage of recurrence, 60,5%. This high recurrence has much to do with the high recurrence rate in the study of Arciero *et al* (1) who reports a recurrence rate of 80% in this age group.

In group 2 (aged between 23 and 30) one can almost see an identical mean percentage of recurrence, 60,7%. In the study of Kirkley *et al* (2) they only mention patients 30 years and younger. In the study of Bottoni *et al* (3) the patients range from 18 to 26 years of age, with a mean age of 23 years. In the study of Wintzell *et al* (4) the patients range from 18 to 30 years of age, with a mean age of 24 years.

### 3.3.5 Returning to sport vs. not returning to sport

It is of vital importance for an athlete to be able to return to his/her sport, depending on the level of performance. Professional athletes are totally dependent on the optimal functioning of his/her body, and want the best possible rehabilitation program after they have experienced injuries. Recovery time range from the onset of injury until the athlete can return to previous level of sport/activity. Three of the studies included in this systematic review (1,2,3) discuss the time used on conventional rehabilitation before the patient is allowed to return to pre-injury level of sport/activity as an outcome measure. The unanimous results from these studies (1,2,3) show a 4-month recovery time.

Five studies included in this systematic review (1,2,3,4,7) give data on how many athletes that are able to return to their previous sport/activity. The percentage of those returning to sport in the non-operative group, ranged from 58% to 100%. Within the surgical group, numbers spanned from 66% to 89,2%.

Both the study of Arciero *et al* (1) and Bottoni *et al* (3) state that 100% of their patients returned to previous activity. Kirkley *et al* (2) made use of a questionnaire, The Western Ontario Shoulder Instability Index (WOSI), in order to evaluate the patients after 30 months. Two of the questions concern the patient's perception of difficulties returning to their previous sport/activity. Of the patients that received conventional exercise rehabilitation, 30,7% answered negatively on the question: "How much has your shoulder affected your ability to perform the specific skills required for your sport?" This means that, 69,3% of the patients were able to fully return to their previous sport/activity. The study of Wintzell *et al* (4) states that 58% of the participants, with an age mean of 24 years, in the exercise therapy control group were still active in sports at the 2-year follow-up, competing in lower divisions or on a recreational level. Finally, Buss *et al* (7) states that 87% of their patients had a successful return to competition and completion of the season after being treated with no period of immobilisation following an episode of instability.

Moreover, visual and auditory electromyography (EMG) feedback of rotator cuff muscle contraction during functional exercise programme performed twice a week, proved to be more effective than an isokinetic resistance exercise programme of same frequency for improving function in sport. This was described in only one RCT (5) where 20 subjects were tested. At 52 weeks follow up, results was noteworthy when assessing the individuals using the Constant and Murley's scale.

### 3.3.6 Measurement tools used to determine when the athlete can return to sport

Four of the included RCT's mentioned measurement tools used in a clinical setting, described in the appendix VI.

## 3.4 Analysing the statistical- and clinical significance

Statistical- and clinical significance are important tools used to analyse the data in randomised control trials. The first tool is used to insinuate if the outcome did occur by chance, that means to reject the null hypothesis if the value of the treatment is small enough, the latter describes how effective the treatment is in a real clinical setting<sup>(46)</sup>.

The following explains the statistical- and clinical significance for the interventions emphasised, when comparing an experimental group to a control group for the five (1,2,3,4,5) studies.



### 3.4.1 What is the effect of the Arthroscopic lavage treatment compared to the non-operative treatment of the dislocated shoulder?

		No re-dislocated shoulder	Re-dislocated shoulder	Total
Experimental group	Arthroscopic lavage	12 (a)	3 (b)	15 (a+b)
Control group	Non-operative treatment	3 (c)	9 (d)	12 (c+d)

Table 13: Dichotomous data for article 14<sup>(68)</sup>

EER (experimental event rate):  $a/(a+b) = 12/15 = 0.80 = 80\%$

CER (control event rate):  $c/(c+d) = 3/12 = 0.25 = 25\%$

RR (risk ratio):  $EER/CER = 0.80/0.25 = 3,2$

RD (risk difference) or ARR (absolute risk reduction):  $EER - CER = 0.55 = 55\%$

Recurrence of shoulder re-dislocation at 2-year follow-up in a prospective randomised trial comparing Arthroscopic lavage treatment to non-operative treatment.	Relative risk reduction (RRR)	Absolute risk reduction (ARR)	Number needed to be treated (NNT)
EER: $a/(a+b)$ 80%	CER: $c/(c+d)$ 25%	(EER-CER)/CER 220%	1/ARR ≈2 people
	95% confidence interval →	23% - 87%	1 to 4 people

Table 14: Clinically useful measures of the effects of treatment<sup>(68)</sup>

95% confidence interval (CI) on an NNT = 1/limits on the CI of its ARR

$= \pm 1.96 \sqrt{((CER \times (1-CER))/\# \text{ of control pts}) + ((EER \times (1-EER))/\# \text{ of exper. pts})}$

$= \pm 1.96 \sqrt{((0.8 \times (1-0.8))/12) + ((0.25 \times (1-0.25))/15)} = \pm 32\%$

