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PREVENTION OF SHOULDER GIRDLE INJURIES IN RECREATIONAL CLIMBERS – AN INTERVENTION BOOKLET

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The purpose of this thesis was to create a shoulder injury prevention package for recreational climbers. The package is built on evidence-based knowledge and it allows the athletes to increase their knowledge about shoulder injuries and to reduce the possibility of shoulder injury. The thesis was done in collaboration with Climbing Club Pori.

The theoretical part of the thesis includes the anatomy and biomechanics of the shoulder girdle, common injuries of the shoulder focusing on working age population and climbing as a sport and its common shoulder injuries. The thesis also investigates the possible risk factors for injury, the importance of health promotion in injury prevention and the effectiveness of different intervention strategies. The information in the booklet is based on current evidence according to the literature. The search for evidence included freely available full text articles by using Medline/PudMed, Ebsco Host, Science Direct and Google Scholar.

Although the studies showed that evidence-based, sport specific training and preventative programs are effective, they are not widely used by coaches and athletes. Also, while contact sports and lower limb injuries are often studied in injury prevention, there is a lack of evidence in other fields.

The intervention booklet allows the climbers through pictures and written instructions to enhance their performance by activating the scapular stabilizers, strengthening the rotator cuff and improving the range of motion of the shoulder.

CONTENTS

1 INTRODUCTION

The shoulder is the most mobile joint in the human body. However, its increased mobility comes with the price of decreased stability. Sports involving repetitive hand movements above the shoulder level cause extreme load on the shoulder which can lead to injury. (Brown, Park & Bicknell 2015.)

Climbing has become increasingly popular in the last two decades. Injuries from falls are less common due to the improvement of protective equipment. Injuries caused by overuse and microtraumas are still frequent. (Sweitzer 2012.) In climbing shoulder injuries are the third most common after finger, hand and arm injuries. However, it is hard to conclude what the most common injuries are because of the lack of consistency in the studies. (Grønhaug & Norberg 2016.) In Finland, 83 % of Finnish climbers had suffered from injuries at some point in their sport life and 67 % of the injuries affected the upper limb (Olli, Käyhkö & Kiesiläinen 2017, 2).

Current evidence suggests that the most probable risk factors for shoulder injuries in athletes are glenohumeral internal rotation deficit, weakness of the external rotators and rotator cuff, and scapular dyskinesis (Cools, Johansson, Borms & Maenhout 2015, 337). There is limited evidence about decreased glenohumeral abduction strength and decreased thoracic mobility as risk factors (Andersson, Bahr, Clarsen, & Myklebust 2016, 75). Injury prevention should focus on normal range of motion of the humerus, rotator cuff strength, scapular control and muscle balance (Cools, Johansson, Borms & Maenhout 2015, 332-336).

Designed health promotion programs aim to prevent injuries. Preventative programs start with identifying people who are at-risk and would benefit from client education. Providing evidence based information and consultation are essential parts of a successful intervention. (Kisner & Colby 2012, 1-45.) Although, evidence-based preventative interventions are available, they are not widely used by coaches and athletes. A preventative programme needs close collaboration between researchers, practitioners, coaches and athletes. (Donaldson et al. 2016, 273.)

2 AIMS AND OBJECTIVES OF THE THESIS

The aim of this thesis is to create a shoulder injury prevention package for recreational climbers. The objectives of the package are to increase knowledge about shoulder injuries and to give practical advice on how to prevent it. The focus of this thesis is to identify the risk factors and the mechanism of shoulder injuries. The package is built on evidence-based knowledge and it allows the athletes to reduce the possibility of shoulder injury.

3 STRUCTURE OF THE SHOULDER GIRDLE

The musculoskeletal system consists of bones, muscles, and joints. The skeletal system could be divided into two parts: the axial skeleton and the appendicular skeleton. The axial skeleton is around the longitudinal axis of the body. Its main function is to protect vital organs. The bones of the shoulder girdle belong to the appendicular skeleton. Therefore, their main function is to produce movement together with the skeletal muscles. The shoulder girdle is linked to the axial skeleton by the sternoclavicular joint. (Tortora & Derrickson 2012, 208-255.)

The shoulder girdle (pectoral girdle) (Figure 1) consists of the clavicle (collarbone), the scapula (shoulder blade) and the humerus. The clavicle lies above the first rib between the sternum (breastbone) and the acromion of the scapula in the anterior part of the thorax. The scapula is a large, flat bone in the posterior part of the thorax. It lies between the level of the second and seventh rib and during upper limb movements it slides along the thoracic wall. It has an articulation with the humerus at the glenoid and the clavicle at the acromion. (Tortora & Derrickson 2012, 257-261.) The scapula controls the position of the glenoid. It also provides a stable base for the glenohumeral joint (Sahrmann 2002, 193). The humerus is a long, large bone of the upper limb and articulates with the scapula (Tortora & Derrickson 2012, 261). The shoulder girdle has three synovial joints: the sternoclavicular, the acromioclavicular and the glenohumeral joint and two functional articulations; the scapulothoracic and the subacromial articulation (Kisner & Colby 2012, 540).

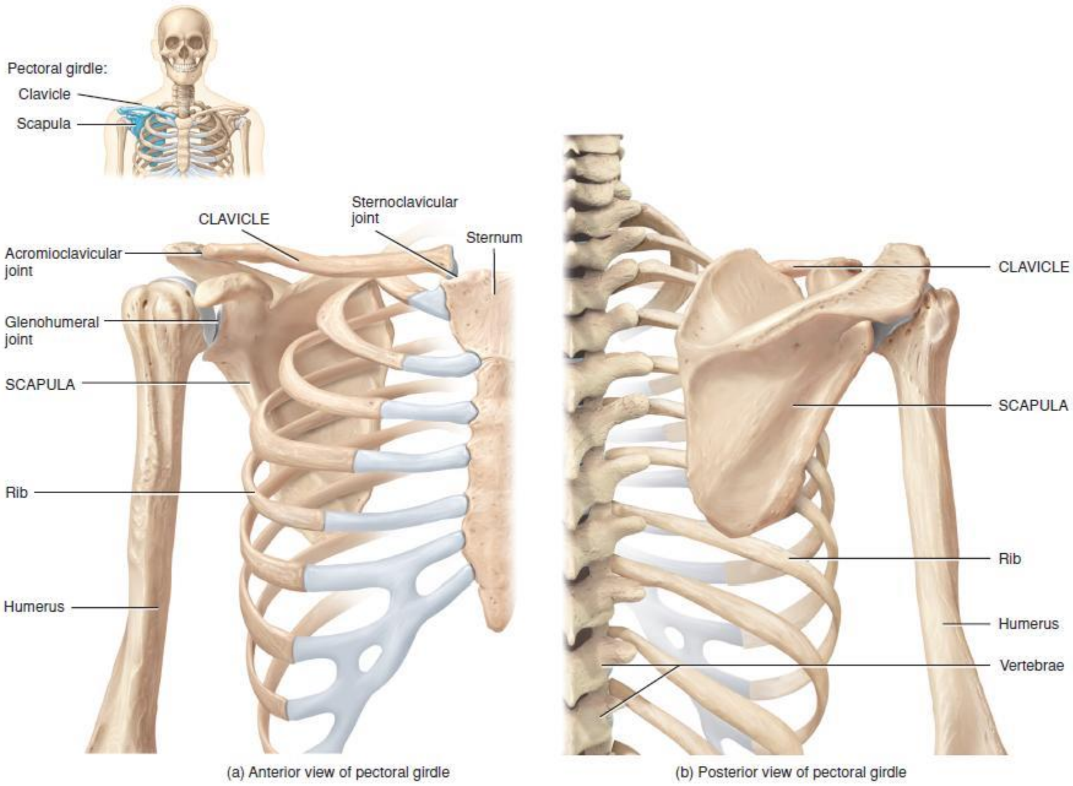

Figure 1. Right shoulder girdle (Tortora & Derrickson 2012, 256)

3.1 Joints of the shoulder girdle

The medial end of the clavicle articulates with the manubrium of the sternum in the sternoclavicular (SC) joint (Figure 2) (Tortora & Derrickson 2012, 257). It is the only bony link between the upper limb and the trunk. The sternoclavicular joint is a modified ball and socket joint with limited gliding movements. The movements are elevation and depression, protraction and retraction, and axial rotation. (Palastanga & Soames 2012, 101-106.) The SC joint is a synovial joint, which means it has a synovial cavity formed by an articular capsule (Tortora & Derrickson 2012, 290). It is stabilized by four ligaments: the costoclavicular ligament, the anterior sternoclavicular ligament, the posterior sternoclavicular ligament and the interclavicular ligament (Palastanga & Soames 2012. 102-103). When the shoulder is fully elevated it is in close-packed position, which means the area of contact in the joint is at a maximum (Hall 2007, 188).

