Effect of Selected Corrective Exercises on Glenohumeral Rotation range of Motion in Overhead Athletes with Scapular Dyskinesis

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Abstract
In overhead Athletes, performing the repetitive and high intensity throwing activities causes to reduce the Glenohumeral internal rotation range of motion (GIR ROM) in dominant shoulder and Scapular Dyskinesis (SD). These factors may make the shoulder predispose to injury. The purpose of this study was to investigate the effect of eight weeks of selected exercises protocol on the Glenohumeral Rotation ROM and SD in overhead athletes. The present study is a descriptive study that was conducted on 54 volleyball players with SD. Goniometer and Lateral scapular slide test (LSST) were used to measure the Glenohumeral Rotation ROM and SD, respectively. The experimental group participated in eight weeks of exercises. Data were analyzed using independent t-test. In the experimental group, the GIR and SD after exercises showed a significant increase (P= 0.001) and a decrease (P= 0.001), respectively; while in the control group, the changes were not significant. Therefore, the exercises protocol can lead to increase the GIR and correct the SD in overhead athletes, and it is recommended to consider it as a part of their routine exercises.

Key words: *rehabilitation protocol, internal rotation range of motion, Volleyball Players, scapular Dyskinesis*

INTRODUCTION

The shoulder is at high risk for injury during overhead sports, in particular in throwing or hitting activities, such as volleyball, baseball, tennis and handball because it faces high loads and forces during serving and smashing (Cools, Johansson, Borms, & Maenhout, 2015). The repetition of high velocity overhead throwing can change the shoulder stability – mobility relationship and ultimately lead to injury (Shimpi et al., 2015). A 'shoulder at risk' in the throwing athletes, is the asymptomatic shoulder with a deficit of varying degree of glenohumeral internal rotation, scapular dyskinesis or both (Burkhart, Morgan, & Kibler, 2003b). In general, three risk factors have been defined that may form the basis for recommendations for the prevention of recurrent injury: glenohumeral internal-rotation deficit (GIRD); rotator cuff strength, in particular the strength of the external rotators; and scapular dyskinesis, in particular scapular position and strength (Cools et al., 2015).

Overhead athletes' shoulders need high stability to perform throwing patterns despite having high mobility (Cools et al., 2015). This sensitive balance between mobility and stability is known as the thrower paradox. If it disturbed, may lead to injury (Shimpi et al., 2015). The movement mechanics of the throw predispose the athlete to an imbalance in the range of motion, especially

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GIRD and decrease in the strength of the Glenohumeral external rotation (GER) (Cools et al., 2015). In this regard, Shimpi et al. (2015) comparing the two groups of overhead (rocket) athletes with the control (non-rocket) group, found that in the group of overhead athletes, Glenohumeral Internal Rotation (GIR) is less and the SD is more than the non-rocket group (Shimpi et al., 2015).

The GIRD in overhead athletes is a common occurrence due to the glenohumeral arthrokinematics changes. It causes a shift in the humeral head center of rotation to an anterosuperior position on the glenoid during forwarding flexion (Harryman 2nd et al., 1990). These arthrokinematics changes cause damage to the shoulder joint structure by increasing pressure and tension forces, joint kinematic changes and interactive movements (Burkhart, Morgan, & Kibler, 2003a; W. B. Kibler, Sciascia, & Thomas, 2012).

In addition to GIRD, the SD is also important risk factors for shoulder injuries (Benjamin W Kibler, Sciascia, & Wilkes, 2012). Altered scapular motion and position have been termed SD (W. B. Kibler et al., 2013). Scapular dyskinesis is not necessarily a pathologic term. In fact, it may be found either in asymptomatic subjects or in patients with pain in the shoulder girdle (Silva, Hartmann, de Souza Laurino, & Biló, 2010), and in overhead athletes (De Mey et al., 2013; Silva et al., 2010). Dyskinesis can affect asymptomatic subject, but it is typically observed in overhead athletes in whom it may cause a SICK syndrome (Scapular malposition, Inferior medial border prominence, Coracoid pain and malposition and dyskinesis of scapular motion), responsible for shoulder pain and functional deficit. When unrecognized and untreated, SD may cause SLAP lesions, subacromial impingement syndrome (SIS) and injuries to cuff tendons (Postacchini & Carbone, 2013). Ghanbari et al. (2019) also found in their study that there is a predictive relationship between Glenohumeral rotation ROM and SD, so that the variables of decreased IR ROM and increased ER ROM can predict SD in overhead athletes (L Ghanbari, Alizadeh, Minoonejad, & Hosseini, 2019). SD is associated with a change in the pattern of activity of the scapulothoracic muscles (Leila Ghanbari, Alizadeh, Minoonejad, & Hosseini, 2018; Ben W Kibler & McMullen, 2003). During arm abduction, the upper trapezius (UT), lower trapezius (LT) and serratus anterior (SA) result in the upward rotation and posterior tilt of the scapula as force couples (B. W. Kibler et al., 2012). Therefore, reducing the strength and activity level of the SA and LT (Cools et al., 2007) as well as delayed onset of activation of these muscles caused a change in the upward rotation and posterior tilt of scapula (Park et al., 2014). Previous studies have reported excessive activation of UT (Cools et al., 2007; Lopes, Timmons, Grover, Ciconelli, & Michener, 2015; Oliveira, Batista, Pirauá, Pitangui, & Araújo, 2013) and decreased activity of SA, LT (Cools et al., 2007), AT/LT, AT/SA in subjects with SD (Oliveira et al., 2013). These altered muscle activation patterns are associated with altered scapular kinematics, including reduced scapular upward rotation, external rotation and posterior tilt (Ludewig & Cook, 2000).

