SCAPULAR MUSCLES STRENGTHENING VERSUS SCAPULAR PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION IN SHOULDER IMPINGEMENT SYNDROME

By

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CHAPTER I
INTRODUCTION

Musculoskeletal conditions are one of the most prevalent and costly disorders globally **(Murray et al., 2012),** with shoulder pain being the third most common cause of musculoskeletal consultation in physiotherapy setting **(Kooijman et al., 2013).** The annual incidence of shoulder complaints is estimated to at 29.3 per 1000 a year and its prevalence in the general population is estimated between 41% and 48% **(Greving et al., 2012).**

Sub-acromial Impingement Syndrome (SIS) has been identified with a prevalence of almost 40% among shoulder pathologies **(Aceituno-Gómez et al., 2019).** SIS has significant economic consequences owing to its treatment costs and losses incurred through workplace absenteeism **(Virta et al., 2012; Hopkins et al., 2016).**

Intrinsic and extrinsic factors that contribute to the development of SIS include Inflammation in the supra humeral space, inhibition of the rotator cuff muscles, degeneration of the rotator cuff tendons, abnormal scapular position and kinematics **(Escamilla et al., 2014)** and altered kinematics. Currently SIS covers a range of pathologies from subacromial bursitis to rotator cuff tendinopathy and full-thickness rotator cuff tears **(Lewis, 2009; Harrison and Flatow, 2011).**

Altered scapular motion that occurs during active shoulder movements is referred to as scapular-thoracic dyskinesia **(Kibler et al., 2009, 2013).** It presents itself by diversified scapular motion resulting in a functional instability in activities involving arm elevation **(Jobe et al.,1989; Kibler et al., 2009, 2013).** Dyskinesia might increase the risk of developing shoulder pain by 43% **(Hickey et al., 2018),** and simultaneously it appears to be a non-specific response to various shoulder dysfunctions, since no specific pattern of dyskinesia is associated with a specific diagnosis **(Ginn and Cohen, 2005).**

In patients diagnosed with rotator cuff tendinopathy, intermuscular coordination between the lower trapezius and serratus anterior, as well as between the lower trapezius and upper trapezius is disrupted in arm elevation tasks, indicating two altered ratios and the importance of the muscle function **(Michener et al., 2016).** Alterations in scapular muscle performance have been found in subjects with scapular dyskinesis. Hyperactivity of the upper trapezius (UT) with reduced middle (MT) and lower trapezius (LT) muscle activation in addition to insufficient serratus anterior (SA) muscle function have been related to decreased amounts of scapular upward rotation, external rotation, and posterior tilt in patients **(Ludewig et al., 2010)**.

Research into scapular stability exercises for the management of SIS is increasing, yet there is little evidence on their efficacy **(Ginn and Cohen, 2005).** Interventions focused on reducing scapular dyskinesia compared to just stretching and strengthening exercises result in significantly better shoulder disability measures **(Moura et al., 2016; Struyf et al., 2013).** The addition of scapular stabilization exercises to stretching and strengthening exercises can be significantly beneficial in increasing the strength, developing joint position sense and decreasing dyskinesia **(Baskurt et al., 2011).**

Proprioceptive neuromuscular facilitation (PNF) is a rehabilitation concept which is widely used by physical therapists **(Westwater-Wood et al., 2010; Smedes et al., 2016),** promoting motor learning, motor control, strength and mobility

(IPNFA, 2019; Smedes et al., 2016). This comprehensive rehabilitation approach includes task-oriented training with manual facilitation aimed at motor learning and motor control **(Adlers et al., 2014; Smedes et al., 2016).** Also, PNF positions improve movement efficiency of the joint by inducing changes in the muscle activation sequence **(Shimura and Kasai, 2002)** and it reportedly helps in the early recovery of the patients with SIS **(Nakra et al., 2013).**

To the authors' knowledge, none of the studies has investigated the potential effect abnormal scapular muscle strengthening versus PNF exercise on the muscle strenth, muscle ratio, and ROM of the scapula during arm elevation in patient with SIS.

Purpose of the study:

The purpose of this study is to compare the effect of scapular muscle strengthening versus PNF exercise on scapular muscle strength, scapular muscles ratio, scapular asymmetry, pain, and function in patients with shoulder impingement syndrome.

Statement of the problem:

Shoulder pain and dysfunction are common complaints among individuals seeking care from physical medicine and rehabilitation specialists. Recently, clinicians and investigators have focused increased attention on the role of the scapula in the pathogenesis of shoulder pain in general and impingement symptoms in particular.

Research question:

What is/are the effect(s) of scapular muscle strengthening compared to PNF exercise on isometric scapular muscle strength, scapular muscles ratio and scapular asymmetry in patients with shoulder impingent syndrome.

Significance of the study:

Shoulder impingement syndrome (SIS) is a common cause of shoulder pain. Shoulder pain is highly prevalent within the general population, second to lower back pain. Studies suggest that SIS is the most common cause of shoulder pain, accounting for approximately 30–35% among the shoulder disorders **(Faber et al., 2006; Michener et al., 2004; Natvig & Juel, 2014)**

Shoulder complaints have an unfavorable outcome; only about 50% of all new episodes presented in the primary care setting show complete recovery within six months, and one year after the first consultation, 40-50% of patients report that their symptoms have persisted or recurred **(Lewis, 2009).**

SIS results in functional limitations which significantly interfere with the subject's quality of life **(Aceituno-Gómez et al., 2019).** Thus, shoulder pain induced by SIS is widespread and imposes a considerable burden on the affected person and society.

There is evidence which demonstrated that motor control and strengthening exercises can improve function in shoulder impingement patients; but the evidence is limited to a small sample single-subject study design. Realigning the scapula can change muscle recruitment patterns in patients with neck pain, but this has yet to be shown in shoulder pain **(Roy et al., 2009)**

An increasing number of studies have correlated abnormalities in scapular position and motion (dyskinesis) with impingement symptoms, rotator cuff dysfunction, and instability **(Hallström & Kärrholm, 2006; Ludewig & Cook, 2000b; McClure et al., 2006),** however, till the author knowledge no study attempted to study scapular muscle training versus scapular PNF exercise in patients with shoulder impingement syndrome.