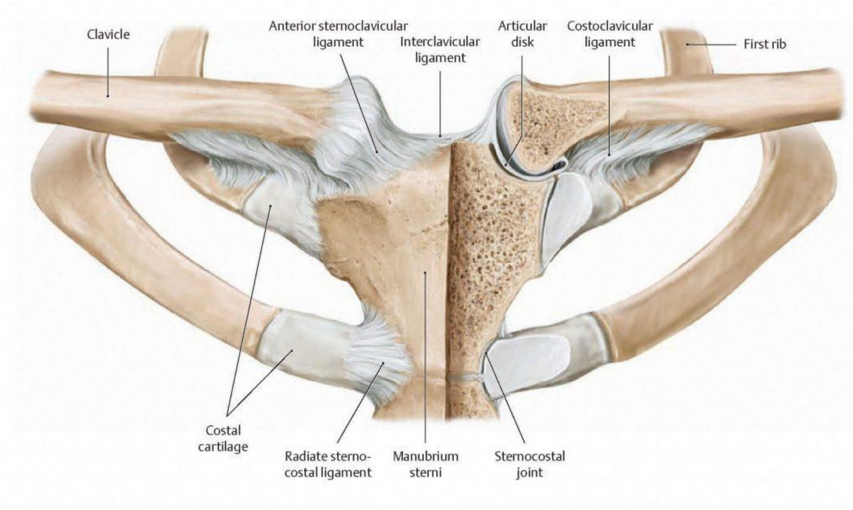

Figure 2. Sternoclavicular joint (Schuenke et al. 2007)

The acromioclavicular (AC) joint (Figure 3) is located between the lateral end of the clavicle and the acromion of the scapula (Tortora & Derrickson 2012, 307). It is a plane synovial joint with gliding movements and axial rotation. All movements of this joint are passive. The main function of the AC joint is to provide an additional range of movement for the shoulder girdle. It is stabilized by the coracoacromial and the coracoclavicular ligament. The coracoclavicular is a very powerful ligament and has two parts: a posteromedial conoid and anterolateral trapezoid part. (Palastanga & Soames 2012, 108-109.) During motion the acromion slides in the same direction as the scapula because of the concave surfaces (Kisner & Colby 2012, 542). When the humerus is in 90 º abduction the acromioclavicular joint is in close-packed position (Hall 2007, 189).

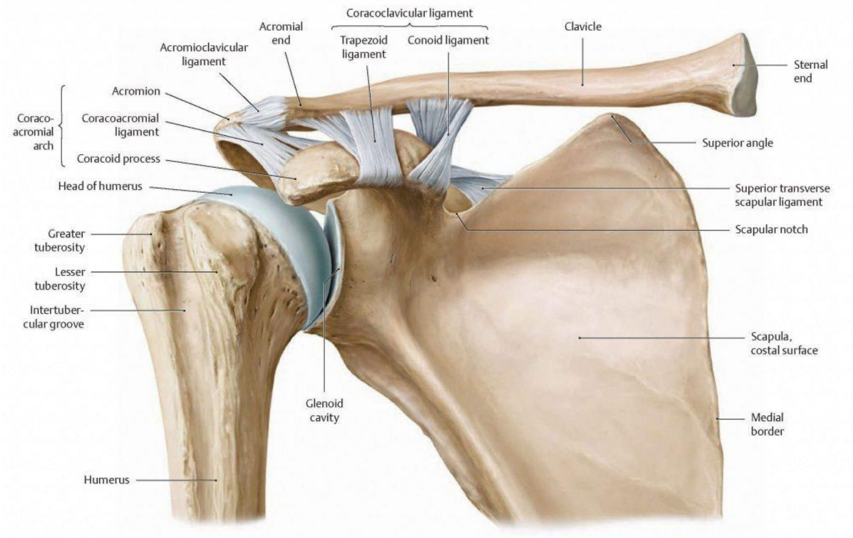

Figure 3. Acromioclavicular joint (Schuenke et al. 2007)

The glenohumeral (GH) joint (Figure 4) is between the glenoid cavity of the scapula and the head of the humerus. It is a synovial ball and socket joint with articular capsule. Its movements are flexion, extension, hyperextension, internal rotation, external rotation, abduction, adduction, horizontal abduction and adduction and circumduction (Figure 5). (Tortora & Derrickson 2012. 310-311.) During movement the convex head of the humerus slides in the opposite direction in the concave glenoid cavity (Kisner & Colby 2012. 541). The glenohumeral joint is stabilized by the coracohumeral and glenohumeral ligaments and the affecting muscles. The balanced work of the rotator cuff muscles keeps the head of the humerus in the glenoid cavity. (Tortora & Derrickson 2012. 311.) The long head of the biceps and the long head of triceps brachii provides a superior and inferior stability during elbow functions (Kisner & Colby 2012, 541). The glenoid labrum (Figure 6) also has a role in shoulder stability. It is a fibrocartilaginous rim that deepens the glenoid fossa. Its outer surface is attached to the glenoid while its inner surface is connected to the head of the humerus. (Palastanga & Soames 2012, 117.) When the humerus is abducted and externally rotated the joint is in close-packed position (Hall 2007. 191).

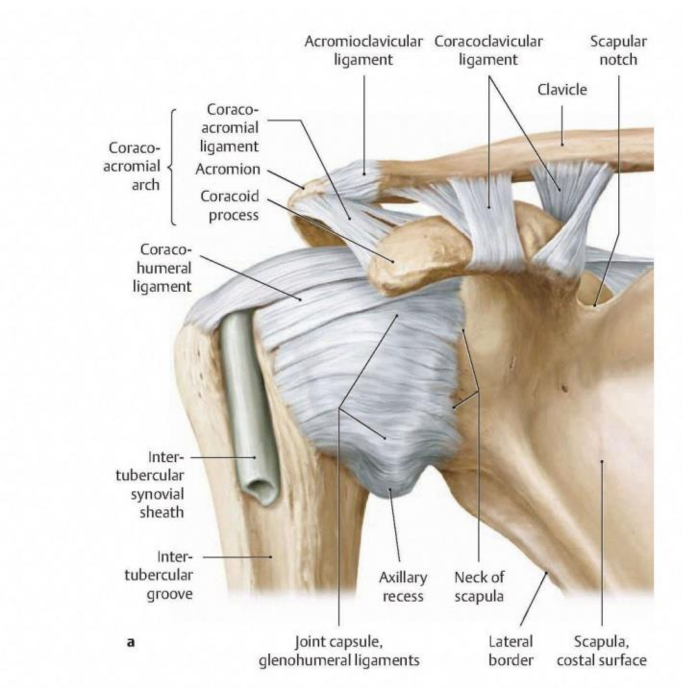

Figure 4. The shoulder joint (Schuenke et al. 2007)

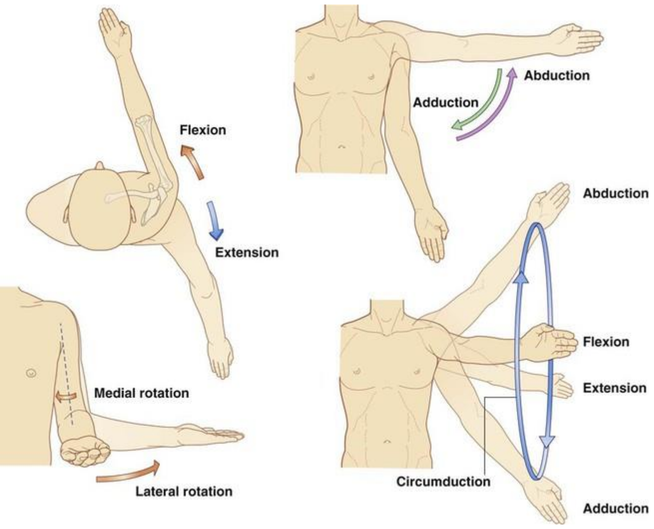

Figure 5. Movements of the shoulder (Website of Clinical Gate 2018)

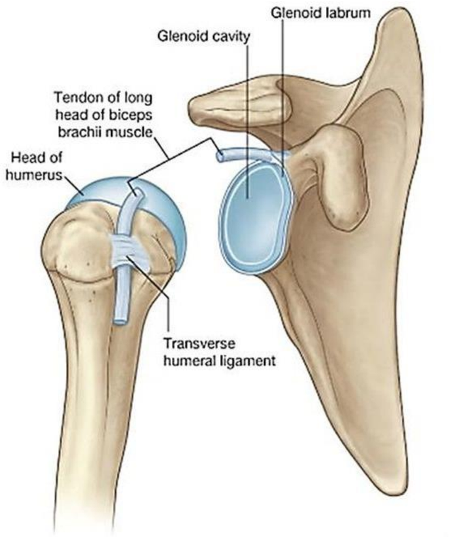

Figure 6. Glenoid labrum (Website of Muscle and Joint Clinic 2017)

The scapulothoracic articulation is a functional articulation and it is the region between the thoracic wall and the scapula. During upper limb movements the scapula slides along the thorax. The muscles affecting on the scapula have an important stabilizing role along with the positioning function. (Hall 2007. 191.)

The bones of the shoulder girdle assist to each other in movements. (Figure 7) During elevation, depression, protraction, and retraction of the scapula, the clavicle moves in the sternoclavicular joint. During upward and downward rotation of the scapula, the clavicle moves at the sternoclavicular joint and rotates at the acromioclavicular joint. Upward rotation occurs during abduction of the upper limb. During internal and external rotation of the scapula, there is movement of the humerus and motion at the acromioclavicular joint. In this scapular motion the medial border of the scapula move away from the thoracic wall. Anterior tilting occurs when the upper limb is extended while posterior tilting happens during elevation of the humerus. (Kisner & Colby 2012. 543.)

