T.C.
YEDİTEPE UNIVERSITY
INSTITUTE OF HEALTH SCIENCES
DEPARTMENT OF SPORTS PHYSIOTHERAPHY

EFFECTS OF CORE STABILIZATION AND PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION EXERCISES ON PAIN, MOTION OF JOINT, MUSCLE STRENGTH, POSTURE, AND FUNCTIONAL STATUS IN PATIENTS WITH SHOULDER SUBACROMIAL IMPINGEMENT SYNDROM

MASTER'S THESIS

ORKUN MENEK

Istanbul-2021

T.C.

YEDİTEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

DEPARTMENT OF SPORTS PHYSIOTHERAPY

EFFECTS OF CORE STABILIZATION AND PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION EXERCISES ON PAIN, MOTION OF JOINT, MUSCLE STRENGTH, POSTURE, AND FUNCTIONAL STATUS IN PATIENTS WITH SHOULDER SUBACROMIAL IMPINGEMENT SYNDROM

MASTER’S THESIS

ORKUN MENEK

SUPERVISOR

Prof. Dr. Feryal SUBAŞI

Istanbul-2021

THESIS APPROVAL FORM

Institute : Yeditepe University Institute of Health Sciences

Programme : Department of Sports Physiotherapy

Title of the Thesis : Effects of Core Stabilization and Proprioceptive Neuromuscular Facilitation Exercises on Pain, Motion of Joint, Muscle Strength, Posture, and Functional Status in Patients with Shoulder Subacromial Impingement Sydrom

Owner of the Thesis : Orkun MENEK

Examination Date : 05.01.2021

This study have approved as a Master Thesisin regard to content and quality by the Jury.

	Title, Name-Surname(Institution)
Chair of the Jury:	Prof. Dr. Feryal SUBAŞI (Yeditepe University)
Supervisor:	Prof. Dr. Feryal SUBAŞI (Yeditepe University)
Member/Examiner:	Assist. Prof. Şule BADILLI DEMİRBAŞ (Yeditepe University)
Member/Examiner:	Dr. Nuray ALACA (Acıbadem University)

APPROVAL

This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated 20.01.2021 and numbered 2021/01-06

Prof. Dr. Bayram YILMAZ

Director of Institute of Health Sciences

DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

23.12.2020

Orkun MENEK

ACKNOWLEDGEMENTS

With all the effort made and attention paid this thesis work has been such a devotion to me and my dedicated supervisor Lect. Ayla AKLAR ÇÖREKÇİ and Prof. Dr. Feryal SUBAŞI. She has been sincerely giving and always there whenever I needed her. For the most part it is a great honor to be her graduate student and I am willing to take our scientific relationship forward..

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

$\bar{x}$	Medyan
AC	Acromioclavicular Joint
MRI	Magnetic Resonance Imaging
SA	Scapulothoracic Articulation
SAS	Subacromial Space
SC	Sternoclavicular Joint
Ss	StandartSapma
RC	Rotator Cuff
SAIS	Subacromial Impingement Syndrome
Sd	Standard Deviation

ABSTRACT

Menek, O. (2021). Effects of Core Stabilization and Proprioceptive Neuromuscular Facilitation Exercises on Motion of Joint, Muscle Strength, Posture, and Functional Status in Patients with Shoulder Subacromial Impingement Sydrom.Yeditepe University, Institute of Health Science, Department of Sports Physiotheraphy, MSc Thesis, İstanbul.

The shoulder is the most mobile joint in the human body, making an individual possible for performing a wide range of motion. Shoulder disorders such as Subacromial Impingement Syndrome (SIS) are the most common forms of musculoskeletal disorders and shoulder pathology with occurrence of pain and dysfunction during daily activities. The SIS injuries and rehabilitation may considerably vary, and are always important to arrange an appointment with a healthcare practitioner. Among the rehabilitation techniques, core stabilization exercises, and proprioceptive neuromuscular facilitation (PNF) improve the shoulder rehabilitation. The objective of this study was to assess the effects of core stabilization and PNF exercises on slow motion of joint, muscle power, posture, and functionality in the patients with SIS. To do this, a total of 50 persons (25 in experimental group and 25 in control group; ages ranging from 18 to 65 yr) attending in a privately owned hospital in İstanbul was involved. All the selected patients were with SIS longer than 6 months. The evaluation were made in the beginning and sixth week of the study by the same physiotherapist according to the pain, strength and endurance of the core muscles, motion of neck and shoulder joint, muscle strength for shoulder muscle, posture, and functional status criteria. The statistical analyses were performedby SPSS 19 package program. The results showed that core stabilization and PNF exercises positively affected strength of core muscle, core endurance, and posture, whereas there were there was not any significant effects on pain, joint range of motion, strength of shulder muscle, and functional values. In conclusion, this study revealed that the core stabilization and PNF exercises may partially improvethe symptoms related to the SIS as compared to the regular treatment in the clinic.

Key words: Core Stabilization, Functional Status, Joint, Muscle Strength, Physiotherapy, Posture, Proprioceptive Neuromuscular Facilitation, Shoulder Subacromial Impingement Sydrom

ÖZET

Menek, O. (2021). Omuz Subakromiyal Sıkışma Sendromu Olan Hastalarda Kor Stabilizasyon ve Propioseptif Nöromusküler Fasilitasyon Egzersizlerinin Ağrı, Eklem Hareketi, Kas Kuvveti, Postür ve Fonksiyonellik Üzerine Etkileri. Yeditepe Universitesi, Sağlık Bilimleri Enstitüsü, Spor FizyoterapisiABD., MasterTezi. İstanbul.

Omuz, insan vücudunda en hareketli organ olup, bu özelliği ile kişilerin çok sayıda farklı hareket yapabilmelerini münkün kılmaktadır. Subakromiyal Sıkışma Sendromu (SAS)gibi omuz sorunları kas-iskelet sistemi bozukluğu ve omuz patolojisi türleri arasında en sık karşılaşılan sağlık problemidir. Hastalığın patolojisi ağrı ve günlük faaliyetlerinde işlevsel bozukluklar ile seyretmektedir.SAS zedelenmeleri ve tedavisi değişiklik gösterebilir ve mutlaka bir sağlık uzmanı tarafından takibi çok önem taşımaktadır.Bu konuda bilinen teknikler arasında, kor stabilizasyon ve Propioseptif Nöromusküler Fasilitasyon (PNF) egzersizleri omuz tedavisinde iyileşmeye yardımcı olmaktadır.Bu çalışmada, SAS sendromu olan hastalarda kor stabilizasyon ve PNF egzersizlerinin ağrı, eklem hareketi, kas kuvveti, postür ve fonksiyonellik üzerine etkilerinin değerlendirilmesi amaçlanmıştır. Bu bağlamda, İstanbul'da özel bir sağlık kuruluşuna devam eden ve altı ayı aşkın süredir SAS sorunu yaşayan ve yaşları 18 ve 65 yıl arasında değişen 25 deney ve 25 kontrol grubu olmak üzere toplam 50 kişi araştırma dâhil edilmiştir. Değerlendirme çalışmanın başlangıcında ve altıncı haftanın sonunda çalışmanın bitiminde olmak üzere aynı fizik tedavi uzmanı tarafından toplam 2 defa yapılmıştır.Katılımcıların ağrı, kor kasları güç ve enduransı, boyun ve omuz eklem hareketleri, omuz kas kuvveti, postür ve fonksiyonellik kriterleri takip edilmiştir.Elde edilen bulgular SPSS 19 hazır paket istatistik programı ile analiz edilmiştir.Araştırma, kor stabilizasyon ve PNF ekzersizlerinin kor kas kuvveti, endürans ve postür üzerinde olumlu etkileri olurken; ağrı, hareket eklem açıklığı, omuz kas kuvveti ve fonksiyonalite üzerinde etki göstermediğini ortaya koymuştur.Sonuç olarak, bu çalışmada, kor stabilizasyon ve PNF ekzersizlerinin SAS pozitif kişilerde geleneksel tedavi yaklaşımlarına göre tedavi amaçlı etkilerinin kısıtlı olduğu anlaşılmıştır.

Anahtar Kelimeler: Kor stabilizasyon, Fonksiyonellik, Eklem, Kas kuvveti, Fizyoterapi, Postür, Propioseptif Nöromusküler Fasilitasyon, Omuz, Subakromiyal Sıkışma Sendromu

1. INTRODUCTION and PURPOSE

The shoulder is a mobilejoint in themusculoskeletal system of the human body. This character makes possible an individual for performing numerous and various motions. Among them there are flexion, abduction, adduction, internal and extention rotation, 360° circumduction, retraction, scapular protraction, depression, and elevation (1).

Shoulder can perform a broad range of movement. Therefore, it isfrequently exposed to some injurementsdue to stretching, torn or detaching. These sorts of injurements are widely observed in the humans (2).

Subacromial Impingement Syndrome (SIS)is a type of shoulder disorder. It is considered as musculoskeletal disorders, and belongs to the shoulder pathology. Its pathology has a high morbidity rate, and more than 50% of the sufferers suffer from thesymptoms after three years, including pain and dysfunction during daily activities (3).

The painful shoulders are the most widely observed conditions in the shoulde r clinics. They lead to loss of range of motion and reduction in the shoulder functions. SIS was firstly described in 1852. Many years later, CharlesNeerdefined the proliferative spur and ridge on the acromion undersurface in 1972. After that, its pathogenesis has provided a challenge in the “impingement” of the shoulder pain and medical intervention (4).

Even though SIS symptoms develop following the trauma, the pain generally occurs over the weeks to months. Some regular daily activities (combing hair andholding a cupboard) maycause the pain. It happens when the structures in SAS are compressed (5-7).

Diagnosis and clinical evaluation of SIS starts with a medical control and physical examination by an expert (8). Understanding “Why” the impingement occuris the most important step to short-term resolution and prevention of recurrent shoulder impingements. The latters predispose us to a rotator cuff tear and subsequent medical intervention (7, 9).

SIS injuries and treatment interventions may considerably vary. It is always important to arrange an appointment with a healthcare practitioner having expertise on the injuries. Improvement of the shoulder muscle strength by appropriate exercises is one of the aims of shoulder rehabilitation. Among them, the core stability has become a popular topic in the physiotherapy and rehabilitation research to preventnumerous spine and lower extremity injuries (10). There are still existing limited interests in core stability as well as relationship between core and shoulder dysfunction (11). Similarly, Proprioceptive Neuromuscular Facilitation (PNF) rehabilitation presents a surplus approach to yield the shoulder rehabilitation by biomechanical stretching. This enables someone increase the functional movements (12).

In this study, we aimed to assess the effects of core stabilization and PNF exercises on slow motion of joint, muscle power, posture, and functionality in the patients with SIS.

2. GENERAL INFORMATION

2.1 Shoulder Structure

The shoulder isa mobile joint of the human bodyand it makes a person enabling for performing various motions (flexion, internal, adduction, abduction, and extention rotation, 360° circumduction, retraction, scapular protraction, depression, and elevation). On the other hand, the shoulder joint may be unstable due to these motions, and this instability is counterbalanced by tendons, rotator cuff muscles, glenoid labrum and ligaments (1).

In this part of the thesis, we willfocus on the anatomy of the human shoulder joint.

2.1.1 Bones

The shoulder is a joint at which three major bones come together, therebyecreate an angle of 90º (13, 14). These major bones can be explained as follows:

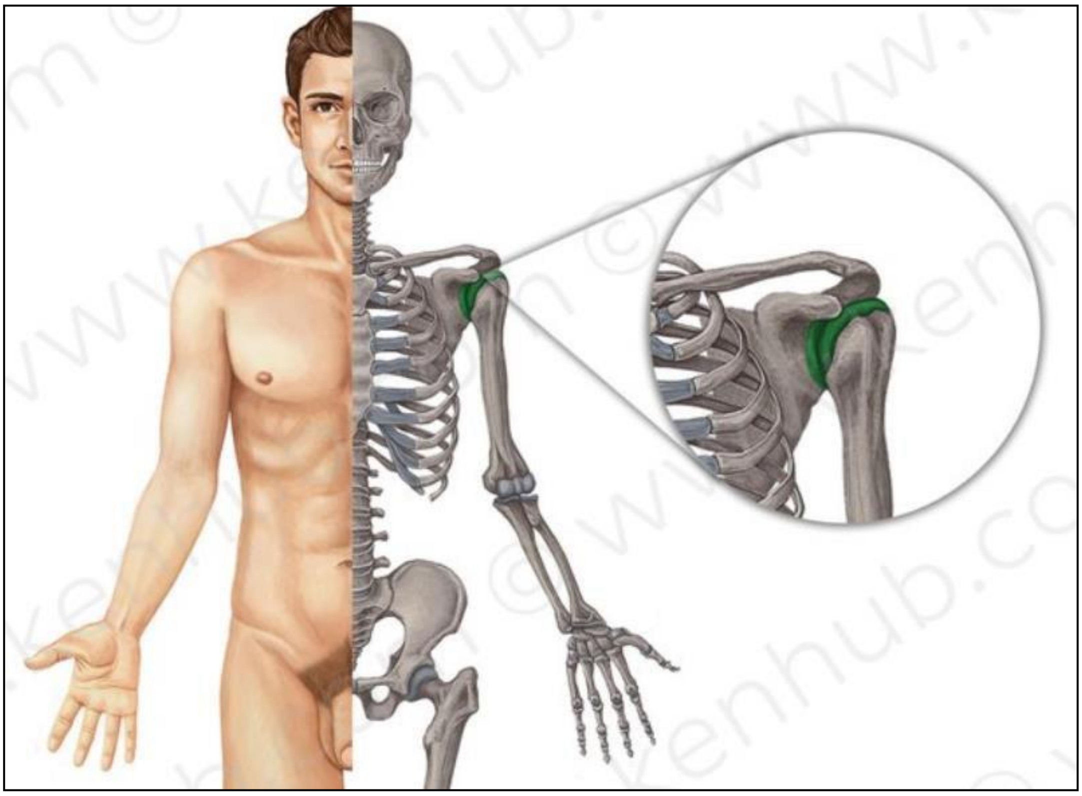


Figure 2.1.Articulatioglenohumeralis (Shoulder joint) (14)

- *Clavicle*: It is also called collarbone, extending across the shoulder's front aligning between sternum and scapula. Its major function is to help the stabilization of the movements of shoulder.
- *Scapula*: It, also called shoulder blade, is a flat triangular bone that is present in the upper back. Its main function is to connect with the collarbone at the front of the body.

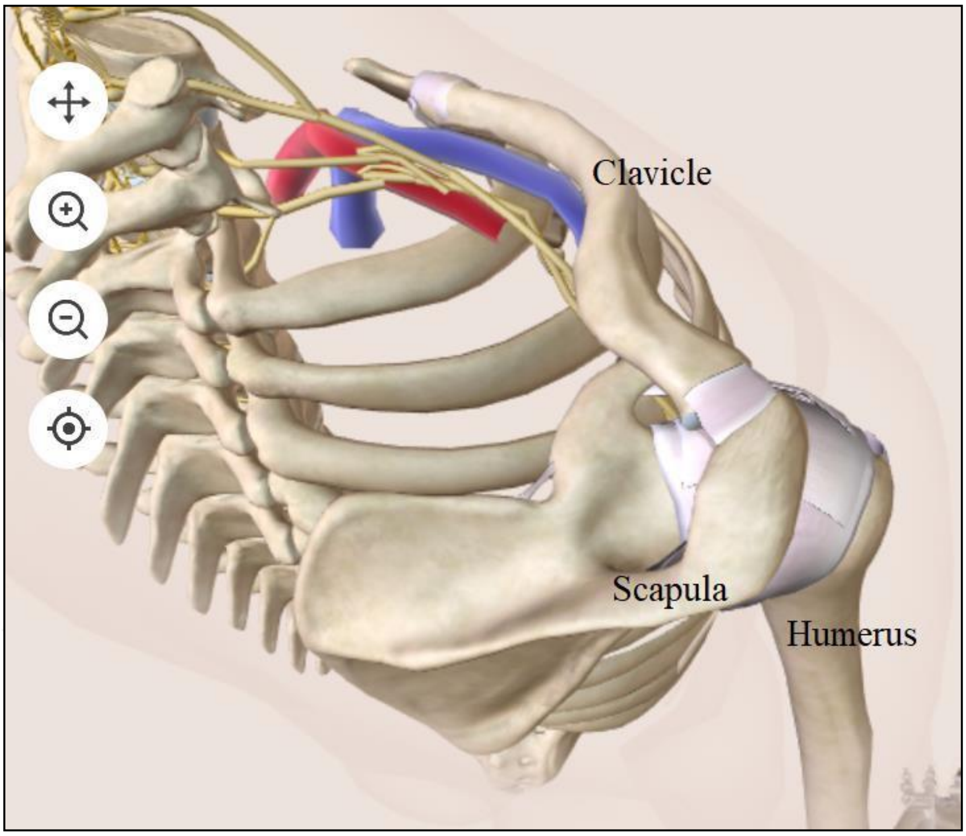


Figure 2.2.Articulatioglenohumeralis (Shoulder joint) (13)

- *Humerus*: As the largest bone in the arm, it is linked to clavicle and scapula in the shoulder. It looks like a ball-like knob, and thus makes a ball-and-socket joint with the scapula.

2.1.1.1 Clavicle

The clavicle, also so called the collar bone, links the shoulder to the rest of the body through two major joints (acromioclavicular and sternoclavicular joints).The clavicles, or collarbones, are two long bones connecting scapula to sternum. Its name originates from *Latin*meaning "little key", its shape looks like askeleton key. The clavicle is a sensitive bone in the Human bodsy, and it is one of the most commonly broken ones. Its superficial projection and location from the trunk make it an easily located bony landmark. The clavicles are cylindrical in shape around 15 cm in length and curved-shapedlike the letter S in the transverse plane (See Fig 2.3 and Fig 2.4) (15).

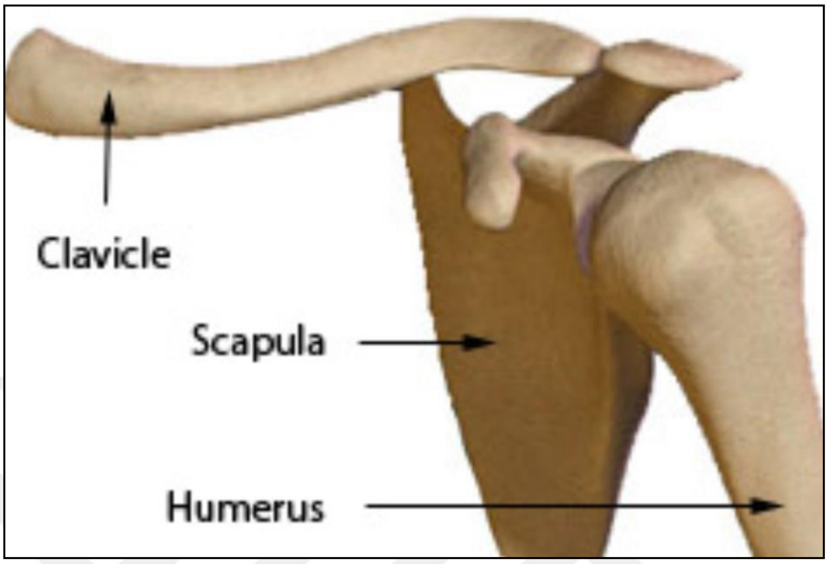


Figure 2.3. Major Bones of Shoulder (16)

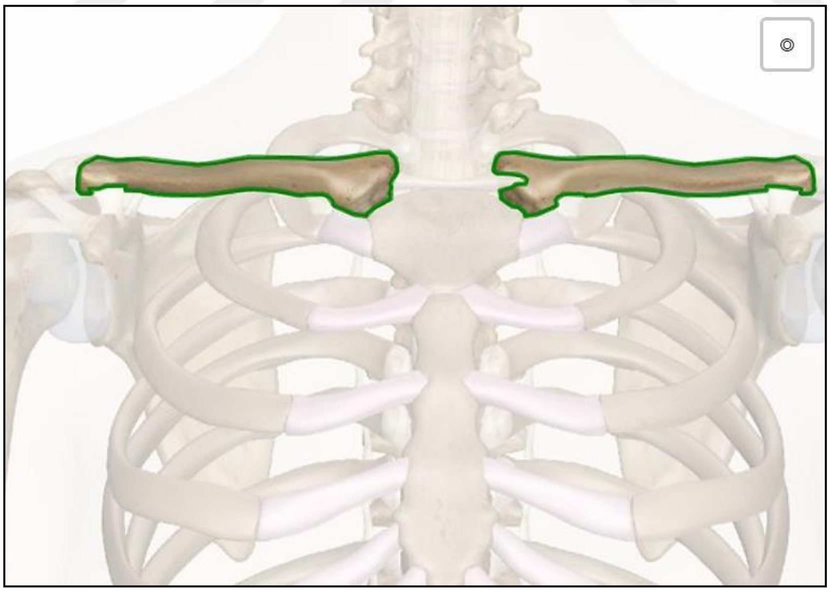


Figure 2.4. Clavicle (15)

2.1.1.2 Scapula

The scapula is a large and flat triangular bone in the Human body, and it has 3 major processes: spine, acromion, coracoid process, respectively. The back part   of the shoulder girdle is mainly formed by scapula. The spine and the acromion are able to be palpated on the patient. The flat blade of the scapula is gided along the back of the chest to make the movement of the armas much extended as possible. The coracoid process is a thick curved structure from scapula, and herebyeligaments and muscles are attached to it. The scapula is also indicated by a comma-shaped and shallow glenoid cavity, articulating with the head of humerus (17).

2.1.1.3 Humerus

The humerus is the long bone in the upper arm, and is located among elbow joint and shoulder. At the elbow, it links primarily to ulna, as forearm's radial bone connects to wrist. On the other hand, at the shoulder, humerusis in connection with the frame of body over glenoid fossa of scapula (See Fig 2.5) (18).