In view of the new insights and research findings on the role of the scapula in shoulder pathologic abnormality, current exercise protocols emphasize the importance of scapular muscle training as an essential component of shoulder rehabilitation **(Bang & Deyle, 2000; Burkhart et al., 2003; Hintermeister et al., 1998).** Restoration of muscle control and balanced coactivation in particular is a challenge to the clinician **(Cools, Dewitte, et al., 2007).**

Previous data were obtained from a group of young, healthy subjects with no history of shoulder impairment **(McClure et al., 2006).** On the basis of their results, we cannot conclude that patients suffering from shoulder pain or local muscle imbalances will show similar muscle balance ratios performing these exercises.

Our study may be considered as a first step in the investigation of rehabilitation exercises for the restoration of normal scapular muscle strength, scapular muscles ratio, scapular asymmetry, pain, and function in patients with SIS.

Hypotheses of the study:

1. There will be no significant difference between scapular muscle strengthening and PNF exercise on improving muscle strength of upper trapezius in patients with shoulder impingement syndrome.

2. There will be no significant difference between scapular muscle strengthening and PNF exercise on improving muscle strength of middle trapezius in patients with shoulder impingement syndrome.
3. There will be no significant difference between scapular muscle strengthening and PNF exercise on improving muscle strength of lower trapezius in patients with shoulder impingement syndrome.
4. There will be no significant difference between scapular muscle strengthening and PNF exercise on improving muscle strength of serratus anterior in patients with shoulder impingement syndrome.
5. There will be no significant difference between scapular muscle strengthening and PNF exercise on muscle ratio of upper trapezius/lower trapezius muscles in patients with shoulder impingement syndrome.
6. There will be no significant difference between scapular muscle strengthening and PNF exercise on muscle ratio of upper trapezius/middle trapezius muscles in patients with shoulder impingement syndrome.
7. There will be no significant difference between scapular muscle strengthening and PNF exercise on muscle ratio of upper trapezius/serratus anterior muscles in patients with shoulder impingement syndrome.
8. There will be no significant difference between scapular muscle strengthening and PNF exercise on scapular symmetry at 0^{o} abduction in patients with shoulder impingement syndrome.
9. There will be no significant difference between scapular muscle strengthening and motor control exercise on scapular symmetry at 45^{o} abduction in patients with shoulder impingement syndrome.
10. There will be no significant difference between Scapular muscle strengthening and motor control exercise on scapular symmetry at 90^{o} abduction in patients with shoulder impingement syndrome.

11. There will be no significant difference between scapular muscle strengthening and PNF exercise on improving pain in patients with shoulder impingement syndrome.
12. There will be no significant difference between scapular muscle strengthening and PNF exercise on improving function in patients with shoulder impingement syndrome.

Delimitation:

This study will be delimited to the following:

Subjects:

1. sixty-six Male and female subjects with SIS and age between 20-50 **(Cools et al., 2012).**
2. body mass index (BMI)<20 kg/m2 **(Celik et al., 2012).**
3. subjects complaining secondary shoulder impingement **(Cools et al., 2012).**
4. subjects with altered scapular resting positions and dyskinesis **(Cools et al., 2007; 2003).**

The instrumentations will be limited to:

1. Hand-held dynamometer.
2. Isometric strength imbalance of shoulder girdle muscles.
3. Modified Lateral Scapular Slide test.
4. shoulder pain and disability index (SPADI).

The intervention will be limited to:

1. Scapular muscle strengthening exercise
2. Proprioceptive neuromuscular facilitation (PNF)

Basic assumption:

It will be assumed that:

- All the subjects will be co-operative and honest in answering the questions
- All the participants will be evaluated under the same conditions.

Definition of terms:

Proprioceptive neuromuscular facilitation (PNF)

Is an exercise modality defined to facilitate the responses of neuromuscular mechanism by stimulating proprioceptors. Effect mechanisms of PNF techniques are stimulating postural reflexes using gravity force to facilitate muscles, using eccentric contractions for muscle activation and utilizing diagonal movement patterns in activation of bi-articular muscles **(ahimura et al., 2002).**

Shoulder impingement

Impingement syndrome was first defined by Charles Neer in 1972, described as the tightness of the soft tissues under the acromion that compromise its functionality **(Neer, 1972).**

Shoulder impingement represents mechanical compression of the rotator cuff tendons and subacromial bursa against the anteroinferior undersurface of the acromion and coracoacromial ligament especially during elevation of Several kinematic changes are present in people with symptoms of impingement which results in further decrease in the available supraspinatus muscle outlet or supra humeral space **(Chilgar et al., 2020).**

Primary and Secondary shoulder impingement

Primary shoulder impingement occurs when the rotator cuff tendons, long head of the bicep's tendon, glenohumeral joint capsule, and/or the subacromial bursa become impinged between the humeral head and the anterior acromion. Secondary shoulder impingement is defined as a relative decrease in the subacromial space due to glenohumeral joint instability or abnormal scapulothoracic kinematics **(Kachingwgwe et al, 2008).**

Scapular dyskinesis

Scapular Dyskinesis Dyskinesis (dys [alteration of] kinesis [motion]) is a general term that is used to describe loss of control of normal scapular physiology, mechanics, and motion. The term dyskinesia is often used interchangeably with dyskinesis (**Kibler et al., 2012).**

CHAPTER III

Subjects, Materials and methods

This study will be conducted in EL KARNAK international hospital, Luxor, Egypt, to compare the effect of scapular muscle strengthening versus PNF exercise on scapular muscle strength, scapular muscle ratio, scapular asymmetry, pain, and function in patients with shoulder impingement syndrome. The study is estimated to run between April 2022 to April 2023 after obtaining the ethical committee approval.

Design

This will be a double blinded, randomized controlled, clinical trial (therapy, level 1B). The principal investigator (PI) will be blinded to the group assignment as it will be performed by a research assistant who will be trained for the group allocation. A flow diagram according to the Consolidated Standards of Reporting Trials (CONSORT) statement will be presented to illustrates the progression of this clinical trial **(Schulz et al., 2010).** Also, this trial will be registered at one of the clinical trial registries.

Randomization:

Patients will be randomly assigned into one of the three groups. We will use a simple randomization method to allocate participants to the groups. A random number generator available online from www.randomization.com will be used.

Sample size calculation:

In order to detect an effect size of Cohen's d= 0.80 with 80% power (alpha= 0.05), G*power software (version 3.1.9.7; Franz Faul, Universitat Kiel, Germany) suggests we will need 64 participants, however, we will aim to recruit 66 subjects to have equal groups representation (22 per group) using analysis of variance (ANOVA) test as shown in the (figure 7).