The numbers from table 13 are used to calculate the CER, EER, RR, and ARR or RD. 80% of the patients in the experimental group experienced no re-dislocation of the shoulder compared to 25 % of the control group. The risk difference or the absolute risk reduction shows that there is a 55% better chance of benefiting from the arthroscopic lavage treatment than the non-operative treatment. The higher the differentiation is between the two groups, the better the experimental group becomes. The RR described that the positive outcome from the experimental treatment was 3 times more likely to occur compared to the non-operative treatment. 2 patients were needed to be treated (NNT) with the experimental treatment to achieve one positive outcome, as shown in table 14. The 95% confidence interval states that there is a 95% probability that a range of the population will benefit from the experimental treatment<sup>(72)</sup>.

The article does not indicate the frequency, duration or the intensity of the treatment plan for neither the arthroscopic lavage group nor the non-operative treatment. Neither mentioning the costs for the arthroscopic lavage treatment, which is an important aspect to have in mind. Taking the results of the ARR in mind, there is an additional 55% likelihood of benefiting from the arthroscopic treatment than the non-operative treatment, which in this case is a strong positive outcome. The NNT indicate that one out of 2 people will have a successful result from the experimental treatment, which is considered good. Adding the 95% confidence interval to the ARR and NNT, do explain the range in reality due to the population. CI ARR indicates that a range from 23% to 87% chance of getting a positive outcome with the arthroscopic lavage treatment. The CI NNT shows a range from 1 to 4 people, where one person will benefit from the experimental treatment. In relation to the above-mentioned statements, the authors of this study believe that the clinical significance provides not well enough statistical outcomes to suggest the arthroscopic lavage treatment rather than the non-operative treatment for shoulder dislocation.

### 3.4.2 What is the effect of the Arthroscopic Bankart repair treatment compared to the non-operative treatment of the dislocated shoulder?

		<i>No re-dislocated shoulder</i>	<i>Re-dislocated shoulder</i>	<i>Total</i>
Experimental group	Arthroscopic Bankart repair	8 (a)	1 (b)	9 (a+b)
Control group	Non-operative treatment	3 (c)	9 (d)	12 (c+d)

Table 15. Dichotomous data for article 15<sup>(68)</sup>

EER (experimental event rate):  $a/(a+b) = 8/9 = 0,89 = 89\%$

CER (control event rate):  $c/(c+d) = 3/12 = 0,25 = 25\%$

RR (risk ratio):  $EER/CER = 0,89/0,25 = 3,56$

RD (risk difference) or ARR (absolute risk reduction):  $EER - CER = 0,89 - 0,25 = 0,64 = 64\%$

Recurrence of shoulder re-dislocations at 3-years follow up in a prospective randomized study comparing Arthroscopic Bankart repair treatment to non-operative treatment.		Relative risk reduction (RRR)	Absolute risk reduction (ARR)	Number needed to be treated (NNT)
EER: $a/(a+b)$ <b>89%</b>	CER: $c/(c+d)$ 25%	$(EER - CER)/CER$ 256% 95% confidence interval →	$EER - CER$ 64% 32% to 96%	$1/ARR$ ≈2 people 1 to 3 people

Table 16. Clinically useful measures of the effects of treatment<sup>(66)</sup>

95% confidence interval (CI) on an NNT =  $1/\text{limits on the CI of its ARR}$

$= \pm 1.96 \sqrt{((CER \times (1 - CER))/\# \text{ of control pts}) + ((EER \times (1 - EER))/\# \text{ of exper. pts})}$

$= \pm 1.96 \sqrt{((0,25 \times (1 - 0,25))/12) + ((0,89 \times (1 - 0,89))/9)} = \pm 32\%$

The dichotomous data in table 15 are used to calculate the CER, EER, RR, and ARR or RD. 89% of the patients in the experimental group did not experience re-dislocation of the shoulder compared to 25% from the control group. The RR describes that there is 3,56 times more risk to succeed with the arthroscopic Bankart repair than the non-operative treatment. A risk difference of 64% implies that the experiment treatment is more benefiting than the non-operative treatment. According to table 16, the NNT describes that 2 people need to be treated to have one favourable outcome. Applying the 95% confidence interval for the ARR provides information that between 32% to 96% of the population will have a positive outcome, while for the CI NNT, there is a 95% chance that 1 to 3 people will have a favourable outcome.

The article provides information about the rehabilitation program, which is the same for both the experimental group and the non-operative group. According to the article, the rehabilitation program consists of 3 phases of 4 weeks with immobilisation and exercises, in total a rehabilitation program of 12 weeks and a follow-up of approximately 36 months. However, the article does not give information about the costs of the surgery, which is probably, an important factor that the patients will find of interest. This study describes a population of young active athletes who are vulnerable to injuries to the upper extremity. ARR indicates an absolute value of 64% of having a successful result, and CI ARR implies that in reality there will be a range from 32% to 96% of succeeding results from the experimental treatment. The NNT require 2 people who need to be treated to result in one successful outcome, which is considered to be good. Furthermore, the CI NNT implies that one out of 1 to 3 persons will achieve a positive result. In total, the clinical significant of this study in consultation with the authors, taken the above-mentioned statements into account, is considered adequately in relation to the rehabilitation programme, time consumption, ARR, and NNT.