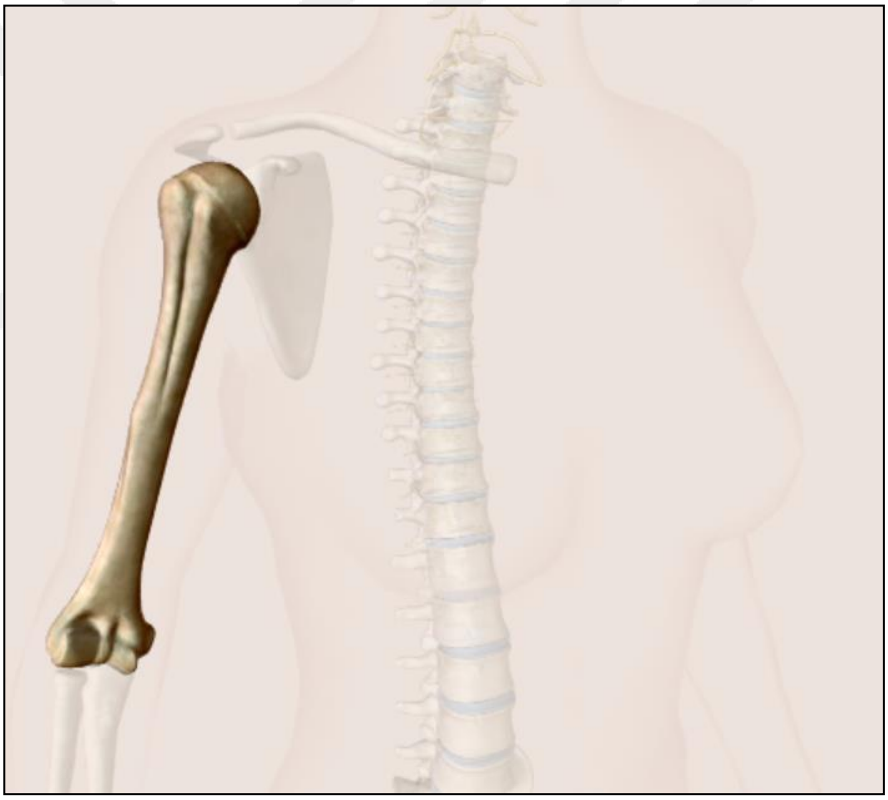


Figure 2.5.Humerus (16)

The humerus is the foundation to which many muscles (deltoid, pectoralis major, and others) insert. Most of the bone's length is travelled bythe brachial artery before subdividing into ulnar and radial arteries at the elbow. In the upper arm, brachial artery branches into several arteries, and carburates oxygenated blood from lungs and heart. The radial nerve runs a similar course over bone and into forearm. Because it links to shoulder with a rotational joint, the humerus supports most of the arm's functions. For instance, the humerus reinforces all lifting and physical activities. The humerus is one of the longest bones in the body, leading to breaking or fracturing in the Human body (See Fig 2.6 and Fig 2.7) (16, 18).

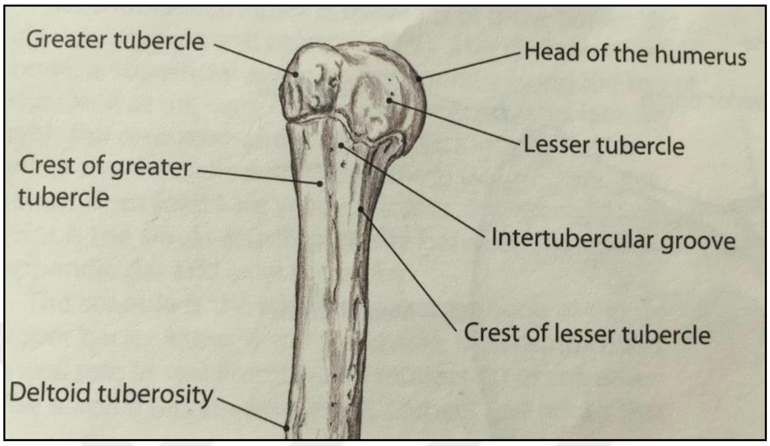


Figure 2.6. A View of the Right HumerusFrom the Front (19)

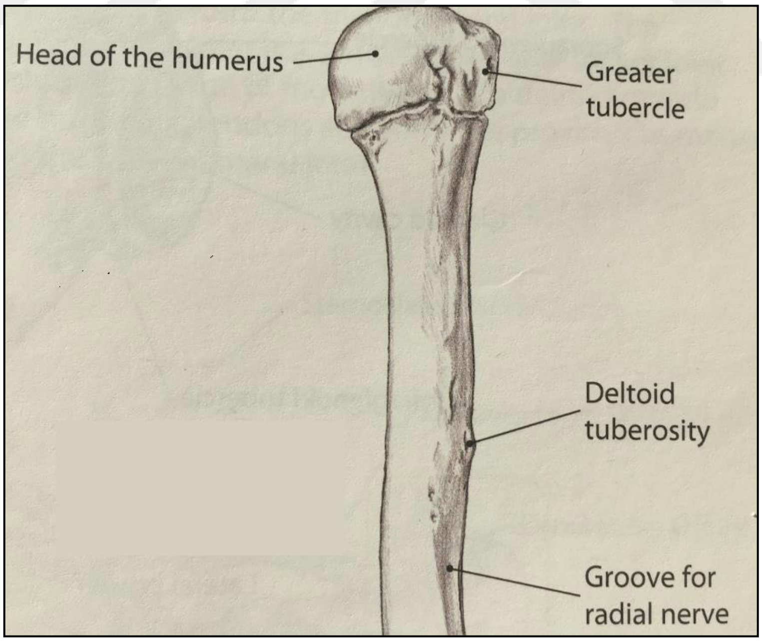


Figure 2.7. A View of the Right Humerusfrom the Back (19)

2.1.2 Bone Junctions

There are four bone junctions, and we can list them as follows:

- Scapulothoracic articulation

- Glenohumeral
- Sternoclavicular (SC joint)
- Acromioclavicular (AC joint)

The shoulder is also so-called glenohumeral, and it is composed oftwo major joints, acromioclavicular and glenohumeral, respectively. The former is where the acromion, part of the scapula and the clavicle come together, while the latter is where the humeral head and the glenoid come together. The rotator cuff linkshumerus to scapula, and is composed of the tendons of supraspinatus, infraspinatus, teres minor and subscapularis (Fig 2.8) (14).

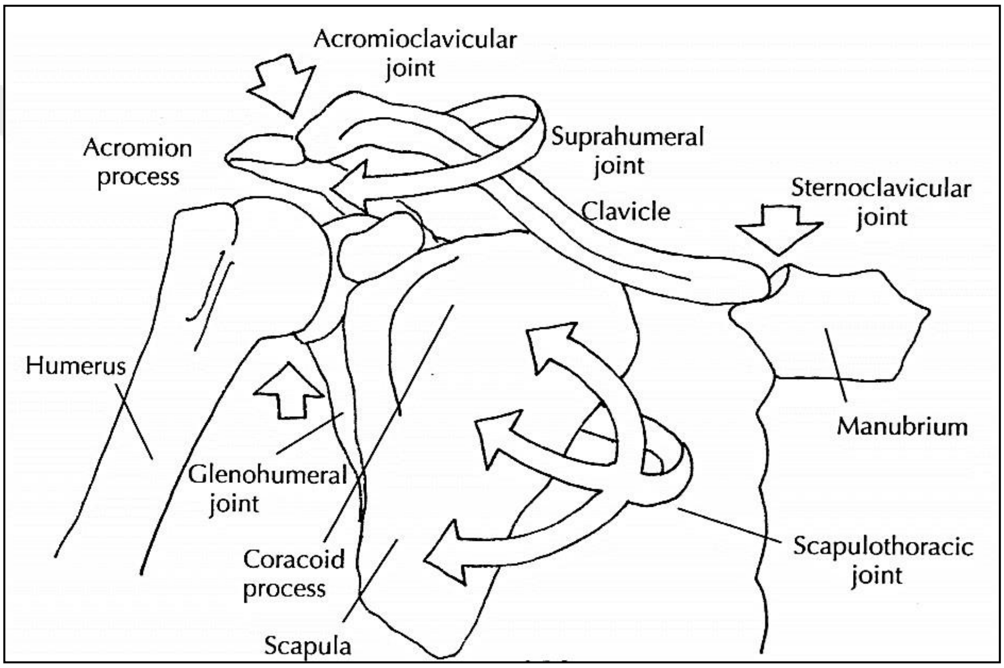


Figure 2.8. Shoulder Girdle, Anterior View (20)

2.1.2.1 Glenohumeral joint

The glenohumeral joint exists in the shoulder, and its main joint. The glenoid and the humeroushead meet here. The flat socket of the glenoid covers twenty to thirhty percent of the humeral head. Due to its weak fit, this joint presents on the soft tissue for support. The labrum is a fibrocartilage tissue ring, and linked to the glenoid. Therebye, it deepens the socket to surround much of the humerus. This joint derived by the humerus and scapula makes possible the arm to rotate circularly, and to step up and out from body. The soft tissue covers the glenohumeral joint, and this joint is reinforced by fibrous ligaments (14).

2.1.2.2 Acromioclavicular joint

The acromioclavicular joint (AC joint) is actually a bony point on the shoulder's top. Its major function is to stabilize the scapula to the chest, and it links the acromion to the clavicle. Here, there is a schock absorber between these two bones, which is considered as a thick disk of fibrocartilage, and this joint's stability is provided by capsule and ligaments (14).

This jointgives shape to the shoulder's highest point byproviding an ability of moving up the arm above the head. Formed by the meeting of scapula and clavicle (20).AC joint is a site at the tip of the shoulder, where the collarbone links to the shoulder blade. The major function of the collarbone is to provide pillar for shoulder blade out from the body by enabling the surrounding muscles to work at their most effective tensions with possible more power. AC joint commonly wears out, leading to arthritis, in particular older times (16).

2.1.2.3 Sternoclavicular joint

The sternoclavicular joint (SC joint) connects the other edge of clavicle to sternum. In similar to AC joint, SC also includes a fibrocartilage disk to assist the bones getting better fit, and provides a perfect support from its covering ligament and joint capsule (14).The SC joint is located at the chest's center, in which clavicle comes together with sternum.Therebye, it enables the clavicles for moving (20). Similarly, it is at the base of the neck as well as a saddle joint sitting between collar bone and breast plate (sternum). This great joint also supports the shoulder blade outstutting from the Human body (16).

2.1.2.4 Scapulothoracicarticulation

The scapulothoracic articulation (SA) is a zone where scapula is hiddenly positioned in muscle glides over thoracic rib cage. The muscles and ligaments covering SA also keep scapula as properly placed as ifthe arm canmove correctly (14).

2.1.3 Cartilages

Cartilages surround arch joint, to pillows the meetings of the bones. The cartilages in the shoulder are classified to major 2 two types, respectively (2):

- Articular cartilage

- Fibrocartilage

2.1.3.1 Articular cartilage

Articular cartilage covers the humeral head's edge, looks like a shiny white coating, and aligns thorugh the glenoid's inside surface. It has threemajor aims (2):

- To make easy movement as smooth and slick surface
- To become an absorber against shocks
- To preserve the underlined

2.1.3.2 Fibrocartilage

Fibrocartilage forms the disks ofAC and SC joints and labrum, and looks like thick tissue. It is also a ring boosting glenoid. Fibrocartilage has 3 major functions (2):

- To behave as a cushion against shocks
- To stabilizethe joint
- To become a spacerfor easy-contact among articular cartilage surfaces

2.1.4 Ligaments

Each joint is surrounded by ligaments, to connect the bones;

The function of the ligaments is to attach the bones to each other, and to provide a static stability in a joint keeping it within the acceptable limits of movement. Based on this fact, the shoulder is supported by heavily relying on the ligaments. The ligaments can be divided into 3 types as follows (2):

- Glenohumeral
- Coracoacromial arch
- Acromioclavicular

2.1.4.1 Glenohumeral ligaments

The glenohumeral ligaments basically shape joint capsule around the head of humerus, and they are aligned in layers from glenoid labrum (2).

2.1.4.2 Coracoacromialarch

The coracoacromial arch is atype of ligaments group, and spaces the bony projections of both coracoid process and acromion (2).

2.1.4.3 Acromioclavicular ligament

The acromioclavicular ligament enables the support needed for AC joint together with coracoclavicular ligaments (2):

2.1.5 Muscles and tendons

Each joint is encircled by muscles; and tendons for the attachment of the muscles to the bones. The function of muscles and tendons is to collaborate with shoulder, and therebye to enable a dynamic stability for shoulder. The musclespresent in shoulder are grouped to 4 categoriesas follows (2):

- Rotator cuff
- Scapulothoracic
- Superficial
- Biceps tendon complex

2.1.5.1 Rotator cuff muscles

Rotator cut off muscles arecollection of tendons and muscles and present in shoulder. Their common function is to stabilize the shoulder, and to keep the head of humerus in glenoid together. The muscles of the rotator cuff are made up of suprasinatus, infraspinatus, teres minor, and subscapularis, respectively. Another function of the rotator cut off muscles is to be the primary stabilizer to keep the ball of humerus to glenoid socket due to having only a short distance from humerus. Hence, these four muscles form a shape of cuff aroundhumeral head, and deliver a security for it the socket. As seen from its name, this group of muscles can also make the arm rotate. The rotator cuff protects glenohumeral joint against dislocation bymeans of the large muscles, which aim to control the shoulder, and to support the mobility of the arm (2).

2.1.5.2 Biceps tendon complex

Biceps tendon complex holds humeral head in glenoid as well as raising the arm (2).

2.1.5.3 Scapulothoracic Muscles

Scapulothoracic muscles are linked to the scapula and thorax. Their major functionality is to makepossible the scapula to perform the motion of shoulder properly (2).

2.1.5.4 Superficial muscles

The superficial muscles are present in shoulder, and have crucial roles in overall functionality of shoulder. Actually, they are a type of strong and large layer of muscles. One of the common functions of the superficial muscles is to harbor deltoid muscle, and to coverrotator cuff muscles (2).

2.1.6 Bursae

A bursa, *bursae in plural*, is a small-fluid-filled pillow-like sac, whose function is to reduce reduce friction by allowing smooth gliding between bone and tendon, or bone and muscle (2).

2.1.6.1 Subacromial and subdeltoid bursa

In the Human body, there are more than 50 bursae; subacromial bursa is placed in shoulder. It is the largest bursa. Subacromial and subdeltoid bursa are mostly considered as a joint structure. The major function of this structure is to discriminateboth deltoid muscle and rotator cuff from acromion (2).

2.2 Shoulder Instability

Shoulders have a broad range of movement, and therefore used often, leading to their injurement commonly. The most encountered injuries in the shoulder can be listed as follows (2):

- Arthritis
- Fractured clavicle
- Dislocation of the glenohumeral joint
- Tear of the rotator cuff
- Fractured scapula

Shoulder instability usuallyoccursin case of stretching, detaching, and torn the structure ofshoulder joint, ligaments or labrum. In this case, the ball of shoulder joint movescompletely or partially out of socket (See Fig 2.9).Shoulder instability usually causes pain in the individuals as the shoulder “gives way.”Diagnosing shoulder instability requires physical examination and radiographycal evaluation such as X-rays. By this way, the cause of the shoulder instability is determined, and other causes of shoulder pain are ruled out. Treatment for shoulder instability usually needs non-operative and surgical options (21).

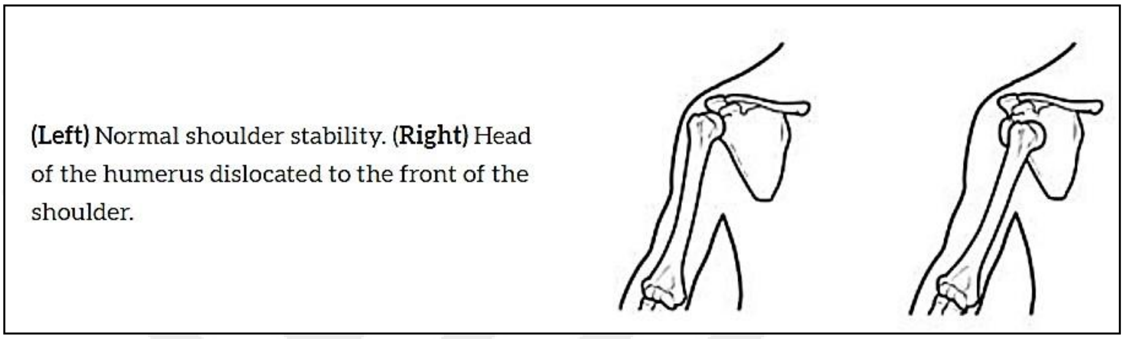


Figure 2.9. Normal Shoulder Stability vs Instability (22)

A severe injury in a normal joint may trigger the subluxation or dislocation of the humeral head. A shoulder subluxation happen if the humerus partially slides in and out of place quickly (Figure 2.10) (21).

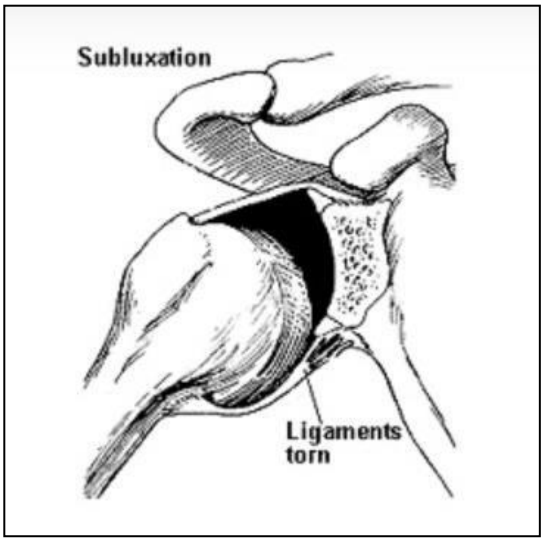


Figure 2.10. Shoulder Subluxation (21)

Soulder dislocations happen if the humerus comes all the way out of the glenoid (Figure 2.11). This discocation is actually the fall back of the shoulder into place after time, and therefore is rquired to put it back into place with medical assistance (21).

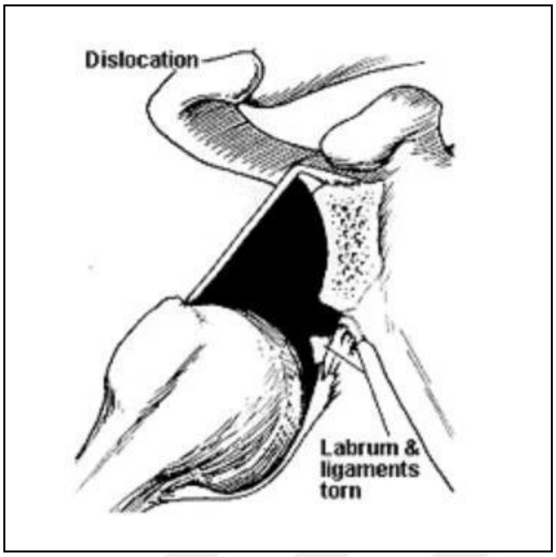


Figure 2.11. Shoulder Dislocation (21)

An initial shoulder dislocation is often caused by severe injury or trauma. As the humerus’headis dislocated, socket bone (glenoid) and ligaments located in the front of the shoulder are often damaged. The labrum-the cartilage turnsaround the edge of the glenoid, and may tear, resulting in an issue commonly called a Bankart lesion. A severe first dislocation may cause regular dislocations with a feeling of instability (See Fig 2.12) (22).

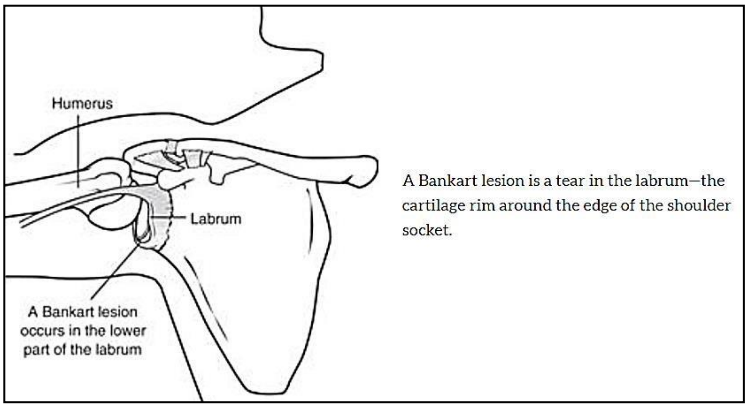


Figure 2.12. Shoulder Dislocation (22)

Shoulder subluxation and dislocation may cause ligaments, labrum, and capsule to be torn, detached or stretched from the bone. When humeral head is returned to its place, the structures again normalize in a strecthed and loose position. On the other hand, this may raise the risk of future occurring of dislocation or subluxation,resulting in increasing tendency toward future instability (See Fig 2.13 and Fig 2.14) (21).