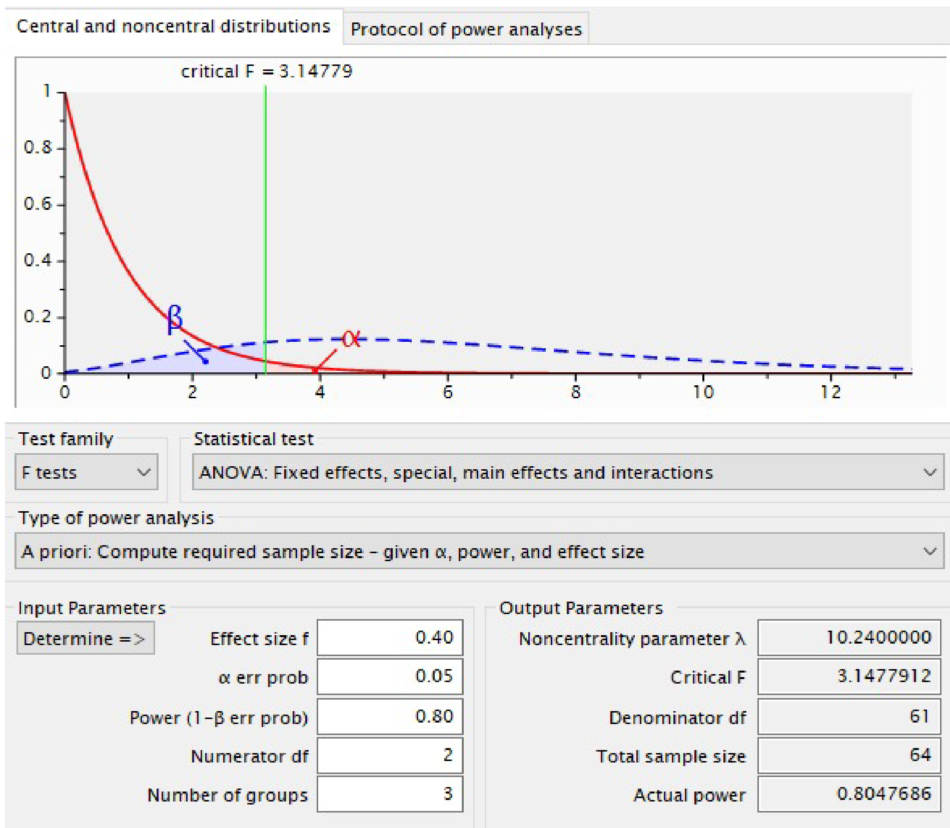


Figure 1 ample size calculation

Subjects:

Sixty-six male and female patients, with age between 20-50 years, diagnosed with SIS will be recruited through direct referrals, thus, a sample of convenience will be used. They will be asked to sign the informed consent form **(Appendix I).** Participants will be randomly allocated to three experimental groups as follow:

Group A (n=22): will receive a program of scapular muscle strengthening exercises for 18 sessions (3 sessions per week for six weeks)

Group B (n=22): will receive a scapular PNF exercise program for the same frequency as in group A

Group C (n=22): will be a control group who will not receive any treatment during the study period.

Inclusion criteria:

- Sixty-six Male and female subjects with SIS and age between 20-50 **(Cools et al., 2012).**
- body mass index (BMI)<20 kg/m2 **(Celik et al., 2012).**
- subjects complaining secondary Shoulder impingement **(Cools et al., 2012).**
- subjects with altered scapular resting positions and dyskinesis **(Cools et al., 2007; 2003).**
- Subjects will be included if they met at least 2 of the following 5 criteria:

(1) Neer's Impingement Test: The patient's arm is passively and forcibly fully elevated in the scapular plane with the arm medially rotated by the examiner **(Fig. 8).** A positive Neer impingement sign is present if pain is produced when the arm is forcibly flexed **(Magee and Manske, 2020).**

Figure 2 Neer's Impingement Test

(2) Hawkins-Kennedy Impingement Test: The examiner forward flexes the arm to 90 and then forcibly medially rotates the shoulder **(Fig.9).** Pain indicates a positive test result for supraspinatus tendinosis or secondary impingement **(Magee and Manske, 2020).**

Figure 3 Hawkins-Kennedy Impingement Test

(3) Supraspinatus ("Empty Can" or Jobe) Test: The patient's arm is abducted to 90 with neutral (no) rotation, and the examiner provides resistance to abduction. The shoulder is then medially rotated and angled forward 30 ("empty can" position) so that the patient's thumbs point toward the floor **(Fig. 10)** in the plane of the scapula. Resistance to abduction is again given while the examiner looks for weakness or pain, reflecting a positive test result **(Magee and Manske, 2020).**

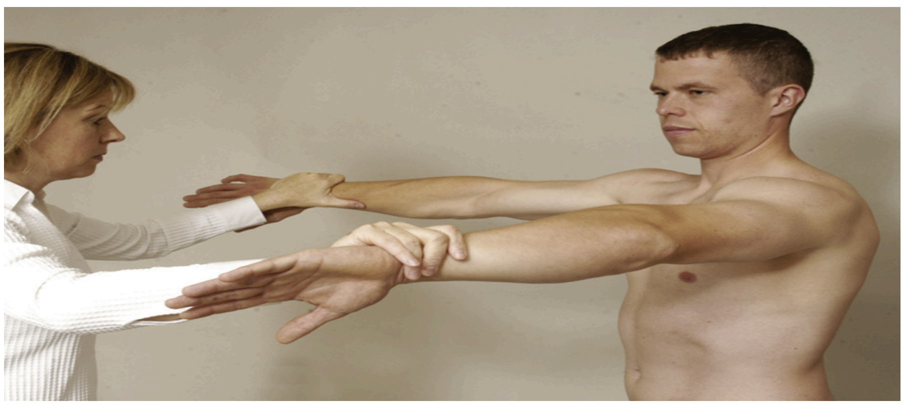


Figure 4 Supraspinatus ("Empty Can" or Jobe) Test

(4) Apprehension and relocation Tests: The examiner abduct the arm to 90 and laterally rotates the patient's shoulder slowly **(Fig11).** A positive test result is indicated by a look or feeling of apprehension or alarm on the patient's face and the patient's resistance to further motion. If the apprehension test result is positive, the examiner then applies a posterior translation stress to the head of the humerus (relocation test). The test result is considered positive if the patient loses the apprehension, pain decreases, and further lateral rotation is possible before the apprehension or pain returns **(Magee and Manske, 2020).**