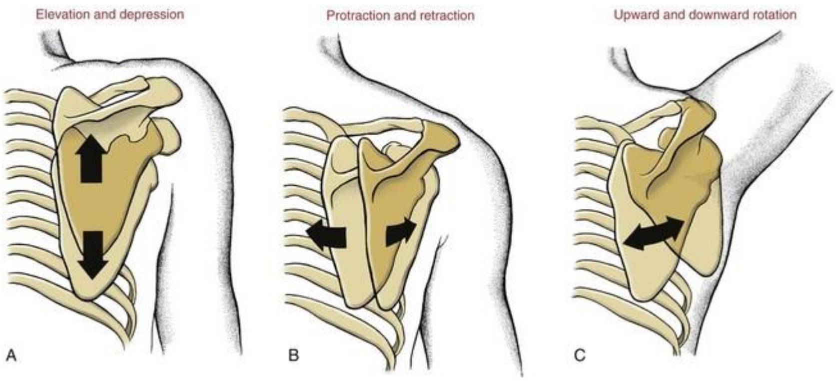

Figure 7. Movements of the scapula (Website of Musculoskeletal Key 2017)

During flexion and abduction of the upper arm, the humerus and the scapula moves together in a synchronized matter. The ratio of the movement is about 2:1, which means that there is 2 º glenohumeral motion the scapula moves 1 º. This is called the scapulohumeral rhythm (Figure 8). When the humerus is in 0 º - 30 º abduction or 0 º - 60 º flexion the scapula is relatively stable, and the movement mainly happens in the glenohumeral joint. This is called the setting phase. (Kisner & Colby 2012, 544.)

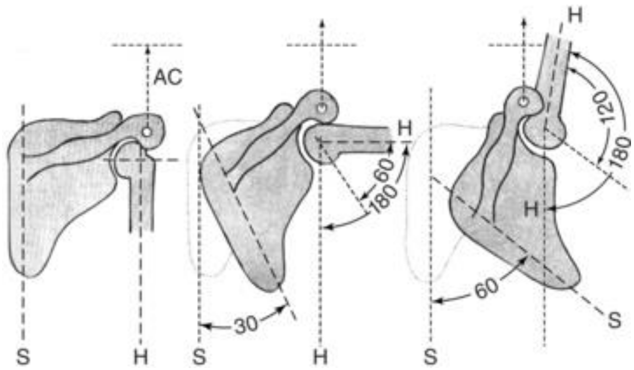

Figure 8. Scapulohumeral rhythm (Website of Musculoskeletal Key 2017)

The subacromial (suprahumeral) space (Figure 9) is the space between the head of the humerus and the coracoacromial arch. The coracoacromial arch is formed by the acromion and the coracoid process of the scapula linked together by the coracoacromial ligament. In the subacromial space lies the supraspinatus tendon and the subacromial bursa. This area is prone to irritation and pain by faulty posture, unbalanced muscle function or injury of the structures. (Kisner & Colby 2012, 544.)

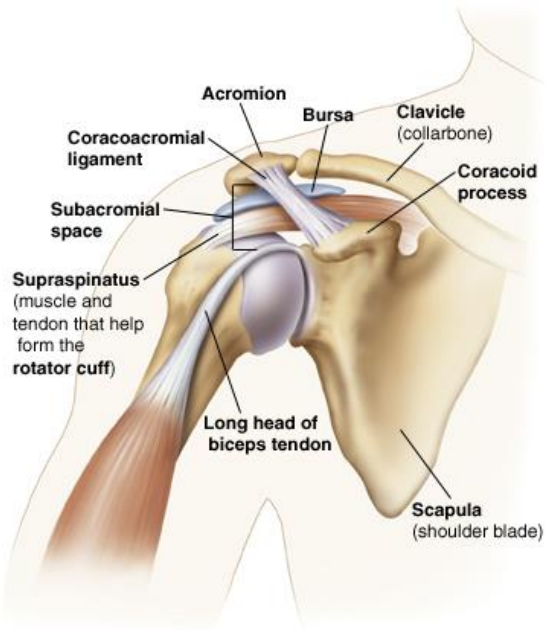

Figure 9. Suprahumereal space (Website of University of Bristol 2017)

3.2 Muscles affecting shoulder function

Skeletal muscles are attached to the bones by tendons at their origin and insertion. Their main function is to produce movement by pulling on the bones during muscle contraction. From a biomechanical point of view, bones are levers and joints are the fulcrums of the levers. (Tortora & Derrickson 2012, 367.)

The muscles of the pectoral girdle (Figure 10 and 11) can be divided into three groups: thoracoscapular, scapulohumeral and thoracohumeral muscles (Table 1) (Sahrmann 2002, 206). These muscles have two important functions: while some muscles produce movements on the humerus, other muscles stabilize the scapula to provide a stable base. With most of the humeral movements the scapula moves in a synchronized fashion as well. (Tortora & Derrickson 2012, 400.) Unbalanced muscle actions can cause impaired movement patterns which can lead to painful shoulder and injury. Therefore, balanced length and strength of these muscles are essential for optimal shoulder function. (Sahrmann 2002, 206.)

The trapezius muscle is a large, triangular shaped, superficial muscle on the back. It is divided into three parts. The upper trapezius muscle goes from to the superior nuchal line of the occipital bone to the lateral third of the clavicle. Its function is extension of the head and upward rotation and elevation of the scapula. (Tortora & Derrickson 2012, 400.) When the upper trapezius is too long it can cause depressed alignment of the shoulder, while shortness of the upper trapezius can cause elevated alignment of the shoulder (Sahrmann 2002, 207). The mid trapezius runs from the spinous processes of C7-T4 to the medial end of the spine of the scapula. Its function is adduction of the scapula. The lower trapezius goes from the spinous processes of T5-T12 to the medial end of the spine of the scapula. Its function is depression and upward rotation of the scapula. (Tortora & Derrickson 2012, 400.)

The levator scapulae is an elongated muscle on the posterior of the neck. It originates at the transverse processes of C1-C4 and inserts at the superior angle of the scapula. Its function is elevation and downward rotation of the scapula. (Tortora & Derrickson 2012, 400.) This muscle is an antagonist for the trapezius for scapular rotation (Sahrmann 2002, 207).

The rhomboid muscles lie parallel to each other under the trapezius. Their function is adduction and downward rotation of the scapula. The rhomboid minor runs from the spinous processes of C7-T1 to the medial border of the scapula, while the rhomboid major goes from the spinous processes of T2-T5 to the medial border of the scapula. (Tortora & Derrickson 2012, 400.) This muscle is a synergist in adduction and an antagonist in scapular rotation for the trapezius (Sahrmann 2002, 208).

The serratus anterior is a fan-shaped muscle between the medial border of the scapula and the top 8 or 9 ribs. Its function is abduction and upward rotation of the scapula. (Tortora & Derrickson 2012, 400.) It is a synergist in rotation for the trapezius. Weakness of the serratus anterior can cause overactivation of the upper trapezius. This muscle is an important stabilizer. It holds the scapula against the ribcage during movements. Insufficient strength and control can cause additional stress on the shoulder joint. (Sahrmann 2002, 209.)

The pectoralis minor is a thin, triangular shaped muscle under the pectoralis major. It runs between the coracoid process of the scapula and the third to fifth ribs. Its function is abduction and upward rotation of the scapula. (Tortora & Derrickson 2012, 400.)

Shortness of this muscle can cause thoracic outlet syndrome and incorrect scapular alignment (Sahrmann 2002, 210).

The deltoid is a thick muscle on the shoulder joint. It originates from the acromion and the spine of the scapula and inserts at the deltoid tuberosity of the humerus. It is divided into three parts. The function of the anterior part is flexion and medial rotation of the arm. The lateral part abducts the arm. The posterior part extends and laterally rotates the arm. (Tortora & Derrickson 2012, 402.) The deltoid pulls the humerus upward to the acromion. The rotator cuff muscles as a counterbalance pull the humaral head into the glenoid. When the deltoid is overactivated and the rotator cuff muscles are insufficient, the humeral head glides superiorly and/or anteriorly and causes impaired shoulder function. (Sahrmann 2002, 212-213.) The teres major muscle is located between the inferior angle of the scapula and the intertubercular sulcus of the humerus. Its function is extension, adduction, and medial rotation of the arm. (Tortora & Derrickson 2012, 402.)