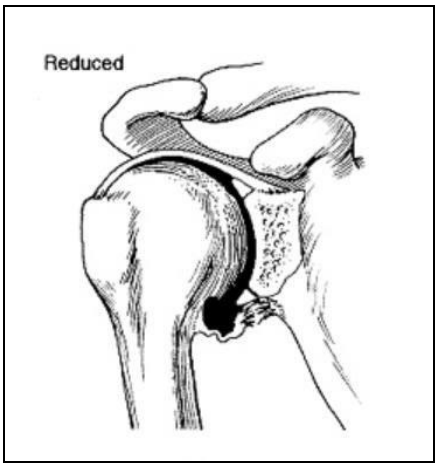


Figure 2.13. Shoulder Dislocation (21)

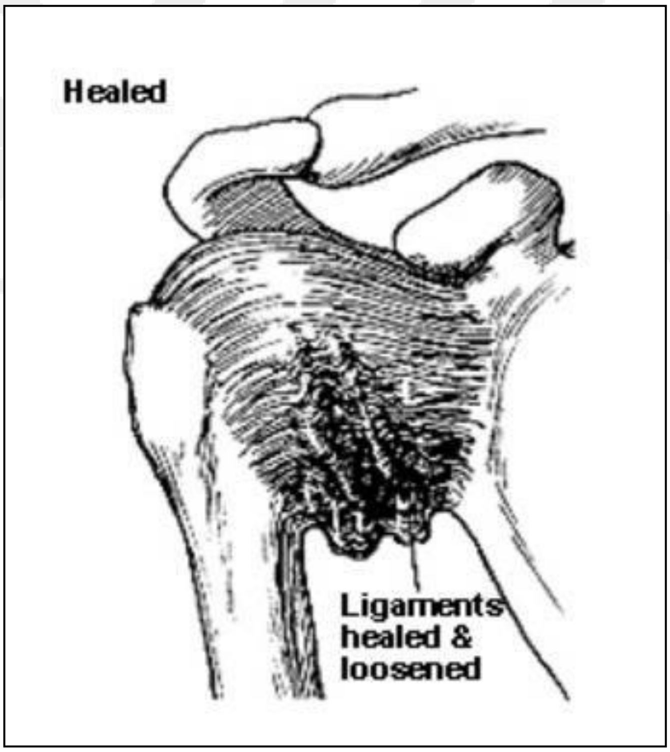


Figure 2.14. Shoulder Dislocation (21)

2.3 Shoulder Subacromial Impingement Syndrome (SIS)

Subacromial Impingement Syndrome (SIS) is one of the mostmajorforms of musculoskeletal and shoulder disorders. Its pathology is related to a high morbidity rate, and more than 50% of the sufferers report continued symptoms after three years. SIS is associated withpathology of subacromial space, and it is diagnosized by pain and dysfunction in the shoulder. SIS is observed in many activities during sporting and vocational pursuits, anddaily life (3).

2.3.1 History

The painful shoulders are the most widely observed conditions in the shoulder clinics, leading to reduced shoulder and mobility function. In addition to that, the sufferers claim less sleep, and face with difficulties in daily life activities. SIS was firstly described in 1852. Later on, Charles Neermade a description of a proliferative spur and ridge on the acromion's undersurface, and required to be deletedforthe symptomsimprovement in 1972. Neer's "impingement" approach was applied for minimum 30 years. However, after that, pathogenesis of SIS has been gained a more extensive knowledge, and started challenging the role of impingement and surgical rehabilitation in shoulder pain (4).

Despite many earlier Studies referring to subacromial pathology, Neer was the first person who used the term "SIS". His argument was that nearly whole of SISand rotator cuff pathology was yielded from impingement of subacromial contents, including supraspinatus tendon and anterior one-third of acromion. In addition to these facts, Neeralso defined pathology, diagnostic method, effective management, guideline, and anterioracromioplasty. Neer'sapproachisstill used in the surgical intervention or rehabilitation of SIS across the World (3, 23, 24).

Even though SIS symptoms develop following the trauma, the pain generally occurs in weeks and even longer. The pain is usually seen in anterolateral acromion, and often radiates to lateral mid-humerus. The patients suffer from pain, in particular at nights, lying on shoulder, or sleeping with arm overhead. Routine daily activities such as combing hair and reaching up into a cupboard may triggerpain. In addition, weakness and stiffness are the most widely seen symptoms, however are with are little pain (5).

2.3.2 Pathogenesis

Subacromial space is the space formed by anterior edge, humeral head inferiorly, under surface of anterior one-third of acromion, coracoacromial ligament and acromioclavicular joint superiorly. This space's heightamong acromion and humeral head is 1.0 to 1.5 cm. Between these 2 structures, there are rotator cuff tendons, long head of the biceps tendon, bursa, and coracoacromial ligament interposed. When association of these subacromial structures is disturbed abnormally, and impingement may occur (25).

SIS occurs when rotator cuff, biceps tendon long head, and subacromial bursa in SAS are compressed. Based on this fact, inflamation under coracoacromial ligament develops. Suprasinatus tendon is particullayat highest risk for irritation and injury, if humerus is put off to 90° and turned 45° internally(See Fig 2.15) (6,7).

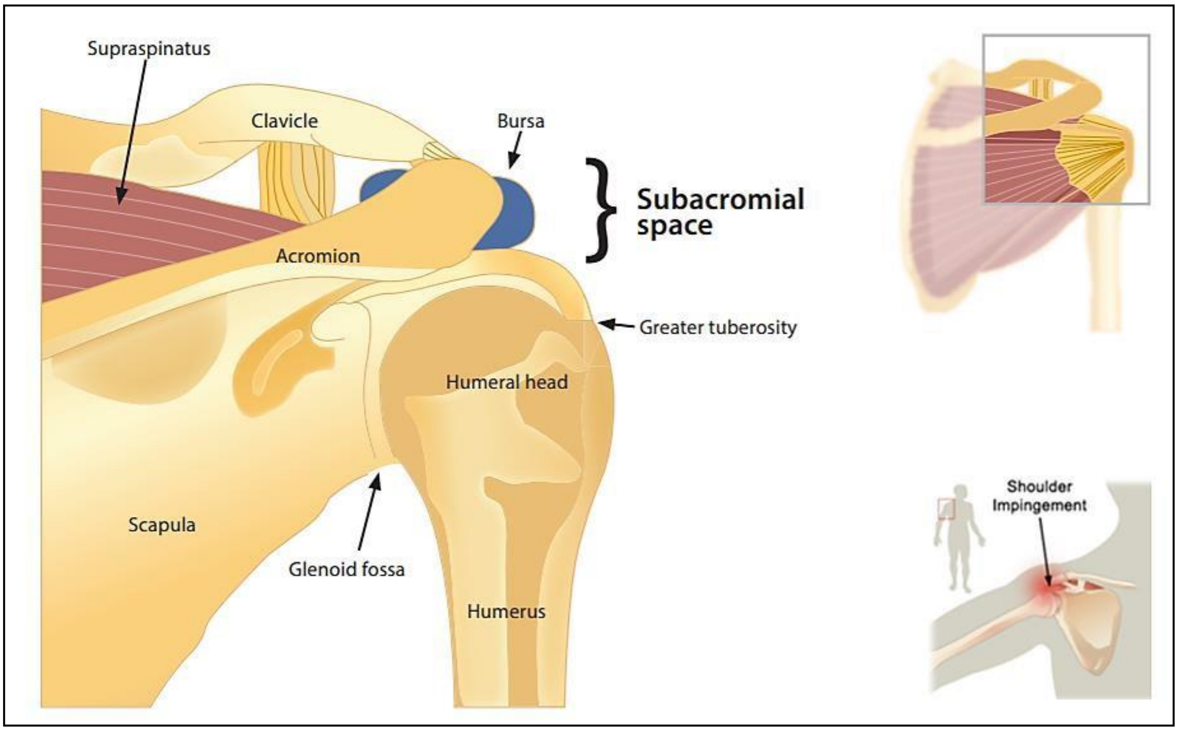


Figure 2.15.Structures Associated with SAS and SI Zone (7, 26)

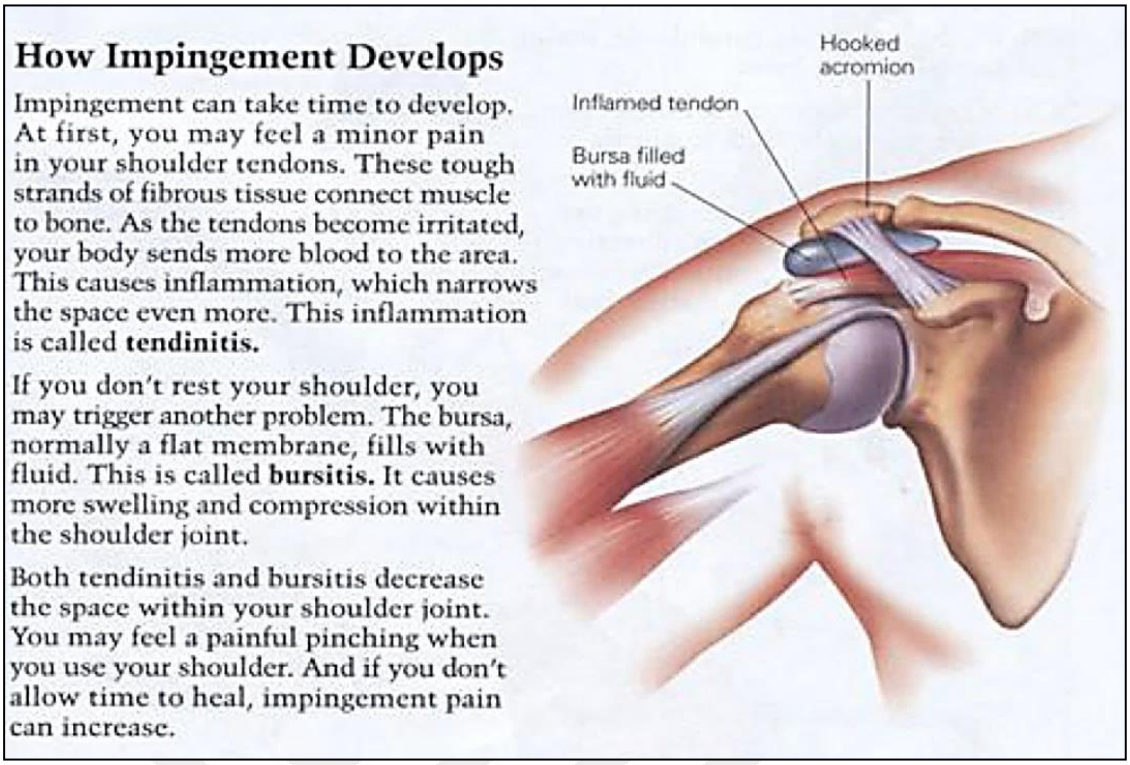


Figure 2.16.Development of SIS (30)

A person performs routine activities indaily life. Even simple motions need the involvement of all four shoulder joints. Let say that; the humerus turnsaround its socket, shoulder blade turns alongribcage and collarbone raises up to make it. Following that, arm, humerus's head and shoulder blade's acromionprocess come closer to each other, and subacromial space is narrowed. These structures mainy contain the followings (6, 27):

- Biceps long head tendon
- Subacromial bursa
- Supraspinatus tendon

Combination of inflamed tissue, bony growths or altered posture is adequate forthe compression of one or more of the above given structures (See Fig 2.16) (28 -30).

2.3.3 Classification

According to Vladimir Janda, the musculoskeletal pathologies can be classified according to major approaches. These approaches are the structural and the functional aspects. The structural evaluationconcentrates on real damage to rotator cuff tendonitis and ligament injury. On the other hand, the functional approach evaluates some factors contributing to structural lesions. The latter is usually good for physical treatment management in the chronic dysfunctions like persistent joint pain and tendonitis. SISs are around44 to 65% of the entireshoulder complaints. As previously said by Neer (See Fig 2.17), SIS can be developed by narrowing subacromial space. Narrowing subacromial space is yielded by reduction in the space. Related to bony growth or soft-tissue inflammation, structural or superior migration in humeral head, and negative issues in humeral head are cause of weakness or muscle imbalance function(6).

Stage 1: Edema and hemorrhage, age <25 years, reversible
Stage 2: Fibrosis and tendinitis, age 25–40 years, recurrent pain with activity
Stage 3: Bone spurs and tendon rupture, age >40 years, progressive disability

Figure 2.17. Neer's Classification (4)

2.3.4 Diagnosis and clinical evaluation

Diagnosis and clinical evaluation of the SIS start with a medical and physical examination by an expert. The patient is subjected to X-ray screening for showing anychange in bone. The screening related findings are interpreted as an indicator of themuscle's injury (8).

Patients with SIS can suffer from acute pain, especially after a definite traumatic event, or restrictions/limitations in their daily live activities. The pain associated with this syndrome is often called anterolateral arm pain. Themajor factors are stretching, lying on shoulder, and reaching up to overhead things (9).

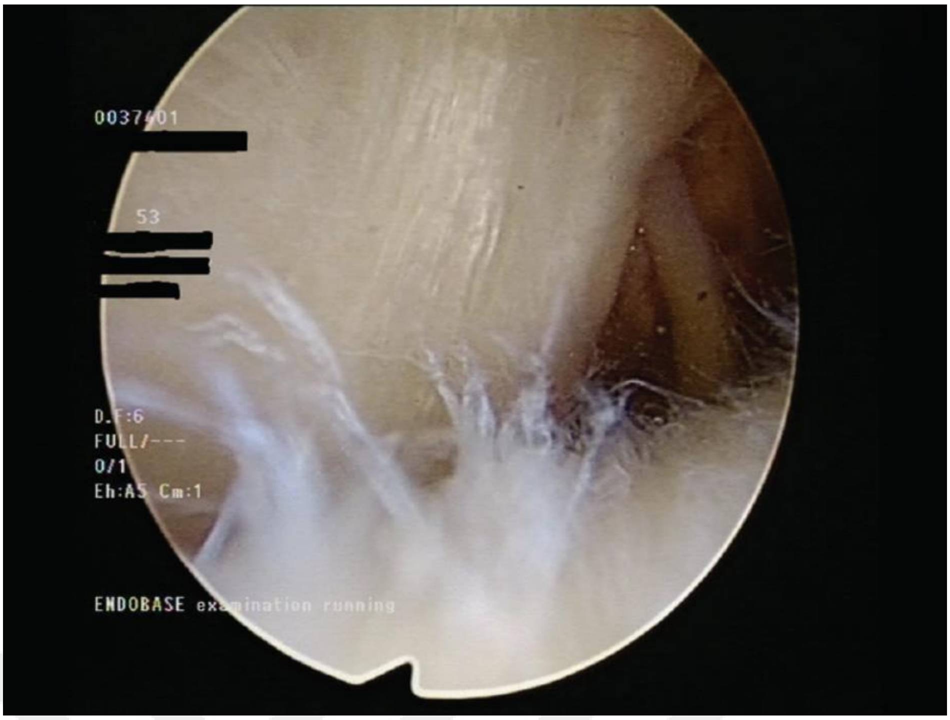


Figure 2.18. Arthrosopic View Showing Impingement Lesion (9)

The literature shows that the incidence of SIS is high, and many alternative hypotheses have been claimed to explain its pathogenesis, cause of pain, and loss of function in shoulder (6).

As seen Fig 2.17, Neer categorized the impingement into 3 subdescriptions as follows (25):

- *Stage-I*: characterized by hemorrhage and edema of subacromial bursa and cuff, and usually observed in patients < 25-yr-old.
- *Stage-II*: characterized by fibrosis and tendinitis of rotator cuff, and typically observed in patients> 25- and <40-yr-old.
- *Stage-III*: characterized by partial or complete tears of rotator cuff, and often detected in patients > 40-yr-old.

In these stages, the shoulder joint and cervical spine should routinely be examined. The criterion is the normality of the passive range of motion of the affected shoulder. For instance, pain on abduction of the shoulder should be between 60° and 120, and evaluated as the painful arc, indicating the presence of SIS (See Fig 2.19) (9).

Sign/Test	Sensitivity	Specificity	Comments
Neer sign	68.0%[24]	68.7%[24]	Passive forward flexion of arm with scapular stabilized - positive if pain on anterior aspect of shoulder
Hawkins–Kennedy sign	71.5%[24]	66.3%[24]	Passive internal rotation of shoulder placed in 90° of abduction - positive if pain is reproduced
Painful arc sign	73.5%[24]	81.1%[24]	Active elevation of arm in plane of scapula
Exclusion tests			
O'Brien's test	67.0%[28]	37.0%[28]	Common test for superior labral anteroposterior pathology but sensitivity suffers if there are concomitant shoulder pathologies
Apprehension test	52.8%[29]	98.9%[29]	Test for gleno-humeral joint instability

Figure 2.19. Common Tests Done During Evaluation for SAIS (9)

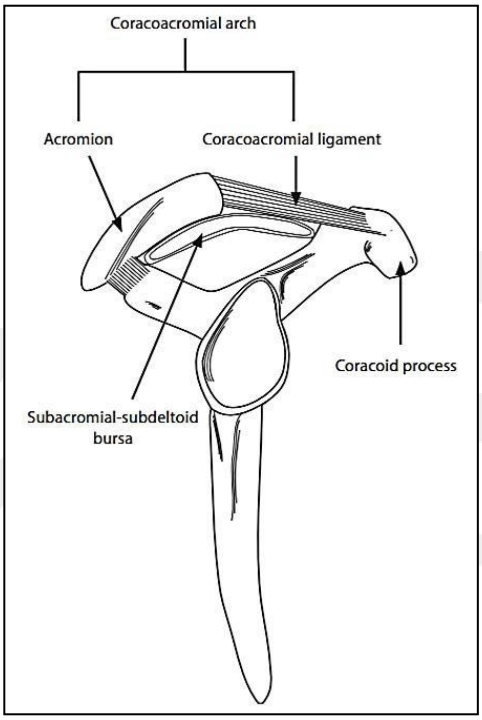


Figure 2.20. Structures Comprising Coracoacromial Arch (26)

Narrowing of the subacromial space denotes SIS as an encroachment of the subacromial tissues and mechanisms of rotator cuff tendinopathy includes extrinsic, intrinsic or a combination of extrinsic and intrinsic factors. In this manner, intrinsic impingement assumes that partial or full thickness tendon tears may happen due to degenerative processesin an extended time because of tension overload, overuse, or tendon's trauma. However, another alternatice theory offers an extrinsic impingement, and this extrincis impingement is characterized by inflammation and degeneration of the tendon due to mechanical compression by the external structures to tendon (See Fig 2.20) (25).

In any case, agroup of extrinsic impingement, internal impingement may be derived due to the articular side's compressionrather than the bursal side of RC tendonswhen arm is in complete external rotation, extension and abduction. Narrowing of subacromial space is not evaluated as a hallmark finding despite taking internal impingement as an extrinsic factor (See Fig 2.21) (25).

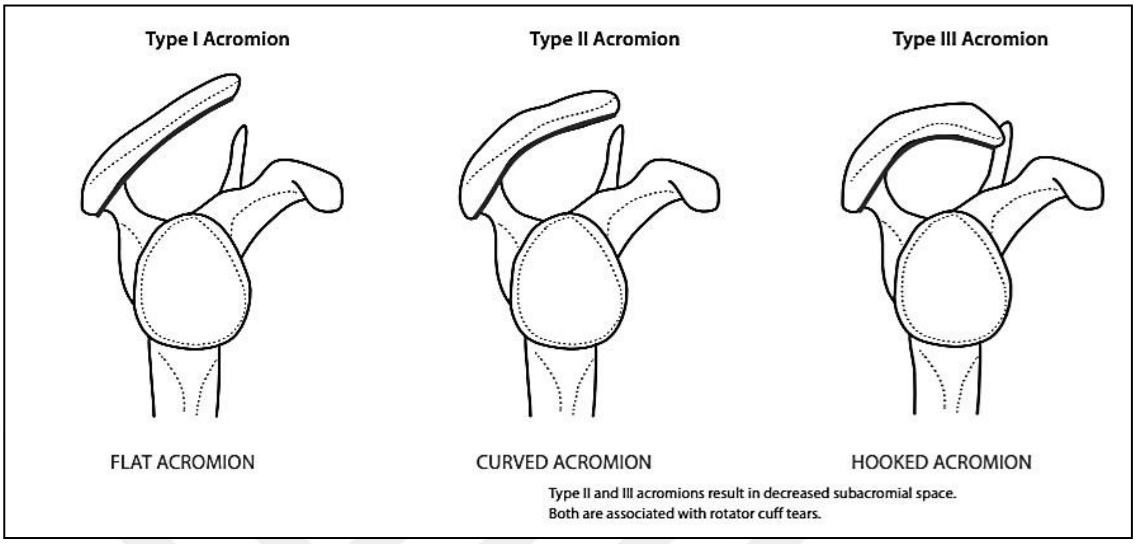


Figure 2.21. Different Structural Types of Acromion (26)

Highlightingreason inSIS can be classified into some intrinsic (IM) and extrinsic mechanisms (EM). The IMsinclude pathologies of rotator cuff tendons associated withtension. Below, some of the IMs are listed (See Fig 2.22) (29, 30):

- Muscular weakness: Weakness in rotator cuff muscles, and cause muscular imbalances in humerus.
- Overuse of shoulder: Repetitive microtraumaby inflammation of rotator cuff tendons and subacromial bursa, and lead to friction between coracoacromial arch and tendons.
- Degenerative tendinopathy: Degenerative changes in acromion, and results in rotator cufftearing.

The EMsharbors pathologies in rotator cuff tendons, and associated with external compression, as follows:

- Anatomical factors: Congenital and/or acquired anatomical changes in acromion's shape and gradient.
- Scapular musculature: Functional reduction inscapular muscles, particularly in serratus anterior and trapezius.

- Glenohumeral instability: An abnormality and/or weakness in glenohumeral joint and/or rotator cuff muscles.