### 3.4.3 What is the effect of the Arthroscopic lavage treatment compared to the non-operative treatment of an acute first time traumatic anterior dislocation of the shoulder?

		No shoulder instability	Shoulder instability	Total
Experimental group	Arthroscopic Bankart repair	18 (a)	3 (b)	21 (a+b)
Control group	Non-operative treatment	3 (c)	12 (d)	15 (c+d)

Table 17. Dichotomous data for article 13<sup>(68)</sup>

EER (experimental event rate):  $a/(a+b) = 18/21 = 0,86 = 86\%$

CER (control event rate):  $c/(c+d) = 3/15 = 0,2 = 20\%$

RR (risk ratio):  $EER/CER = 4,3$

RD (risk difference) or ARR (absolute risk reduction):  $EER - CER = 0,86 - 0,20 = 0,66 = 66\%$

Shoulder instability in a prospective randomized study comparing Arthroscopic Bankart repair treatment to non-operative treatment.		Relative risk reduction (RRR)	Absolute risk reduction (ARR)	Number needed to be treated (NNT)
EER: $a/(a+b)$ 86%	CER: $c/(c+d)$ 20%	$(EER - CER)/CER$ 329%	$EER - CER$ 66%	$1/ARR$ ≈ 2 people
		95% confidence interval →	41% to 91%	1 to 2 people

Table 18. Clinically useful measures of the effects of treatment<sup>(66)</sup>

95% confidence interval (CI) on an NNT =  $1/\text{limits on the CI of its ARR}$

$= \pm 1.96 \sqrt{((CER \times (1 - CER))/\# \text{ of control pts}) + ((EER \times (1 - EER))/\# \text{ of exper. pts})}$

$= \pm 1.96 \sqrt{((0,2 \times (1 - 0,2))/15) + ((0,86 \times (1 - 0,86))/21)} = \pm 25\%$

Table 17 contains the data used to calculate the CER, EER, RR, and ARR or RD. 86% of the experimental group experienced no shoulder instability in relation to 20% of the non-operative group. The RR describes that there is 4,3 more likely risk to recover from a shoulder dislocation with an arthroscopic Bankart repair treatment compared to the non-operative treatment. The RD or ARR describe that 66% of the patients being treated with the experimental treatment will have a successful outcome in relation to the control treatment. Table 18 illustrates that there are a 41% to 91% chance of recovering after suffering a shoulder dislocation with the arthroscopic Bankart repair treatment, taking the population into account, using the 95% CI ARR. The CI NNT shows that it takes 1 to 2 people to have one successful outcome from the population.

Reviewing the prospective study, it contained a rehabilitation programme that was alike for both the Bankart repair treatment and the non-operative treatment, with an exception for the surgery in the experimental treatment. The program consisted of four weeks of immobilisation, strengthening of the rotator cuff, and at four months the patients were allowed to return to previous sports. There was an average follow-up of 32 months. The study did not mention the costs of having a Bankart repair treatment. When looking at ARR and NNT, they provide adequate numbers, which is strong evidence for the clinical significance in a clinical situation.

### 3.4.4 What is the effect of the Electromyographic Biofeedback Re-education (EMBGF) compared to Isokinetic Resistance Exercises (IRE) of anterior shoulder instability in athletes?

This article contains neither an experimental group nor a control group, but two different treatments compared to each other. Therefore when entering the dichotomous data, the EMBGF became the experimental group and the IRE became the control group, due to the question stated above.

		<i>No limitation</i>	<i>Moderate limitation</i>	<i>Total</i>
Experimental group	EMBGF	8 (a)	1 (b)	9 (a+b)
Control group	IRE	7 (c)	3 (d)	10 (c+d)

Table 19. Dichotomous data for article 11<sup>(68)</sup> Function: Work

EER (experimental event rate):  $a/(a+b) = 8/9 = 0,89 = 89\%$

CER (control event rate):  $c/(c+d) = 7/10 = 0,70 = 70\%$

RR (risk ratio):  $EER/CER = 1,27$

RD (risk difference) or ARR (absolute risk reduction):  $EER - CER = 0,89 - 0,70 = 0,19 = 19\%$

Anterior shoulder instability in a pilot study comparing Electromyographic Biofeedback Re-education to Isokinetic Resistance Exercises for functional ability within work.		Relative risk reduction (RRR)	Absolute risk reduction (ARR)	Number needed to be treated (NNT)
EER: $a/(a+b)$ 89%	CER: $c/(c+d)$ 70%	$(EER - CER)/CER$ 27%	$EER - CER$ 19%	$1/ARR$ $\approx 5$
		95% confidence interval $\rightarrow$	-16% to 54%	-6 to 2 people