Four deep muscles build up the rotator cuff around the glenohumeral joint: supraspinatus, infraspinatus, teres minor and subscapularis. The rotator cuff has an essential stabilizing function in the shoulder. (Tortora & Derrickson 2012, 404.) These muscles counterbalance the actions of the deltoid muscle and pull the humeral head into the glenoid (Sahrmann 2002, 213-214). The supraspinatus muscle is between the supraspinous fossa of the scapula and the greater tubercle of the humerus. It assists in abduction of the arm. (Tortora & Derrickson 2012, 402.) It also depresses and stabilizes the head of the humerus in the glenoid. This muscle is prone to injury when the shoulder is depressed because it goes under the acromion. During flexion and abduction of the arm the supraspinatus tendon can be compressed between the humeral head and the coracoacromial ligament if the humeral head does not glide enough inferiorly or rotate enough laterally. (Sahrmann 2002, 214.) The infraspinatus muscle lies between the infraspinous fossa of the scapula and the greater tubercle of the humerus. Its function is lateral rotation of the arm. (Tortora & Derrickson 2012, 402.) It also depresses the head of the humerus (Sahrmann 2002, 214). The teres minor muscle is between the lateral border of the scapula and the greater tubercle of the humerus. Its function is lateral rotation and extension of the arm. (Tortora & Derrickson 2012, 402.) It also depresses and laterally rotates the head of the humerus. The infraspinatus and the teres minor muscles are important lateral rotators. Weakness or stiffness of these muscles is very common. When this occurs, the humeral head can glide anteriorly or superiorly which can lead to impingement during flexion. (Sahrmann 2002, 215.) The subscapularis is a large muscle that runs between the subscapular fossa of the scapula and the lesser tubercle of the humerus. Its function is medial rotation of the arm. (Tortora & Derrickson 2012, 402.) It also depresses and pulls posteriorly the head of the humerus. It provides anterior glenohumeral stability. When the subscapularis is weak it can cause the head of the humerus glide anteriorly which leads to impingement. (Sahrmann, 2002, 215.)

The teres major is a thick, flat muscle that attaches to the inferior angle of the scapula and the intertubercular sulcus of the humerus. Its function is shoulder extension. It also assists in medial rotation and adduction of the arm. (Tortora & Derrickson 2012, 402-403.) Shortness of the teres major limits flexion of the arm and it can prevent sufficient lateral rotation and depression of the head of the humerus (Sahrmann 2002, 216).

The pectoralis major muscle is a large muscle that attaches to the clavicle, sternum and the costal cartilages of the second to sixth ribs and runs to the greater tubercle of the humerus. Its function is adduction and medial rotation of the arm. It also depresses the shoulder girdle. The clavicular end of the muscle assists in flexion of the arm. (Tortora & Derrickson 2012, 402.) In normal shoulder function the subscapularis should be a counterbalance for this muscle (Sahrmann 2002, 211). The latissimus dorsi muscle attaches to the thoracolumbar fascia, the iliac crest and the spinous processes of T7-L5 and runs to the intertubercular sulcus of the humerus. Its function is extension, adduction and medial rotation of the arm. It also depresses the shoulder. (Tortora & Derrickson 2012, 402.) The pectoralis major and the latissimus dorsi have an important role in normal scapulohumeral rhythm. These muscles are powerful medial rotators and can dominate shoulder rotation instead of the scapulohumeral muscles. When these muscles dominate, there is no proper control over the head of the humerus. If these muscles are overactivated the shoulder is depressed and there is no proper elevation during shoulder flexion. (Sahrmann 2002, 211.)

The coracobrachialis muscle is attached to the coracoid process of the scapula and the medial surface of the shaft of humerus. Its function is flexion and adduction of the arm.

The biceps brachii is a large muscle that has two heads of origin. The long head is attached to the tubercle above the glenoid cavity of the scapula while the short head originates from the coracoid process of the scapula. The insertion is at the radial tuberosity of the radius. The function of the biceps brachii muscle is flexion and supination of the forearm and flexion of the arm. The triceps brachii is also a large muscle with three heads of origin. The long head attaches at the infraglenoid tubercle, the lateral head attaches at the lateral and posterior surface of the humerus, the medial head attaches at the posterior surface of the humerus. The insertion point is at the olecranon of the ulna. The function of this muscle is extension of forearm and extension of arm. (Tortora & Derrickson 2012, 406.)

Table 1. Muscles affecting the shoulder (Tortora & Derrickson 2012, 400-404; Sahrmann 2002, 206-216)

Muscle	**Function**
Thoracoscapular muscles	
Trapezius – upper trapezius	Extension of the head Upward rotation and elevation of the scapula
Trapezius – mid trapezius	Adduction of the scapula
Trapezius – lower trapezius	Depression and upward rotation of the scapula
Levator scapulae	Elevation and downward rotation of the scapula
Rhomboid major and minor	Adduction and downward rotation of the scapula
Serratus anterior	Abduction and upward rotation of the scapula
Pectoralis minor	Abduction and upward rotation of the scapula
Scapulohumeral muscles	
Deltoid – anterior part	Flexion and medial (internal) rotation of the arm
Deltoid - lateral part	Abduction of the arm
Deltoid – posterior part	Extension and lateral (external) rotation the arm
Rotator cuff: supraspinatus	Abduction of the arm Depression and stabilization of the humeral head
Rotator cuff: infraspinatus	Lateral (external) rotation of the arm Depression and stabilization of the humeral head
Rotator cuff: teres minor	Lateral (external) rotation and extension of the arm Depression and lateral rotation of the humeral head

Rotator cuff: subscapularis	Medial (internal) rotation of the arm Depression and posterior pull of the humeral head
Teres major	Extension of the arm Assists in medial rotation and adduction of the arm
Thoracohumeral muscles	
Pectoralis major	Adduction and medial (internal) rotation of the arm Assists in flexion of the arm
Latissimus dorsi	Extension, adduction and medial rotation of the arm
Other affecting muscles	
Coracobrachialis muscle	Flexion and adduction of the arm
Biceps brachii	Flexion and supination of the forearm and flexion of the arm
Triceps brachii	Extension of forearm and extension of arm

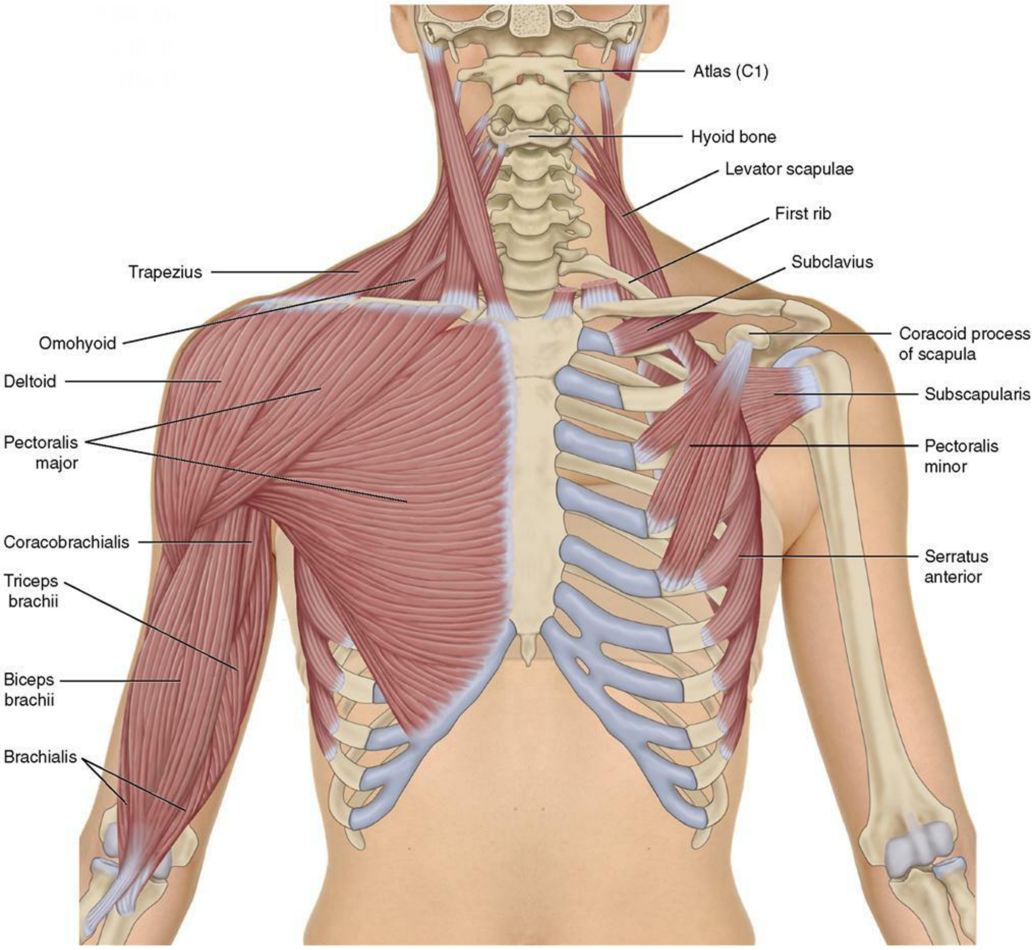

Figure 10. Muscles of the shoulder girdle, anterior view (Website of Musculoskeletal Key 2018)