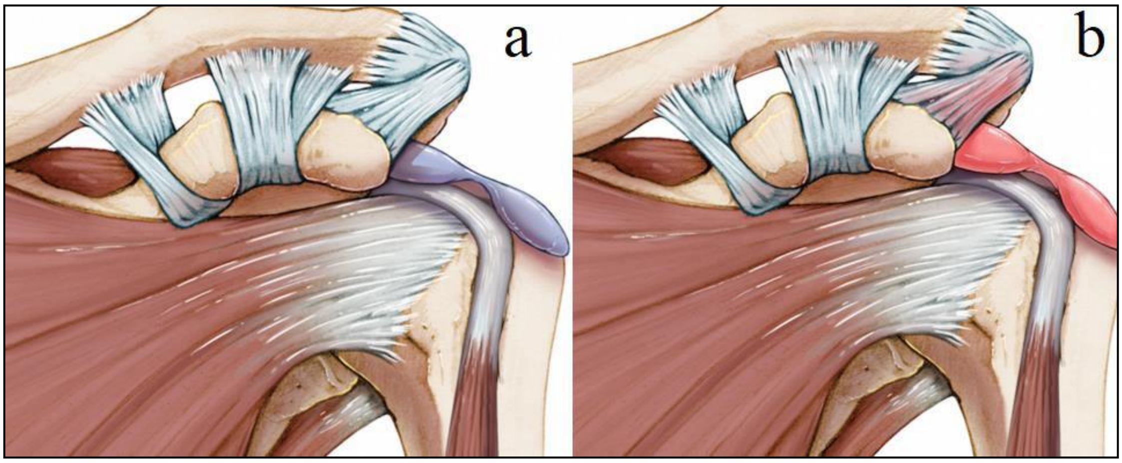


Figure 2.22. (a) Healthy shoulder showing bursa and tendons anatomy versus (b) inflammation and thickening in bursa and rotator cuff tendons (31)

Clinical Featuresof the SIS may come suddenly or on gradually. The major actions causing pain in SIS can be listed as follows (32):

- Spreading from shoulder's top toward elbow.
- Lifting arm.
- Sleep at night.
- Lying on sole shoulder.
- Putting hand head or behind back.
- Reaching up.

The pain in the anterior superior shoulder is the most usual indicator of progressive SIS. The affected shoulder and relieved by rest classically exacerbate the pain by abduction in, and is related to weakness and stiffness secondary to the pain (29).

There are two major examination signs in the cases of SAIS. These tests are as follows (9):

- Neers Impingement test
- Hawkins test

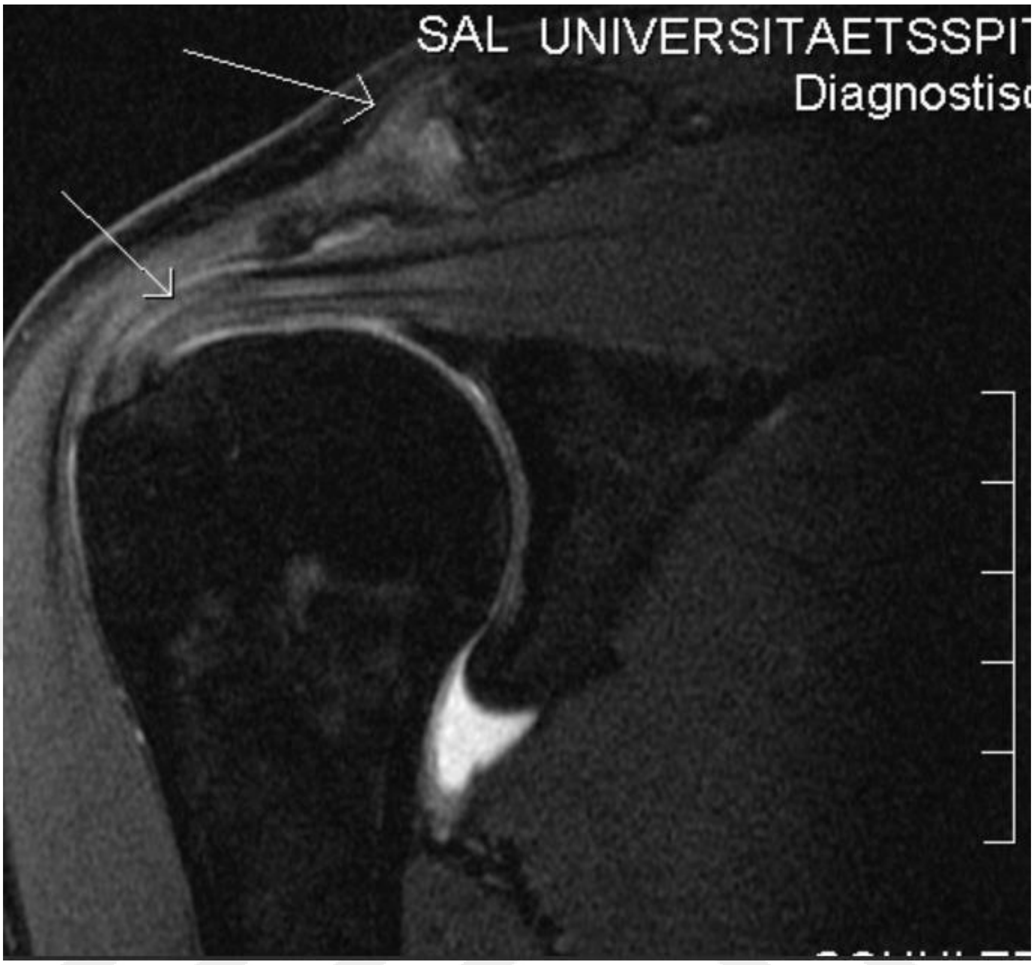


Figure 2.23.MRI Imaging inSIS (A Partial Rupture of Supraspinatus Tendon) (29).

Also, differential diagnoses of the tears in particular rotator cuff, long head of biceps, the weakness persistsin spite of the shoulder pain being relieved. For example (32);

- Neurological pain such as thoracic outlet syndrome, cervical radiculopathy, brachial plexus injury, weakness is likely be associated with paraesthesia and/or pain, yet the weakness persists despite the shoulder pain being relieved.
- Frozen shoulder syndrome, incuding adhesive capsulitis or calcific tendinitis, stiffness persists even if the pain is relieved.
- Acromioclavicular pathology such as acromioclavicular arthritis, glenohumeral arthritis, introduces a much more generalised pain, also with weakness and stiffness related to pain.

Investigations in the diagnosis of the SIS should be often conrifmed with additional imaging techniques. For instance, MRI imaging of an injured shoulder is one of the techniques. Its features hide significant information related to subacromial osteophytes and sclerosis, humeral cystic changes, narrowing of subacromial space, and subacromial bursitis (See Fig 2.23) (29).

2.3.5 Approaches to treatment of SIS

There are various and numerous structures that may be damaged in rotator cuff impingement and each structure may, therefore, need a different treatment approach. The importance of understanding "Why" the impingement occursis the most important step to both the short-term resolution and the prevention of recurrent shoulder impingements, and the lattersprediSpose us to a rotator cuff tear and subsequent medical intervention (6, 7).

The SIS injuries and treatment interventions may considerably vary, and always important to arrange an appointment with a healthcare practitioner who has an expertise on the shoulder injuries. Some of them are given below (4).

- Immobilization
- Physical therapy
- Ultrasound
- Manual therapy
- Nonsteroidal antiinflammatory drugs
- Cortisone injections
- Elastic theraupatic tape
- Acupuncture

2.3.5.1 Core Stabilization Exercises

The shoulder rehabilitation's goal is to improve shoulder muscle strength by appropriate exercises, includingeccentric training, open and closed chain activities, isometric, or concentric. Among them, the core stabilization exercises (CSEs) are known as neuromuscular retraining exercises, principally aims to provide balance in the muscles to provide a rigid cylinder around lumbo-pelvic-hip area against body perturbations (10).

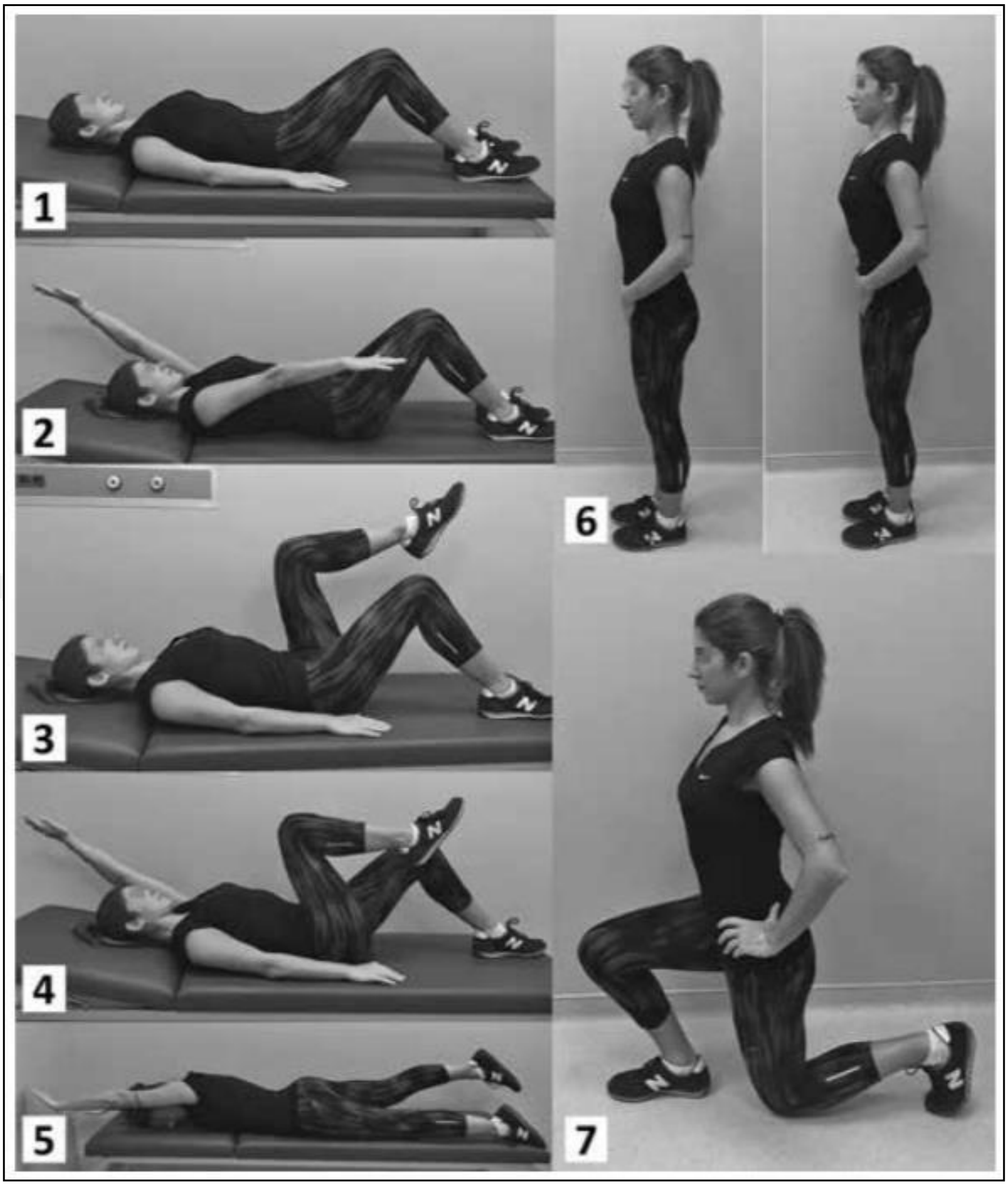


Figure 2.24. Basic Core Stabilization Trainings (33).

The CSEsbasically concentrates on the recruitments of the local and global stabilizers, as well as global mobilizer and load transfer muscles. Muscles move in a chain.Optimal function occurs with the coordinated movement of the muscles .A change in the kinetic chain causes serious changes in other structures in the kinetic chain.Regional muscles are small, deep, and coordinate movement between the spine.Large-scale muscles are large, superficial and transfer on-body loads additionally increase intra-abdominal pressure.

Local Muscles: Multifidus, rotators, interspinal and intertransverse.

Global Muscles: Rectus Abdominis, Internal and External Obliq ue Abdominis, Transversis Abdominis, Erector Spinae, Quadratus Lumborum.

A core stabilization program is based on abdominal drawing-in or bracing training to make better the neuromuscular control of the local stabilizers toward further improvement of the neuromuscular control and joint stabilization by some progresses to promote distal mobility (See Fig 2.24). We can list them as follows (33):

- movements related to abdominal drawing-in, w/ alternating upper and lower extremity, or both,
- forward lunge,
- raising arm oppositely in prone position,
- pelvic tiltingin standing,

The CSprogram enhances strength and endurance of peripheral joints by making transfer of energy toward distal segments, not only loweringany load on vertebral column (34).

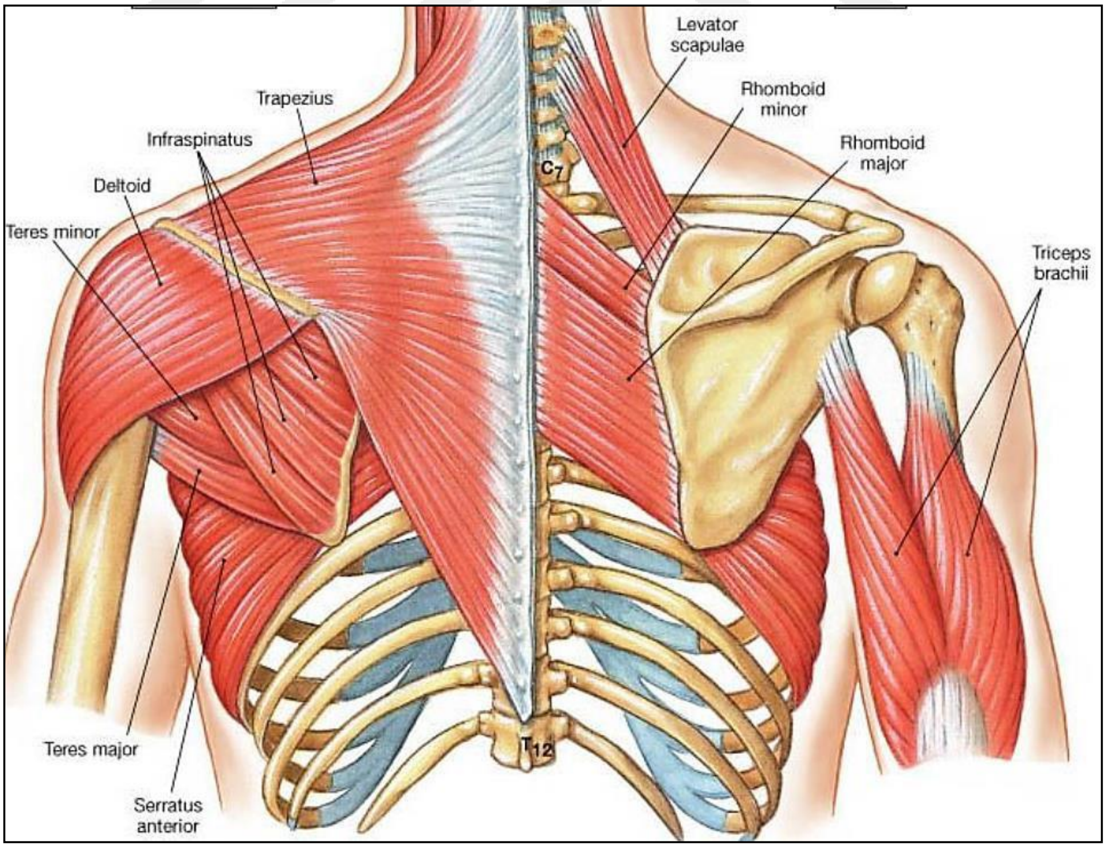


Figure 2.25. Shoulder Muscles (Tavel, 2017).

The scapula, also referring to shoulder blade, is a large-flat bone positioning on top of rib cage, and fixed in place by shoulder girdle’s muscles (Figure 2.25). Unlike most other joints in body, itis not connected to the body by the tissues, including fibrous, cartilaginous or synovial. But, it relies on seventeen muscles as seen in Figure 2.25 (35).

In Fig 2.26 and Fig 2.27, numerous shulder strengthening trainings for the SIS patients are illustrated, and one example of the program strucuture is given in Appendix-2(36):

The shoulder pain arised from SAIS is a major issue, and relatively poor responses to treatment existi. Therefore, the research to explore physical therapists' perspectives on the management of this syndrome is restricted. A study investigated physical therapists' perceptions and experiences with regard to treatment of SIS patients, and the results showed that the core stabilization exercises were central in treating the SIS patients (37).

Core stability has become a popular topic in the physiotherapy and rehabilitation research in the prevention of numerous spine and lower extremity injuries. The balance of an individual is a part of the core stability. Various clinical neuromuscular imbalances are derived from synergistic and antagonistic muscles. On the other hand, there are still existing limited interest in the core stability and the the relationship between the core and shoulder dysfunction (11).

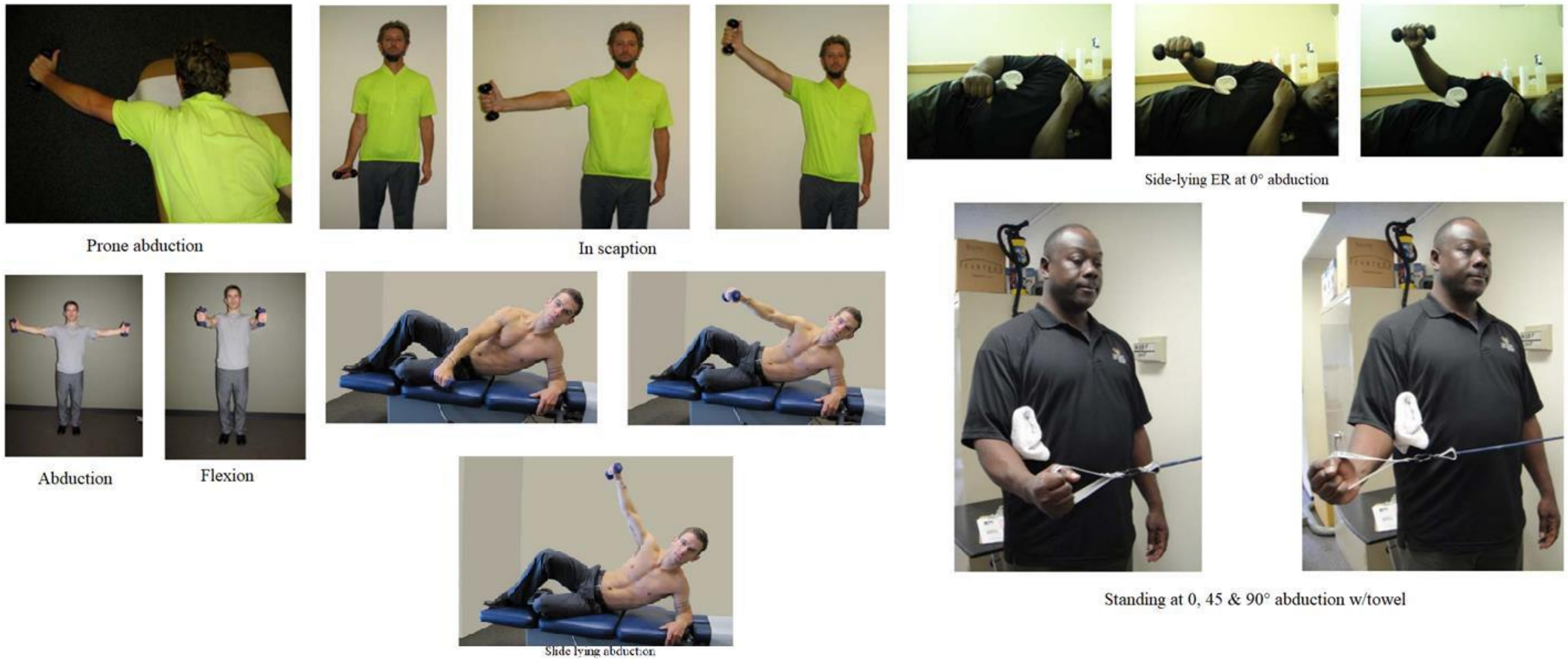


Figure 2.26. Shoulder Strengthening Exercises-I (36).

Figure 2.27. Shoulder Strengthening Exercises-II (36).

2.3.5.2 Proprioceptive Neuromuscular Facilitation Technique

Proprioceptive Neuromuscular Facilitation (PNF) rehabilitation addresses motor impairments depending on musculoskeletal parameters likepareticlims's stretching and/or strengthening, and motor control and learning in the SIS patients. Shoulder is very susceptible to some traumas and/or disturbances due to microtraumasdirectly in contact the skeletal constituents or failure of some soft parts in rotator cuff and other muscles embedded in glenohumeral joint. Therefore, shoulder rehabilitation concentrates on flexibility and strength (38, 39).

PNF presents a surplus technique to developshoulder rehabilitation by biomechanical stretching. This maximum biomechanical stretching movement raises functional movements based on proprioceptive and muscular stimulation (12).

PNF is equivalent to diagonal exercises with an objective of increasing functional movement based on inhibition, muscular facilitation, relaxation, and strengthening. Suchtrainings targets to develop motion alternatives and responses to physical efforts (40).

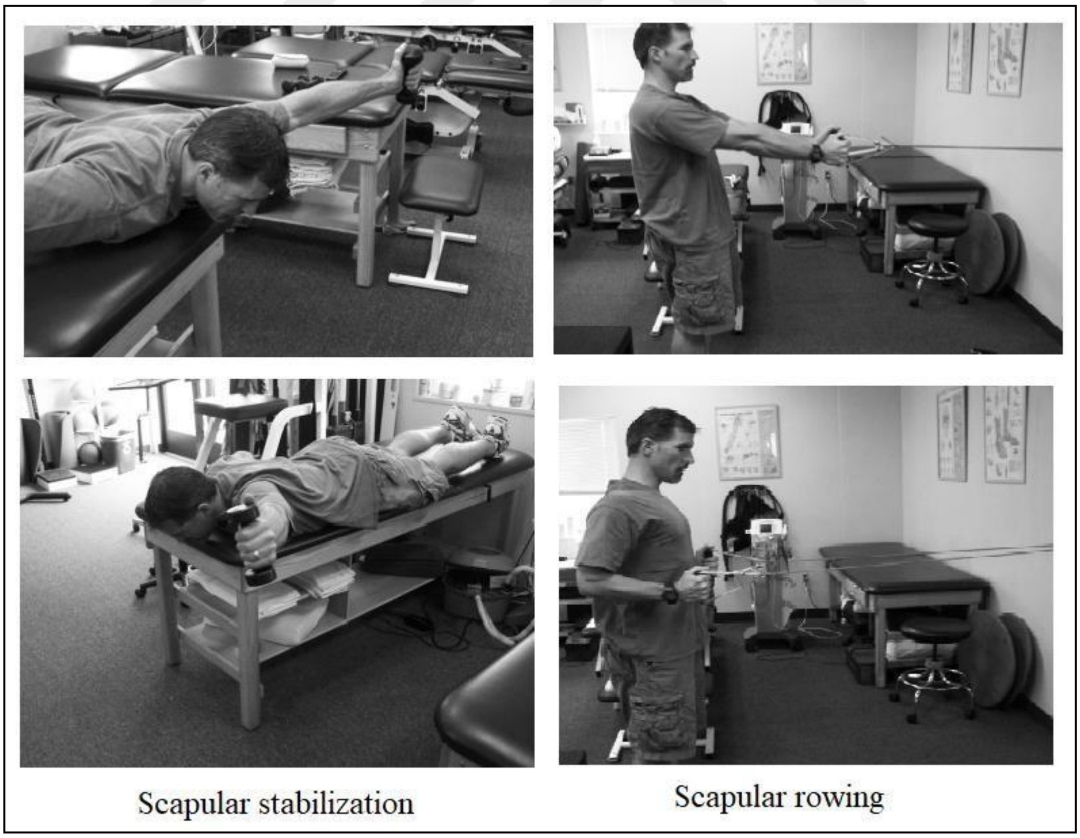


Figure 2.28.PNF Exercises-Scapular Stabilization and Rowing (41).

