Combined effect of closed-kinetic chain and open-kinetic chain exercises on a traumatic shoulder instability

Gamal Salaheldin, and Essraa Mahmuod Abdelaziz Farag

Out-Patient Clinic of the Faculty of Physical Therapy, Cairo University. Egypt
Department of Orthopaedic Surgery, Ahmed Maher Teaching Hospital, Cairo, Egypt

Abstract: Background: The atraumatic multidirectional instability of the shoulder is a complex problem in terms of diagnosis and treatment. Distinct from multidirectional hyperlaxity, multidirectional instability has symptoms related with increased translations in more than one direction. **Objective:** The purpose of this study was to investigate the combined effect of closed-kinetic chain and open-kinetic chain exercises in treatment of patients with atraumatic shoulder instability. **Methods:** Twenty patients had participated in this study; with age ranged for eighteen to forty years, they were randomly assigned into two experimental groups. Group A consisted of 10 patients with median age of 23.5 (20.0-40.0) years, received closed and open kinetic chain exercises program. Group B consisted of another 10 patients with median age of 24 (20.0-29.0) years, received a program of open kinetic chain exercises only. Treatment was given 3 times/ week, every other day, for 4 consecutive weeks. Patients were evaluated pre and post treatment for their shoulder functional ability, shoulder joint's stability, and shoulder pain. **Results:** the results revealed that there were no statistical significant differences between both groups after treatment regarding the improvement in shoulder functional ability, pain, and shoulder joint's stability. **Conclusion:** Closed and open kinetic chain exercises yield similar effects of pain level, function, and stability of the glenohumeral joint in subjects with atraumatic multidirectional shoulder instability after four weeks of treatment.
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Key words: Atraumatic shoulder instability, kinetic chain exercises physical therapy.

1. Introduction

The term "shoulder instability" constitutes a spectrum of disorders that includes dislocation, subluxation and laxity **(Mahaffey and Smith, 1999).** It is characterized by symptomatic global laxity of the glenohumeral joint **(Beasley *et al.,* 2000).**

Deficiencies concerning shoulder instability may be classified as unidirectional (anterior, posterior, or inferior) or multidirectional instability (MDI) **(Matsen *et al.,* 1991; Sillman and Hawkins, 1993; Speer, 1995).**

Multidirectional instability can occur in males and females, in different age groups and in most segments of the population from sedentary individuals to elite athletes and is considered to be a serious and more prevalent condition than previously realized **(An and Friedman, 2000).**

Neer (1980) first described the condition of MDI by identifying subjects who displayed involuntary subluxation, or dislocation inferiorly, anteriorly or posteriorly. Since this time, authors have classified the malady as having instability in at least two planes: inferior and anterior, or inferior and posterior **(Sillman and Hawkins, 1993)** although discrepancy exists **(Richards, 2003).** Repetitive overuse, acute trauma, or a congenital tendency towards instability including generalized ligamentous laxity, or collagen diseases may be a predisposing factor **(Foster, 1983; Sillman and Hawkins, 1993; Tzannes and Murrell, 2002).**

Shoulder instability is caused by a wide spectrum of pathologies and involving static and dynamic structures. Static stabilizers include the labrum, the ligamentocapsular complex and the shape, size and orientation (version) of the glenoid. Dynamic stabilizers include the rotator cuff muscles, but also the other muscles of the shoulder girdle. Insufficiency of the stabilizers can lead to instability with subluxation or dislocation of the shoulder **(Zumstein *et al.,* 2005).**

MDI patients present with a wide array of symptoms. They may note weakness and vague pain commonly in the lateral deltoid region, the anterior rotator cuff structures, and/or medial border of the scapula **(Yuehuei and Friedman, 2000)** with activity **(Mahaffey and Smith, 1999),** or after activity **(Foster, 1983).** Shoulder fatigue, discomfort, apprehension, parasthesia and numbness are other common subjective maladies **(Foster, 1983)**. The patient commonly exhibits significant apprehension and guarding in the direction of greatest instability. MDI can be distinguished from other forms of instability as pain is commonly experienced in the midrange of glenohumeral joint motion such as that observed during normal activities of daily living **(Beasley *et al.,* 2000)** and may be easily provoked **(Schnek and Brems, 1998)**.

Different studies have shown that patients with multidirectional shoulder instability have poor co-ordination and strength of their rotator cuff muscles and of the scapulothoracic muscles **(Rowe *et al.,* 1973 Matsen *et al.,* 1990; Morrey and An, 1990; Kronberg *et al.,*1991; Mallon and Speer, 1995)**. Muscles lose their dynamic stabilizing action when fatigued, and allow increased humeral head motion, exposing the static restraints to greater stress **(Warme *et al.,* 1999)**.

Histologic studies have demonstrated the presence of mechanoreceptors in the glenohumeral joint **(Bresch and Nuber, 1995; Vangsness *et al.,* 1995)**. With clinical evaluation **(Lephart *et al.,*1994),** have documented impaired proprioception in patients with unstable shoulders. These findings have supported proprioception's role in shoulder instability. Because mechanoreceptors must be deformed or loaded to function, they may not be sufficiently stimulated in a lax or injured capsule. Alteration of the normal state of negative intra-articular pressure may also affect the function of the mechanoreceptors and contribute to shoulder instability **(Warner *et al.,* 1993; Gibb *et al.,* 1991)**. Muscle coordination abnormalities have been noted in studies of patients with generalized laxity as well **(Kronberg *et al.,* 1991)**. These studies support the need for a rehabilitation program that includes neuromuscular adaptation and focuses on improving muscle tone and general coordination **(Kennedy, 1993; Cordasco *et al.,* 1996)**.

One frequently used physical therapy intervention is shoulder rehabilitation that emphasizes exercises to strengthen rotator cuff and scapular stabilizers, in an effort to restore proper shoulder biomechanics **(Burkhead and Rockwood., 1992).** The rehabilitation process should focus on restoring range of motion (ROM), strength, neuromuscular control, and proprioception. Although open-kinetic chain (OKC) exercises are necessary to properly strengthen the shoulder musculature for any upper body activity, it's imperative that the mechanoreceptors in the joint be trained, as well. The mechanoreceptors responsible for proprioception and neuromuscular control are maximally stimulated when the joint surfaces are compressed, which can be accomplished through closed-kinetic chain (CKC) exercise **(Ubinger *et al.,* 1999).**

Conservative management involves a program of exercises for shoulder rehabilitation, along with close follow-up. Physical therapists concentrate on four phases of rehabilitation Phase I includes rest and pain control. Phase II begins with strengthening exercises for the dynamic rotator cuff and the scapular stabilizers (the serratus anterior, pectoralis and latissimus dorsi muscles), initially with isometric exercises and progressing to isotonic exercises. Isometric exercises strengthen a muscle without changing its length, while isotonic exercises allow the resistance to move through the muscle's range of motion**.** Phase III adds an endurance program to the strengthening exercises, with the goal of reaching 90 percent strength in the injured shoulder compared with the uninjured shoulder. The last phase consists of progressively increasing the patient's activity to sport- or job-specific activities **(Mahaffey and Smith, 1999).**