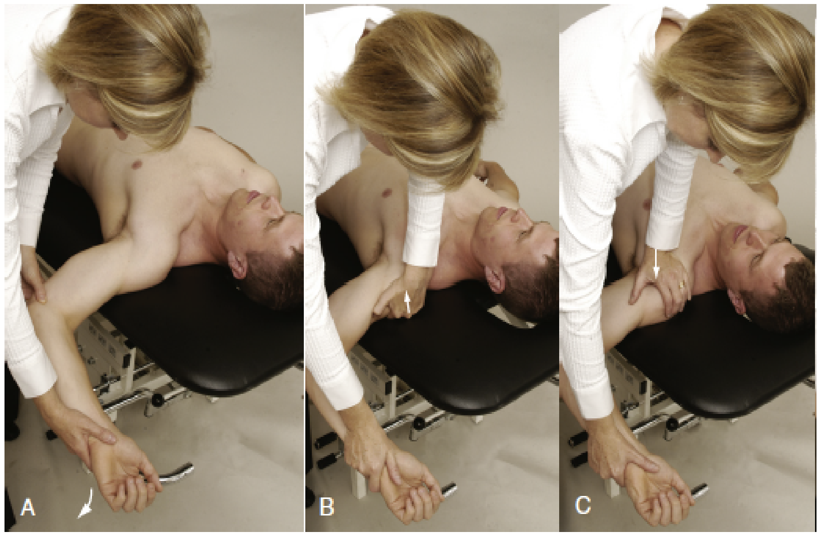


Figure 5 Apprehension and Relocation Tests

Exclusion criteria

Patients will be excluded if they had any of the following conditions: **(Cools et al., 2012).**

- Undergone shoulder surgery**.**
- Exhibited symptoms related to the cervical spine
- Taking nonsteroidal anti-inflammatory medications
- Received a steroid injection in the past 12 months
- Were already enrolled in a physical therapy program

Assessment Instrumentation

The following tools will be used for assessment:

1- Hand-held dynamometer.
2- isometric strength testing.
3- Modified Lateral Scapular Slide test
4- shoulder pain and disability index.

Hand-held dynamometer (HHD):

Hand-held dynamometer (Model 01165, Lafayette Instrument Company, Indiana) **(figure 12).** is an easy and reliable device to assess isometric muscle strength for shoulder and scapular muscles in both clinical and research settings, (ICCs) ranged from .77 to .99 in healthy subjects and from .75 to .99 in patients with impingement, for all muscle groups except the upper trapezius ($P < .05$).

Reliability values ranged from good to high in healthy subjects but were less consistent for the upper trapezius (ICC .45–.65). The relationship with BMI and muscle strength illustrates that as BMI increases, there is a decrease in reliability values of the upper trapezius (ICC = .35–.65) **(Celik et al., 2012)**

Figure 6 Lafayette Handheld dynamometer (Adopted from Celik et al., 2012).

Isometric strength imbalance of shoulder girdle muscles:

Isometric strength imbalance of shoulder girdle will be examined bilaterally. Subject will perform four scapular muscle tests (SA, UT, MR and LR). Then agonist and antagonist ratio of UT/SA, and MR/LR will be calculated. Hand held dynamometer (HHD) will be used to record the amount of maximum muscle force applied by the subject during the muscle test.

Lateral Scapular Slide test

The lateral scapular slide test (LSST) **(Kibler, 1998)** is reliable in screening scapular position. used to determine scapular involves measuring the distance from the inferior angle of the scapula to the nearest vertebral spinous process using a tape measure or goniometer in three positions: shoulder in neutral, shoulder at 45 degrees of coronal plane abduction with hands resting on hips, and the shoulder at 90 degrees abduction with the arms in full internal rotation **(figure 13).**

Overall ICC ranged from .83 to .96. The coefficients of determination ranged from .38 to .89. The SEM ranged from 3.00 to 8.26 mm LSST provides more objective measures than pure observation **(Curtis et al., 2006).**

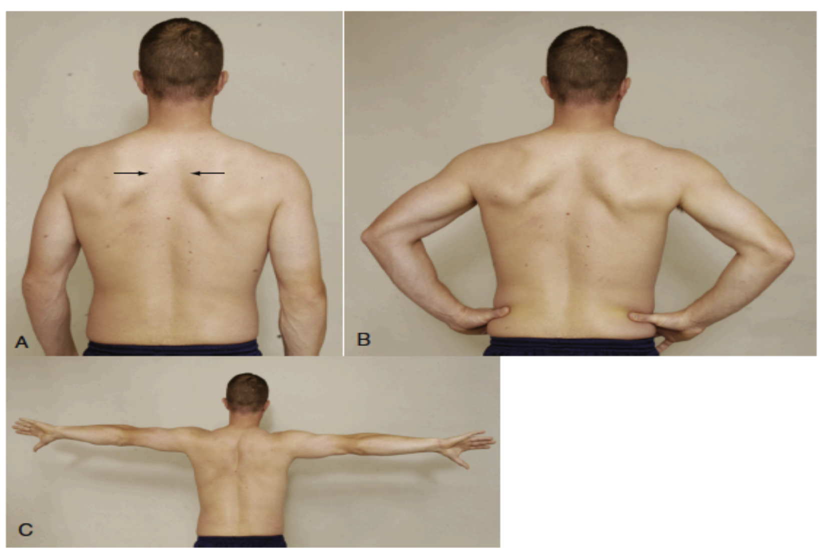


Figure 7 Lateral scapular slide test. The examiner measures from the spinous process to the scapula at the level of the base of spine of the scapula

Shoulder pain and disability index (Appendix II):

Self-report questionnaire developed to measure the pain and disability associated with shoulder pathology.The SPADI consists of 13 items in two subscales: pain (five items) and disability (eight items).