Shoulder dysfunctions like AC and subacromial impingement may potentially cause some significant changes in scapula’s position. PNF is a theoretical treatment concept based on 4 mechanisms. These mechanisms arestress relaxation, autogenic and reciprocal inhibition, and theory of gate control to enhance ROM and muscle activation. Within therapeutic approaches, the joint mobilization based on PNF positively affectsROM, muscle strength and pain (See Fig 2.28) (40-43).

Figure 2.29.PNF Exercises (40).

2.3.5.3 Other Treatment options and indications

In the Treatment of the SIS, there are other techniques across the World. The objective of the proper rehabilitation is to initially eliminate the pain, and subsequently to restore the joint function. According to the literature, the better results in the rehabilitation can be obtained using conservative and surgical approaches in almost 80% of the SIS cases. However, there are still no fullfilling techniques indicating which patients stand to get benefit from conservative treatment and/or surgical operation (44-46).

If there is no a major and serious structural damage in the patient, some conservative multimodal treatments can be applied to the patient during 3 to 6 months as the preliminary therapy of choice. The conservative approach targets to reduce the pain at first, and then passive and active motion, followed by strength and coordination. A broad range of conservative rehabilitation techniques is available as seen Figure 2.30 (47).

- Immobilization
- Nonsteroidal anti-inflammatory drugs (NSAID)
- Cortisone injections
- Physical therapy
- Ultrasound
- Application of heat and electricity
- Manual therapy
- Elastic therapeutic tape
- Acupuncture

Figure 2.30. Other Conservative Treatment Techniques in SIS (47).

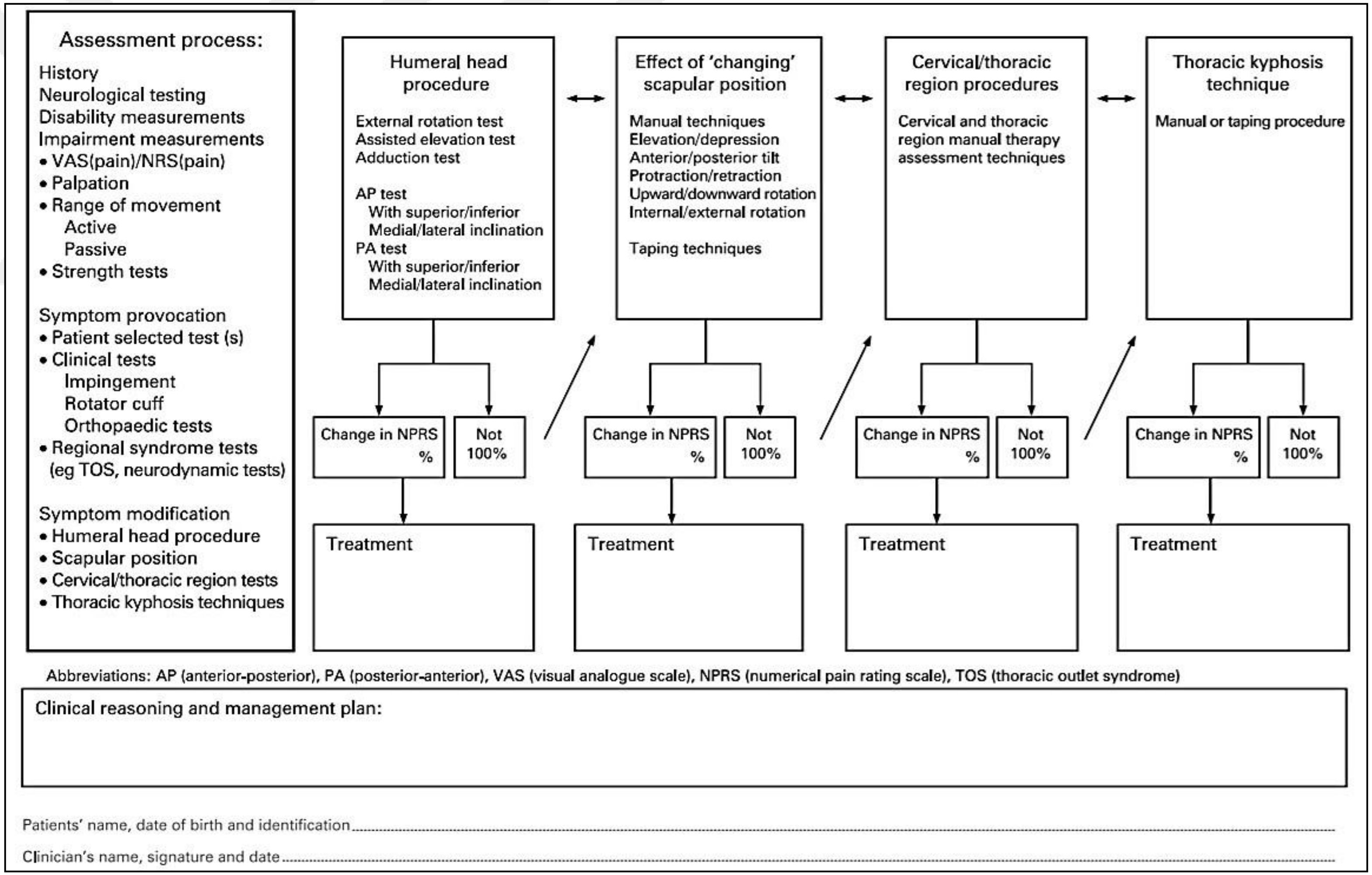


Figure 2.31.SISModification Procedure (48).

3. MATERİAL and METHODS

3.1 Experimental Conditions

3.1.1 Subjects and Selection Criteria

The work was performed from March 01 to August 30, 2019. A total of 50 persons (25 in experimental group and 25 in control group; ages ranging from 18 to 65 yr was involved in this study) .

All the selected patients attending in a privately owned hospital in İstanbul were with shoulder subacromial impingement syndrom longer than 6 months according to the MR results. Before getting started the study, each participant was particularlyinformed about the objective of the study and the experimental methods.

The selection of the participants involved in the study was performed according to the following criteria:

- Those with shoulder SIS longer than 6 months according to the MR results,
- Those with an age ranging from 18 to 65 year-old.

On the other hand, the persons having at least one of the following criteria were not included in the study;

- Those with trauma or medical intervention
- Those with hypertension
- Those with open wound
- Those with infection
- Those with rheumatoid arthritis
- Those with reflex sympathetic dystrophy
- Those with adhesive capsulite

3.1.2 Experimental Protocols

The study has been designed retrospectively. Experimental protocols were conducted according to the guidelines and regulations of the human welfare and experimentation set by the Turkish law, and the ethical approval dated on October 9, 2019 by the Ethical Committee of Istanbul Yeditepe University, IstanbulSchool of Medicine, Istanbul (See Appenndix-I).

The study was a prospective clinical trial in those meeting the criteria of selection as previously described in “3.1.1Subjects and selection Criteria”. To do this, a total of 50 patients with SIS longer than 6 months according to the MR results and meeting the given criteria of selection were randomly divided in to 2 major groups (control and experimental) for further tests. Before starting the study, each participant was clearly informed about the scope and possible adverse effects of the study, and the volunteer participation form was asked to fill in from each.

The experimental procedure was continued for 6 weeks. A patient from each group was exposed to a 6-week intervention. All the evaluations were performed twice (at the beginning and and the end of the study for each patient by the same physiotherapist. To make the evaluations, the practicer used some documents/forms, including patient’s evaluation form, motion of neck and shoulder joint crietria, pain, strengthing and endurance of core muscles, and muscle strength for shoulder muscle, respectively. The control group (n=25) was exposed to the regular treatment and PNF exercise, whereas the experimental group (n=25) was subjected to the regular treatment, core stabilization and proprioceptive neuromuscular faclitationexercies on pain, motion of joint, muscle strength, posture, and functional status. The regular treatment included Transcutaneous Electrical Nerve Stimulation (TENS) for 30 min, infrared radiation for 30 min, ultrasound for 5 min, and home exercise programme.

In the electrotherapy intervention, infrared treatment was applied wit h the conventional TENS during 30 minutes. The duration and frequency of the ultrasound treatment was 5 minutes and 1.5 W/cm^{2}at 1 Mhzbatch mode. An exercise programme with twice a day at home was offered. The exer cises were repeated 10x twice a day not to exceed the pain thresold. The patient was asked to do home exercises for 6 weeks Theprogramme included the Codman exercise, flexion exercise at the ladder, and the Wand exercise for flexion and extansion. In the PNF programme, the patient was kept at at the supine position, including the shoulder at 10^0 flexion and 30^0 abduction, and the arm positioned when the elbow at 90^0 flexion. The patient was reuired to make isometric contradiction for 7 s, followed by actively outer rotation. The PNF exercises were repeated five times.PNF exercises were done 3 times a week for 6 weeks with a physiotherapist.

In the treatment group, the same interventions among the control group were conducted. In addition, the core stabilization exercise was performed. All the exercises were performed by the physiotherapist during 6 week with a repeat of 3 times a week. The number of repeat for each exercise wasfive. The interventions of the core exercise were applied when the patient lied on his/her back with his/her knees at flexion. The further steps in the exercises were extended according to the activation duration of the core muscles, and this extention was elongated 5 s every week. The number of the core exercise for a patient was six, as explained below:

i. Dead insect exercise: The dead bug exercise involves lying face up on your mat with your arms in the air above your torso and your legs in the air with your knees bent at 90-degree angles. Then, you lower opposite arm and leg toward the floor in a slow and controlled fashion. Return to center and then repeat on the other side.
ii. Half shuttle exercise: In this intervention, the patient was asked to bring his/her both two arms at 45 degree flexion, and his/her eyes to point out toward a fixed point at the top. Then, he/she was required to stand up up to his/her scapula, and stay at that position for 5 s.
iii. Bridge exercise: Both legs of the patient was positioned at theflexion on to the bed. Then, the patient lied on his/her back with hands at the sides, knees bent, and feet flat on the floor under the knees. He/she stayed at this position for 5 s by activating the core muscles.
iv. Dog peeing: With his/her leg away from you, he/she was asked to start with hip flexion, hip abduction, hip internal rotation, dorsiflexion, and eversion, followed by pulling the leg in and behind him/her to hip extension, hip adduction, hip external rotation, plantarflexion, and inversion. This position activated the core muscles, and continued for 5 s.

v. The Wall sit exercise: The stabilizatiom ball was placed on the back of the patient. Accordingly, he/she formed a right angle (90 degrees) at hips and knees, his/her back was flat against the wall, and the heels were on the ground by activating the core muscles for 5 s.

vi. Stability ball workout: It was a workout targeting the core muscles, the patient was asked to start in a plank position with feet on stability ball (toes pointed), engage core and pull knees forward until they're under hips, keeping hips level, return to plank position during 5 s.

All the participants were followed up during 6 weeks and 3x a week. However, the monitoring was performed 2x a week during 6 weeks for those engaged at home exercises.

	
Figure 3.1. Bridge exercise	**Figure 3.2.** Pull-ups exercise

Figure 3.3. PNF muscle relaxation tecnique

3.1.3 Patient Evaluation Form

A case report form was prepared to collect the data for the personal and disease data belonging to each patient involved in the study. Given the form, the pain was measured by a visual analog scale, the upper extremity and range of motion of neck by a goniometer, the upper extremity muscle strength by manual muscle strength, the core strength for back and neck by Sharmann Protocol, the core endurance by Sorenson, front plank, and right & left bridge tests, the posture by New York Posture Evaluation test, and the function of upper extremity by shoulder pain and disability index, respectively. All the daha gathered were filled in the form accordingly (See Appendix 3).

3.2 Evaluation

The evaluation of the effects of the core stabilization and proprioceptive neuromuscular faclitationexercies and the regular treatment was performed according to the following criteria:

- Pain
- Strengthing and endurance of core muscles
- Motion of both neck and shoulder joint
- Muscle strength for shoulder muscle
- Posture
- Evaluation of functional status

3.2.1 Pain

The pain was evaluated at rest and on motion status using the visual analog scale (VAS) describing the pain with a 0-10 scale. Here, 0 means no pain, and 10 means the worst pain imaginable.

3.2.2 Strengthing and Endurance of Core Muscles

3.2.2.1 Strengthingof Core Muscles

The strengthing of Core Muscles was evaluated using Sharmann Protocol. The measurements were repeated 3 times, and an arithmatic average value was used. With the Sharmann test, a transducer is placed under the patient's lumbar spine while he/she lies supine in a hook-lying position. Then, the transducer is inflated to 40 mm Hg, while the patient activates the stabilizing musculature via abdominal hollowing technique.

Abdominal hollowing, if performed correctly, results in either no change in pressure or a slight decrease from the initial 40 mm Hg. The Sahrmann protocol can be used as a scientifically based protocol to test the ability of the core musculature to stabilize the spine with and without motion of the lumbopelvic complex.

3.2.2.2 Endurance of Core Muscles

The endurance of core muscles was evaluated by using Sorensen, front plank, and right and left bridge tests. Each test was repeated three times, and the arithmatic average of the measurements was used.

The Biering-Sørensen test measures howmany seconds the participant is able to keep the unsupported upper partof the body in a horizontal position. In this test, the load is equal to theweight of the upper part of the body, with torque determined by the leverarm from the pubic symphysis to the upper body centre of gravity. The participant was positioned prone over an examination table. Thelower extremities were stabilized by 2 belts at the level of the hips andjust below the knees. The iliac crests were positioned at the edge ofthe table with the trunk extended beyond the table and initially hanging flexed in 90°. The trunk then was raised to the horizontal positionwith hands crossed over the chest. The test was continued until theparticipant could no longer control the horizontal posture, or until heor she reached limit of fatigue pain (68).

Right and left side bridge endurance abilities were recorded. Every participant was instructed to lie down on eitherside and bear upper trunk weight on arm with shoulder abducted to 90ºand elbow flexed to 90º. Every participant was instructed to put the non-weight arm acrossthe chest with keeping the hand on the opposite shoulder. The lowermost leg was maintained in semiflexedposition while the uppermost leg was put just anterior to the other leg. Each holding time was recorded using a stopwatch (69).

For the prone plank test, participants maintained a prone position in which the body weight was supported by the toes and forearms. The side plank test was performed with the participant lying on their side, supported by the foot and elbow. The side plank test was performed on both sides. Participants were instructed to maintain a neutral position of the spine and pelvis, and to breathe normally during testing. Each test was terminated when the participant was unable to maintain their posture or their pelvis moved up or down five or more cm. Each holding time was recorded using a stopwatch. The holding time of the prone plank test, right and left side plank tests, and the combined score of all plank tests were used for analyses (70).

3.2.3 Motion of Neck and Shoulder Joint

The motion of neck and shoulder joint was evaluated using a goniometer according to the criteria by Kendall McCreary. The measurements were repeated three times to determine the loss of motion, and an arithmatic average of the measurements was used.

3.2.4 Muscle Strength for Shoulder Muscle

The evaluation of the muscle strength for shoulder muscle was performed manually by the physiotherapist.

3.2.5 Newyork Posture Test

Posture tests are used in clinical settings to detect body alignment deviations and to prescribecorrective exercises or procedures to improve posture or alignment. The NYPT applies a quantitative approach to assess proper and improper alignment of various body segmentsfor an individual in the anatomical position. It includes aset of three figure drawings for each of 13 body alignment segments contributing to overall posturalalignment. The 13 body alignment segments include posterior views of the head, shoulders, spine, hip, feet, and arches, and lateral (left side) views of the neck, chest, shoulders, upper back, trunk, abdomen, and lower back (See Appendix 4) (71).

3.2.6 Functional Evaluation

The functional values within the examined groups wasperformed in the beginningand the end of the study (6th week) (See Appendix 5).The Shoulder Pain and Disability Index (SPADI) was developed to measure current shoulder pain and disability in an outpatient setting. The SPADI contains 13 items that assess two domains; a 5-item subscale that measures pain and an 8-item subscale that measures disability. There are two versions of the SPADI; the original version has each item scored on a visual analogue scale (VAS) and a second version has items scored on a numerical rating scale (NRS). The latter version was developed to make the tool easier to administer and score. In this study, we used the questionaire retrieved from Bumin, Tüzün& Tonga (2008) entitled "The Shoulder Pian and Disability Index (SPADI); Cross Cultural Adaptation, reliability, and validity of the Turkish version.

3.3 Statistical Analysis

Statistical analysis was conducted by SPSS 19 (SPSS Inc., USA). The in-group and between-group data were initially exposed to descriptive analysis, including median, standard deviation (ss), frequency, and %. Subsequently the frequencies in the beginning and end of the study between sampling groups were compared for statistical significance using Shapiro Wilk Test and Mann-Whitney U Test ($p<0.05$). We also captured the demographic information in the participants.

4. RESULTS

In this section of the study, the evaluation was performed using a case-form. The case-form included the personal information and the disease histroy of each subject involved in the study. In the form, pain was determined on visual analog scale; upper limb and motion of neck by goniometer; muscle strength of upper limb by manual muscle power; core endurance for back and neck regions by Sharmann Protocol; core endurance by Sorensen, front plank, right and left bridge tests; posture evaluation by Newyork Posture Test; and functional status of upper limb by shoulder pain and disability index, respectively.

4.1 Demographic Results

The demographic analysis within the examined groups was given in Table 4.1 and Table 4.2. According to the analyses, no significant difference between control and experimental groups were observed regarding their demographic data (age, symptom duration, dominant side and affected shoulder) ($p>0.05$).

The age and duration correlation between the examined groups showed that the average ages of the control group and experimental groups were 48.16±9.41 and 48.00±7.90 ($p=0.948$), respectively. On the other hand, the symptom duration were determined to be 8.04±2.35 in the control group, and 7.96±2.05 in the experimental group ($p=0.880$).

The affected sides correlation analysis indicated that the frequencies in the dominant side (right and left) were found as 22 and 3 in the control group, and 24 and 1 in the experimental group ($p=1.000$). On the other hand, the analysis showed that the affected shoulder (right and left) were measured as 15 and 10 in the control group, whereas 17 and 8 in the experimental group ($p=0.700$).

Table 4.1. Age, Symptom Duration, Dominant Side and Affected Shoulder Correlation BetweenTreatment Groups

Parameter	Treatment Groups		P
	Control ($\bar{x}$ ±Sd)	Experimental($\bar{x}$ ±Sd)	
Age	48.16±9.41	48.00±7.90	0.948
Symptom Duration	8.04±2.35	7.96±2.05	0.880
Dominant side			
Right	22	24	1.000
Left	3	1	
Affected Shoulder			
Right	15	17	0.700
Left	10	8	
Total	25	25	

4.2 In-Group Results

All the in-group results between the treatment groups included:

- VAS, joint range of motion
- Strength of shoulder muscle
- Strength of core muscle
- Core endurance
- Posture Newyork Test
- Functional Values

All the in-group results were given in Table 4.2.

4.2.1 Pain

The level of pain between the groups wasmeasured in the beginning and the end of the study (6th week).

The analysis of pain in the control group revealed that the differences between the pain at rest and pain on motion status in the beginning and in the end of the study (6th week) and there was statistically significant ($p<0.05$). The VAS at rest and VAS on motion data were 6.32±1.37 and 7.88±0.92 in the beginning ($p=0.000$), while 2.04±1.45 and 2.12±1.39 in the 6th week ($p=0.000$).

The analysis of pain in the experimental group indicated that the differences between the pain at rest and pain on motion status in the beginning and in the end of the study (6th week) and there was statistically significant ($p<0.05$). The VAS at rest and VAS on motion data were 6.44±1.91 and 6.92±1.44 in the beginning ($p=0.000$), while 2.00±1.32 and 2.00±1.32 in the 6th week ($p=0.000$).

4.2.2 Joint Range of Motion

The join range of motion between the groups wasfollowed up in the beginning and the end of the study (6th week).

According to the analysis of the joint range of motion, the differences in the shoulder flexion, shoulder external rotation, neck lateral flexion (right and left), and neck rotation (right and left) meaurements in the beginning and the end of the study were found statistically significant ($p<0.05$). In the beginning, the joint range of kotion measurements in the control group were 129.44±27.34 in shoulder flexion, 43.52±16.01 in shoulder external rotation, 33.84±5.35 in neck lateral flexion (right), 32.64±6.42 in neck lateral flexion (left), 49.48±3.35 in neck rotation (right), and 50.20±3.40 in neck rotation (left), respectively.

The data obtained in the experimental group were 167.44±10.23 in shoulder flexion, 64.96±13.00 in shoulder external rotation, 39.44±1.22 in neck lateral flexion (right), 38.80±2.51in neck lateral flexion (left), 54.56±1.00 in neck rotation (right), and 54.56±1.00 in neck rotation (left), respectively.