The long-term goals of the treatment program are to improve the strength, endurance, and coordination of the shoulder musculature so that the joint kinematics are enhanced to a point that dynamic control of the glenohumeral joint is adequate to compensate for the excessively lax ligamentous restraints **(Misamore *et al.,* 2005).**

Closed kinetic chain (CKC) exercises have recently gained popularity and are frequently used in upper limb rehabilitation programs. These exercises are included in painful or unstable shoulder rehabilitation programs since they are considered biomechanically safer and more functional than Open Kinetic Chain (OKC) exercises, in which the hand moves freely with or without the presence of load. The advantages attributed to CKC exercises result from the joint approximation effect caused by the axial load on the limb, which increases proprioceptive stimuli and muscle co-activation, resulting in greater joint stability **(Dillman *et al.,* 1994).**

When CKC exercises are performed with support over a relatively unstable surface, e.g. by supporting the hand on a medicine ball **(Anderson and Behm, 2004),** these exercises become more complex. The additional instability created by the support on an unstable surface increases demand over the neuromuscular system, increasing muscular coactivation **(Lephart and Henry, 1996).** Increase in strength was another advantage attributed to unstable CKC training. This strength gains can be attributed to neural adaptations, as increase in number and in firing rate recruitment of motor units **(Behm *et al.,* 2002)** and improved coordination of the agonist, antagonist, synergist and stabilizer muscles **(Rutherford and Jones, 1986; Stone *et al.,* 1998).**

2. Patients and methods

This randomized clinical trial, was conducted in the out-patient clinic of the faculty of physical therapy, Cairo University to compare between the combined effect of closed kinetic chain exercises and open kinetic chain exercises and open kinetic chain exercises alone on Atraumatic shoulder instability.

Subjects:

The study was conducted on 20 patients referred from an orthopedic surgeon after they were diagnosed clinically as atraumatic shoulder instability, their ages ranged from 18-40 years and they were randomly assigned into two experimental groups:

Group (A): Consisted of ten patients who received a program of closed kinetic chain upper-extremity exercises combined with open kinetic chain exercises for shoulder and scapular muscles for 4 weeks.

Group (B): Consisted of ten patients who received open kinetic chain exercises for shoulder and scapular muscles as in group (A) for 4 weeks.

Inclusion criteria:

Patients met the following criteria in order to participate in the study:

1. Patients diagnosed atraumatic shoulder instability.
2. Patients were referred from an orthopedic surgeon.
3. Age ranged from 18-40 years.
4. Patients were non-athletics

Exclusion criteria:

Patients were excluded from the study when they met the following criteria:

1. Patients with traumatic upper limb injuries including fractures, dislocations or recurrent dislocations.
2. Patients with traumatic shoulder instabilities.
3. Patients who had performed any upper limb surgeries.
4. Patients who had signs and symptoms of complex regional pain syndrome (CRPS).
5. Systematic diseases that affect proprioception as Diabetes Mellitus.

Instrumentations:

Patients were assessed just before and after the 4 weeks of exercise program and the following assessment tools were used:

Instrumentations used for evaluation:

1- American shoulder and elbow surgeons (ASES) Rating Scale :

The ASES is a functional rating scale designed for broad applicability **(Field and Savoie, 1993).** This rating scale is heavier weighted towards function in the activities of daily living and widely used **(Williams *et al.*,1999).**

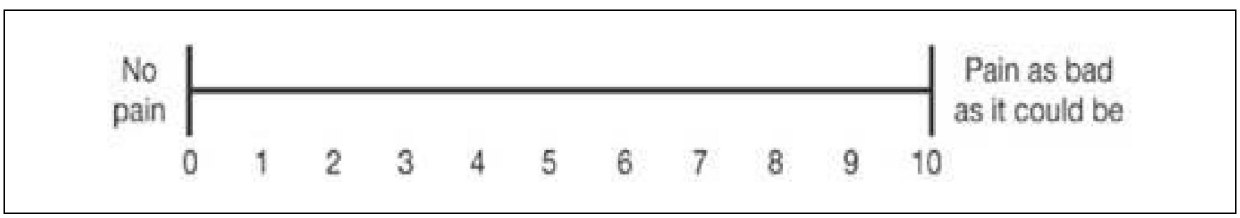
The ASES score consists of four parts which are pain, functional activities, strength and stability. Each part has its own score (pain=5, functional activities= 60, strength=20 and stability= 15). And the total score= 100, the higher the score, the better the function. The test-retest reliability of the patient self-report section of the ASES is considered to be excellent **(Portney and Watkins, 2000).**

2- Closed Kinetic chain Upper-Extremity Stability Test:

Davies and Dick-Hoffman (1993) described a modification of the standard push-up that they termed the closed kinetic chain upper-extremity stability test. The CKC of Upper-Extremity Stability Test form contains the specific instructions for administering the CKC Upper-Extremity Stability test, as well as normative data for both males and females. Data is normalized on this test for males and females by dividing the number of line touches by the subject's height in inches.

Goldbeck and Davies (2000) recently completed a test-retest reliability study of this closed chain upper-extremity stability test. Subjects were tested twice using identical methodology, resulting in a reliability coefficient of.927, indicating that this test is a highly reliable clinical evaluation tool. The average number of line touches for the 24 male college students in the study was 27.8 ± 1.77 for the pretest and 27.9 ± 1.97for the retest.

3- Visual Analog Scale (VAS) (Figure 1):



VAS is a line scale with anchors at 0 and 10 (0 indicating no pain, 10 indicating the worst pain imaginable). The patient self-rated his/her shoulder pain, by placing a mark on the line representing his/her level of pain. This scale has been established as a reliable and valid instrument to measure acute and chronic pain **(Flandry *et al.,* 1991)**. **Flandry *et al.* (1991)** reported that the (VAS) was shown to be valid. It brought greater sensitivity and statistical power to data collection; it allowed graphic representation and numeric analysis of the collected data.

Instrumentations used for treatment:

1- Balance board for closed kinetic chain exercises.

Evaluation procedure:

First initial evaluation was made to check if patients met the inclusion criteria, then all assessment and treatment procedures were explained to the patient and they all signed an informed consent form. Evaluation procedure was performed before starting the program and after treatment.

1) Assessment of pain using visual analogue scale:

To measure the degree of pain, visual analogue scale was used. Each subject was made aware the (VAS) as being 10 cm horizontal line with one end described as (no pain = 0), and other end (the worst pain I ever felt = 10). Patient was instructed to mark with pencil at point which refers to degree of his/her pain**.**

2) Assessment of shoulder joint function, using ASES Rating scale:

All patients were assessed before and after the exercise program for their functional disabilities, using the self-report section from the ASES scale. All patients received verbal and written description of how to fill in the scale. Each patient filled two questionnaires; one before and the other after the treatment. Then the score of functional level (ranging from 0 to 60) out of 100 was calculated for each patient pre and post treatment in both groups.