Table 20. Clinically useful measures of the effects of treatment<sup>66</sup>

95% confidence interval (CI) on an NNT = 1/limits on the CI of its ARR

$= \pm 1.96 \sqrt{((CER \times (1 - CER))/\# \text{ of control pts}) + ((EER \times (1 - EER))/\# \text{ of exper. pts})}$

$= \pm 1.96 \sqrt{((0,7 \times (1 - 0,7))/10) + ((0,89 \times (1 - 0,89))/9)} = \pm 35\%$

The dichotomous data illustrated in table 19 are used to calculate the CER, EER, RR, and ARR or RD. 89% gained a positive result from the EMBGF treatment compared to 70% from the IRE treatment concerning functioning within work. There is 1,27 risk to succeed with the EMBGF treatment compared to the IRE treatment. The RD or ARR imply that there is 19% chance of having a favourable result with the experimental treatment. The NNT of one person out of 5 will have a positive outcome, as illustrated in table 20. Because of the low ARR the 95% confidence interval for both ARR and NNT become negative.

		<i>No limitation</i>	<i>Moderate limitation</i>	<i>Total</i>
Experimental group	EMBGF	0,5 (a)	9,5 (b)	10 (a+b)
Control group	IRE	0,5 (c)	10,5 (d)	11 (c+d)

Table 21. Dichotomous data for article 9 Function: Sport

EER (experimental event rate):  $a/(a+b) = 0,5/10 = 0,05 = 5\%$

CER (control event rate):  $c/(c+d) = 0,5/11 = 0,045 = 4,5\%$

RR (risk ratio):  $EER/CER = 0,05/0,045 = 1,1$

RD (risk difference) or ARR (absolute risk reduction):  $EER - CER = 0,005 = 0,5\%$

Anterior shoulder instability in a pilot study comparing Electromyographic Biofeedback Re-education to Isokinetic Resistance Exercises for functional ability within sport.		Relative risk reduction (RRR)	Absolute risk reduction (ARR)	Number needed to be treated (NNT)
EER: $a/(a+b)$ 5%	CER: $c/(c+d)$ 4,5%	$(EER - CER)/CER$ 11%	$EER - CER$ 0,5%	$1/ARR$ 200
		95% confidence interval $\rightarrow$	-17,5% to 18,5%	-6 to 5 people

Table 22. Clinically useful measures of the effects of treatment

95% confidence interval (CI) on an NNT = 1/limits on the CI of its ARR  
 $= \pm 1.96 \sqrt{(((\text{CER} \times (1 - \text{CER})) / \# \text{ of control pts}) + ((\text{EER} \times (1 - \text{EER})) / \# \text{ of exper. pts}))}$   
 $= \pm 1.96 \sqrt{(((0,045 \times (1 - 0,045)) / 11) + ((0,05 \times (1 - 0,05)) / 10))} = \pm 18\%$

The dichotomous data in table 21 are used to calculate the CER, EER, RR, and ARR or RD. 5% of the experimental group and 4,5% from the control group experienced a stable shoulder after the treatment. The RR shows that there is 1,1 times better risk of having a successful treatment with the EBMGF treatment than the IRE treatment. According to table 78, the RD or ARR tells that 0,5% of the patients will benefit from the EBMGF treatment compared to IRE treatment.

When looking at the table in this article, the baseline was stated. However, the post-testing was not. The first variable after the baseline was eight weeks after the post-testing, which are the numbers that have been used in tables 19 and 21. The article also emphasised in the significant difference in the functional part in the post-testing, hence the calculations extracted above. The rehabilitation for both groups took into account the posture, the avoidance of pain, altered activities, and the groups were to attend the clinic 2 times a week. When looking at the ARR, table 22 states that there is a low outcome difference between the two treatments. Taking the table 22 into consideration, the high number of patients needed to treat states a low significance of the experimental treatment. The low ARR, however, explains that there is almost no difference between the two treatment approaches. The calculations indicate that in reality it may be possible that the IRE treatment is more beneficial than the EMGBF treatment. Results obtained states that in a clinical setting, it does not matter which treatment approach to use.

### 3.4.5 What is the effect of the Arthroscopic Stabilisation compared to immobilisation and rehabilitation in first time traumatic anterior dislocation of the shoulder?

		Stable shoulder	Shoulder re-dislocation	Total
Experimental group	Arthroscopic stabilisation	13 (a)	3 (b)	16 (a+b)
Control group	Immobilisation and rehabilitation	6 (c)	9 (d)	15 (c+d)

Table 23. Dichotomous data for article 13<sup>(68)</sup>

EER (experimental event rate):  $a/(a+b) = 13/16 = 0,81 = 81\%$

CER (control event rate):  $c/(c+d) = 6/15 = 0,40 = 40\%$

RR (risk ratio):  $\text{EER}/\text{CER} = 2,025$

RD (risk difference) or ARR (absolute risk reduction):  $\text{EER} - \text{CER} = 0,81 - 0,40 = 0,41 = 41\%$