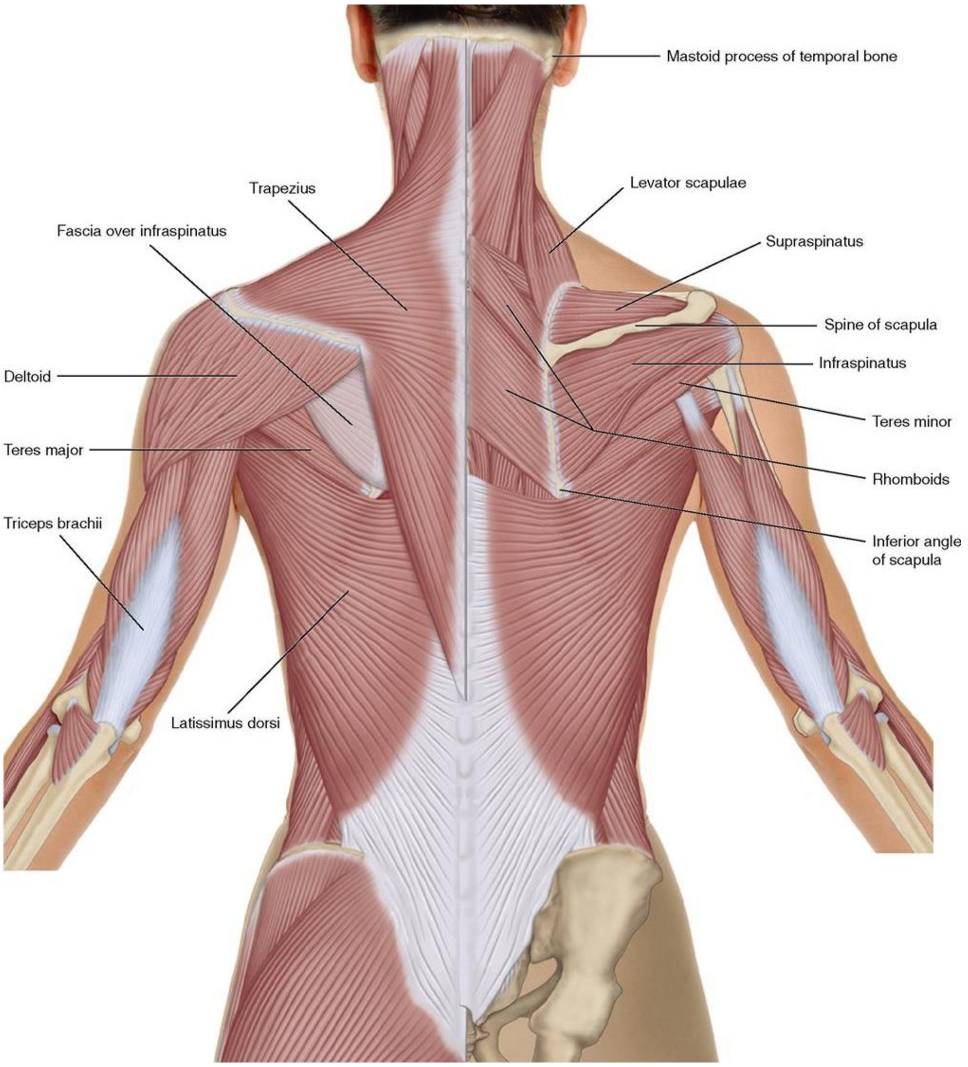

Figure 11. Muscles of the shoulder girdle, posterior view (Website of Musculoskeletal Key 2018)

3.3 Biomechanics and normal alignment of the shoulder

Biomechanics means analyzing the human body by the laws of physics with a mechanical perspective. Although the joints of the shoulder girdle act as a unit during shoulder movement, the glenohumeral joint supports directly the arm. Therefore, it has the greatest load. The arm is approximately 5 % of body weight. When the arm is extended, and the shoulder is in abduction or flexion, it creates large moment arms and large torque which means the load can be as much as 50 % body weight on the shoulder muscles. When the elbow is flexed, and the forearm is horizontal, it creates rotational torque as well on the shoulder. The rotator cuff muscles keep the head of the humerus in the joint socket and counterbalancing the actions of the large muscles that move the arm. (Hall 2007, 199-201.)

Normal alignment of the humerus means that the humeral head protrudes less than one third in front of the acromion, the olecranon faces posteriorly, and the palm faces towards the body. Normal alignment of the shoulder is slightly below the first thoracic vertebra from posterior view. Normal alignment of the scapula means that the medial border of the scapula is parallel to the spine and is approximately 7.5 centimeters from the midline. The scapula is flat against the thorax between T2 and T7 and rotated 30 ° anteriorly. For correct performance of the shoulder the humerus should be in the plane of the scapula during abduction. Therefore, scapular stability has a crucial role in the alignment of the glenohumeral joint. Problems in alignment can cause greater load on the joint that can lead to injury. Correct timing and control of the movements of the scapula are essential for preventing impairments. (Sahrmann 2002, 194-214.) During elevation of the arm, the humerus needs to externally rotate in order to move smoothly in the joint socket. Insufficient external rotation may lead to impingement. The supraspinatus muscle also has an important stabilizing and compressing role in arm elevation. The infraspinatus, teres minor and subscapularis also stabilizes the humerus during arm elevation. Disturbance between the balance of the deltoid and the rotator cuff muscles can cause microtrauma and dysfunction. (Kisner & Colby 2012. 545.)

4 COMMON SHOULDER INJURIES

The shoulder is the most mobile joint in the human body. The extreme mobility comes with the price of decreased stability. Therefore, the shoulder is prone to injuries. Natural degeneration with age, certain types of sports and certain types of work are risk factors. Work or sports involving repetitive hand movements above the shoulder, manual material handling and vibration cause extreme load on the shoulder. (Brown, Park & Bicknell 2015.) In Finland, according to the Terveys 2000 study, every 6th man and every 4th woman had shoulder problems in the previous month. In 2013, shoulder problems caused 704 000 days of sick leave which cost 43.7 million euros. (Website of Käypähoito 2014.) Common shoulder diagnoses are rotator cuff disorders (rotator cuff tears, subacromial impingement), adhesive capsulitis (frozen shoulder), glenohumeral instabilities and acromioclavicular (AC) disorders (Brown, Park & Bicknell 2015).

4.1 Impingement syndrome and rotator cuff injuries

Impingement syndrome is common in those professions and sports that involve repetitive movements over the head. During flexion and abduction of the arm the structures between the head of the humerus and the acromion can be pinched. When this occurs repetitively, the structures become inflamed and painful. When the load continues, it can lead to tear and rotator cuff injury. (Tortora & Derrickson 2012, 405.) The symptoms of impingement are tenderness, pain and hypermobility of the anterior shoulder capsule. Decreased medial rotation of the humerus and weakness of the shoulder may be also present. (Hall 2007, 203.)

Impingement can be categorized as primary impingement, secondary impingement or internal impingement. In primary impingement, anatomical or biomechanical factors decrease the subacromial space resulting in a mechanical wear in the rotator cuff tissues. For example, a flat acromion or degenerative changes in the AC joint can cause primary impingement. Secondary impingement is due to instability of the glenohumeral joint. (Kisner & Colby, 2012. 562-563.) Secondary or functional impingement is common in young overhead athletes (less than 35 years of age). Excessive external rotation of the humerus leads to anterior instability while tightness of the posterior capsule may lead to decreased internal rotation. This requires planned therapeutic exercises that address the causing problems. (Page 2011, 52-53.) Overactive deltoid muscle is a very common finding. In this case the counterbalancing rotator cuff muscles are weak. This leads to an increased superior movement for the head of the humerus causing irritation of the tendons. (Hall 2007, 203.) Overuse of the supraspinatus muscle is also common. It can be caused by inadequate muscle work of the teres minor, infraspinatus or subscapularis. Insufficient scapular movement also can lead to impingement when the scapula has decreased upward rotation. (Sahrmann 2002, 194.) Internal impingement is common with throwing athletes. It occurs when the arm is in elevation, horizontal abduction and the end range of external rotation. Posterior capsule tightness and scapular dysfunction may be present.

Neer categorized impingement syndrome by the irritated structures. Possible pathologies are supraspinatus tendonitis, infraspinatus tendonitis, bicipital tendonitis, superior glenoid labrum tears, subdeltoid (subacromial) bursitis, anterior strains (subscapularis, pectoralis minor, short head of biceps) and inferior strains (long head of triceps). Anterior strains are common overuse injuries in sports while inferior strains are typically caused by trauma. (Kisner & Colby 2012, 563-564.)

Marik and Roll studied the effectiveness of different treatments of the shoulder in a literature review. (2017) They analysed 76 studies from which 67 had level I evidence, 7 had level II evidence and 2 had level III evidence. According to the review strong evidence supports that exercise has good short- and long-term results in the case of impingement syndrome. The studies about conservative treatment versus surgery were controversial. However, exercise therapy after surgery showed good results. There was mixed evidence about other interventions such as electrotherapy, neuromuscular reeducation, steroid injections and joint mobilization. There was moderate evidence for taping for short-term pain relief. (Marik & Roll 2017.)

Untreated impingement can lead to rotator cuff tears (Tortora & Derrickson 2012, 405). Rotator cuff strains and tears are very common. Studies estimate that 65 – 70 % from all shoulder complaints involves the rotator cuff. It can be caused by acute injury or trauma or chronic degeneration of the tendons. Chronic degeneration can be without symptoms and it is unknown why some people have pain while others do not.