3) Assessment of the shoulder joint stability, using Closed Kinetic Chain Upper-Extremity Stability test:

An individual started the test in a standard push-up position, with the hands on two parallel pieces of tape 3 feet (0.9m) apart, below the shoulders. The individual is instructed to move both hands as rapidly as possible from one tape line to the other, touching each line alternately in a “windshield wiper” fashion. The number of line touched in 15 seconds is recorded using a stopwatch for objective quantification of upper-extremity closed kinetic chain function **(Davies and Dick-Hoffman, 1993).**

Treatment procedure:

I- Group (A):

All patients in this group received 12 sessions of closed kinetic chain and open kinetic chain exercise program (3 sessions per week for 4 weeks). The CKC exercise program consisted of the following exercises:

Weight bearing on a table, clock exercise, Wall slide-scapula control, and Quadruped on balance board **(Gibson, 2004).**

All exercises were performed for 30 seconds and progressed by 5 seconds each week. Repetitions began with 10 repetitions for each exercise and then progressed by two repetitions each week.

a- Weight bearing on a table:

Simple weight bearing exercises facilitate co-contraction of the rotator cuff. The patient can vary the degree of rotation by altering the hand position, so biasing different cuff components. Scapula dissociation exercises were also incorporated in this position **(Gibson, 2004).**

b- Clock exercise:

‘Clock’ exercises: The patient stood with his/her hand on the wall. The patient performed scapular movements - elevation, depression, protraction and retraction, i.e. to the different points on the ‘clock’. This facilitates scapula dissociation in conjunction with cuff co-contraction. As rehabilitation progressed the same exercises were performed with the hand on an unstable surface. The use of a mirror aided visual feedback, emphasized optimal postural alignment and corrected exercise technique **(Gibson, 2004).**

c- Wall slide-scapula control:

The patient faced the wall and pushed a towel up through elevation to facilitate optimal recruitment of the scapula stabilizers. Due to the closed kinetic chain aspect of this exercise it had excellent proprioceptive properties **(Gibson, 2004).**

d- Quadruped on balance board:

Start position: on hands and knees, with the hands and knees directly under the shoulders and hips, respectively, and hands approximately shoulder-width apart on a balance or rocker board.

Exercise action: in the early stage of rehabilitation, the individual simply attempted to balance over the board, keeping all sides of the board off the ground. In later stages, the board moved in a circular pattern both clockwise and counterclockwise, keeping all edges of the board off the ground. The patient was asked to maintain his balance for 30 seconds while performing the exercise, and each week the time was increased by 5 seconds for progression **(Ellenbecker and Davies, 2001).**

II- Group (B):

All patients in this group received 12 sessions of open kinetic chain exercise program (3 sessions per week for 4 weeks) the program consisted of: strengthening exercises for shoulder and scapular muscles (strengthening exercises for the dynamic rotator cuff and the scapular stabilizers).

All exercises began with isometric exercises and progressed to isotonic exercises**.** Each exercise was performed as 3 sets of 10 repetitions, with increase in resistance as strength improved**.**

1- Shoulder abduction: patient was standing, head in neutral position and carrying the proper dumbbell in his hand according to 10 repetitions maximum technique to detect the proper weight **(Schneider and Prentice, 1999).**

2-Shoulder flexion: patient was standing, head in neutral position and carrying the proper dumbbell in his hand **(Schneider and Prentice, 1999).**

3-For shoulder external rotators: from side lying, elbow 90 degrees flexion, proper dumbbell was carried in the hand and shoulder external rotation **(Brewster and Schwab, 1993)**

4-For shoulder internal rotators: from side lying on the involved shoulder, elbow 90 degrees flexion of the involved shoulder, proper dumbbell was carried in the hand and shoulder external rotation **(Brewster and Schwab, 1993)**

5- For strengthening of scapular stabilizers and rotator cuff: Arm was raised and held 30° forward with the thumb up or down and resistance was added by placing my hand on the distal end of the forearm or by using weights. This exercise was done only when there was no pain **(Kuhn, 2009).**

6- Rowing exercise: was performed to improve the strength of the scapular retractor and shoulder extensor muscles. Rowing was performed by using a rowing machine **(Donatelli, 2004).**

7- Shoulder shrugging with resistance: for upper fibres of trapezius and levator scapulae muscle **(Kisner and Colby, 2007).**

8- Pull-down exercise: was performed with shoulder adduction and extension.This exercise was performed to strengthen the latissimus dorsi muscle **(Donatelli, 2004).**

3. Results

This study was conducted to compare between the combined effect of closed kinetic chain and open kinetic chain exercises and open kinetic chain exercises alone on pain, function and shoulder stability after atraumatic shoulder instability.

A total of twenty patients (males and females) had participated in this study. They were randomly assigned into two experimental groups; group A received closed and open kinetic chain exercises. It consisted of ten patients (3 males and 7 females) with median age of 23.5 (20.0-40.0) years, and group B received open kinetic chain exercises. It consisted of another ten patients (1 male and 9 female) with median age of 24 (20.0-29.0) years.

Mann-Whitney U test was used to show difference between the two groups as regard to the age. This test revealed no statistical significant difference between the group A with median age of 23.5 (20.0-40.0) and group B with median age of 24 (20.0-29.0) with Z-test = -0.342 and P value = 0.739 **(Table 1).**

Chi square test was used to show the significant difference between the sex distributions in the two groups. This test revealed no statistical significant difference between females and males in group A [7/3 (70/30%)] and their corresponding in group B [9/1 (90/10%)] with Chi square test = 1.250 and P value = 0.255 **(Table 1).**

Mann-Whitney U test was used to show difference between the two groups as regards the weight. This test revealed no statistical significant difference between the group A with median weight of 160.86 (114.5-200.6) and group B with median weight of 128.9 (114.5-185.0) with Z-test = -1.023 and P value = 0.315 **(Table 1).**

Mann-Whitney U test was used to show difference between the two groups as regards the height. This test revealed no statistical significant difference between the group A with median height of 64.17 (61.02-74.01) and group B with median height of 62.99 (61.81-67.71) with Z-test = -1.444 and P value = 0.165 **(Table 1).**

Table 1: Demographic data of both groups.

	Group A (n= 10)	Group B (n= 10)	Z-value	*P* value
Age (yrs.)	23.5 (20.0-40.0)	24 (20.0-29.0)	-0.342	0.739 (NS)
Gender (F/M)	7/3 (70%/30%)	9/1 (90%/10%)	χ^2=1.250	0.255 (NS)
Weight (Ib)	160.86 (114.5-200.6)	128.9 (114.5-185.0)	-1.023	0.315 (NS)
Height (inch)	64.17 (61.02-74.01)	62.99 (61.81-67.71)	-1.444	0.165 (NS)

Data are expressed as median (minimum-maximum) or number (%) χ^2= Chi square test. NS= Not significant.

1-Shoulder joint function (American shoulder and elbow surgeons rating scale):

A. Within groups

i. Group A

Wilcoxon sign rank test was used to show difference between pre- and post treatment in group A as regards the American shoulder and elbow surgeons rating scale variable. This test revealed that there was a statistical significant difference between the pre treatment with median of 39.5 (38.0-42.0) and post treatment with median of 51.0 (45.0-53.0) with Z test = -2.816 and p value = 0.005 **(Table 2; Fig.2).**

ii. Group B

Wilcoxon sign rank test was used to show difference between pre- and post-treatment in group B as regards the American shoulder and elbow surgeons rating scale variable. This test revealed that there was a statistical significant difference between the pre treatment with median of 40.0 (36.0-41.0) and post treatment with median of 47.5 (42-51) with Z test = -2.850 and p value = 0.004 **(Table 2; Fig.2).**

Table 2: Comparison between the median values of the American shoulder and elbow surgeons rating scale variable measured pre and post treatment in the two studied groups.