The pain dimension consists of five questions regarding the severity of an individual's pain. Functional activities are assessed with eight questions designed to measure the degree of difficulty an individual has with various activities of daily living that require upper-extremity use. The SPADI takes 5 to 10 minutes for a patient to complete and is the only reliable and valid region-specific measure for the shoulder **(Roash al., 1991).**

Patients asked to mark the appropriate point on the scoring system of the questionnaire, which represented their status of shoulder pain and disability. Total pain score: / 50 x 100 = %, Total disability score: / 80 x 100 = % and Total SPADI score: / 130 x 100 = % Higher score on the SPADI is indicative of higher pain and/or disability **(Breckenridge al., 2011).**

Psychometric Properties the SPADI :MDC: 18 point (MDC 95%) with ICC ≥ 0.89, The MCID has been reported to be 8 points; this represents the smallest detectable change that is important to the patient (**Paul et al 2004).**

No large floor or ceiling effects for the SPADI have been observed **(Bot et al 2004, Roy et al 2009).**

Procedures:

The participants will be interviewed and details and importance of the study will be discussed with them. Participants who agree to share in the study will sign a written consent form **(Appendix I).** After that the following procedures will be conducted

Assessment procedure

Assessment procedure will be performed before and after the treatment. The following procedure will be conducted

1. Measuring isometric strength with HHD

The HHD will be used to record the amount of resistance (in kilograms) applied by the examiner during the 4 scapular muscle tests as shown in **Figures 14 to 17.**

Muscle testing will be performed by first pre-positioning the scapula in the midrange position of scapular motion for the specific muscle test. The midrange position will be located by having the subject go through the available scapular range of motion, and then the midrange will be estimated as the midpoint of the motion.

This midrange position will be selected to optimize the length-tension relationship of the tested muscle and, therefore, the generation of a maximum isometric contraction **(Michener et al., 2005).**

The subjects will be instructed to maintain the midrange position during each muscle test as resistance was gradually applied via the HHD until the examiner matchs the subject's effort **(Michener et al., 2005).**

The LT muscle test will be performed as described by Hislop et al. **(1995)** with the resistance force from the HHD being applied to the spine of the scapula midway between the acromial process and the root of the spine, as shown in **Figure 14.**

Figure 8 Lower trapezius muscle test.

The force on the scapula will be applied in the superior and lateral direction parallel to the long axis of the humerus, which will be at 140 degrees of elevation. The scapular motion for this test is scapular adduction and depression.

The SA muscle test will be performed as described by Kendall et al., **(1993).** The original test described resistance applied against the subject's closed fist. For this study, the elbow will be placed in 90 degrees of flexion, and resistance will be applied to the ulna at the olecranon process along the long axis of the humerus.

The triceps muscle will be monitored visually and by palpation to ensure that it does not contribute to force production during the SA muscle test. The scapular motion for this test was scapular protraction **Figure 15.**

Figure 9 Serratus anterior muscle test.

The MT muscle test will be performed as described by Hislop et al. **(1995).** The HHD resistance force will be applied to the spine of the scapula midway between the acromial process and the root of the spine, as shown in **Figure 16.**

The force will be applied in the lateral direction parallel to the long axis of the humerus, which will be placed in 90 degrees of abduction. Scapular retraction was the scapular motion for the MT muscle test **Figure 16.**

Figure 10 Middle trapezius muscle test.

The UT muscle test will be performed as described by Hislop et al. **(1995).** The HHD will be placed over the superior scapula. Force will be applied directly downward (inferior) through the HHD in the direction of scapular depression. Scapular elevation will be the scapular motion for the UT muscle test **Figure 17.**

Figure 11 Upper trapezius muscle test.

All subjects will perform the muscle tests in the same order: LT, SA, MT, and UT muscle tests. The examiner will not view the digital readout on the HHD during performance of the muscle test. After the muscle test is completed, the examiner then will view the kilograms and recorded the information on a data recording sheet. Each muscle test will be performed 3 times consecutively, and the average will be used for data analysis.

2. Isometric strength imbalance of shoulder girdle muscles

Isometric strength imbalance of shoulder girdle will be examined bilaterally. Based on the muscle test results from the previous measurement, The ratio of UT/SA and MR/LR will be calculated.

3. Lateral Scapular Slide test

Subjects will be standing with both arms at the sides, in glenohumeral joint neutral. The inferior-most aspect of the inferior angle of the scapula and the adjacent spinous process of the reference vertebra in the same horizontal plane will be identified through palpation and will be marked with marker pen by the examiner as shown in **Figure 18.**

For test position 2 – subject will actively place both hands on the ipsilateral hips (in medial rotation) at 45° of abduction in the coronal plane **Figure 19.**

Position 3 - subject will actively extend both elbows and place the upper extremities in a position of maximum medial rotation at 90° of abduction in the coronal plane **Figure 20.**

Measurements will be taken with a vernier caliper from the inferior angle of scapula to adjacent spinous process of reference vertebra. The examiner will obtain the measurements bilaterally.

Figure 12 LSST position 1- arm at the sides

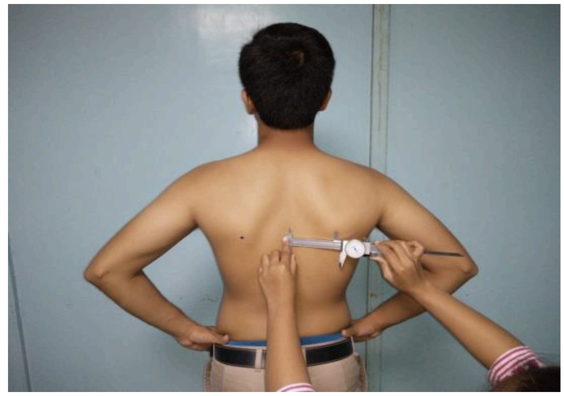


Figure 13 Position 2 both hands on ipsilateral hips

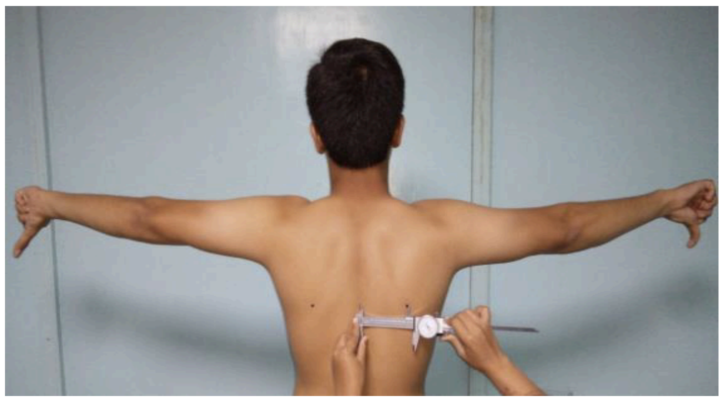


Figure 14 Position 3 of abduction 90° and medial rotation

4. Shoulder pain and disability index

Patients is asked to circle the number that best describes his/her level of pain or dysfunction of the questionnaire (**Appendix II)**. This represents their status of shoulder pain and disability. Total pain score: / 50 x 100 = %, Total disability score: / 80 x 100 = % and Total SPADI score: / 130 x 100 = % Higher score on the SPADI is indicative of higher pain and/or disability

This index will be scored before and after the treatment procedure to measure the function and pain on patients with SIS.