(Edwards et al. 2016, 280.) Strain and tear can occur on any of the rotator cuff tendons, but the supraspinatus tendon is the most vulnerable due to its location. Increased load on the shoulder due to work or sports, poor posture and incorrect movement patterns are risk factors for this type of injury. (Tortora & Derrickson 2012, 405.) The symptoms are pain and weakness in the shoulder that may increase during elevation and internal rotation of the humerus (Hall 2007, 203). It is typical that the active range of motion of the shoulder is limited or painful while the passive range of motion is full and painless. Muscle atrophy of the rotator cuff muscles also may be present. (Sahrmann 2002, 218.) In the Neer classification system there are three stages of rotator cuff injury. The first stage is acute inflammation, the second stage is degenerating, chronic inflammation and the third stage is rupture or arthritis. When a rotator cuff tear involves the entire thickness of the tendon, it is called full thickness tears. Cofield classified full thickness rotator cuff tears by size. Small tears are less than a centimetre. Medium tears are 1 – 3 cm. Large tears are 3 – 5 cm and massive tears are greater than 5 cm. (Hopman, Krahe, Lukersmith, McColl & Vine 2013, 15-19.)

Rotator cuff injuries can cause activity and participation limitations during the recovery. Recovery time can be slow, and recurrence rates are high. Time for recovery is usually eight to twelve weeks but it can take longer in 40% of the cases. The treatment can be surgical or conservative. In conservative treatment, therapeutic exercises are prescribed. The focus is on shoulder mobility and stability. The exercises consist of range of motion exercises, scapular control exercises and eccentric strength and progressive resistance training. Surgical and conservative treatments are both popular. In the case of inflammation or small ruptures, conservative treatment shows equally good outcomes as surgical treatment. Larger than 3 cm full thickness tears need surgical attention. Surgery could be repair of the tear and/or decompression of the subacromial space. (Hopman et al. 2013, 29-45.)

According to Marik and Roll there is moderate evidence that progressive strengthening exercises, ROM exercises, and joint mobilizations are effective as conservative management of rotator cuff tears. There is strong evidence that progressive tendon forces and standard rehabilitation programs are effective after rotator cuff repair. (Marik & Roll 2017.)

4.2 Frozen shoulder/adhesive capsulitis

Frozen shoulder or adhesive capsulitis is a common musculoskeletal disorder among people between the age of 40 and 60. The symptoms are limited range of motion, thickened joint capsule, inflammation of the surrounding tissues and pain. (Kisner & Colby 2012, 547.) According to the evidence-based guidelines of the American Physical Therapy Association (APTA) primary adhesive capsulitis is between 2 % to 5.3 % of the population. Meanwhile, secondary adhesive capsulitis related to diabetes mellitus and thyroid disease is between 4.3 % and 38 %. Current evidence suggests that age, gender, diabetes and thyroid disease are risk factors for frozen shoulder. Adhesive capsulitis causes impaired function. Patients have pain and difficulty with dressing and grooming and reaching above the shoulder level or behind the back. (Kelley et al. 2013, 6-26.) Night pain, disturbed sleep, pain in motion and rest, decreased ROM, limited external rotation, abduction and flexion are common symptoms. Faulty posture, protracted and anteriorly tilted scapula, rounded shoulders are risk factors. Poor endurance of the rotator cuff and overuse of the scapular muscles are common findings. (Kisner & Colby 2012, 547.)

Adhesive capsulitis can be described with four phases. The symptoms in the first phase are sharp pain at the end ranges of shoulder motion, pain at rest, nocturnal pain and decreased external rotation. This stage can last up to 3 months. The symptoms in the second phase, sometimes called the “painful” or “freezing” phase, are gradually decreased range of motion in all directions due to pain. This stage can last from 3 to 9 months. The third phase is called the “frozen” stage. Its symptoms are pain and decreased range of motion in the shoulder. This phase lasts from 9 to 15 months. In the fourth phase, called the “thawing” stage, the pain gradually decreases but shoulder stiffness persists from 15 to 24 months. The treatment consists of patient education, encouraging movement, corticosteroid injections combined with mobility and stretching exercises. (Kelley et al. 2013, 6-26.)

According to Marik and Roll there is strong evidence that ROM exercises, stretches and joint mobilization combined with steroid injection improve function and decrease pain in the case of adhesive capsulitis. The review also mentions that there is limited evidence for cryotherapy, laser therapy or electrotherapy. (Marik & Roll 2017.)

4.3 Glenohumeral instability and dislocations

Glenohumeral instability can be traumatic or non-traumatic. Instability can be present anteriorly, inferiorly or posteriorly. Non-traumatic instability can be divided into further subcategories such as multidirectional instability, generalized joint hypermobility, muscle patterning instability and repetitive overuse. Abnormal muscle patterning is very common among people with shoulder instability and can be caused by various reasons such as muscle weakness, pain or altered proprioception. Commonly overactive muscles are the pectoralis major and latissimus dorsi, while lower trapezius, infraspinatus, deltoid and supraspinatus have delayed or reduced activation. Instability also can be caused by weakness of the rotator cuff muscles as they fail to keep the humeral head in the joint socket during shoulder motion. Other causes of glenohumeral instability can be inappropriate scapula and humeral position and decreased scapular stability. The scapula should upwardly rotate during elevation to support the humerus. The most common problems are downward rotation, forward tilt or winging of the scapula and excessive internal rotation of the humerus during arm motion. (Barrett 2015, 60-66.)

Dislocations or subluxations are also common in the glenohumeral joint due to its extreme mobility and loose structure. Dislocations happen most commonly in anterior and inferior directions, but it can occur posteriorly as well. Glenohumeral dislocations are usually due to trauma, commonly falls or other great external forces on the shoulder and usually happen when the shoulder is abducted and externally rotated. (Hall 2007, 202.)

Current guidelines for instability prefer conservative treatment over surgical. The rehabilitation program depends on the underlying causes. The treatment plan can include learning the correct scapular and humeral alignment, increasing scapular stability, learning the correct motor pattern, relaxation and stretching of the overactive muscles and strengthening the rotator cuff muscles. (Barrett 2015, 66-69.) Glenohumeral dislocation requires external reduction. This injury causes damage to the surrounding tissues and sometimes also the nerves. Strengthening of the rotator cuff and scapular stabilizers starts after 3-6 weeks of immobilization. Gentle range of motion exercises start as the pain allows. (Khiami, Gérometta & Loriaut 2015, 51-57)

5 CLIMBING AS A SPORT AND ITS MOST COMMON INJURIES

Climbing has become increasingly popular in the last two decades. Sport climbing was added to the Olympic Games in 2016 and climbers can compete at the Olympics in 2020 in Tokyo. Other international and regional competitions have been held already since 1980. (Website of the International Federation of Sport Climbing 2017.) In Finland, the Finnish Climbing Association (SKIL, Suomen Kiipeilyliitto ry) was founded in 1995 and was accepted as a member of the Finnish Olympic Committee in 2011 (Website of Suomen Kiipeilyliitto 2018).

The most popular types of climbing are sport climbing and bouldering. The goal of climbing is ascending and descending on rocks or indoor climbing walls. In sport climbing fixed bolts, ropes and harnesses are used as protective equipment while in bouldering the climbs are short and low, and a protective mat is placed on the ground. Both types require balance, strength and endurance. (Website of International Climbing School 2014). Climbing routes are rated depending on their difficulty from 3 to 8 and a, b or c. From 3 to 5 is beginner, 6a to 6c is intermediate, 7a-7b is advanced, 7b-8a is expert and elite is above 8b. (Website of 99Boulder 2018.) In Finland, bouldering is the most popular form of climbing (Website of Suomen Kiipeilyliitto 2018).

5.1 Most common injuries in climbing

Jones, Asghar and Llewellyn investigated in the epidemiology of climbing injuries. (2007) 201 climbers answered a questionnaire in the United Kingdom. Half of the participants had suffered from injury in the previous 12 months. Fall-related injuries were the least common, with 21 participants, from which 2 had upper limb fracture. Overuse injuries were the most common, with 67 participants, from which 20 suffered from shoulder injury. 57 climbers had injury due to strenuous moves and 16 of them affected the shoulder. Jones suggests that climbers who practice bouldering on high difficulty level are at greater risk to suffer injuries from strenuous moves. Rock climbers are more prone to overuse injuries. The study suggests that educating climbers and coaches about the most frequent injuries and preventative exercises would be beneficial. (Jones, Asghar and Llewellyn 2007, 773-778.)

Sweitzer studied climbing from a medical point of view. (2012) According to the study climbing became safer due to the improvement of protective equipment and injuries from falls are less common. The most frequent injuries are due to overuse and micro-traumas and involve the fingers and the shoulder girdle. The most common shoulder problems were outlet impingement with rotator cuff tears, proximal biceps tendonitis, biceps tendon pulley lesion, superior labrum antero-posterior lesion of the glenoid (SLAP lesion) and bursitis subacromialis. Sweitzer also mentions that overstrain injuries are more common among older climbers. (Sweitzer 2012.)

Schöffl, Popp, Küpper and Schöffl studied climbing between 2009 and 2012 with 836 patients, all together 911 cases of climbing injuries in the Klinikum Bamberg hospital in Germany. The patients were indoor and outdoor climbers. The study included acute traumas and overstrain cases as well. The injuries and the climbing level of the patients were determined and analyzed. 380 cases were acute traumas and 531 were overstrain injuries. 157 cases, the second most common, were shoulder injuries. SLAP tear (51), impingement syndrome (40), dislocation (16), sprain (17) and supraspinatus tendonitis (7) were the most common shoulder injuries. The study also mentions that according to the collected data older climbers with more climbing years are more prone to overstrain injuries. (Schöffl, Popp, Küpper & Schöffl 2015, 62-67.)