	Pre	Post	Z-value	P value
Group A	39.5 (38.0-42.0)	51.0 (45.0-53.0)	-2.816	0.005**
Group B	40.0 (36.0-41.0)	47.5 (42-51)	-2.850	0.004**

Data are expressed as median (minimum-maximum). **p< 0.01= highly significant.

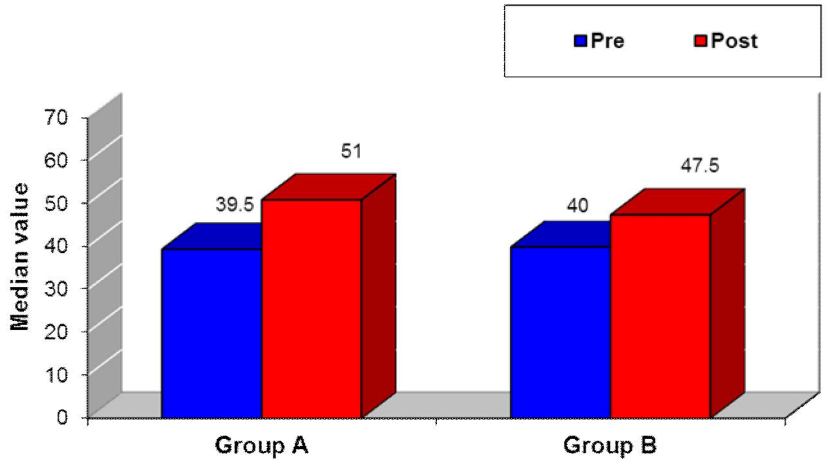


Fig. (2): Comparison between the median values of the American shoulder and elbow surgeons rating scale variable measured pre and post treatment in the two studied groups.

b. Between groups

i. Pre-treatment:

Mann-Whitney U test was used to show difference between the two groups as regards the American shoulder and elbow surgeons rating scale variable measured pre-treatment. This test revealed that before treatment there was no statistical significant difference between the median value of group A [39.5 (38.0-42.0)] and the median value of group B [40.0 (36.0-41.0)] with Z-test = -0.039 and P value = 0.969 **(Table 3; Fig. 3).**

ii. Post-treatment:

Mann-Whitney U test was used to show difference between the two groups as regards the American shoulder and elbow surgeons rating scale variable measured post-treatment. This test revealed that after treatment there was no statistical significant difference between the median value of group A [51.0 (45.0-53.0)] and the median value of group B [47.5 (42-51)] with Z-test = -1.872 and P value = 0.061 **(Table 3; Fig. 3).**

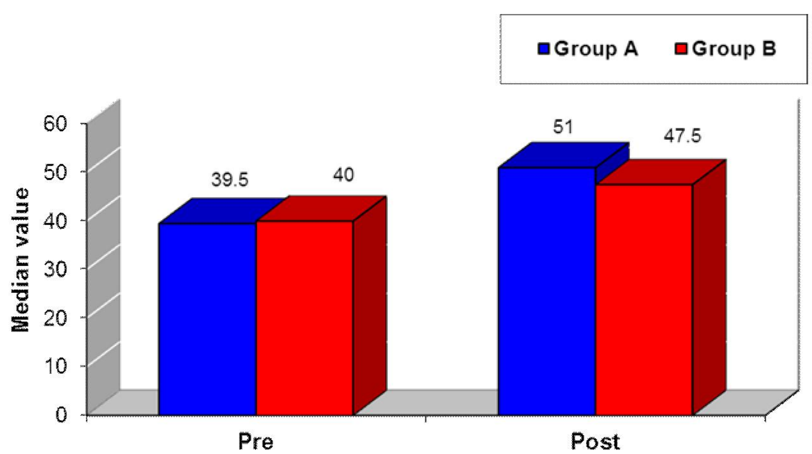


Fig. 3: Comparison between the median value of the American shoulder and elbow surgeons rating scale variable measured pre- and post-treatment between the two studied groups.

Table 3: Comparison between the median values of the American shoulder and elbow surgeons rating scale variable measured pre- and post-treatment between the two studied groups.

	Group A (n= 10)	Group B (n= 10)	Z-value	*P* value
Pre	39.5 (38.0-42.0)	40.0 (36.0-41.0)	-0.039	0.969 (NS)
Post	51.0 (45.0-53.0)	47.5 (42-51)	-1.872	0.061 (NS)

Data are expressed as median (minimum-maximum).
NS= Not significant.

2- Pain (VAS)

a. Within groups

i. Group A

Wilcoxon sign rank test was used to show difference between pre- and post-treatment in group A as regards the VAS variable. This test revealed that there was a statistical significant difference between the pre treatment with median of 8.5 (7.5-9.0) and post treatment with median of 5.0 (5.0-6.0) with Z test = -2.877 and p value = 0.004 **(Table 4; Fig. 4).**

ii. Group B

Wilcoxon sign rank test was used to show difference between pre- and post treatment in group B as regards the VAS variable. This test revealed that there was a statistical significant difference between the pre treatment with median of 8.5 (7.5-9.0) and post treatment with median of 5.5 (4.0-6.0) with Z test = -2.848 and p value = 0.004 **(Table 4; Fig. 4).**

Table 4: Comparison between the median values of the pain variable measured pre and post treatment in the two studied groups.

	Pre	Post	Z-value	P value
Group A	8.5 (7.5-9.0)	5.0 (5.0-6.0)	-2.877	0.004**
Group B	8.5 (7.5-9.0)	5.5 (4.0-6.0)	-2.848	0.004**

Data are expressed as median (mimium-maximum).
**p< 0.01= highly significant.