The analysis of the joint range of motion in the experimental group showed that the differences in the shoulder flexion, shoulder external rotation, neck lateral flexion (right and left), and neck rotation (right and left) meaurements in the beginning and the end of the study were found statistically significant ($p<0.05$). In the beginning, the joint range of motion measurements in the control group were 136.00±26.35 in shoulder flexion, 47.92±16.41in shoulder external rotation, 34.08±5.46 in neck lateral flexion (right), 32.64±6.80 in neck lateral flexion (left), 48.56±4.55 in neck rotation (right), and 49.56±4.09 in neck rotation (left), respectively ($p=0.000$).

The data related to the experimental group were 167.44±9.54 in shoulder flexion, 66.72±18.73 in shoulder external rotation, 38.72±2.99 in neck lateral flexion (right), 38.80±2.161in neck lateral flexion (left), 54.44±1.26 in enck rotation (right), and 54.56±1.00in neck rotation (left), respectively ($p=0.000$).

4.2.3 Strength of Shoulder Muscle

The strength of shoulder muscle among the groups wasobtained in the beginning and the end of the study (6th week).

The results of the strength of shoulder muscle in the control group determined that the differences in the serratus anterior, pectoralis major, top trapezoid, and deltoidmeaurements in the beginning and the end of the study were found statistically significant ($p<0.05$). In the beginning, the meausrements taken in the control group were found to be 4.16±0.55 in serratus anterior, 4,16±0.74 in pectoralis major, 4.84±0.37 in top trapezoid, and 3.96±0.53 in deltoid, respectively, whereas by the end of the 6th week, the data were 4.80±0.40 in serratus anterior, 4.76±0.43 in pectoralis major, 5.00±0.00 in top trapezoid, and 4.64±0.48 in deltoid, respectively ($p= 0.000$ to $p=0.043$).

The findings of the strength of shoulder muscle in the experimental group revealed that the differences in the serratus anterior, pectoralis major, top trapezoid, and deltoid meaurements in the beginning and the end of the study were found statistically significant ($p<0.05$) (Table 4.8). In the beginning, the meausrements taken in the control group were found to be 4.24±0.72 in serratus anterior, 4.16±0.62 in pectoralis major, 4.60±0.50 in top trapezoid, and 3.92±0.70 in deltoid, respectively, whereas by the end of the 6th week, the data were 4.68±0.47 in serratus anterior, 4.64±0.48 in pectoralis major, 4.84±0.37 in top trapezoid, and 4.60±0.50 in deltoid, respectively ($p= 0.000$ to $p=0.011$).

4.2.4 Strength of Core Muscle

The strength of core muscle among the groups wasanalyzed in the beginning and the end of the study (6th week).

The results of the strength of core muscle in the control group indicated that the differences in the core strengths of waist area and neck in the beginning and the end of the work were determined to be significant stattistically ($p<0.05$) . The analysis showed that the core muscle strength measurements in the control group in the beginning and in the end of the 6th month were determined to be 1.44±0.65 and 1.60±0.64 in core strength of waist area ($p=0.043$), and 2.28±0.97 and 2.44±0.96 in core strength of neck ($p=0.043$), respectively.

The results of the strength of core muscle in the experimental group indicated that the differences in the core strengths of waist area and neck in the beginning and the end of the work were determined to be significant statistically ($p<0.05$). The analysis showed that the core muscle strength measurements in the experimental group in the beginning and in the end of the 6th month were determined to be 1,68±0,69 and 3,08±0,75 in core strength of waist area ($p=0.000$), and 2,28±1,17 and 3,64±0,90 in core strength of neck ($p=0.000$), respectively.

4.2.5 Core Endurance

The strength of core endurance within the examined groups wasderived in the beginning and the end of the study (6th week).

The findings showed that there was statistically significant correlation between t he core endurance values of the control group with respect to Sorenson test, front plank test, right bridge, and left bridge, respectively ($p<0.05$).The analysis showed that the core endurance measurements in the control group in the beginning and in the end of the 6th month were determined to be 10.25±3.32 and 15.91±2.88 in Sorensen test ($p=0.000$), 13.14±3.68 and 17.94±3.47 infront plank test ($p=0.000$), 11.79±4.08 and 16.56±3.92 in right bridge ($p=0.000$), and 11.45±3.96 and 17.26±3.91 in left bridge ($p=0.000$), respectively.

The analysis showed that there was a significant relation between the core endurance values of the experimental group with respect to Sorenson test, front plank test, right bridge, and left bridge, respectively ($p<0.05$). The analysis showed that the core endurance measurements in the control group in the beginning and in the end of the 6th month were determined to be 10.54±3.30 and 14.81±2.75 in Sorensen test (p=0.000), 13.09±3.60 and 24.28±3.57 in front plank test (p=0.00 0), 11.64±3.79 and 21.74±3.56 in right bridge (p=0.000), and 11.51±3.41 and 20.64±3.15 in left bridge (p=0.000), respectively.

4.2.6 Posture Newyork Test

The posture Newyork test within the examined groups wasperformed in the beginning and the end of the study (6th week). The results revealed that there was not a statistically significant correlation between the posture Newyork test values of the control group ($p<0.05$).

The analysis showed that the posture Newyork test measurements in the control group in the beginning and in the end of the 6th month were determined to be 41.36±7.21 and 43.36±6.86 in posture value, respectively (p=0.953). The results showed that there was a statistically significant correlation between the posture Newyork test values of the experimental group ($p<0.05$). The analysis showed that the posture Newyork test measurements in the experimental group in the beginning and in the end of the 6th month were determined to be 41.48±6.32 and 51.40±5.15 in posture value, respectively (p=0.953).

4.2.7 Functional Values

The functional values within the examined groups were performed in the beginningand the end of the study (6th week). The results of functional values showed that there was not a significant relation between the beginning and the end of the study in the control group ($p>0.05$). The analysis showed that the functional value measurements in the control group in the beginning and in the end of the 6th month were determined to be 65.49±7.23 and 54.62±6.85 in functional value, respectively (p=0.652).

The results of functional values indicated that there was n ot a statistically significant association among the beginning and the end of the study in the experimental group ($p>0.05$). The analysis showed that the functional value measurements in the experimental group in the beginning and in the end of the 6th month were determined to be 64.36±8.61and 51.96±8.12 in functional value, respectively (p=0.232).

Table 4.2. In-group results between the treatment groups including VAS, joint range of motion, strength of shoulder muscle, strength of core muscle, core endurance, posture Newyork test, and functional values

GROUP/PARAMETER	**CONTROL GROUP**			**EXPERIMENTAL GROUP**		
	VAS					
	Beginning (x̄ ±Sd)	**6th week (x̄ ±Sd)**	**p**	**Beginning (x̄ ±Sd)**	**6th week (x̄ ±Sd)**	**P**
at rest	6.32±1.37	2.04±1.45	0.000	6.44±1.91	2.00±1.32	0.000
on motion	7.88±0.92	2.12±1.39	0.000	6.92±1.44	2.00±1.32	0.000
	JOINT RANGE OF MOTION					
Shoulder Flexion	129.44±27.34	167.44±10.23	0.000	136.00±26.35	167.44±9.54	0.000
Shoulder External Rotation	43.52±16.01	64.96±13.00	0.000	47.92±16.41	66.72±18.73	0.000
Neck Lateral Flexion (Right)	33.84±5.35	39.44±1.22	0.000	34.08±5.46	38.72±2.99	0.000
Neck Lateral Flexion (Left)	32.64±6.42	38.80±2.51	0.000	32.64±6.80	38.80±2.16	0.000
Neck Rotation (Right)	49.48±3.35	54.56±1.00	0.000	48.56±4.55	54.44±1.26	0.000
Neck Rotation (Left)	50.20±3.40	54.56±1.00	0.001	49.56±4.09	54.56±1.00	0.000
	STRENGTH OF SHOULDER MUSCLE					
Serratus Anterior	4.16±0.55	4.80±0.40	0.000	4.24±0.72	4.68±0.47	0.001
Pectoralis Major	4,16±0.74	4.76±0.43	0.000	4.16±0.62	4.64±0.48	0.000
Upper Trapezoid	4.84±0.37	5.00±0.00	0.043	4.60±0.50	4.84±0.37	0.011
Anterior Deltoid	3.96±0.53	4.64±0.48	0.000	3.92±0.70	4.60±0.50	0.000

	STRENGTH OF CORE MUSCLE					
Core Strength of Waist Area	1.44±0.65	1.60±0.64	0.043	1,68±0,69	3,08±0,75	0,000
Core Strength of Neck	2.28±0.97	2.44±0.96	0.043	2,28±1,17	3,64±0,90	0,000
	CORE ENDURANCE					
Sorensen Test	10.25±3.32	15.91±2.88	0.000	10.54±3.30	14.81±2.75	0.000
Front Plank Test	13.14±3.68	17.94±3.47	0.000	13.09±3.60	24.28±3.57	0.000
Right Bridge	11.79±4.08	16.56±3.92	0.000	11.64±3.79	21.74±3.56	0.000
Left Bridge	11.45±3.96	17.26±3.91	0.000	11.51±3.41	20.64±3.15	0.000
	POSTURE NEWYORK TEST					
	41.36±7.21	43.36±6.86	0.953	41.48±6.32	51.40±5.15	0.000
	SHOULDER PAİN AN DISABILITY INDEX					
	65.49±7.23	54.62±6.85	0.652	64.36±8.61	51.96±8.12	0.232

Overall, the in-group differences were statistically evaluated fort he beginning and the end of the study (6th week). The statistical highlighting remarks were given below:

- *Pain:* The in-group differences between pain at rest and on motion status were statistically significant ($p<0.05$).
- *Joint Range of Motion*: The in-group differences in the shoulder flexion, shoulder external rotation, neck lateral flexion (right and left), and neck rotation (right and left) meaurements were statistically significant ($p<0.05$).
- *Strength of Shoulder Muscle*: The in-group differences in the serratus anterior, pectoralis major, top trapezoid, and deltoid meaurements were statistically significant ($p<0.05$).
- *Strength of Core Muscle*: The in-group differences in the core strengths of waist area and neck in the beginning and the end of the work were statistically significant ($p<0.05$).

- *Core Endurance:*The in-group differences between the core endurance values of the control group with respect to Sorenson test, front plank test, right bridge, and left bridge were statistically significant (p<0.05).
- *Posture Newyork Test:* The in-group differences were statistically insignificant for the posture Newyork test values of the control group (p>0.05), whereas significant for the experimental group (p<0.05).
- *Functional Values:* The in-group differences were statistically insignificant for both groups (p>0.05).

4.3 Inter-Group Results

All the between-group results between the groups included:

- VAS, joint range of motion
- Strength of shoulder muscle
- Strength of core muscle
- Core endurance
- Posture Newyork Test
- Functional Values

All the in-group results were given in Table 4.3.

4.3.1 Pain

The VAS at rest and on motion measurements between the groups were performed. According to the analysis, we did not find a significant difference between the pain analysis of the groups among the VAS at reast and VAS on motion results (p<0.05).The measurements showed that the VAS at rest and VAS on motion values between the control group and experimental group in the beginning and in the end of the 6th month were determined to be 4.28±1.92 and 4.44±1.50 (p=0.756), and 5.76±1.53 and 4.92±0.99 (p=0.061), respectively.

4.3.2 Joint Range of Motion

The joint range of motion measurements between the groups were performed with respect to shoulder flexion (SF), shoulder exterior rotation (SER), neck lateral flexion (right) (NLFR), neck lateral flexion (left) (NLFL), neck rotation (right) (NRR), and neck rotation (left) (NRL). The analysis revealed that there was not a significant difference between the joint range of motion of the groups ($p<0.05$).

The measurements showed that the SF, SER, NLFR, NLFL, NRR, and NRLbetween the groups in the beginning and in the end of the 6th month were determined to be 38.00±20.60 and 31.44±18.60 (p=0.224), 21.44±7.08 and 18.80±13.67 (p=365), 5.60±4.54 and 4.64±5.25 (p=0.475), 6.16±4,79 and 6.16±5.19 (p=1.000), 5.08±2,78 and 5.88±3.63 (p=0.320), and 4.56±3,04 and 5.00±3.46 (p=0.584), respectively.

4.3.3 Strength of Shoulder Muscle

The strength of shoulder muscle measurements between the groups were conducted with respect to serratus anterior, pectoralis major, top trapezoid, and deltoid. The analysis provided that there was not a significant difference between the strength of shoulder muscle measurements regarding serratus anterior, pectoralis major, top trapezoid, and deltoid data occurring from the subjects in the control and experimental groups ($p<0.05$).

The measurements indicated that the serratus anterior, pectoralis major, top trapezoid, and deltoid values between the control group and experimental group in the beginning and in the end of the 6th month were found as 0.64±0.56 and 0.44±0.58 (p=0.203), 0.60±0.70 and 0.48±0.58 (P00.503), 0.16±0.37 and 0.24±0.43 (p=0.491), and 0.68±0.62and 0.68±0.62 (p=0.250), respectively.

4.3.4 Strength of Core Muscle

The strength of core muscle measurements obtained from the gro ups showed that there was a significant difference between the core strength of waist area and the core strength of neck among the subjects in the control and experimental groups ($p>0.05$).

The measurements indicated that the core strength of waist area and core strength of neck values between the control group and experimental group in the beginning and in the end of the 6th month were found as 0.16±0.37 and 1.40±0.50 (p=0.000), and 0.16±0.37and 1.36±0.70 (p=0.000), respectively.

4.3.5 Core Endurance

The core endurance analysis based on the measurements from the groups indicated that there was a significant difference between the Sorensen test, front plank test, right bridge, and left bridge among the subjects in the control and experimental groups ($p>0.05$).

The core endurance measurements showed that the Sorensen test, front plank test, right bridge and left bridge values between the control group and experimental group in the beginning and in the end of the 6th month were 4.75±1.35 and 8.50±2.15 ($p=0.000$), 4.80±1.15 and 11.18±2.18 ($p=0.000$), 4.77±0.79 and 10.10±1.79 ($p=0.000$), and 5.80±0.99 and 9.13±1.78 ($p=0.000$), respectively.

4.3.6 Posture Test

The posture Newyork test analysis indicated that there was a significant difference between the subjects in the control and experimental groups($p<0.05$).The posture Newyork test results between the control group and experimental group in the beginning and in the end of the 6th month were 2.00±1.52 and 9.92±2.03 ($p=0.000$).

4.3.7 Functional Values

The functional value analysis showed that there was not a significant difference between the subjects in the control and experimental groups ($p>0.05$).The functional values between the control group and experimental group in the beginning and in the end of the 6th month were 10.86±2.47and 12.39±2.23 ($p=0.058$).

Table 4.3. Descriptive statistical inter-group results between the treatment groups including VAS, joint range of motion, strength of shoulder muscle, strength of core muscle, core endurance, posture Newyork test, and functional values

PARAMETER	CONTROL GROUP	EXPERIMENTAL GROUP	
	VAS		
	Difference between Beginning and 6th week ($\bar{x}$ ±Sd)		p
At rest	4.28±1.92	4.44±1.50	0.756
On motion	5.76±1.53	4.92±0.99	0.061
	JOINT RANGE OF MOTION		
Shoulder Flexion	38.00±20.60	31.44±18.60	0.224
Shoulder External Rotation	21.44±7.08	18.80±13,67	0.365
Neck Lateral Flexion (Right)	5.60±4.54	4.64±5.25	0.475
Neck Lateral Flexion (Left)	6.16±4,79	6.16±5.19	1.000
Neck Rotation (Right)	5.08±2,78	5.88±3.63	0.320
Neck Rotation (Left)	4.56±3,04	5.00±3.46	0.584
	STRENGTH OF SHOULDER MUSCLE		
Serratus Anterior	0.64±0.56	0.44±0.58	0.203

Pectoralis Major	0.60±0.70	0.48±0.58	0.503
Upper Trapezoid	0.16±0.37	0.24±0.43	0.491
Anterior Deltoid	0.68±0.62	0.68±0.62	0.250
	STRENGTH OF CORE MUSCLE		
Core Strength of Waist Area	0.16±0.37	1.40±0.50	0.000
Core Strength of Neck	0.16±0.37	1.36±0.70	0.000
	CORE ENDURANCE		
Sorensen Test	4.75±1.35	8.50±2.15	0.000
Front Plank Test	4.80±1.15	11.18±2.18	0.000
Right Bridge	4.77±0.79	10.10±1.79	0.000
Left Bridge	5.80±0.99	9.13±1.78	0.000
	NEWYORK POSTURE TEST		
	2.00±1.52	9.92±2.03	0.000
	SHOULDER PAİN AND DISABILITY		
	10.86±2.47	12.39±2.23	0.058

Overall, the between-group differences were statistically evaluated forthe beginning and the end of the study (6th week). The statistical highlighting remarks were given below:

- *Pain:* There was not a significant difference between the groups among VAS at reast and on motion ($p<0.05$).
- *Joint Range of Motion*: There was not a significant difference between the groups among shoulder flexion, shoulder external rotation, neck lateral flexion (right and left), and neck rotation (right and left) meaurements ($p<0.05$).

- *Strength of Shoulder Muscle*: There was not a significant difference between the groups among serratus anterior, pectoralis major, upper trapezoid, and anterior deltoid data ($p<0.05$).
- *Strength of Core Muscle*: There was a significant difference between the groups among Sorensen test, front plank test, right bridge, and left bridge results ($p>0.05$).
- *Core Endurance:* There was a significant difference between the groups among the core strength of waist area and the core strength of neck results ($p>0.05$).
- *Posture Newyork Test:* There was a significant difference between the groups results ($p<0.05$).
- *Functional Values:* There was not a significant difference between the groups results ($p<0.05$).

5. DISCUSSION and CONCLUSION

This study showed that CS and PNF exercises applied to the patients with SISsyndrom have positive impacts on improving strength of core muscle and endurance, posture. On the other hand, they did not have any significant effect on pain, joint range of motion, strength of shoulder muscle, and functional values as compared to the regular treatment in the clinic.

SIS is the most common reported clinical syndrome with shoulder pain . It presents significant subacromial pathologies (bursitis, rotator cuff tendinosis, and partial tears). Its prevalence is estimated to be around 7%–34%. In other words, it is observed in 14.7 new cases per1, 000 patientsin clinics, or 2/3 of all shoulder pain (9). Therefore, CS and PNF exercises would be good way for reducing the undesired symptoms on core strength of waist area and neck, low back pain, and endurance assessment during activities(activation ofanterior muscular chain, strengthening gluteus muscles and hamstrings, and postural alignment changes) (9, 49, 50). In this study, we revealed that CS and PNF exercises are not sufficient alone. Regular treatment techniques are still valid for pain, joint range of motion, strength of shoulder muscle, and functional value. Therefore, these techniques should be considered as a complementary part of the physiotherapy in the patients with SIS syndrom.

The current literature seems to be poor and inadequate for therapists'servingCSE and PNF training to counteract SIS. Areeudomwong and Buttagat (2019) assessed the impacts of CSE and PNF exercises on pain in the low backpatients, ranging from 18 to 50 years of age. Following a four-week intervention, CSE and PNF exhibited short- and long-term impactson pain-related throughputs (50). Other researchers also evaluated the effectiveness of PNF training. For example, Byuon and Son (2012) found that PNF exercise was good for pain (51); Franklin et al. (2013) provided that PNF program is better suited forchronic pain as compared to CSE (52).In this study, we performed a 6-week intervention. Our results indicated that the regular treatment techniques are important for managing pain, joint range of motion, strength of shoulder muscle, and functional value symptoms. However, CS and PNF exercises should be used together for a much better effective treatment on the patients. In addition, the duration/period of our intervention would be longer than 6 weeks. From point of a physician's view, he/she needs to apply consider them as a complementary part of the physiotherapy in the SIS patients.

CSEs are as effective, but not superior to other modes of physiotherapy management in the treatment of chronic pain. Areeudomwong and Buttagat (2019) showed that the effects of three-week PNF trainingdid not reach a clinically meaningful level (53). On the other hand, some researchers studied on CSE approach's effectiveness. Core muscles are often grouped functionally based on their stabilizing and/or mobilizing roles. In this stage, neuromuscular control plays an important role in the coordination of this complex structure for maximum dynamic stabilization (54). In our work, the practice continued for 6 weeks. This was longer than Buttagat (2019). Actually, one of the weaknesses of our study was the duration. If it was longer than 6 weeks, then we would have observed more significant throughputs. Chang et al. (2015) determined that core strength training is more effective than typical training for chronic pain (55). Similarly, Selkow et al.(2017) highlighted that transversus abdominis activation and timing improved following core stability training in the patients with chronic pain (56). In this study, the in-group differences between pain at rest and on motion status were statistically significant ($p<0.05$), and there was not a significant difference between the groups ($p<0.05$). Thus, we proved that CSEs are not superior to, other modes of physiotherapy management in the treatment of chronic pain. To conclude, the therapists need to take care in recommending it based on their effectiveness as compared to the regular treatment.

Many dynamic and static structures contribute to shoulder stability. Scapula is one of the structures that helps the movement of the shoulder. The scapula does not attach to the joints around it with tissue. The scapula through the activation of the surrounding musclesprovide the stability of it.According to the kinetic chain theory, the change in the activation of one of the muscles in the chain affects the other muscles.The multifidi muscles run along the spine.Multifidi helps stabilize locally.One of the most important muscles in the kinetic chain is the latissimus dorsi.Latismusdorsi adheres to scapula.It affects the movements of the scapula.The core muscles act as a whole and affect the extremity functions.In this study, there were positive changes in posture as well as core strength and endurance.Based on these results, core stabilization exercises reduce symptoms of shoulder impingement syndrome. Physiotherapists should create exercise programs based on these effects in the clinic.