Anterior dislocation of the shoulder in a prospective randomised clinical trial comparing Arthroscopic stabilisation to immobilisation and rehabilitation.		Relative risk reduction (RRR)	Absolute risk reduction (ARR)	Number needed to be treated (NNT)
EER: $a/(a+b)$ 81%	CER: $c/(c+d)$ 40%	$(\text{EER} - \text{CER})/\text{CER}$ 103%	$\text{EER} - \text{CER}$ 41%	$1/\text{ARR}$ ≈2 people
		95% confidence interval →	10% - 72%	1 to 10 people

Table 24. Clinically useful measures of the effects of treatment<sup>(66)</sup>

95% confidence interval (CI) on an NNT = 1/limits on the CI of its ARR

$= \pm 1.96 \sqrt{(((\text{CER} \times (1 - \text{CER})) / \# \text{ of control pts}) + ((\text{EER} \times (1 - \text{EER})) / \# \text{ of exper. pts}))}$

$= \pm 1.96 \sqrt{(((0,4 \times (1 - 0,4)) / 15) + ((0,81 \times (1 - 0,81)) / 16))} = \pm 31\%$

The numbers from table 23 are used to calculate the CER, EER, RR, and ARR or RD. 81% from the experimental treatment group and 40% from the control group obtained a successful treatment. The difference between the two groups, ARR, is 41% in regards to who will have a positive result from the arthroscopic stabilisation compared to the immobilisation and rehabilitation. In reality there will be a range from 10% - 72% of patients that will benefit from the experimental treatment than the control treatment, as described in table 24. There is a risk of 2 times better chance to have a favourable result from the arthroscopic treatment than the immobilisation and rehabilitation group. 2 people need to be treated to have one successful outcome, and in reality there is a range from 1-10 people who needs to be treated to have one favourable result from the experimental treatment than from the control treatment.

The prospective randomised clinical trial is based on the study from 1999, Kirkley *et al.* The study describes the arthroscopic stabilisation treatment with the same rehabilitation treatment as the control group received. According to the study, the rehabilitation consists of 3 weeks immobilisation and 12 weeks of exercises before finally returning to full sporting activities. Though, it does not mention the duration, frequency or intensity of the rehabilitation programme. Not to forget that the calculations stated above are numbers taken from the 24 months follow-up. One table in the study indicates that there were no re-dislocations after ending the rehabilitation programme from either group. This implies a positive outcome for both treatment groups. Costs for the surgery or the rehabilitation are not mentioned, which might be an important factor for the patient. Anyhow, the calculations above state that the experimental treatment is better when looking at the ARR of 41% indicating that the arthroscopic stabilisation is in favour over immobilisation and rehabilitation. Furthermore, 2 people need to be treated to have one successful outcome for the experimental treatment. There is a great clinical significance of the arthroscopic stabilisation compared to the immobilisation and rehabilitation.



## 4. Discussion

### 4.1 Introduction

In this chapter a discussion is conducted around the results of this systematic review. The study selection and the quality of the included studies will be addressed followed by an interpretation of the results obtained.

### 4.2 Study selection

Selection of all relevant studies is crucial for the validity of the systematic review. Although we also searched for studies published in Norwegian, Swedish, and Danish, only English studies were identified and included.

Despite the fact that the patients of interest to this systematic review, in four of the studies (1,2,3,4), belong to the control group, articles are included due to the very limited number of studies focusing on the non-operative treatment as a main group

The original in- and exclusion criteria were changed, to a minor degree, to involve the study by Ubinger *et al*, which concerned other groups of participants than what was initially intended. The reason for this was that a limited amount of studies available to directly support the main question, and this additional study was believed to have good relation to the main focus of this systematic review. In the study of Ubinger *et al* (1999), the effect of a 4-week Closed Kinetic Chain (CKC) training program was investigated on the neuromuscular control of the upper extremity. Even though the participants in this study were not athletes performing overhead activities suffering from shoulder instability, but thirty-two physically active participants with no injuries, the study emphasises that these types of exercises are essential in the rehabilitation of all overhead sports.

### 4.3 Discussion of the quality of the studies

The fact that all the studies (1,2,3,4,5,6,7) fulfilled the first criteria on the PEDro scale concerning eligibility means that the inclusion and exclusion criteria's was explicitly chosen for all the seven clinical trials.

The studies, in which the subjects were randomly allocated to groups, ensure that treatment and control groups are comparable. The fact that the inclusion and exclusion criteria's was explicitly chosen for all the subjects ensures a decent comparison.

Studies that do not conceal allocation risk a systematic bias. The decision about whether or not to include a person in a trial could be influenced by knowledge of whether the subject was to receive treatment or not.

When the therapist has not been blinded, one can not rule out that if the effect or lack of effect was due to the therapist's level of enthusiasm and knowledge. The low score on the items considered blinding of subjects and therapist could be explained by the fact that most of the studies made comparisons between operative and non-operative treatments. This makes it difficult for blinding.

The measurement in a study should include more than 85% of the subjects initially allocated to the groups to avoid potential bias. The reason for the high number of dropouts in one of the studies (5), is the fact that a large number of its members moved during a 52-week period of the study. This has made it difficult to rely on the results from this study.

When available, an intention to treat analysis, must be included in a study for subjects with a low level of participants, who does not complete treatment or is not able to attend measurement to avoid bias.