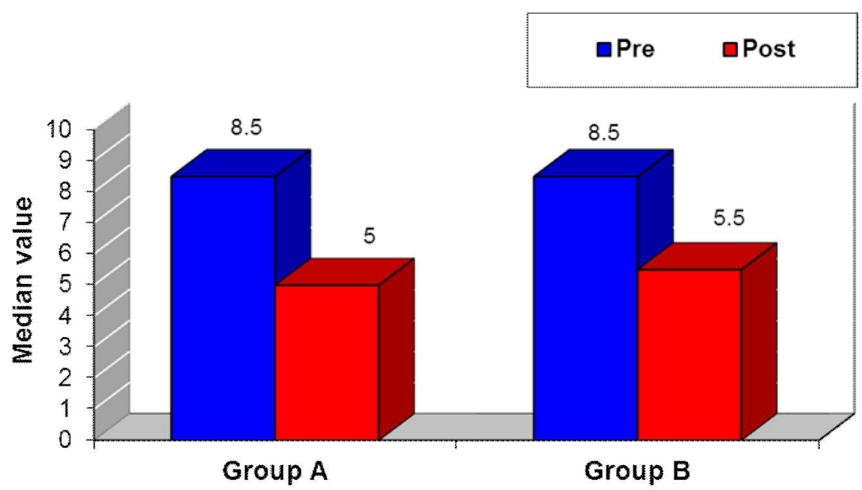


Fig. 4: Comparison between the median values of VAS measured pre and post treatment in the two studied groups.

b. Between groups

i. Pre-treatment:

Mann-Whitney U test was used to show difference between the two groups as regards the VAS variable measured pre-treatment. This test revealed that there was no statistical significant difference between the median value of group A [8.5 (7.5-9.0)] and the median value of group B [8.5 (7.5-9.0)] with Z-test = -0.555 and P value = 0.579 **(Table 5; Fig. 5).**

ii. Post-treatment:

Mann-Whitney U test was used to show difference between the two groups as regards the VAS variable measured post-treatment. This test revealed that there was no statistical significant difference between the median value of group A [5.0 (5.0-6.0)] and the median value of group B [5.5 (4.0-6.0)] with Z-test = -0.780 and P value = 0.435 **(Table 5; Fig. 5).**

Table 5: Comparison between the median values of pain variable measured pre- and post-treatment between the two studied groups.

	Group A (n= 10)	Group B (n= 10)	Z-value	*P* value
Pre	8.5 (7.5-9.0)	8.5 (7.5-9.0)	-0.555	0.579 (NS)
Post	5.0 (5.0-6.0)	5.5 (4.0-6.0)	-0.780	0.435 (NS)

Data are expressed as median (minimum-maximum).
NS= Not significant.

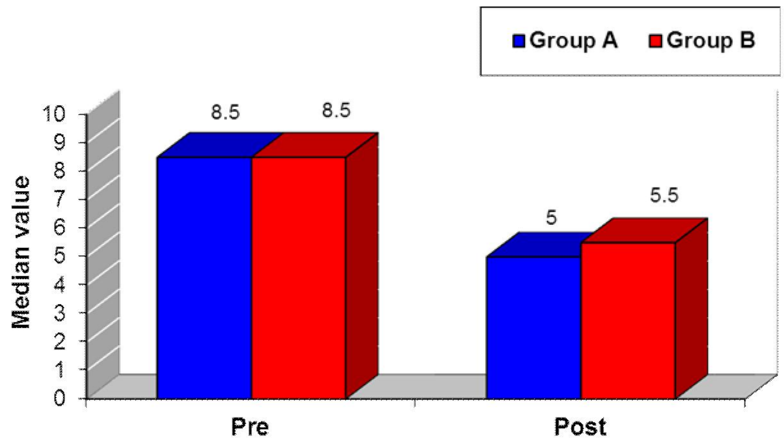


Fig. 5: Comparison between the median values of the VAS variable measured pre- and post-treatment between the two studied groups.

3. Shoulder stability (closed kinetic chain upper-extremity stability test)

a. Within groups

I. Score variable

Group A

Wilcoxon sign rank test was used to show difference between pre- and post treatment in group A as regards the score variable. This test revealed that there was a statistical significant difference between the pre-treatment with median of 0.24 (0.23-0.26) and post-treatment with median of 0.29 (0.26-0.32) with Z test = -2.803 and p value = 0.005 **(Table 6; Fig. 6).**

Group B

Wilcoxon sign rank test was used to show difference between pre- and post treatment in group B as regards the score variable. This test revealed that there was a statistical significant difference between the pre-treatment with median of 0.24 (0.22-0.27) and post-treatment with median of 0.28 (0.25-0.30) with Z test = -2.803 and p value = 0.005 **(Table 6; Fig. 6).**

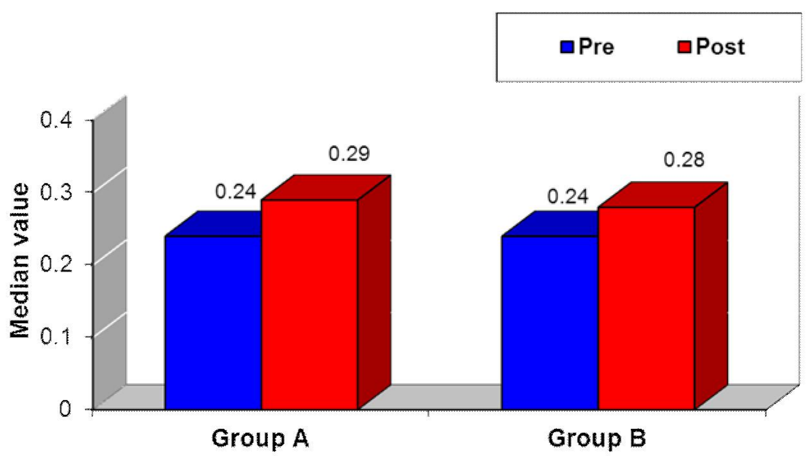


Fig. 6: Comparison between the median values of the score section of the stability variable measured pre and post treatment in the two studied groups.

Table 6: Comparison between the median values of the score section of the stability variable measured pre and post treatment in the two studied groups.

	Pre	Post	Z-value	P value
Group A	0.24 (0.23-0.26)	0.29 (0.26-0.32)	-2.803	0.005**
Group B	0.24 (0.22-0.27)	0.28 (0.25-0.30)	-2.803	0.005**

Data are expressed as median (mimium-maximum). **p< 0.01= highly significant.

II. Power variable

Group A

Wilcoxon sign rank test was used to show difference between pre- and post-treatment in group A as regards the power variable. This test revealed that there was a statistical significant difference between the pre treatment with median of 99.24 (77.86-136.48) and post treatment with median of 120.2 (96.80-161.04) with Z test = -2.803 and *p* value = 0.005 **(Table 7; Fig. 7).**

Group B

Wilcoxon sign rank test was used to show difference between pre- and post treatment in group B as regards the power variable. This test revealed that there was a statistical significant difference between the pre treatment with median of 92.70 (76.13-124.44) and post treatment with median of 105.24 (91.72-141.03) with Z test = -2.803 and *p* value = 0.005 **(Table 7; Fig. 7).**

Table 7: Comparison between the median values of the power section of the stability variable measured pre and post treatment in the two studied groups.

	Pre	Post	Z-value	*P* value
Group A	99.24 (77.86-136.48)	120.2 (96.80-161.04)	-2.803	0.005**
Group B	92.70 (76.13-124.44)	105.24 (91.72-141.03)	-2.803	0.005**

Data are expressed as median (minimum-maximum).
**p< 0.01= highly significant.