Grønhaug and Norberg studied chronic climbing injuries in a review. (2016) The review suggests that shoulder injuries are the third most common after finger, hand and arm injuries. They also mention the lack of consistency of the studies. Methodology, the participants, inclusion and exclusion criteria widely differ in the current literature. Some studies do not mention the age of the participants, while other studies focus only on competitive climbers. The studies also do not exclude injuries that are very common in the general population, therefore it is hard to determine the problems caused by climbing. (Grønhaug and Norberg 2016.)

In Finland, according to studies, 83 % of Finnish climbers had had injuries at some point in their sport life and 67 % of the injuries affected the upper limb (Olli, Käyhkö and Kiesiläinen 2017, 2).

5.2 Risk factors

Muscle balance is essential for healthy function. Studies have shown that athletes with shoulder complaint have altered movement patterns and muscle imbalance. Muscle imbalance can be present at the glenohumeral and/or the scapulothoracic articulation. Tightness of the pectoralis major can pull the humerus too much anteriorly, while a tight pectoralis minor limits scapular movement such as upward rotation. Other observations in overhead athletes with shoulder dysfunction are overactive upper trapezius and decreased activation of serratus anterior and lower trapezius. (Page 2011, 52-58.) Overactive pectoralis major and the latissimus dorsi can dominate shoulder rotation instead of the scapulohumeral muscles and there is no proper control over the head of the humerus. This leads to depressed shoulders and there is no proper elevation during shoulder flexion. (Sahrmann 2002, 211.) An overactive deltoid muscle can pull the head of the humerus too much superiorly causing irritation of the tendons while the rotator cuff muscles are not activated enough or weak (Hall 2007, 203). Weakness of the teres minor, infraspinatus or subscapularis can lead to overuse of the supraspinatus muscle (Sahrmann 2002, 194). When the rotator cuff muscles and the long head of biceps fatigue, their ability to stabilize the humeral head decrease and leads to mechanical irritation (Kisner & Colby 2012, 565).

Protruded scapula is common in climbers due to hypertrophied subscapularis (Sahrmann 2002, 198). Climbing strengthens the internal rotators of the arm well while the external rotators stay weaker (Olli, Käyhkö and Kiesiläinen 2017, 143).

Sport climbing and bouldering require muscle endurance from climbers. Static postures and resting with extended arms and relaxed shoulders are typical on overhanging walls. However, this hanging position may lead to shoulder injury. SLAP tears, impingement and rotator cuff injuries are common and linked to faulty movement patterns and weak scapular stabilizers. Baláš et al. studied activation of the scapula stabilizers in four different positions. (2016) The conclusion of the study was that climbers tend to elevate the shoulder during static postures and the thoracoscapular muscles have lower activation. The study suggests that climbing with correct posture and activated thoracoscapular muscles would be a recommended therapeutic exercise. (Baláš et al. 2017, 107-113.)

Maenhout et al. investigated the changes of the acromiohumeral space and scapular positions after muscle fatigue in 29 recreational overhead athletes. (2015) Their hypothesis was that the acromiohumeral space decreases after muscle fatigue making the athletes prone to impingement and rotator cuff injury. Their findings suggested the contrary. The acromiohumeral space increased during motion after muscle fatigue as a protective mechanism. More changes could be observed in the scapular positions. Increased posterior tilt and increased upward and external rotation was observed during motion. Changes were not significant at rest. Although several studies observed changes in the scapular positions after muscle fatigue, the results are controversial. There is need for further good quality studies and bigger sample sizes. (Maenhout et al. 2015, 281-288.)

Chopp, Fischer and Dickerson also investigated the effects of muscle fatigue in their study with 10 participants. (2011) Increased posterior tilt and upward rotation of the scapula were observed when the participants performed a global muscle fatigue program. No changes were observed after a local muscle fatigue program. The local muscle fatigue program focused on the external and internal rotators. The study suggests that the rotator cuff muscles have a bigger role in creating subacromial space than scapular orientation. (Chopp, Fischer & Dickerson 2011, 40-45.)

Joshi et al. also suggest that fatigue of the glenohumeral external rotators may lead to injury. Their study investigated the correlation between shoulder external rotation and scapular muscle activation in 25 overhead athletes. (2011) Their findings suggested that external rotation muscle fatigue leads to altered muscle activation. They observed decreased activation in the lower trapezius and increased activity in the infraspinatus causing increased upward rotation of the scapula. There were no changes in the upper trapezius and serratus anterior, but their fatigue protocol might had not activated these muscles enough. Changes at rest were not significant. The study acknowledges their limited sample size and lack of comparison. Further studies are needed to fully understand the effects of muscle fatigue. (Joshi et al. 2011, 349-357.)

Cools suggests that the most probable risk factors for shoulder injuries in athletes are glenohumeral internal rotation deficit (GIRD), weakness of the external rotators and rotator cuff, and scapular dyskinesis. (Cools, Johansson, Borms & Maenhout 2015, 337). There is limited evidence about decreased glenohumeral abduction strength and limited thoracic mobility as risk factors (Andersson, Bahr, Clarsen, & Myklebust 2016, 75). Injury prevention should focus on normal range of motion of the humerus, rotator cuff strength, scapular control and muscle balance. (Cools, Johansson, Borms & Maenhout 2015, 332-336).

6 INJURY PREVENTION

Physiotherapy is beneficial for clients who want to improve their fitness level, enhance performance and reduce the risk of injury or movement disorders. Injuries can cause impairments such as pain, limited range of motion, muscle weakness or joint hypermobility. Impairments may lead to reduced function, activity and participation limitations. Designed health promotion programs aim to prevent injury and disease. Preventative programs start with identifying people who are at-risk and would benefit from client education. Providing evidence based information and consultation are essential parts of a successful intervention. (Kisner & Colby 2012, 1-45.) Research suggests that, although evidence-based preventative interventions are available, they are not widely used by coaches and athletes. Also, there is limited information about specific strategies. A successful preventative programme needs close collaboration between researchers, practitioners, coaches and athletes. (Donaldson et al. 2016, 273.)

Vriend et al. investigated the effectiveness of different preventative strategies in their systematic review. (2017) 155 studies were analyzed, from which only 4 targeted the upper limb. The studies included strategies such as improvement of equipment, rule-modifications, educational programs and trainings of physical skills. Most studies focused on equipment modifications and improving physical fitness. The results were inconsistent. More studies are needed about educational and other training programs. There are gaps in the literature concerning several sports. Most of the studies focused on contact sports and the lower limb while other sports are not studied. The upper limb was the least researched area in injury prevention. (Vriend et al. 2017, 2027-2043.)

6.1 Patient education

Strong evidence shows that appropriate patient education leads to better treatment results. Patient education gradually became an important part of rehabilitation and health promotion since the 1970's. Nowadays it is well known that behavioral factors and lifestyle choices of the client are influencing the outcomes of the treatment. In the 70's and the 80's the emphasis was mainly on providing information. In the 21st century the clients have a more active role in their treatment such as active involvement in the decision-making process and learning self-management skills. (Hoving, Visser, Mullen and Van den Borne 2010, 275-279.) Shared decision-making programs are shown to be effective in motivation, increasing knowledge and producing more realistic expectations (Hopman et al. 2013, 29).

In the case of shoulder injuries, poor understanding of the problem leads to inappropriate activity, kinesiophobia and fear-avoidance. Therefore, appropriate patient education is needed. Patient education promotes appropriate load to the tissues and learning correct movement patterns and motor control. (McClure and Michener 2015, 794-797.)

During planning an intervention, it is important to take into consideration what are the personal beliefs of the client and their individual and environmental factors (e.g. time management, equipment). It is important to plan what is the best place and way to learn. Clear instructions, visual presentation, written handouts and active participation of the client can help the learning process and motivation. (Kisner & Colby 2012, 27-48.)

6.2 Therapeutic exercises

Therapeutic exercises are a fundamental part of physiotherapy treatments. Therapeutic exercises aim to modify certain risk factors in injury prevention. Therapeutic exercise programs consist of individually planned, specific movements which are intended to improve body function, prevent or rehabilitate impairments, correct body alignment or improve fitness. The human body reacts and adapts according to the affecting external loading and stress. Excessive load can cause acute injuries or repetitive stress disorders while the absence of load can cause degeneration and loss of muscle and bone mass. Therefore, therapeutic exercises slowly and gradually expose the body to stress to make the musculoskeletal system adapt to the required load. The muscle needs to be challenged during training and be fatigued after exercise. The type of appropriate therapeutic exercises depends on the underlying causes and the individual goals of the client. Progression in exercises is needed for challenging the muscles after they have adapted to the previous load. More repetitions, progressing from closed chain (working body segment is stabilized) to open chain (working body segment is free in space) exercises, challenging the balance, increasing the load are all techniques for progression. (Kisner & Colby 2012, 1-11., 158-194.)