Olędzka and Jaczewska-Bogacka (2017) assessed the effectiveness of PNF treatment on the shoulder range of motion in SIS patients. They found that PNFmight improve active and passive range of shoulder movement (57). Another study by Godges et al. (2003) showed that PNF was helpfulfor derivating instant developments in overhead reaching up and glenohumeral external rotation in the SIS patients (58).Similarly, Çitaker et al. (2013) compared the effectiveness of PNF in the treatment of SIS. They found that PNF was helpful effective (59). In addition, Smedes et al. (2016) screened Pubmed, ScienceDirect, PEDro, Cochrane library and International PNF databases. They investigated the related studies (60). In our study, our findings were matching with the results derived by Olędzka and Jaczewska-Bogacka (2017), Godges et al. (2003) and Çitaker et al. (2013). In addition, our statistical analyses showed that the in-group differences in shoulder flexion, shoulder external rotation, neck lateral flexion (right and left), and neck rotation (right and left) meaurements were statistically significant ($p<0.05$), whereas there was not a significant difference between the groups among serratus anterior, pectoralis major, top trapezoid, and deltoid information ($p<0.05$).Overall, our study indicated that there was a substantial body of research supporting PNF as a comprehensive rehabilitation concept, and further investigation was recommended.

Shalaby et al. (2018) investigated the relationship between CS and shoulder function in SIS syndrome. They found that core stability tests were not significantly related to shoulder function (61). However, our work showed that the in-group differences in core strengths of waist area and neck during the intervention programmewere statistically significant ($p<0.05$). In addition, the in- group differences between core endurance values of the control group with re spect to Sorenson test, front plank test, right bridge, and left bridge were statistically significant ($p<0.05$). On the other hand, regarding strength of shoulder muscle, there was not a significant difference between the groups ($p<0.05$) . Regarding strength of core muscle, there was a significant difference between the groups ($p>0.05$).

This study completed the joint range of motion measurements between the CSE and PNF methods as well as the traditional one regarding SF, SER, NLFR, NLFL, NRR, and NRL. Overall, the results revealed that there was not a significant difference among approaches ($p<0.05$).

In the literature, there have been some researches invesitgating the effectiveness of CSEs on SIS patients. For example, Mısırlıoğlu et al (2018) evaluated the effect of CSEs on strength of shoulder maximal voluntary isometric contraction (MVIC). The results highlightedthe importance of CSEs within early periods of SIS intervention when the exercises to strength the shouldermuscle are painful (10).Although the inclusion of CSEs into arehabilitation program related to shoulder’s injury wasstudied byBrumitt, and Dale (2009) (62) and Radwan et al. (2014) (11). The evidence to show direct effect of CS onstrength of shoulder muscle still remains unclear. A thesis conducted by Çelik (2019) examined PNF on muscle strength on 30 on patients with SIS syndrome. She found improvement on muscle strength in regular and PNF treatment technics. All indicates that there was a significant difference between them. In this study, our findings indicated that strength of shoulder muscle measurements based on serratus anterior, pectoralis major, top trapezoid, and deltoid measurements based on both traditional and contemporary approaches did not exhibit any significant difference within our groups ($p<0.05$) (63).Our study also revealed that further study should be performed in core training when designing rehabilitation programs for SIS patients.

A work focused on regular therapy to exercise SIS patientsin7 sessions during 3 weeks during one-year. The findings revealed that regular treatment demonstrateda reduction in pain by 70%, an increase in functionality by 35% and a raise in isometric shoulder strength by 16%. In contrast to these improvements, the exercise group declared a decrease in pain by 35% andimprovementin functionality by 17%. But no significant development was observed in shoulder strength (64). Another work by Ojoawo et al (2017) revealed that stabilization exercises performed in any combination of position positively affected management of pain and disability of SIS patients (65).Clausen et al. (2018) from Denmark showed that patient-reported function and pain sigficantly improved after a period of 6 month-care, but strength and ROM did not exhibit a similar improvement. In our work, our findings seem to be so interesting because strengtheningexercises are already an important of current interventions.Thus;we examined thestrength of core muscleby taking measurements from the regularly treated group and the intervention group. We determined that there was a significant difference between core strengths of both waist area and neck among the different groups ($p>0.05$) (66).In summary, this studyexactly matched with some other studies in the literature as given here.

Exercise	Reps/ Sets
Side plank with shoulder external rotation	2-3 sets x 15 repetitions each side
Three point plank with shoulder horizontal abduction with external rotation	2-3 sets x 15 repetitions each side
Three point plank with shoulder extension	2-3 sets x 15 repetitions each side
Three point plank with shoulder row	2-3 sets x 15 repetitions each side
Three point plank with diagonal arm raise	2-3 sets x 15 repetitions each side

Figure 5.1. A Sample of Integrated CSE Routine (67)

A comprehensive program for SIS patients should contain some modalities in order to lowermobility, pain, and regular therapy to clear motion related deficits, as well as the exercises to strength and treat shoulder weaknesses. Any failure to characterize and intervent contributing dysfunctions may lead to a patient'sreturn to daily life. A study offers increasing the endurance capacity and developing the ratios within core endurance tests. Core exercises (bridges, planks, and side-front ones) are designed for a higher capacity of the muscular endurance (67). In this study, the evaluation was performed using personal information and disease histroy of each subject involved. Pain was determined on visual analog scale, followed by upper limb and motion of neck by goniometer; muscle strength of upper limb by manual muscle power; core endurance for back and neck regions by Sharmann Protocol; core endurance by Sorensen, front plank, right and left bridge tests; posture evaluation by Newyork Posture Test; and functi onal status of upper limb by shoulder pain and disability index.In another similar study,acore endurance intervention program was developed and validated by Tse et al (2009). The findings indicated that a 8-week core endurance intervention program made the core endurance be selected in the healthy individuals. However, its effectiveness on various functional performance aspects remained poor (81). Similarly, another work in USA assessed the efficacy of a 8-week core stability intervention program on the endurance. The results indicated that the applied CSprogram significantly might increase muscle endurance (82). In our study, core endurance analysis showed that there was a significant difference between Sorensen test, front plank test, right bridge, and left bridge among the subjects in the groups ($p>0.05$). Therefore, our findings were matching with other international works.

A study in Nazarene University in South Korea by Cho and Gong (2017) indicated that PNF patterns improved trunk stabilization, resulting in the positive effec ts on posture (70). Similarly, Park and Moon (2016) recommended further studies to be performed for various interventions for the patients with SIS except for PNF. In this context, dynamic exercises over PNF patterns may be recommended for further correction of postural issues (83). In our study, the statistical analyses showed that the in-group differences were statistically insignificant for the posture Newyork test values of the control group ($p>0.05$), whereas significant for the experimental group ($p<0.05$). On the other hand, there was a significant difference between-group results ($p<0.05$). The posture test we performed in this work indicated that there was a significant difference between the subjects in both groups. Therefore, PNF basically improved some positive effects on posture as matching with other international findings.

Kim and Lee (2017) investigated the efficacy of PNF-based muscle strengthening on functional disability index in the patients with chronic pain. They showed that it was effective in decreasing functional disability index (75).Tedla and Sangalada (2019) completed a meta analysis regarding PNF techniques. 90% of the analyzed works indicated that the group exposed to PNF was superior in terms of the decrease of pain and reduced disability, increased ROM, and improved functionality. The study also provided that PNF was superior to conventional physical therapy from point of pain, external rotation, and abduction ROM (76). However, our study showed that the functional value analysis did not yield any strong association between the groups (p>0.05).Beside, Areeudomwong and Buttagat (2020) emphasized on conducting studies as a head -to-head comparison of CSE and PNF training for CLBP. They found that four-week training provided short-term and long-term effects on pain-related outcomes (77). Our study was based on a longer period (6 weeks). To conclude, if the duration of practice was longer than the actual one, much better results would have been obrained. In other words, the intervention of such an treatment should not be lower t han 4 week. Longer is preferable. Similarly, Gong (2020) supported that dynamic stabilization exercise utilizing PNF patterns seem to help increase the balance of healthy adults (78). In addition, Lee et al. (2020) examined the effects of treatment using PNF extension techniques on pain, pressure pain, and neck and shoulder functions of upper trapezius muscles of MPS patients. None of the VAS, PP T, and NDI results showed significant differences between the groups, while performing postures, internal rotation, and external rotation among the CMS items showed significant differences between the groups. The exercise programs applying PNF techniques can be said to be effective at improving the function of the patients (79).

The weaknesses of our study can be given as follows:

- The number of the participants involved in the experimental and control groups could be higher for much more significant results/findings;
- The evaluation was performed by one examiner only. This would lead to invest less/inadequate time in the anamnesis or practice. Thus, a better standar of evaluation could not be gained;
- The exercises could be based on a intervention-period longer than 6 weeks for revealing the real effects of practices on the patients;

Based on the above weaknesses, our study should be extended for further investigation.

In this study, the findings showed that core stabilization and PNF exercises as applied to the patients with SIS positively affected strength of core muscle, core endurance, and posture, whereas there were no significant effects on pain, joint range of motion, strength of shulder muscle, and functional values. Overall, we can conclude that the core stabilization and PNF exercises may partially improvethe symptoms related to the SIS as compared to the regular treatment in the clinic.

6. REFERENCES

1) Kishner S. *Shoulder Joint Anatomy*. Accessed 30.11.2017, https://emedicine.medscape.com/article/1899211-overview.
2) Steadman Clinic. AC Separation. Accessed 30.12.2019, https://www.thesteadmanclinic.com/patient-education/shoulder/ac-separation.
3) Lewis, J. S,, C. Wright and N. Green. Subacromial Impingement Syndrome: The Effect of Changing Posture on Shoulder Range of Movement. *Journal of Orthopaedic& Sports Physical Therapy*, 2014; 35(2): p. 72-87.
4) Consigliere, P., O. Haddo, O. Levy and G. Sforza. Subacromial impingement syndrome: management challenges. *Orthopedic Research and ReviewsDovepress*. 2018; 10: p.83-91.
5) Koester MC, George MS, Kuhn JE. Shoulder impingement syndrome. *Am J Med.* 2005;118:p.452–5.
6) Page P. Shoulder muscle imbalance and subacromial impingement syndrome in overhead athletes. *Int J Sports Phys Ther*. 2011; 6(1): p.51–58.
7) Miller, J. and Russell, Z. *Shoulder Impingement*. Acessed 30.06.2019, https://physioworks.com.au/injuries-conditions-1/rotator-cuff-impingement.
8) WebMD. *Shoulder* Impingement Syndrome. Accessed 31.12.2019, https://www.webmd.com/arthritis/impingement-syndrome#1.
9) Singh, B., N. Bakti, and A. Gulihar. Current concepts in the diagnosis and treatment of shoulder impingement. *Indian Journal of Orthopaedics*. 2017; 51(5): p. 516-523.
10) Mısırlıoğlu, T. Ö., Eren, İ., Canbulat, N., Çobanoğlu, E., Güberbüyük, C., and Demirhan, M. Does a core stabilization exercise program have a role on shoulder rehabilitation? A comparative study in young females. *Turk J Phys Med Rehab*. 2018; 64(4): p. 328-336.
11) Radwan, A., Francis, J., Green, A., Kahl, E., Maciurzynski, D., and Quartulli, A. Is there a relation between shoulder dysfunction and core instability: *Int J Sports Phys Ther*. 2014; 9: p. 8-13.

12) Birinci, T., RazakOzdincler, A., Altun, S., and Kural, C. A structured exercise programme combined with proprioceptive neuromuscular facilitation stretching or static stretching in posttraumatic stiffness of the elbow: a randomized controlled trial. *ClinRehabil* 2019; 33(2): p. 241-252.
13) Healthline. *Shoulder*. Accessed 23.03.2015, https://www.healthline.com/human-body-maps/shoulder#1.
14) Ken Hub. *Shoulder (Glenohumeral) joint*. Accessed 20.12.2019, https://www.kenhub.com/en/library/anatomy/the-shoulder-joint.
15) Barclay T. *Clavicle*. Accessed 09.10.2017, https://www.innerbody.com/image_skelfov/skel15_new.html.
16) HealthEngine. *Anatomy of the shoulder (glenohumeral joint/scapulo-thoracic joint)*. Accessed 29.04.2010, https://healthengine.com.au/info/anatomy-of-the-shoulder-glenohumeral-jointscapulo-thoracic-joint#c5
17) Funk L. *Bones & Joints of the Shoulder*. Accessed 18.12.2019, https://www.shoulderdoc.co.uk/article/1177.
18) Mostafa E, Varacallo M. Anatomy, Shoulder and Upper Limb, Humerus. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2019 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK534821/
19) Appland T. *The Shoulder: Bony Anatomy, Part 2*. Accessed 24.08.2018, https://www.tamiapland.com/blog/2018/8/24/the-shoulder-bony-anatomy-part-2
20) Kibler WB, Sciascia A, Wilkes T.Scapulardyskinesis and its relation to shoulder injury. *J Am AcadOrthop Surg*., 2012; 20(6):364-72. doi: 10.5435/JAAOS-20-06-364
21) John Hopkins. *Shoulder Instability*. Accessed 02.01.2020, https://www.hopkinsmedicine.org/health/conditions-and-diseases/shoulder-instability.
22) OrthoInfo. *Chronic Shoulder Instability*. Accessed 31.12.2019, https://orthoinfo.aaos.org/en/diseases--conditions/chronic-shoulder-instability/.
23) Neer CS. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. *J Bone Joint Surg Am*. 1972;54: p.41-50.
24) Neer CS. Impingement lesions. *ClinOrthop*. 1983; p.70-77.
25) Umer M, Qadir I, Azam M. Subacromial impingement syndrome. *Orthop Rev (Pavia).* 2012;4(2):e18. doi:10.4081/or.2012.e18

26) De Yang Tien J, Tan AHC. Shoulder impingement syndrome, a common affliction of the shoulder: a comprehensive review. *Proc Singapore Healthcare* 2014;23(4):297-305.
27) Escamilla, R. F., T. R. Hooks and K. E. Wilk..*Optimal management of shoulder impingement syndrome*. Open Access Journal of Sports Medicine, 2014; 5(1): p.13-24.
28) Fontaine, M. Shoulder Impingement: The keys to dealing with swimmers' shoulder. *American Chiropractic Association News*, 2014; p. 20-21.
29) Norris, C. Shoulder Impingement. *SportEX dynamics*, 2014; 42(1): p.21-28.
30) Geier, N. *Subacromial Shoulder Impingement Syndrome*. Accessed 24.03.2015, https://pivotalphysio.com/subacromial-shoulder-impingement-syndrome/
31) Lexmedicus. *Shoulder Impengement Syndrome*. Accessed 27.12.2019, http://pathologies.lexmedicus.com.au/pathologies/shoulder-shoulder-impingement-syndrome
32) NHS Ayrshire & Arran. *Subacromial Impingement Syndrome*. Accessed 31.12.2019, https://www.nhsaaa.net/allied-health-professionals-ahps/musculoskeletal-service/subacromial-impingement-syndrome/.
33) Brumitt, J., Matheson, J. W., and Meira, E. P. Core stabilization exercise prescription, part I: current concepts in assessment and intervention. *Sports Health* 2013; 5:p. 504–509
34) Yörükoğlu, A. Ç., Şavkın, R., Büker, N., and Alsayani, K. Y. A. Is there a relation between rotator cuff injury and core stability?.*J Back MusculoskeletRehabil* 2019; 32(3): p. 445-452.
35) Tavel, R. *5 Exercises To Improve Scapular Stabilization And Prevent Elbow, Wrist and Hand Injuries*. Accessed 01.08.2017, https://physiologicnyc.com/5-exercises-improve-scapular-stabilization-prevent-elbow-wrist-hand-pain/.
36) LeFebvre, R. *Shoulder Exercises: Building Strength and Endurance*. Accessed 01.01.2011, http://ftp.uws.edu/main.html?download&weblink=3d1c2c00ac784f0be6a829943d20a02f&realfilename=Shoulder_Exercises.pdf.
37) Hanratty, C. E., Kerr, D. P., Wilson, I. M., McCracken, M., Sim, J., Basford, J. R., and McVeigh, J. G. Physical Therapists' Perceptions and Use of Exercise in the Management of Subacromial Shoulder Impingement Syndrome: Focus Group Study. *Phys Ther* 2016; 96(9): p. 1354-63.

38) de Souza, R. J. P., Brandão, D. C., Martins, J. V., Fernandes, J., and Dornelas de Andrade, A. Addition of proprioceptive neuromuscular facilitation to cardiorespiratory training in patients poststroke: study protocol for a randomized controlled trial. *Trials*. 2020; 14;21(1): p. 184.
39) Birinci, T., Mustafaoglu, R., Kaya Mutlu, E., and RazakOzdincler, A. Stretching exercises combined with ischemic compression in pectoralis minor muscle with latent trigger points: A single-blind, randomized, controlled pilot trial. *Complement TherClinPract* 2020; 38: p. 101080.
40) Comel, J. C., Nery, R. M., Garcia, E. L., da Silva Bueno, C., de Oliveira Silveira, E., Zarantonello, M. M., and Stefani, M. A. A comparative study on the recruitment of shoulder stabilizing muscles and types of exercises. *J ExercRehabil* 2018; 14(2): p. 219-225.
41) González-Ravé, J. M., Sánchez-Gómez, A., and Santos-García, D. J. Efficacy of two different stretch training programs (passive vs. proprioceptive neuromuscular facilitation) on shoulder and hip range of motion in older people. *J Strength Cond Res* 2012; 26(4): p. 1045-1051.
42) Lee, J. H., Park, S. J., and Na, S. S. The effect of proprioceptive neuromuscular facilitation therapy on pain and function. *J Phys Ther Sci*. 2013; 25(6): p. 713-716.
43) Balcı, N. C., Yuruk, Z. O., Zeybek, A., Gulsen, M., and Tekindal, M. A. Acute effect of scapular proprioceptive neuromuscular facilitation (PNF) techniques and classic exercises in adhesive capsulitis: a randomized controlled trial. *J Phys TherSci* 2016; 28(4): p. 1219-1227.
44) Wurnig, C. Impingement. *Der Orthopäde*. 2000; 29: p. 868–880.
45) Dorrestijn, O., Stevens, M., Winters, J. C., van der Meer, K., and Diercks, R. L. Conservative or surgical treatment for subacromial impingement syndrome? A systematic review. *J Shoulder Elbow Surg* 2009; 18: p. 652–660.
46) Saltychev, M., Aarimaa, V., Virolainen, P., and Laimi, K. Conservative treatment or surgery for shoulder impingement: systematic review and meta-analysis. *DisabilRehabil* 2015; 37: p. 1–8.
47) Garving, C., Jakob, S., Bauer, I., Nadjar, R., and Brunner, U. H. Impingement Syndrome of the Shoulder. *DeutschesArzteblatt international* 2017; 114(45), p. 765–776.
48) Lewis, J. S. Rotator cuff tendinopathy/subacromial impingement syndrome: is it time for a new method of assessment?.*Br J Sports Med* 2009; 43:p. 259–264.

49) Strand, S. L., Hjelm, J., Shoepe, T. C., and Fajard, M. A. Norms for an Isometric Muscle Endurance Test. Journal of Human Kinetics. 2014; 40: p. 93-102. doi: 10.2478/hukin-2014-0011

50) Areeudomwong, P., and Buttagat, V. Comparison of core stabilisation exercise and proprioceptive neuromuscular facilitation training on pain-related and neuromuscular response outcomes for chronic low back pain: a randomised controlled trial. *Malays J Med Sci*. 2019; 26(6): p. 77–89. https://doi.org/10.21315/mjms2019.26.6.8

51) Byuon, S., and Son, H. The effects of proprioceptive neuromuscular facilitation and stabilizing exercise on trunk repositioning errors. *J Phys Ther Sci*. 2012; 24(10): p. 1017–1020. https://doi.org/10.1589/jpts.24.1017

52) Franklin, C. V. J., Kalirathinam, D., Palekar, T., andNathani, N. Effectiveness of PNF training for chronic low back pain. *J Nurs Health Sci*. 2013; 2(4): p. 41–52. https://doi.org/10.9790/1959-0244152

53) Areeudomwong, P., and Buttagat, V. Proprioceptive neuromuscular facilitation training improves pain-related and balance outcomes in workingage patients with chronic low back pain: a randomized controlled trial. *Braz Phys Ther*. 2019: 23(5): p.428–436. https://doi.org/10.1016/j.bjpt.2018.10.005

54) HuxelBliven, K. C., and Anderson, B. E. Core stability training for injury prevention. *Sports Health*. 2013; 5(6): p. 514–522. https://doi.org/10.1177/1941738113481200

55) Chang, W. D., Lin, H. Y., and Lai, P. T. Core strength training for patients with chronic low back pain. *J Phys Ther Sci*. 2015; 27(3): p. 619–622. https://doi.org/10.1589/jpts.27.619

56) Selkow, N. M., Eck, M. R., and Rivas S. Transversus abdominis activation and timing improves following core stability training: a randomized trial. *Int J Sports Phys Ther*. 2017; 12(7): p. 1048-1056. https://doi.org/10.26603/ijspt20171048

57) Olędzka, M., andEkici, G. Jaczewska-Bogacka, J. Effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) in Improving Shoulder Range of Motion. A Pilot Study. *OrtopTraumatolRehabil*. 2017; 19(3): p. 285-292.

58) Godges, J. J., Mattson-Bell, M., Thorpe, D., and Shah, D. The Immediate Effects of Soft Tissue Mobilization With Proprioceptive Neuromuscular Facilitation on Glenohumeral External Rotation and Overhead Reaches. *J Orthop Sports Phys Ther*. 2003; 33: p. 713-718.