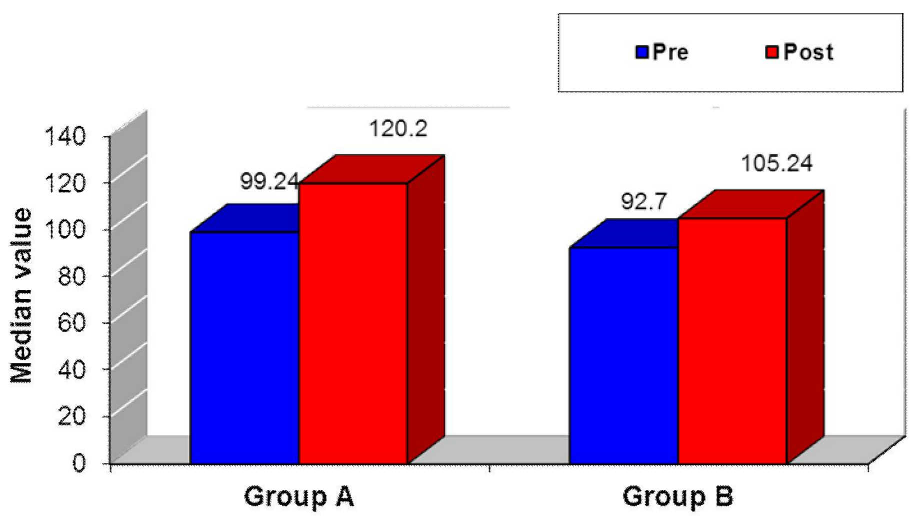


Fig. 7: Comparison between the median values of the power section of the stability variable measured pre and post treatment in the two studied groups.

b. Between groups

I. Score variable

Pre-treatment:

Mann-Whitney U test was used to show difference between the two groups as regards the score variable measured pre-treatment. This test revealed that there was no statistical significant difference between the median value of group A [0.24 (0.23-0.26)] and the median value of group B [0.24 (0.22-0.27)] with Z-test = -0.492 and P value = 0.623 **(Table 8; Fig. 8).**

Post-treatment:

Mann-Whitney U test was used to show difference between the two groups as regards the score variable measured post-treatment. This test revealed that there was no statistical significant difference between the median value of group A [0.29 (0.26-0.32)] and the median value of group B [0.28 (0.25-0.30)] with Z-test = -1.512 and *P* value = 0.130 **(Table 8; Fig. 8).**

Table 8: Comparison between the median values of the score section of the stability variable measured pre- and post-treatment between the two studied groups.

	Group A (n= 10)	Group B (n= 10)	Z-value	*P* value
Pre	0.24 (0.23-0.26)	0.24 (0.22-0.27)	-0.492	0.623 (NS)
Post	0.29 (0.26-0.32)	0.28 (0.25-0.30)	-1.512	0.130 (NS)

Data are expressed as median (minimum-maximum). NS= Not significant.

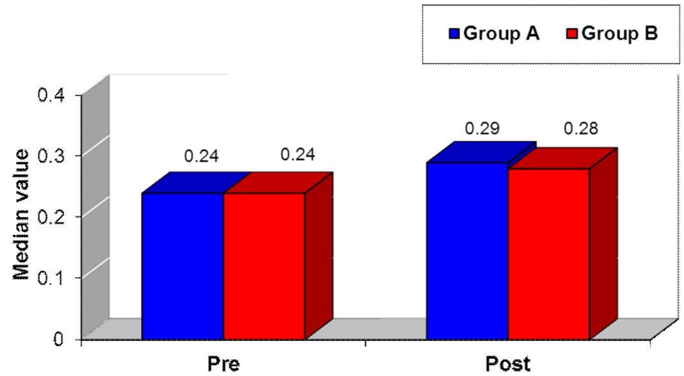


Fig. 8: Comparison between the median values of the score section of the stability variable measured pre- and post-treatment between the two studied groups.

II. Power variable

Pre-treatment:

Mann-Whitney U test was used to show difference between the two groups as regards the power variable measured pre-treatment. This test revealed that there was no statistical significant difference between the median value of group A [99.24 (77.86-136.48)] and the median value of group B [92.7 (76.13-124.44)] with Z-test = -0.567 and P value = 0.570 **(Table 9; Fig. 9).**

Post-treatment:

Mann-Whitney U test was used to show difference between the two groups as regards the power variable measured post-treatment. This test revealed that there was no statistical significant difference between the median value of group A [120.2 (96.80-161.04)] and the median value of group B [105.24 (91.72-141.03)] with Z-test = -1.172 and P value = 0.240 **(Table 9; Fig. 9).**

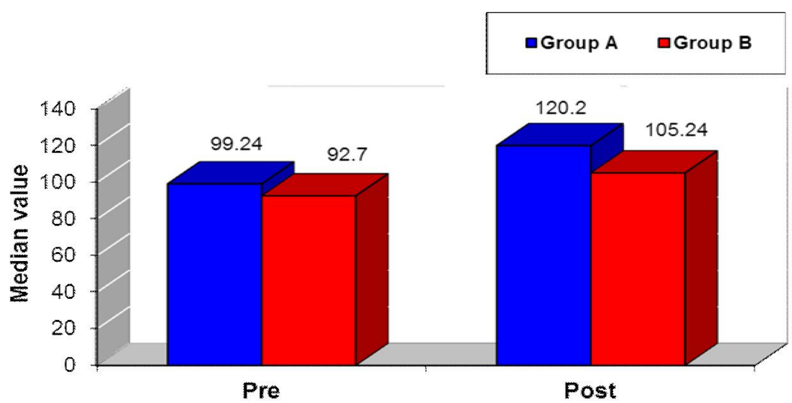


Fig. 9: Comparison between the median values of the power section of the stability variable measured pre- and post-treatment between the two studied groups.

Table 9: Comparison between the median values of the power section of the stability variable measured pre- and post-treatment between the two studied groups.

	Group A (n= 10)	Group B (n= 10)	Z-value	*P* value
Pre	99.24 (77.86-136.48)	92.7 (76.13-124.44)	-0.567	0.570 (NS)
Post	120.2 (96.80-161.04)	105.24 (91.72-141.03)	-1.172	0.240 (NS)

Data are expressed as median (minimum-maximum). NS= Not significant. **p< 0.01= highly significant.

4. Discussion

The etiology of multidirectional instability is probably multifactorial but there are four major etiological categories that can lead to instability either on their own or in combination **(Mallon and Speer, 1995).** These are bone and labral abnormalities, ligamentous abnormalities, impaired muscular control, and collagen abnormalities. In addition, a number of authors, including ourselves, have found that psychological elements also play a significant role in the development of MDI.

This was a randomized clinical trial with level 1b of evidence (individual randomized clinical trial) that was to compare between the combined effect of closed kinetic chain and open kinetic chain exercises and open kinetic chain exercises alone on pain, function and stability after atraumatic shoulder instability. We had investigated the effect of these exercises on pain, function, and stability of the glenohumeral joint in subjects with atraumatic multidirectional shoulder instability.

We had assessed pain using VAS, function of the glenohumeral joint using ASES rating scale, and the stability of the glenohumeral joint using closed-kinetic chain upper extremity stability test. Although there was significant improvement with each group pre and post treatment, our results showed that there was no statistical significance difference between the two groups after treatment regarding improvement of pain severity, function of the shoulder, and the stability of the shoulder joint.

Getahun *et al.* (2000) conducted a study to investigate the concurrent validity of patient rating scales in assessment of outcome after rotator cuff repair. They concluded that the selection of outcome questionnaires should be based on measurement properties and the practicalities of the situation in which they are to be used.