Treatment procedure

Group (A) will have scapular muscle training and group (B) will have a scapular PNF program and Group (C)will be a control group will not receive any treatment. Both groups A and B will receive 18 therapy visits (3 sessions per week for 6 weeks).

Group (A) Scapular muscle strengthening

The following four exercise will be performed according to **Cools et al. (2007):** (1) side-lying forward flexion, (2) side-lying external rotation, (3) prone horizontal abduction with external rotation, and (4) prone extension in neutral position **(Figure 21).**

Before starting the program, the patient will be thoroughly instructed in the four exercises, and illustrations with specific exercise instructions will be provided, as well as a compliance log. All subjects will perform the exercises with the affected side for three sets of 10 repetitions for each exercise, with a 1-minute rest between sets. The exercises are described in (**table 1)**

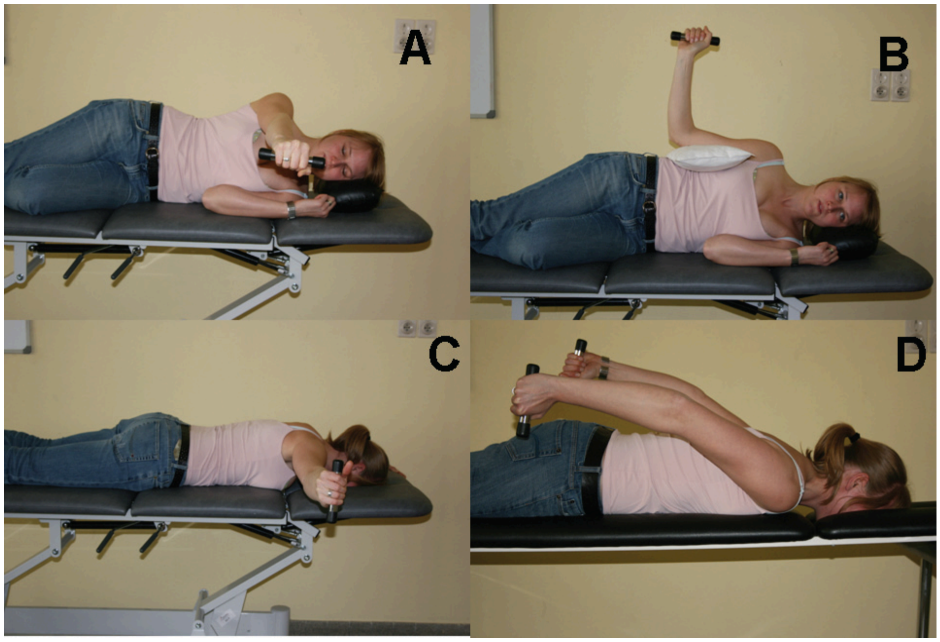


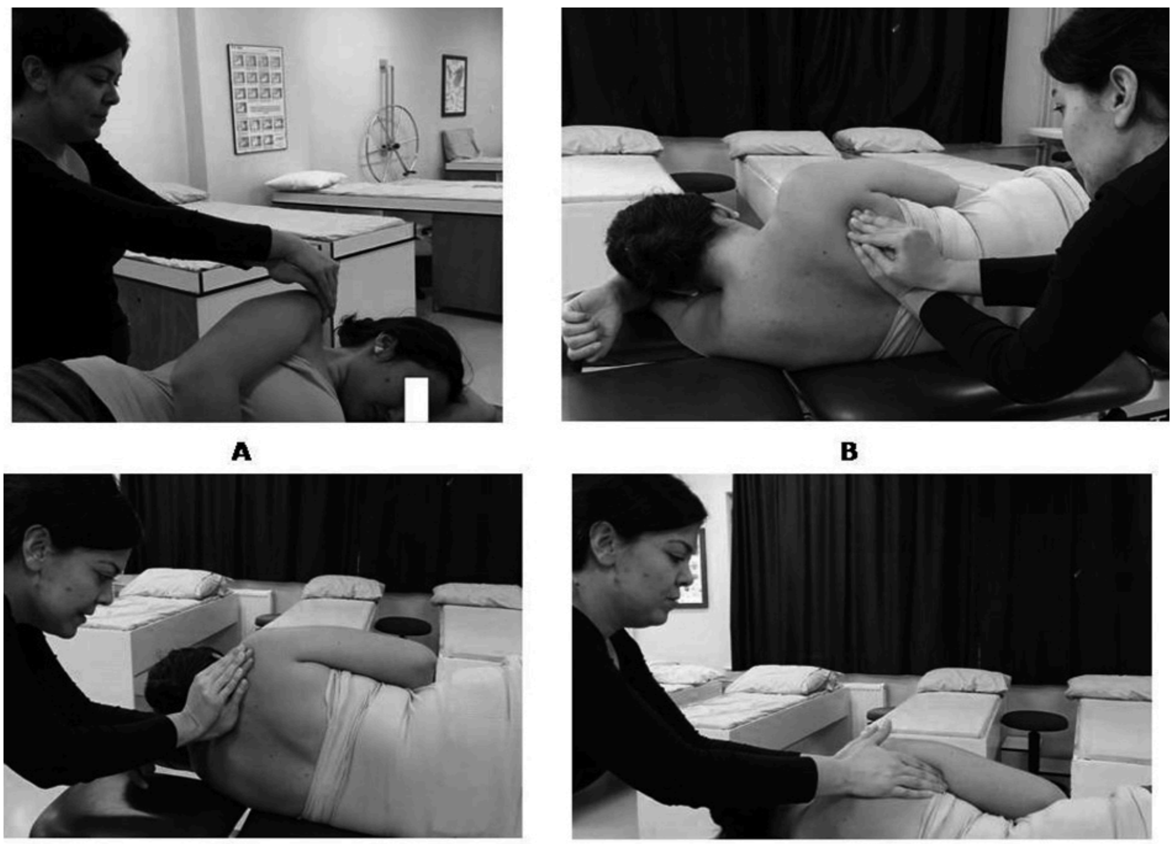
Figure 15 the proposed scapular strengthening program