In this systematic review, the effect of exercise therapy for athletes performing overhead activities suffering from shoulder instability and/or rotator cuff injuries are of interest. The operated participants are therefore not taken into consideration. Furthermore, it is believed that there is no difference between the effects of exercise therapy for male and female patients. However, no conclusion can be drawn on this matter until a research, which differentiate between male and female athletes performing overhead activities that are suffering from shoulder instability and/or rotator cuff injuries, is conducted.

#### **4.4 Interpretation of results**

The information from the clinical trials is valued as the most reliable due to the fact that there is no way to know if the narrative reviews constitute scientific material. The results from the narrative reviews (8,9,10,11,12,13,14,15) should therefore be considered as background information, as they do not clearly state where and how the information was gathered. There is a possibility that the authors of the narrative reviews have only included the information found useful to state their personal opinion in the narrative review. Due to the fact that there is no search description, the assumption that the narrative reviews are of a subjective character can easily be made.

##### **4.4.1 Discussion of recurrence rate**

Recurrence rate was one of the outcomes of interest for this systematic review. Five of the included studies (1,2,3,4,7), all RCT's, mentioned this as an outcome measure. The percentage of recurrence rate among those receiving exercise therapy treatments differed from 41% (7) to 80% (1). Results showed that this was according to differences in:

- Immobilisation time
- Rehabilitation program (exercise therapy)
- The age of the participants

##### **4.4.2 Discussion of immobilisation time**

The study of Arciero *et al* (1) employed 4 weeks of shoulder immobilisation followed by rehabilitation for acute, initial anterior shoulder dislocations in their comparison study of non-operative treatment versus arthroscopic Bankart repair. They found that 80% of the non-operative patients developed recurrent episodes, whereas in the study of Buss *et al* (7) patients had no period of immobilisation, and rehabilitation was immediately initiated, with the overall result of a 41% recurrence rate of instability during the athlete's current season. However, the study of Buss *et al* (7) concentrated on the short-term recurrence rates, they were interested in the athlete's ability to return to his/her current season and compete effectively. Out of the 41% of the athletes who were able to return to the current season, 46% subsequently underwent surgical stabilisation after completing their current season. Importantly, no athletes reported any short-term injury in relation to shoulder instability that affected either their ability to compete or their post-season surgical options.



#### 4.4.3 Comparison of rehabilitation program (exercise therapy)

Studies show the significance of providing the athlete with a substantial overview of interventions necessary to employ in order to achieve previous pre-morbid level. Clearly, a well-defined and outlined rehabilitation programme should contain a description of various phases with correlating interventions. Furthermore, there should be stated time of duration of each activity, with what intensity and frequency, which the above mentioned studies failed to consider. Nevertheless, the guidelines are of great value to the injured overhead athlete, as well as they can serve as preventive measures. For more detailed description of interventions, refer to appendix VIII.

#### 4.4.4 Comparison of age of the participants

Group 1 (aged 22 and younger): The statement "22 and younger" can include several ages and is not specific enough for drawing conclusions. Moreover, the data is derived from only two studies (1,7) that furthermore has got different time perspective in the sense of follow up. This might result in a less reliable outcome.

Group 2 (aged between 23 and 30): Also this group can contain different ages and is neither specific enough for drawing conclusions.

The variation in the age of the participants makes it difficult to give a clear comparison between the groups. It was expected to clearly see that the recurrence rate would increase with younger age. This expectation was based on the study of Rowe *et al* <sup>(51)</sup>, where it is stated that there is a 100% re-dislocation rate in patients younger than 10 years, 94% re-dislocation rate between the age of 10 and 20 years, and re-dislocation rate of 79% between the age of 20 and 30 years.

#### 4.4.5 Comparison of returning to sport vs. not returning to sport (recovery time)

However, this trial was conducted at West Point Military Academy. It is stated that physical education is a major part of the study at the military academy, and there is also a participation criterion. If the cadet fails to meet these criteria he/she will be excluded from further education at the academy. The participants used in the study are therefore highly motivated and eager to return to pre-injury levels of participation. This is the reason why the number 100% of the patients returning to previous activity are correct. The tricky thing in this case is that these patients are totally dependent on returning, and this will definitely influence their decision. This can represent a bias of the study, but also on the other hand give a picture of how a professional athlete would behave if injured.

In this study, all the patients were active-duty personnel assigned to military units in Hawaii. The average age of the participants was 2 years older than the cadets participating in the study of Arciero (1). In the study of Bottoni (3) the participants consisted of active-duty soldiers and sailors with diverse athletic interests who were assigned to a variety of duties. It would be easy to believe that the participants in this study closely approximates a relatively athletic group within the general population who are unwilling or unable to modify demands placed on the upper extremities and the shoulder in particular. On the other hand, according to Kirkley *et al* (2), the fact that military personnel have extraordinary demands placed on them because of their military and obligatory athletic training, is a potential explanation for the increased re-dislocation rate at such facilities. They suggest that studies performed at military facilities, although well done, are not a true representation of the general population, apparently because of the rigorous physical demands placed on the active-duty personnel and their more strict compliance with rehabilitation.