According to **Fuchs *et al.* (2000); Gerber *et al.* (2000); Jost *et al.* (2000); Jost et al. (2003),** the goal of such measurement systems is to provide a reproducible, responsive, and valid assessment of a patients' shoulder function. The important attributes of an outcome measure are that it accurately reflects the perspective of the subject and that it is independent of the diagnosis. The assessment should ideally be simple and easy to administer for both the subject and the examiner. Furthermore, an outcome measure obtained from a subject without the subject being present for an examination is desirable. An ideal outcome would be represented as a single numeric value with respect to subjects' ease of completion. We had found the ASES efficient at detecting clinical improvement, simpler for subjects to complete, quicker to administer, easier to score, and was simpler for both therapist and subjects.

Davies and Dick-Hoffman (1993) described a modification of the standard push-up that they termed the closed kinetic chain upper-extremity stability test. The CKC of Upper-Extremity Stability Test form contains the specific instructions for administering the CKC Upper-Extremity Stability test, as well as normative data for both males and females. Data is normalized on this test for males and females by dividing the number of line touches by the subject's height in inches. **Goldbeck and Davies (2000)** completed a test-retest reliability study of this closed chain upper-extremity stability test. Subjects were tested twice using identical methodology, resulting in a reliability coefficient of.927, indicating that this test is a highly reliable clinical evaluation tool. The average number of line touches for the 24 male college students in the study was 27.8 ± 1.77 for the pretest and 27.9 ± 1.97for the retest.

Different studies have shown that patients with multidirectional shoulder instability have poor co-ordination and strength of their rotator cuff muscles and of the scapulothoracic muscles **(Matsen *et al.*, 1990; Mallon and Speer, 1995).** We used the closed-kinetic chain upper extremity stability test to address these important elements. Although there was significant difference within each group regarding improving in stability, the results of the current study showed no statistical significance difference between the two groups after treatment.

Salem (2006) concluded that proprioceptive training is recommended in shoulder rehabilitation program to return the normal mechanics of the shoulder and to regain maximum clinical improvement of pain severity and shoulder function.

The results of the current study which showed significant difference in shoulder pain and function before and after treatment in each group matched the same results of **Salem (2006)** who investigated the effect of proprioceptive training and the traditional program in patients with rotator cuff impingement syndrome to detect the benefits of early usage of proprioceptive rehabilitation program in treatment of rotator cuff impingement syndrome. The results of his research showed statistical significant difference in both groups in the post-experimental values for shoulder function and pain levels, But proprioception was significantly improved only in the experimental group which emphasized the importance of proprioceptive training in the rehabilitation program after shoulder injuries.

Afifi (2011) studied the effect of a suggested postoperative physical therapy rehabilitation program following Arthroscopic Bankart repair on shoulder pain severity, shoulder function, and shoulder range of motions for regaining shoulder function. The suggested program was a conventional physical therapy program which consisted of cryotherapy, scapular exercises, range of motion exercises, isometric exercises, strengthening exercises and elbow and wrist isotonic exercises combined with proprioceptive training exercises for 3 sessions/ week for 12 months while the control group received a traditional physical therapy program only.

The study showed a significant difference between both groups in shoulder pain, ROM and function which attributed the benefits of the traditional program and the benefits of the proprioceptive training and concluded that the combination of proprioceptive exercises and traditional program were more effective than the traditional therapeutic exercises alone in improving all measured variables **(Afifi, 2011)**.

The VAS scale has been established as a reliable and valid instrument to measure acute and chronic pain **(Bijur PE *et al.*, 2001)**. **Flandry *et al.* (1991)** reported that the (VAS) was shown to be valid. It brought greater sensitivity and statistical power to data collection; it allowed graphic representation and numeric analysis of the collected data.

The VAS is widely used because it is easily administered and requires little to no training or equipment. However, it has several limitations in clinical use. Because pain is subjective the difference between a score of 1 and 3 is not necessarily the same as the difference between a score of 8 and 10, even though the interval between the numbers is the same. Therefore, it is not a valid use of the scale to say that a particular patient whose VAS scored dropped from 10 to 5 has experienced a 50 percent reduction in his or her pain **(Wewers and Lowe, 1990).**

The investigator and supervisors of this study would think that the results of the current study would have reached a significant difference between the treatment groups after the interventions if we had a large sample size or the duration of the intervention was more than four weeks. This is true for almost all variables but specifically true for ASES and power part of the closed-kinetic chain upper extremity stability test. We would recommend replication of this study with large sample size and lengthy treatment intervention.

One of the major limitations of this study is the small number of subjects at the time the data were analyzed. We had 10 patients dropped out of the study. Conducting the study in the clinic made it difficult to control collection of post-rehabilitation data. Once patients start to feel better, they often discharge themselves regardless of whether they have completed their rehabilitation program.

Another limitation of conducting the study is that treatment durations were 4 weeks. Patients do not achieve rehabilitation goals at the same rate. Another limitation was the patient's compliance, some patients weren't compliant enough and some were reluctant to the exercise program.

Summary

This study had been carried out to investigate the combined effect of closed kinetic chain and open kinetic chain exercises and open kinetic chain exercises alone on pain, function and stability after atraumatic shoulder instability.

Twenty male and female subjects had participated in this study, their ages ranged from 18-40 years and they were randomly assigned into two experimental groups. Group A received a program of closed chain upper-extremity exercises combined with open kinetic chain exercises for shoulder and scapular muscles for 4 weeks. Group B received open kinetic chain exercises for shoulder and scapular muscles as in group (A) for 4 weeks

Although there was significant improvement with each group pre and post treatment, our results showed that there was no statistical significance difference between the two groups after treatment regarding improving in pain severity, function of the shoulder, and the stability of the shoulder joint.

Conclusion

It could be concluded that Closed and open kinetic chain exercises yield similar effects of pain level, function, and stability of the glenohumeral joint in subjects with multidirectional shoulder instability after four weeks of treatment.

References

1. Afifi RM. Suggested physical therapy program for post arthroscopic repair of the shoulder. Unpublished master thesis. Faculty of physical therapy, Cairo University, Giza, Egypt, 2011.