59) Çitaker, S., Taskiran, H., Akdur, H., Arabaci, Ü. Ö., and Ekici, G. Comparison of the mobilization and proprioceptive neuromuscular facilitation methods in the treatment of shoulder impingement syndrome. *The Pain Clinic*. 2005; 17(2): p. 197-202.
60) Smedes, F., Heidmann, M., Schäfer, C., Fischer, N., and Stepien, A. The proprioceptive neuromuscular facilitation-concept; the state of the evidence, a narrative review. *Physical Therapy Reviews*. 2016; 21(1): p. 17-31.
61) Shalaby, M. E., Abdelmageed, S. F., Ewada, R. S., and Elazizi, H. M. Relationship between core stability and shoulder function in shoulder impingement Syndrome in athletes. *Bioscience Research*. 2018; 15(4): p. 4630-4637.
62) Brumitt, J., and Dale, R. B. Integrating shoulder and core exercises when rehabilitating athletes performing overhead activities. *N Am J Sports Phys Ther*. 2009; 4: p. 132-138.
63) Çelik, M. S. (2019). *Subakromiyalsıkışmasendromluhastalardafarklımanuelterapiuygulamalarınınağrı, fonksiyonel durum, eklemhareketaçıklığı, kaskuvvetiveyaşamkalitesiüzerineetkilerininincelenmesi* (Unpublished Master's Thesis). Başkent University Institute of Health Sciences, Ankara.
64) Bang, M., and Deyle, G. Comparison of supervised exercise with and without manual physical therapy for patients with shoulder impingement syndrome. *Journal of Orthopaedic& Sports Physical Therapy*. 2000; 30(3): p. 126-137.
65) Ojoawo, A. O., Hassan, M. A., Olaogun, M. O. B., Johnson, E. O., and Mbada, C. E. Comparative effectiveness of two stabilization exercise positions on pain and functional disability of patients with low back pain. *Journal of Exercise Rehabilitation*. 2017; 13(3): p. 363-371.
66) Clausen, M. B., Merrild, M. B., Witten, A., Christensen, K. B., Zebis, M. K., Hölmich, P., and Thorborg, C. Conservative treatment for patients with subacromial impingement: Changes in clinical core outcomes and their relation to specific rehabilitation parameters.*PeerJ*. 2018; 6: e4400. doi: 10.7717/peerj.4400
67) Brumitt, J., and Dale, R. B. Integrating Shoulder and Core Exercises When Rehabilitating Athletes Performing Overhead Activities. *North American Journal of Sports Physical Therapy*. 2009; 4(3): p. 132-138.

68) Gruther W, Wick F, Paul B, et al. Diagnostic accuracy and reliability of muscle strength and endurance measurements in patients with chronic low back pain. *Journal of Rehabilitation Medicine*. 2009;41(8):613-619. doi:10.2340/16501977-0391

69) El-Gohary TM, Elkader SMA, Emara HA, Ibrahim MI, Khaled OA, Ahmed MS. Right versus left side bridge static endurance ability among healthy collegiate students at Taibah University. *Journal of Back and Musculoskeletal Rehabilitation*. 2018;31(2):231-237. doi:10.3233/bmr-169538

70) Tse, M. A., McManus, A. M., and Masters, R. S. W. Development and Validation of A Core Endurance Intervention Program: Implications for Performance in College-Age Rowers. *Journal of Strength and Conditioning Research*. 2005; 19(3): p. 547–552.

71) Mcroberts LB, Cloud RM, Black CM. Evaluation of the New York Posture Rating Chart for Assessing Changes in Postural Alignment in a Garment Study. *Clothing and Textiles Research Journal*. 2013;31(2):81-96. doi:10.1177/0887302x13480558

72) Hoppes, C. W., Sperier, A. D., Hopkins, C. F., Griffiths, B. D., Principe, M. F., Schnall, B. L., Bell, J. C., and Koppenhaver, S. L. The efficacy of an eight-week core stabilization program on core muscle function and endurance: *A randomized trial. Int J Sports Phys Ther*. 2016; 11(4): p. 507-519.

73) Cho, M., and Gong, W. The effects of dynamic exercise using the proprioceptive neuromuscular facilitation pattern on posture in healthy adults. *J Phys Ther Sci*. 2017; 29(6): p. 1070–1073. doi:10.1589/jpts.29.1070

74) Park, S. E., and Moon, S. H. Effects of trunk stability exercise using proprioceptive neuromuscular facilitation with changes in chair height on the gait of patients who had a stroke. *J Phys Ther Sci. 2016*; 28(7): p. 2014–2018. doi:10.1589/jpts.28.2014

75) Kim BR, and Lee HJ. Effects of proprioceptive neuromuscular facilitation-based abdominal muscle strengthening training on pulmonary function, pain, and functional disability index in chronic low back pain patients. *J ExercRehabil*. 2017; 13(4): p. 486–490. doi:10.12965/jer.1735030.515

76) Tedla, J. S., and Sangadala, D. R. Proprioceptive neuromuscular facilitation techniques in adhesive capsulitis: a systematic review and meta-analysis. *J Musculoskelet Neuronal Interact* 2019; 19(4): p. 482-491.

77) Areeudomwong, P., Buttagat, V. Comparison of Core Stabilisation Exercise and Proprioceptive Neuromuscular Facilitation Training on Pain -related and Neuromuscular Response Outcomes for Chronic Low Back Pain: A Randomised Controlled Trial. *Malaysian Journal of Medical Sciences* 2020; 26(6): p.77-89.

78) Gong W. Effects of dynamic exercise utilizing PNF patterns on the balance of healthy adults. *J Phys Ther Sci*. 2020;32(4): p. 260-264.

79) Lee, J.H., Park, S.J., Na, S.S. The effect of proprioceptive neuromuscular facilitation therapy on pain and function. *Journal of Physical Therapy Science* 2020; 25(6): p. 713-716.

7. APPENDICES

Appendix-1: Ethical Approval

T.C. YEDİTEPE ÜNİVERSİTESİ

Sayı : 37068608-6100-15- 1757 **1010/2019**
Konu: Klinik Araştırmalar
Etik kurul Başvurusu hk.

İlgili Makama (Orkun Menek)

Yeditepe Üniversitesi Sağlık Bilimleri Fizyoterapi ve Rehabilitasyon Bölümü Dr.Öğr.Üyesi Ayça Aklar Çörekçi'nin sorumlu araştırmacı olduğu **"Omuz Subakromiyal Sıkışma Sendromu Olan Hastalarda Kor Stabilizasyon ve Propioseptif Nöromusküler Fasilitasyon Egzersizlerinin Ağrı , Eklem Hareketi , Kas Kuvveti, Postür ve Fonskiyonellik Üzerine Etkileri''** isimli araştırma projesine ait Klinik Araştırmalar Etik Kurulu (KAEK) Başvuru Dosyası **(1744)** kayıt Numaralı KAEK Başvuru Dosyası).Yeditepe Üniversitesi Klinik Araştırmalar Etik Kurulu tarafından **09.10.2019** tarihli toplantıda incelenmiştir.

Kurul tarafından yapılan inceleme sonucu, yukarıdaki isimi belirtilen çalışmanın yapılmasının etik ve bilimsel açıdan uygun olduğuna karar verilmiştir (**KAEK Karar No: 1102**).

Prof. Dr. Turgay ÇELİK
Yeditepe Üniversitesi
Klinik Araştırmalar Etik Kurulu Başkanı

Appendix-2: Sample Program Appropriate For Shoulder Exercises and Building Strength and Endurance

DAY 1	Exercises	Target Muscles
	**Serratus punch** and **push up with +** (progress over time to **serratus punch or dynamic hug <u>with resistance</u>).**	**serratus anterior** subscapularis supraspinatus
	**Full can** (in 3 planes)	**supraspinatus** rhomboids traps & rhomboids
	**Side lying ER**	**infraspinatus** teres minor traps & rhomboids
	**Side lying abduction**	**supraspinatus** subscapularis
	**Unilateral prone abduction full can (ER) in 3 positions (Y,T,V)**	**supraspinatus** infraspinatus (at 90°) teres minor (at 90°) rhomboids & lower traps (at 90° and above)

Sample Program (using weights)

	Start	Final target
Repetitions	10	20-30
Resistance	1 lb	3-5 lbs
Sets	1-2 general rehab 3 advanced athlete	
Schedule	Daily (alternating two exercise "packages")	

DAY 2	Exercises	Target Muscles
	**ER standing** (progress to bilateral ER with resistance)	**infraspinatus** teres minor traps & rhomboids serratus anterior (at 90°)
	**IR standing**	**subscapularis** **serratus anterior (at 90° and diagonal)**
	**Prone row** (with a plus)	**middle traps** supraspinatus lower traps & rhomboids upper traps
	**Prone ER**	**lower traps** middle traps & rhomboids infraspinatus teres minor
	**Bilateral prone abduction** (IR, ER & neutral)	**middle traps** supraspinatus lower traps & rhomboids
	**Biceps curl**	**biceps**

Appendix-3: Patient Evaluation Form

T.C. YEDİTEPE ÜNİVERSİTESİ	KLİNİK ARAŞTIRMALAR ETİK KURULU OLGU RAPOR FORMU	TARİH: VERSİYON:

ÇALIŞMAYA / ARAŞTIRMAYA DAHİL **EDİLME** KRİTERLERİ 18-65 yaş aralığında kişiler, 6 aydan fazla omuz ağrısı olan kişiler, MR sonuçlarına göre impingement tanısı konmuş kişiler
ÇALIŞMAYA /ARAŞTIRMAYA DAHİL **EDİLMEME** KRİTERLERİ Travma ya da operasyon hikayesi olan, Hipertansiyonu, Açık yarası, Enfeksiyonu, Kırığı, Şişliği, Romatoid artiriti, Refleks sempotik distrofisi, Adezif kapsüliti olan kişiler

T.C. YEDİTEPE ÜNİVERSİTESİ	KLİNİK ARAŞTIRMALAR ETİK KURULU OLGU RAPOR FORMU	TARİH: VERSİYON:

Katılımcı Kodu:
Yaş:
Cinsiyet:
Boy:
Kilo:
Mesleği:
Medeni Hali:
Telefon:
E-mail:
Adres:
Ağrı Süresi:
Hastanın Hikayesi:
MRI Sonuçları:

Ağrı Değerlendirmesi

VAS (*Visual Analog Scale*)

Aşağıdaki çizgi üzerinde ağrınızın şiddetini gösteren noktayı işaretleyiniz

0 ____ 10

Ağrı Değerlendirmesi	Aktif Durumda	Dinlenim Durumunda
VAS Skoru		
ROM DEĞERLENDİRMESİ	OMUZ	BOYUN
BOYUN ROTASYON		
BOYUN LATERAL FLEKSİYON		
FLEKSİYON		
DIŞ ROTASYON		

T.C. YEDİTEPE ÜNİVERSİTESİ	KLİNİK ARAŞTIRMALAR ETİK KURULU OLGU RAPOR FORMU	TARİH: VERSİYON:

Kor Kasları Kuvvetini Değerlendirme

Sharmann Protokolü

SEVİYE 1	Sırt üstü iken kanca pozisyonunda karın boşluğunu sabit tutarken 1 bacağı kalça 100 derece fleksiyona getir. Ardından diğer bacakla aynı hareketi tekrarla
SEVİYE 2	Kalça fleksiyon pozisyonunda 1 bacağı yatağa değene ve dizi düzeltene kadar indir. Sonra fleksiyon pozisyonuna geri dön
SEVİYE 3	Kalça fleksiyon pozisyonunda 1 bacağı yerden 12 cm yukarıya kadar indir ve dizi düzelt. Sonra fleksiyon pozisyonuna geri dön
SEVİYE 4	Kalça fleksiyon pozisyonunda 2 bacağı yatağa değene ve dizi düzeltene kadar indir. Sonra fleksiyon pozisyonuna geri dön
SEVİYE 5	Kalça fleksiyon pozisyonunda 2 bacağı yerden 12 cm yukarıya kadar indir ve dizi düzelt. Sonra fleksiyon pozisyonuna geri dön

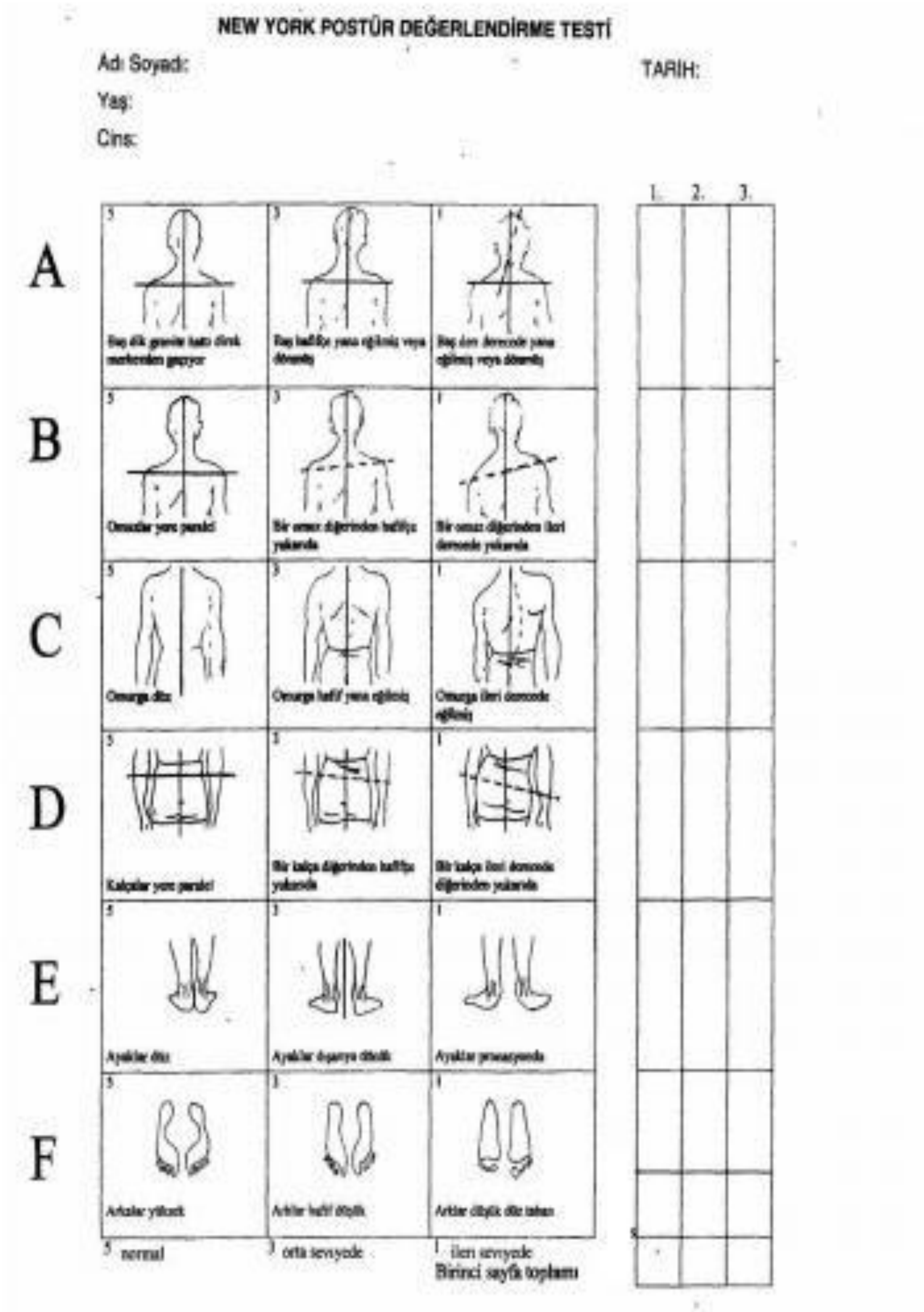
KOR KUVVETİ DEĞERLENDİRMESİ	Sharmann Protokolü
Boyun	
Bel	

KOR ENDURANS DEĞERLENDİRMESİ	SKOR
SORENSEN TEST	
FRONT PLANK TEST	
SAĞ SİDE BRİDGE TEST	
SOL SİDE BRİDGE TEST	

KAS KUVVETİ DEĞERLENDİRMESİ	SKOR
SERRATUS ANTERİOR	
PECTORALİS MAJOR	
ÜST TRAPEZ	
ÖN DELTOİD	

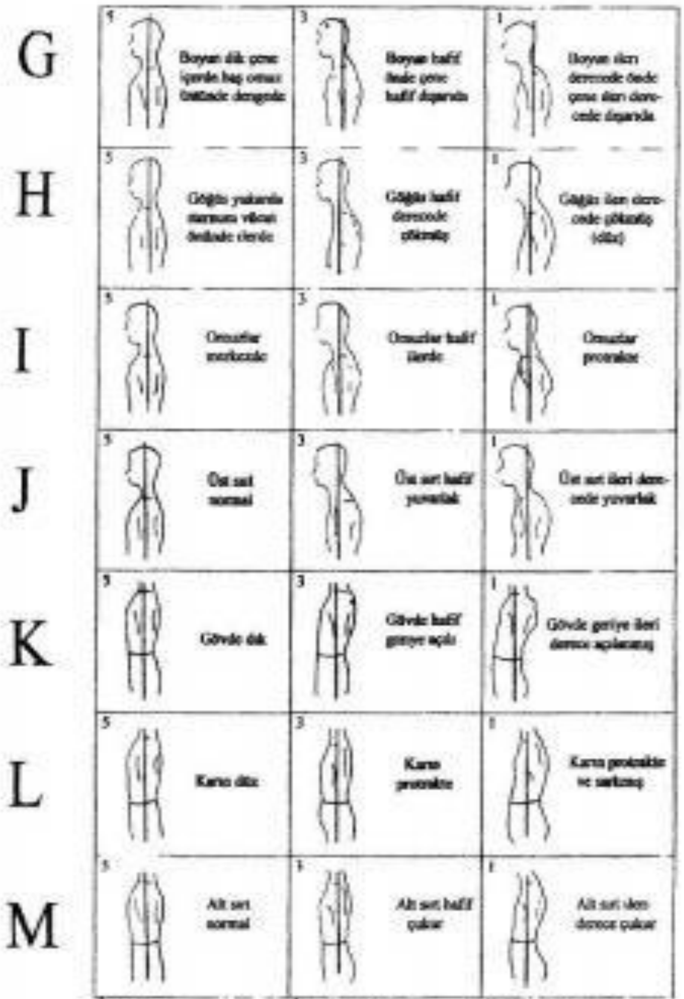
Appendix-4: Newyork Posture Test Evaluation Form

EK 2



EK 2

BİRİNCİ SAYFA TOPLAMI



5 normal 3 orta seviyede 1 ileri seviyede

1.Eğer sol kolondaki açıklamaya uygun ise 5 puan
2.Eğer orta kolondaki açıklamaya uygun ise 3 puan
3.Eğer sağ kolondaki açıklamaya uygun ise 1 puan ekleyin.

TOPLAM SKOR

1.	2.	3.

Appendix-6: Shoulder Pain and Disability Index

OMUZ AĞRI VE DİSABİLİTE İNDEKSİ

Lütfen geçen hafta omuz probleminizi en iyi belirten puanı işaretleyin.

AĞRI SKALASI

Ağrınız ne kadar şiddetlidir?

Ağrınızı en iyi tanımlayan rakamı daire içine alınız. 0=hiç ağrı yok 10= düşünülebilen en kötü ağrı.

Ağrınızın en kötü hali	0	1	2	3	4	5	6	7	8	9	10
Etkilenmiş taraf üzerine yatarken	0	1	2	3	4	5	6	7	8	9	10
Yüksek raftaki bir şeye uzanırken	0	1	2	3	4	5	6	7	8	9	10
Boynunuzun arkasına dokunurken	0	1	2	3	4	5	6	7	8	9	10
Etkilenmiş kolla iterken	0	1	2	3	4	5	6	7	8	9	10

Toplam skor:____________________/50 x 100=___________%

(Eğer hasta tüm sorulara cevap vermemişse mümkün olan skoru böl. Örneğin 1 soru eksikse 40 üzerinden böl.)

DISABILITE SKALASI

Ne kadar zorluk çekiyorsunuz?

Durumunuzu en iyi tanımlayan rakamı daire içine alınız. 0=hiç zorluk yok 10= aşırı zor, yardıma ihtiyaç duyuyor.

Saçınızı yıkarken	0	1	2	3	4	5	6	7	8	9	10
Sırtınızı yıkarken	0	1	2	3	4	5	6	7	8	9	10
Atlet ya da kazak giyerken	0	1	2	3	4	5	6	7	8	9	10
Önden düğmeli gömlek giyerken	0	1	2	3	4	5	6	7	8	9	10
Pantolonunuzu giyerken	0	1	2	3	4	5	6	7	8	9	10
Yüksek bir rafa bir eşya koyarken	0	1	2	3	4	5	6	7	8	9	10
4.5 kg'lık ağır bir eşyayı taşırken	0	1	2	3	4	5	6	7	8	9	10
Arka cebinizden bir şey çıkarırken	0	1	2	3	4	5	6	7	8	9	10

Toplam disabilite puanı: :_____________/ 80 x 100=_________%

(Eğer hasta tüm sorulara cevap vermemişse mümkün olan skoru böl. Örneğin 1 soru eksikse 70 üzerinden böl.)

Toplam Spadi skor: :_______________/ 130 x 100=_________%

8. CURRICULUM VITAE

Personal Informations

Name	Orkun	**Surname**	MENEK
Place of Birth		**Date of Birth**	
Nationality		**TR ID Number**	
E-mail		**Phone number**	

Education

Degree	Department	The name of the Institution Graduated From	Graduation year
Doctorate			
Master			
University	AcıbademÜniversitesi	SağlıkBilimleriFakültesi	2014
High school	Selimpaşa Atatürk Anatolian High School	-	2009

Languages	**Grades (#))**
YDS	55

#All the grades must be listed if there is more than one (KPDS, ÜDS, TOEFL; EELTS vs),

Work Experience (Sort from present to past)

Position	**Institute**	**Duration (Year - Year)**
Physiotherapist	Private Esencan Hospital	2016-2020
		-

Computer Skills

Program	**Level**
Microsoft Office	Good

***Excellent, good, average or basic**

Others (Projects / Certificates / Rewards)

Lymph edema therapy / FöldiSchule / June – July. 2015