Kisner and Colby suggest that for improving function, endurance training shows better results than strength training. This means that the muscle works against mild or moderate resistance with several repetitions. This way, light resistance does not irritate the soft tissues as much as heavy loads. For adults 8-12 repetitions with moderate load and two to three sets are appropriate. (Kisner & Colby 2012, 158-194.) Lauersen, Bertelsen and Andersen found strength training the most efficient in preventative programs in a systematic review. (2014) In strength training, the muscle or muscle group works against heavy loads with few repetitions. Multiple exposure programs such as strength combined with proprioceptive training, had moderate evidence. Stretching alone did not show significant effect. Lauersen suggests that a preventative program needs to find the right ratio between strength and other interventions. The included studies focused on competitive contact sports and most of them focused on the lower limb. (Lauersen, Bertelsen & Andersen 2014, 871-877.)

To improve shoulder function, the aim is activating and strengthening the scapular stabilizers such as the rhomboids, middle trapezius, serratus anterior and lower trapezius; and strengthening the rotator cuff muscles, especially the external rotators for glenohumeral stability. Athletes also need to learn to avoid elevation of the scapula when raising the arm. (Kisner & Colby 2012, 596-610.) For scapular muscle activation isokinetic protraction and retraction exercises were found the most beneficial (Cools Johansson, Borms & Maenhout 2015, 337). For activation of the middle and lower trapezius arm extension in prone and external rotation of the arm in side lying showed the best muscle activation in a study (De Mey et al. 2013). In the case of strengthening the rotator cuff, eccentric training techniques were studied recently. Eccentric training means when the muscle works against the load when it is lengthening. Usually a muscle can work against more load in the eccentric, lengthening phase than in the concentric, shortening phase. Although the results are promising, more studies are needed for confirming this theory. (Camargo, Alburquerque-Sendín & Salvini 2014, 634-644.)

A randomized controlled trial was made about shoulder injury prevention among Norwegian handball players. (2014) 46 teams participated with 660 players, aged between 16 and 47. The participants were divided into an intervention group and a control group. For the intervention group a ten-minute exercise program (all-together 5 exercises) was added to their warm up routine. They performed the exercises three times per week throughout the season. The program targeted strength of internal and external rotators of the humerus, scapular control and thoracic mobility. The results showed fewer shoulder injuries by 28% in the intervention group. (Andersson, Bahr, Clarsen & Myklebust 2016, 75-80.) However, Andersson et al. could not confirm their original findings in their follow up study a year later (Andersson, Bahr, Clarsen & Myklebust 2017).

6.3 Stretching

Flexibility means the ability to move joints smoothly and easily without pain through the range of motion. Flexibility depends on the surrounding soft tissues and the kinematics of the joint. Muscle length and muscle flexibility has an important role in healthy range of motion. Muscle flexibility depends on the ability of a muscle to relax or deform and yield to stretching forces. Dynamic flexibility or active mobility (AROM) means when the movement of the joint happens by active muscle work of the body. Passive flexibility or passive mobility (PROM) means that the muscles are relaxed and external forces move the joint. (Kisner & Colby 2012, 73.)

Flexibility is essential for healthy function. Reduced range of motion of the joints leads to reduced function and disability. Maintaining normal range of motion of the joints is important also in injury prevention. Decreased mobility can change the movement patterns and may put excessive stress on the muscles, tendons and joints. Flexibility can be maintained by gentle regular stretching. Stretching improves joint mobility and muscle length. It also relaxes the muscles by releasing intramuscular pressure and increasing fluid flow; therefore, stretching is believed to be important in the recovery process after strenuous training. (Ylinen 2008, 3-4.)

Effective stretching needs proper position which elongates the targeted muscle group. Appropriate technique, duration, frequency and intensity also need to be determined. Evidence shows that low-intensity stretching with longer duration causes less tissue damage and better results than short, high intensity stretching. There are several classifications for stretching. Stretches can be static, static progressive or cycling (intermittent). Static stretch means that gentle force is applied on the tissues for a longer period of time (30 - 60 seconds). Static progressive stretch means the stretch is held until the client feels comfortable and then the muscle is stretched gently further. In cycling stretch a gradually increasing force is applied repeatedly but for a shorter period of time (5 - 10 seconds). According to evidence 30 to 60 seconds static stretch 2 times a day is appropriate for healthy young or middle-aged people. Stretches longer than 60 seconds did not show more improvement. If the client feels joint pain or soreness 24 hours after the stretch, too much force was applied causing inflammatory responses. Sufficient warm up by low intensity active exercises before stretching is important. Strengthening of the antagonist muscles in the new range of motion after stretching is essential for successful stretching programs. (Kisner & Colby 2012, 85-100.)

Current evidence is controversial about the effectiveness of stretching in injury prevention. According to a review by Behm (2016) static stretch had no effect on overuse injuries when they were performed before exercise. Stretching may be beneficial in reducing acute muscle injuries in endurance sports. None of the reviewed studies found stretching harmful. Stretching may be useful to enhance performance, increase ROM, and reduce muscle injury. (Behm, Blazevich, Kay, & McHugh 2016.)

In the case of shoulder, stretching the shortened muscles can be beneficial. Typical shortened muscles are pectoralis major, pectoralis minor, latissimus dorsi, teres major, subscapularis, upper trapezius and levator scapulae. (Kisner & Colby 2012, 591-595.)

7 INTERVENTION PACKAGE

An interview was made with a more experienced climber who has also done coaching in the past. She has been climbing for 11 years and her highest performance is 7c in sport climbing and 7a in bouldering. She is an advanced/expert climber. She suffered once from a mild shoulder injury. “It was supraspinatus tendonitis. It happened around the third year when I was training twice a week. It was not serious, but my shoulder was painful. After that, I trained easier routes for a month and did exercises mostly for the shoulder blades.”- she described it. She mentioned that in her sport career she had met only one climber who suffered from more serious shoulder problems. However, mild shoulder pain, instability or weakness is common in her opinion. She suggested that a shoulder exercise program may not prevent injuries but can enhance climbing performance.

To find out more about the special needs of the clients, several questions were asked from Finnish and Hungarian climbers from different climbing clubs. The climbing level varied from 4 to 7. The questions were: Did you have shoulder problems in the past? Do you load your shoulder at work? What did you do for recovery? What kind of exercises did you do? Did you have to stop climbing for a while? What moves were difficult? Did you recover completely? Several people never had problems with their shoulder. Some people had mild injuries in the past. Severe injuries were not common. A typical answer was: “I don’t know what happened. Hanging was painful.” Some people had loading work at the time of their injury. The typical approach was “taking it easy” for a month. Only a few turned to professionals with their injury. Everybody recovered fully. Many climbers do specific shoulder warm up and strengthening exercises. While rotator cuff strengthening exercises are well known, there is less focus on the thoracoscapular muscles in their training.

The form of the package was decided so that it can be hanged on the wall. In this way every climber can see it easily. The intervention booklet (Appendix 1) was designed to be easy to understand and easy to follow for athletes. The exercises include muscle balance, scapular stability, scapular movement patterns, shoulder mobility and rotator cuff strength. However, the focus is on posture and the thoracoscapular muscles as it was less known for the clients. It was also important that the athletes can perform the exercises and stretches alone without a partner. The booklet starts from beginner level with phase 1 and progresses to intermediate level with phase 2. The exercises take 15 - 20 minutes to do. The booklet gives recommendations about the frequency and the intensity of the exercises. Availability of the equipment was also taken into consideration. The booklet also provides information about the causes and the goals for the program.

8 DISCUSSION

Climbing is an increasingly popular sport. Although more experienced climbers are eager to help to the beginners, structured and instructed training is rare in climbing gyms. The author noticed faulty postures on climbing competitions and has a background of painful shoulders as well. The intervention booklet aims to help climbers to increase their shoulder stability and keep healthy posture, therefore avoid injury.

After the topic was decided the thesis plan was accepted in February of 2017. The theoretical part was written in the autumn of 2017. The discussions, interview and exercise package were made in January-February of 2018. Final changes were made in February of 2018.

The most challenging part in the process was to find freely available full text good quality articles about current evidence. While shoulder injuries and rehabilitation strategies are well studied there is little focus on injury prevention. Injury prevention is a developing area in physiotherapy. However, most of the injury prevention studies focus on contact sports and the lower limb. Studies about the upper limb mostly focus on throwing motion or lifting heavy loads repeatedly overhead. There is little information about the overhanging position which is the most typical position in climbing. It is hard to conclude the results because of the lack of consistency in the studies. Also, there is a lack of studies about the importance of health promotion and motivation in injury prevention.

In climbing, shoulder injuries are the third most common according to statistics. However, the interview and discussions suggested that shoulder pain is common, but climbers do not turn to professionals.

The exercise package was based on the needs of the clients. While many had good knowledge about shoulder training, the scapula stabilizers were less known. The booklet includes two phases and starts from beginner level. It could be improved in the future with a third phase which focuses on more sport specific exercises such as protraction-retraction of the scapula in hanging position.

Shoulder rehabilitation is based on the specific identified problems. There is a need for proper screening tools in injury prevention that identifies the risk factors in athletes such as scapular dyskinesis or weakness of the rotator cuff muscles. A prevention program cannot fit for all clients. The problem, the knowledge, the background and the activity level widely vary among athletes.

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