2. An YH and Friedman RJ. Multidirectional instability of the glenohumeral joint. Orthop Clin North Am 31:275–285, 2000.
3. Anderson KG and Behm DG. Maintenance of EMG activity and loss of force output with instability. J Strength Cond Res;18(3):637–40, 2004.
4. Beasley L, Faryniarz DA, Hannafin JA. Multidirectional instability of the shoulder in the female athlete. Clin Sports Med 19:331–349, 2000.
5. Behm DG, Anderson K, Curnew RS.Muscle force and activation under stable and unstable conditions. J Strength Cond Res. Aug; 16(3):416-22, 2002.
6. Bresch JR, Nuber G. Mechanoreceptors of the middle and inferior glenohumeral ligaments: histologic study of human cadaver shoulders. J Shoulder Elbow Surg; 4: 563-4, 1995.
7. Burkhead WZ and Rockwood CA. Treatment of instability of the shoulder with an exercise program. J Bone Joint Surg; 74A: 890-96, 1992.
8. Cordasco FA, Wolfe IN, Wootten ME, Bigliani LU. An electromyographic analysis of the shoulder during a medicine ball rehabilitation program. Am J Sports Med.; 24: 386-392, 1996.
9. Dillman CJ, Murray TA, Hintermeinster RA. Biomechanical differences of the open and closed chain exercises with respect to the shoulder. J Sports Rehabil; 3:228–38, 1994.
10. Donatelli RA. Muscle length testing electromyographic data for manual strength testing and exercises for the shoulder. In: Donatelli R.A, physical therapy of the shoulder, p.435-465, 2004.
11. Ellenbecker TS and Davies GJ. Upper-extremity closed kinetic chain exercises. In: Ellenbecker T.S., Davies G.J. (eds.), closed kinetic chain exercise; a comprehensive guide to multiple-joint exercise. Human kinetics, p. 78-98, 2001.
12. Foster C. Multidirectional instability of the shoulder in the athlete. Clin Sports Med 2(2): 355-367, 1983.
13. Getahun TY, MacDermid JC, and Patterson SD. concurrent validity of patient rating scales in assessment of outcome after rotator cuff repair. Journal of Musculoskeletal Research, Vol. 4, No. 2, 119–127, 2000.
14. Gibb TD, Sidles JA, Harryman DT II, McQuade KJ, Matsen FA III. The effect of capsular venting on glenohumeral laxity. Clin Orthop; 268: 120-127, 1991.
15. Gibson K, Growse A, Korda L, *et al.* The effectiveness of rehabilitation for nonoperative management of shoulder instability: A systematic review; J Hand Ther; 17:229–242, 2004.
16. Goldbeck TG, Davies GJ. Test-retest reliability of the closed kinetic chain upper extremity stability test: a clinical field test. J Sport Rehabil; 9:35-45, 2000.
17. Jost B, Puskas GJ, Lustenberger A, Gerber C. Outcome of the pectoralis major transfer for the treatment of irreparable subscapularis tears. J Bone Joint Surg Am; 85:1944-51, 2003.
18. Kennedy K. Rehabilitation of the unstable shoulder. Oper Techniq Sports Med.; 1: 311-324, 1993.
19. Kisner C, Colby L A. Resistance Exercise For Impaired Muscle Performance. In KISNER C, COLBY L A. (eds.) Therapeutic Exercise Foundations and Techniques, fifth edition. Copyright © 2007 by F. A. Davis Company chapter 6 p.190.
20. Kronberg M, Brostrom LA, Nemeth G. Differences in shoulder muscle activity between patients with generalized joint laxity and normal controls. Clin Orthop.; 269: 181-192, 1991.
21. Kuhn JE. Exercise in the treatment of rotator cuff impingement: A systematic review and a synthesized evidence- based rehabilitation protocol. J Shoulder Elbow Surg.; 18: 138-160, 2009.
22. Lephart SM, Henry TJ. The physiological basis for open and closed chain rehabilitation for the upper extremity. J Sports Rehabil;5: 71–87, 1996.
23. Lephart SM, Warner JP, Borsa PA, Fu FH. Proprioception of the shoulder joint in healthy, unstable, and surgically repaired shoulders. J Shoulder Elbow Surg; 3: 371-380, 1994.
24. Mahaffey BL and Smith PA. Shoulder Instability in Young Athletes. American Family Physician vol. 59, No. 10, MAY 15, 1999.
25. Mallon WJ, Speer KP. Multidirectional instability: current concepts. J Shoulder Elbow Surg 4:54–64, 1995.
26. Matsen F, Harryman T, *et al.* Mechanics of glenohumeral instability. Clin Sports Med 10(4): 783-788, 1991.
27. Matsen FA III, Thomas SC, Rockwood CA Jr. Glenohumeral instability. In: Rockwood CA Jr, Matsen FA III (eds) The shoulder, vol 1. Saunders, Philadelphia, pp 526–622, 1990.
28. Misamore GW, Sallay PI, and Didelot W. A longitudinal study of patients with multidirectional instability of the shoulder with seven- to ten-year follow-up. J Shoulder Elbow Surg Volume 14, Number 5, 2005.
29. Morrey BF, An K-N. Biomechanics of the shoulder. In: Rockwood CA Jr, Matsen FA III (eds) The shoulder, vol 1. Saunders, Philadelphia, pp 208–245, 1990.

30. Neer C. and Foster C. Inferior capsular shift for the involuntary inferior and multidirectional instability of the shoulder: a preliminary report. J Bone Joint Surg 62: 897-907, 1980.
31. Portney LG, Watkins MP. Foundations of clinical research: applications to practice, 2nd ed. Upper Saddle River (NJ): Prentice Hall Health, p. 565, 705-11, 2000.
32. Richards R. The diagnostic definition of multidirectional instability of the shoulder: searching for direction. J Bone Joint Surg 85-A (11): 2145-2146, 2003.
33. Salem, M. M. (2006). The role of proprioceptive training in treatment of rotator cuff impingement syndrome. A thesis submitted to Cairo University fulfillment of doctoral degree. Faculty of physical Therapy. Supervisors: Hussein AH, El Senergy AE And Fawzy E.
34. Schnek T. and Brems J. Multidirectional instability of the shoulder: pathophysiology, diagnosis and management. J Am Acad Orthop Surg 6: 65-72, 1998.
35. Sillman J, and Hawkins R. Classification and physical diagnosis of instability of the shoulder. Clin Orthop 291: 7-19, 1993.
36. Speer K. Anatomy and pathomechanics of shoulder instability. Clin Sports Med 14(4): 751-760, 1995.
37. Tzannes A. and Murrell G. Clinical Examination of the unstable shoulder. Sports Med 32(7): 447-457, 2002.
38. Ubinger ME, Prentice WE and Guskiewicz KM. Effect of closed kinetic chain training on neuromuscular control in the upper extremity. Journal of sport rehabilitation, 8, 184-194, 1999.
39. Vangsness Jr CT, Ennis M, Taylor JG, Atkinson R. Neural anatomy of the glenohumeral ligaments, labrum, and subacromial bursa. Arthroscopy; 11: 180-184, 1995.
40. Warme WJ, Arciero RA, Taylor DC.Anterior shoulder instability in sport: current management recommendations.Sports Med. Sep;28(3):209-20. Review, 1999.
41. Warner JJP, Deng X, Warren RF, Torzilli PA, O'Brien SJ. Superior inferior translation in the intact and vented glenohumeral joint. J Shoulder Elbow Surg.; 2: 99-125, 1993.
42. Williams GN, Gsangel TJ, Arciero RA, Uhorchak JM and Taylor DC: Comparison of the single assessment numeric evaluation method and two shoulder rating scales. Am J Sports Med 27 (2): 214-221, 1999.
43. Yuehuei H. and Friedman R. Multidirectional instability of the glenohumeral joint. Orthop Clin N 31: 275-283, 2000.
44. Zumstein MA, Jost B, Gerber C. Instability of the Shoulder in Athletes Schweizerische Zeitschrift für «Sportmedizin und Sporttraumatologie» 53 (1), 27–35, 2005.

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