The participants in this study represented persons from the normal community and not highly motivated military cadets. Another aspect is that the age range of the participants in the study of Kirkley (2) was larger, from 17-30 years, compared to for example that of Arciero *et al* (1), which ranged from 18-22 years.

However, this study also states that the patients who quit their sporting activities because of the shoulder injury, had previously been active in overhead racket or throwing sports and had their dominant side affected by the dislocation. This matter is not discussed further into detail, hence it is difficult to emphasise the results of this study the most.

This study followed athletes with an average age of 17 years through their current athletic seasons. The purpose was not to try to identify long-term recurrence rates, but rather the athlete's ability to return to his/her current season and compete effectively.

The five studies mentioned might implicate that patients who are at young age and dependent on returning to pre-injury level of sport/activity, might present with a higher motivation (e.g. professional athlete) However, the scientific evidence is not large enough to support such a claim.

#### **4.4.6 Discussion of the statistical- and clinical significance**

Two studies were excluded (6,7) from the calculations. There was one observational research study (7) that did not consist of an experimental group and a control group. Another study (6) did not consist of efficient numbers to use in the matrixes for the calculation. Five studies (1,2,3,4,5) were included in the calculations. Two of the studies (1,3) compared Bankart repair to non-operative treatment, they presented a similar outcome, which stated strong evidence that the Bankart repair was efficient when associated with a rehabilitation programme. Another study (2) described a transglenoid suturing technique compared to immobilisation and rehabilitation, which was considered clinical significant due to the statistical outcome, the description of the participants, and the rehabilitation protocol. Furthermore (4), one was of low clinical significance, even though the NNT and ARR outcomes were sufficient, the study neither described the non-operative treatment nor duration, frequency, and intensity. These four studies (1,2,3,4) in relation to the calculation outcomes, defined that surgery in combination with a rehabilitation programme is the most effective treatment for shoulder dislocation. The last study (5) compared EMGBF- to IRE treatment for shoulder instability, but there were no significant statistically difference between the two treatment groups, which resulted in low clinical significance, since the two treatment approaches can barely be differentiated. There were no studies found concerning the best effective exercises compared to non-treatment or placebo, which would be the most informative studies for this systematic review. Nevertheless, in this systematic review the best effective treatment, based on evidence based studies, is surgery in combination with a rehabilitation programme for shoulder dislocation.

#### **4.4.7 Discussion on measurement tools used to determine when the athlete can return to sport**

Measurement tools, also known as outcome measures, are of value to the athlete, the coach and the health care provider in order to assess potential progression of interventions applied in the treatment. If used properly, a positive outcome of the treatment is likely to find place and the athlete might be able to return to sport.

Measurement tools described in the three articles obtained show rather similar findings and provide correlating advice as how functional outcomes should be applied in a clinical setting. These are questionnaires tested out on patients suffering from shoulder problems, such as rotator cuff tendinitis and shoulder instability.

Bot *et al* performed a fairly extensive study on 16 shoulder disability questionnaires with the aim to evaluate the clinimetric quality of all instruments retrieved. Of the three studies obtained, Bot *et al* placed a focus on the validity, reproducibility, responsiveness, interpretability and overall quality of the questionnaires. On the other hand, Placzek *et al* did a comparison of six functional tests by correlating the components of the scales and the total scores that will aid in determining where excessive information exist. The final study by Kirkley *et al* was done to develop a tool covering the aspects regarding quality of life, the Western Ontario Shoulder Instability Index (WOSI) (appendix IX). Validity and responsiveness were issues taken into consideration, with additional description of reliability and pre-testing of the tool.

Mutual opinions derived from the three studies were that there is still need for further investigation regarding devices and scales. There is no scientific evidence on which tool is the best, although there exists advice that is given as to which tool to be used in different situations where athletes present with shoulder injury. However, the DASH (appendix X), SPADI, SST (appendix XI), and ASES are the most reviewed tools found in the literature, and the DASH receives best critics for its clinimetric properties. According to Placzek *et al*, individual components compared shows low to moderate correlation. This in turn indicate that the tools differ in their evaluation of the degree to which the scale's components measure different factors.

A specified purpose of each questionnaire failed to appear (Bot *et al*). Furthermore, the number of given scales should correspond with the number of dimensions. This was only found in five of the sixteen questionnaires studied (Bot *et al*), which might provide difficulties with interpretation of the tools.

Other forms of measurement tools other than questionnaires can be made use of in the event of assessing range of motion, strength and functional activities. Although, not discussed in the studies reviewed, they ought to be granted some attention due to the fact that they are frequently spoken about in clinical settings (1,3,7,8). The Goniometer and electromyography (EMG) are devices occasionally employed for investigating range of motion and movements detected in individual muscles. These can accompany the use of questionnaires when establishing the development of the treatment. Besides, the two devices can be applied independently of the questionnaires in order to frequently ensure that stagnation does not occur.