Table 1. Description of the scapular training program

Exercise	Description
Prone extension	The subject is prone with the shoulders resting in 90of forward flexion. From this position, the subject performs bilateral extension to a neutral position with the shoulder in neutral rotation.
Forward flexion in side lying	The subject is in a side-lying position, with the shoulder in neutral. The subject performs 90 of unilateral forward flexion in a sagittal plane.
External rotation in side lying	The subject is side lying with the shoulder in neutral position and the elbow flexed 90. From this position, the subject performs 90 of external rotation of the shoulder with a towel between the elbow and trunk to avoid compensatory movements.
Prone horizontal abduction with external rotation	The subject is prone with the shoulders resting in 90 of forward flexion. From this position, the subject performs bilateral horizontal abduction to a horizontal position, with an additional external rotation of the shoulder at the end of the movement.

Group (B) Proprioceptive neuromuscular facilitation (PNF)

In the PNF group, scapular PNF will be applied by a trained therapist in two diagonals, anterior elevation and posterior depression **(Fig. 22A and 22B**, respectively) and posterior elevation and anterior depression **(Fig. 22C and 22D**, respectively) for three sets of 10 repetitions, The rest interval between repetitions will be 20 seconds **(Mtaspinar et al., 2013; Park et al., 2008).**



A B C D

Figure 16 A) Anterior elevation of the scapula, B) posterior depression of the scapula, C) posterior elevation of the scapula, D) anterior depression of the scapula

Patients will lay on the unaffected side while the therapist stands in the line of desired motion. Firstly, the therapist will give preparatory instructions. In the beginning of the pattern, the therapist pulls the scapula to the elongated position and then gives instructions for the desired movement.

Rhythmic initiation and repeated contractions facilitation techniques will be applied in all patterns. The rhythmic initiation technique teaches the motion, helps the patient to relax, improves coordination, and normalizes the motion. The repeated contractions technique increases active range of motion and strength and guides the patient's motion towards the desired motion. **(Mtaspinar et al., 2013; Park et al., 2008).** Description of each scapular PNF pattern is described below

Scapular anterior elevation (Fig. 23A and 23B)

- Muscles: levator scapulae, rhomboids, serratus anterior
- Positioning: sidelying with hips/knees flexed appropriately
- Grip: overlapping fingers on anterior aspect of GH joint and acromion
- Sequence: pull scapula down and back into posterior depression so anterior-lateral neck muscles are taut; don't pull so far that you lift patient's head; no trunk rotation
- Command: "Up"
- Movement: scapula moves up and slightly anterior
- Body Mechanics: arms relaxed; provide resistance by shifting weight from back to front leg
- Resistance: arc following curve of patient's body

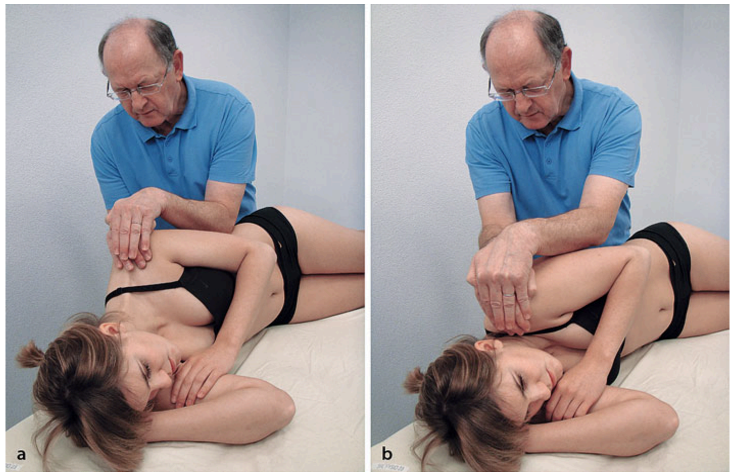


Figure 17 SCAPULAR ANTERIOR ELEVATION

Scapular posterior depression (Fig.24A and 24B)

- Muscles: lower serratus anterior, rhomboids, latissimus
- Positioning: sidelying with hips/knees flexed appropriately
- Grip: heels of hands along vertebral border of scapula with one hand just above (cranial to) the other and fingers on scapula pointing towards acromion
- Sequence: push scapula up and forward into anterior elevation until posterior muscles below the spine of the scapula are taught; no trunk rotation
- Command: “Down”
- Movement: scapula moves down and slightly posterior
- Body Mechanics: arms relaxed; provide resistance by shifting weight from front to back leg
- Resistance: arc following curve of patient’s body

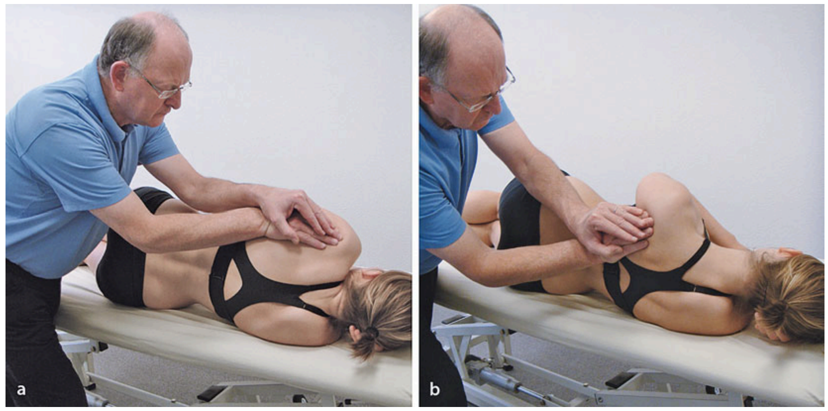


Figure 18 SCAPULAR POSTERIOR DEPRESSION

Scapular posterior elevation (Fig. 25A and 25B)

- Muscles: trapezius, levator scapulae
- Positioning: sidelying with hips/knees flexed appropriately
- Grip: overlapped hands posteriorly on upper trapezius muscle, superior to scapular spine
- Sequence: push scapula down and slightly forward into anterior depression so posterior-lateral neck muscles are taut; don't push so far that you lift patient's head; no trunk rotation
- Command: "Up"
- Movement: scapula moves up and slightly posterior
- Body Mechanics: arms relaxed; provide resistance by shifting weight from front to back leg
- Resistance: arc following curve of patient's body