To this date, there does not exist one specified tool that covers exact aspects necessary to assess in the injured overhead athlete. Acquired knowledge of the pre-morbid level is to prefer in order to have a starting point as to what goals to set for the treatment that lies ahead. When this has not been attained, it is recommended that the persons own perception of changes in health status is to be an indication of the success of the treatment (Kirkley *et al*).

Further guidelines are needed in order to provide and set standards defining the criteria by which the instruments should assess. Though, an advice ought to be created in a holistic<sup>17</sup> questionnaire that covers several domains that can give a substantial answer to the athlete's treatment progression. Additionally, it is recommended that testing should be performed when the athlete is presenting at a high level in their sport. Estimations of the outcome of treatment can be easier to predict with this in mind.

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<sup>17</sup> emphasizing the organic or functional relation between parts and the whole

## 5. Conclusion

Although there are numerous protocols for the conservative management of shoulder instability published in scientific journals, the majority of these are based only on physiological rationale and biological evidence rather than on specific clinical trials. This reflects the paucity of such evidence, with the few primary research articles published since 1980 consisting of generally low methodological quality. Due to this lack of evidence based clinical trials it was felt important to include any potentially useful evidence. However, quality assessment in this systematic review was often hampered by insufficient information reported concerning subject selection criteria, trial validity, treatment parameters, and standardised outcome measures.

Results from the seven studies included in this systematic review show a weak but positive trend for conservative treatment programs for managing shoulder instability. Specifically, positive effects were noted with respect to decreasing recurrence of instability, promoting the return to pre-morbid work or sport activity, and decreasing or resolving symptoms associated with instability. Although weak, the trend was best supported by a program of immobilisation for three weeks followed by a twelve-week program of ROM, glenohumeral and scapular stabilisation exercises. Although the evidence to date is insufficient to strongly support the use of EMG biofeedback alone to decrease shoulder instability, the result of one low-quality RCT do suggest it may be a beneficial adjunct to conservative management programs. Moreover, one medium-quality RCT suggested that Closed Kinetic Chain (CKC) training increase the ability of the upper extremities to maintain a stable stance by using the neuromuscular control mechanism within the joints. This becomes very important when considering rehabilitation programs for athletes, e.g. those involved in overhead sports. Most of the clinical trials examining effective treatment of shoulder instability used a cohort study design to prospectively compare the outcomes of interest between subjects being managed conservatively and subjects choosing surgical management. These results consistently demonstrated poorer outcomes after conservative management than with surgical management, particularly in individuals 30 years of age and younger.

Returning to previous level of sports is most of the times the primary goal of an athlete who has sustained injury. In this review, it is possible to conclude with the fact that there does not exist one particular measurement tool for the injured overhead athlete that can provide specific information as to whether pre-morbid level has been obtained or not. Nevertheless, evidence show that the obtained outcome measures can be administered for the athlete presenting with shoulder injury, if applied appropriately. In this instance one must be extremely specific as to defining the exact purpose for choosing one over the other in order to justify information acquired.

### **5.1 Limitation of this systematic review**

This systematic review was limited by a paucity of primary evidence in the literature pertaining to exercise therapy for the management of shoulder instability and/or rotator cuff injuries in athletes performing overhead activities. Generally, the methodological quality of the included studies is quite low, and most of them fail to provide sufficient descriptions of exercise treatment protocols. This weakness limits both the strength and clarity of our conclusions. The absence of studies concerning exercise therapy versus a control group limits this systematic review to calculate surgical treatment compared to non-operative treatment. The most favourable studies for this review would contain exercise therapy as an experimental group. Also, the fact that only English-language publications were included could mean that potentially good-quality foreign studies, which might have strengthened our recommendations, were missed. Furthermore, the group encountered a limited amount of systematic reviews concerning specific measurement tools for the overhead athlete. In

this event, changes in the original project proposal had to be adjusted to make it possible to obtain any form of answer to the sub-question pertaining to this issue. The change made was based on facts revealing the absence of a tool to establish whether the athlete has gained or not the previous level of sports activity. Thus a change was made which placed a focus whether or not the athlete was able to return to sport after treatment had ended.

## **5.2 Implications for further research**

A priority for future research is the use of more rigorous research designs with well-defined exercise therapy treatment protocols. Randomised controlled trials with long-term follow-up are required to identify both the functional and recurrence rates. A thorough review of the biologic, physiological, and kinematic foundations for shoulder stability deficits and restoration should serve as the basis for establishing an ideal exercise approach. A comprehensive program that includes appropriate immobilisation (minimum three weeks) followed by intensive strengthening to restore the balance and stability of the shoulder musculature appears to be the optimal approach, although the exact parameters of this approach remain undefined. Ultimately, conservative management trials should compare patient outcomes following two different exercise treatment protocols to determine specific treatment parameters and frequency, intensity, type, and time protocols. There is also need for further research comparing rapid return to sport with conservative exercise treatment versus early primary repair to compare the advantages and disadvantages of both treatment methods. These studies are required to provide evidence on which to base conservative management guidelines. Furthermore, additional research is advisable to be able to compose a thorough and well-defined measurement tool specifically for the overhead athlete.

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