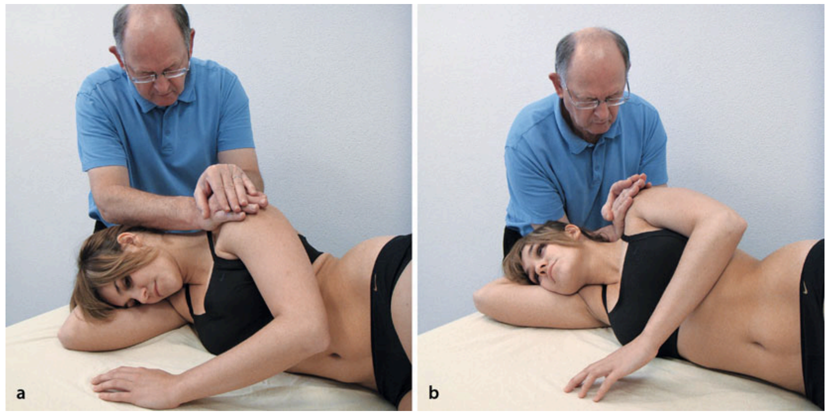


Figure 19 SCAPULAR POSTERIOR ELEVATION

Scapular Anterior Depression (Fig. 26A and 26B)

- Muscles: rhomboids, serratus anterior, pectoralis minor/major
- Positioning: sidelying with hips/knees flexed appropriately
- Grip: hands on anterior and posterior axilla with fingers pointing toward opposite hip
- Sequence: lift scapula up and back into posterior elevation; don't push so far that you lift patient's head; no trunk rotation
- Command: "Down"
- Movement: scapula moves down and slightly anterior
- Body Mechanics: arms relaxed; provide resistance by shifting weight from back to front leg
- Resistance: arc following curve of patient's body

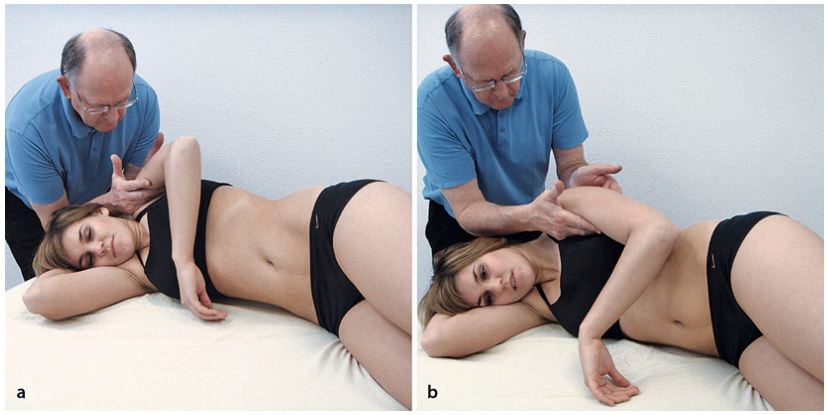


Figure 20 SCAPULAR ANTERIOR DEPRESSION

Statistical analysis

- Data will be analyzed using the statistical package for social science (SPSS) program, version 27 (SPSS Inc, Chicago, IL, USA).
- Descriptive statistics will be used to summarize the data. Data will be reported as mean ± SD for quantitative variables and frequency distribution (%) for categorical variables.
- The normality of data will be checked using Shapiro–Wilk test.
- Levene's test will be used to check the homogeneity between groups.
- Two-way Multiple Analysis of Variance (MANOVA) will be conducted to compare the mean values of the measured variables of the three groups.
- The level of significance for all statistical tests will be set at $\alpha = 0.05$.

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Appendix I. Informed consent

I am freely and voluntarily consent to participate in a research program under the direction of **Dr. Amr Mohamed Ahmed Khalil**
A thorough description of the procedure has been explained and I understand that I may withdraw my consent and discontinue participation in this research at any time without prejudice to me.

Date **Participant**

إقرار

أقر انا الموقع أدناه أنني وفقت علي الأشتراك في برنامج البحث تحت إشراف الباحث:**عمرو محمد احمد خليل**
وقد تم شرح خطوات البحث لي بالتفصيل وأنه من حقي أن انسحب من الدراسة في أي وقت أشاء

التاريخ **المشارك**

Appendix II. Shoulder and pain disability index

Patient Name ____ Date __________________

Shoulder Pain & Disability Index (SPADI)

Pain Scale: How severe is your pain?

0 ———————————————————————————————— 10
No Pain   Worst Pain Imaginable

For each question below, circle the number that best describes your pain based on the scale above

At its worst?	0	1	2	3	4	5	6	7	8	9	10
When lying on the involved side?	0	1	2	3	4	5	6	7	8	9	10
Reaching for something on a high shelf?	0	1	2	3	4	5	6	7	8	9	10
Touching the back of your neck?	0	1	2	3	4	5	6	7	8	9	10
Pushing with the involved arm?	0	1	2	3	4	5	6	7	8	9	10

Disability Scale: How much difficulty do you have?

0 ———————————————————————————————— 10
No Difficulty   Unable to Perform

For each question below, circle the number that best describes your difficulty based on the scale above

Washing your hair?	0	1	2	3	4	5	6	7	8	9	10
Washing your back?	0	1	2	3	4	5	6	7	8	9	10
Putting on an undershirt or pullover sweater?	0	1	2	3	4	5	6	7	8	9	10
Putting on a shirt that buttons down the front?	0	1	2	3	4	5	6	7	8	9	10
Putting on your pants?	0	1	2	3	4	5	6	7	8	9	10
Placing an object on a high shelf?	0	1	2	3	4	5	6	7	8	9	10
Carrying a heavy object of 10 pounds?	0	1	2	3	4	5	6	7	8	9	10
Removing something from your back pocket?	0	1	2	3	4	5	6	7	8	9	10

Pain Scale Score: ____ /50 x 100 = _____ % Disability Scale Score: ____ /80 x 100 = _____ %	**TOTAL SCORE:** ____ /130 x 100 = _____ %

Scoring: Summate the scores and divide by the number of scores possible. If an item is deemed not applicable, no score is calculated. Multiply total score by 100. The higher the score, the greater the impairment.