Treatment is based on rehabilitation, but not for all exercises there are sound proofs of efficacy. Some researchers were recommended performing exercises aimed at increasing the activity level of the LT (Burkhart et al., 2003a; Ben W Kibler & McMullen, 2003; Ludewig & Reynolds, 2009) and SA muscles (Cools et al., 2007) while minimizing the activity level of the UT (Cricchio & Frazer, 2011) through conducting electromyographic studies (Leila Ghanbari et al., 2018; B. W. Kibler et al., 2012; Park et al., 2014).

In addition, shoulder stretching exercises can improve posterior capsule stiffness and IR ROM (B. W. Kibler et al., 2012). Kuhn (2009) confirmed that a shoulder intervention program must focus on strengthening of the rotator cuff and periscapular muscles, joint mobilization, and posterior capsule stretching (Kuhn, 2009). The exercise program of Tang et al. (2021) also emphasized scapular stabilization exercises. The results of this study provide evidence of the effect of targeted scapular stabilization exercise in improving shoulder function and correcting scapular dyskinesis(Tang et al., 2021).

The treatment of SD described in the literature is based on exercises that increase soft tissue flexibility and ROM. Others have also suggested strengthening exercises for the periscapular muscles without overload of the hyperactive muscles (Cools et al., 2007; B. W. Kibler et al., 2012). In addition, specify studies have examined the effects of exercises protocol on overhead athletes with SD. However, there is a need for further investigation and descriptions of exercise protocol focused on SD correction and improve the GIR in overhead athletes. Thus, the purpose of this study was to describe the exercise protocol that emphasizes GR ROM and SD correction on overhead athletes. It was hypothesized that after this exercise protocol, subjects would experience improved GR ROM and SD.

MATERIALS AND METHODS

The present study is a descriptive study and the subjects consisted of 54 female volleyball players (club-level, 18–25 years old) who were selected by available method. Inclusion criteria include: female gender, having at least three years of regular sports experience in volleyball and the presence of SD, and the exclusion criteria included pain in the shoulder girdle and neck in the normal and practice conditions, history of fracture or dislocation in each shoulder girdle bones, complete rupture of shoulder girdle muscles; and history of surgery in the shoulder girdle (B. W. Kibler et al., 2012).

A total of 177 volleyball players were evaluated by an experienced physiotherapist and According to the inclusion and exclusion criteria, 54 subjects with SD were selected. Then They were divided into two groups: experimental, who participated in exercise protocol (n= 27, age= 21.59± 2.63 years old, weight: 62.48± 7.25 kg and height: 165.66± 3.58 cm) and control (n = 27, age= 22.85±2.1 years old, weight: 62.88±5.51 kg and height: 164.92±4.35 cm), who didn't participate in exercise protocol. Written consent was also obtained from all subjects.

Data measurement methods

Scapular Dyskinesis (SD): The Lateral scapular slide test (LSST), was used to investigate the SD. In this test, the distance between the inferior angle of the scapula to the corresponding spinous process in the three positions of 0, 45 and 90 degrees of shoulder abduction was measured. Each of the measurements was repeated three times in both arms and then their average was calculated (figure 1). If there was a difference of 1.5 cm or more between two the scapulae, the test was considered positive. Kibler reported the in-group reliability of this test from 0.84 to 0.88 and the out-group reliability from 0.77 to 0.85 in different aspects (Ben Kibler, 1998).

IR ROM and ER ROM: The passive rotational range of motion for the glenohumeral joint was assessed by a standard goniometer (360°, Lafayette company product). The participant lay supine on a treatment table with the legs straight and the dominant arm in 90° abduction in the coronal plane and 90° of elbow flexion with the elbow slightly off the table's edge. Maximal external and internal rotation were measured with the goniometer's axis in line with the shaft of the humerus, the stable arm perpendicular to the floor and the movable arm in line with the ulnar styloid. When measuring internal rotation, we allowed motion to occur until the spine of the scapula began to lift off the table. This defined the maximal value for internal rotation. The movement reaches its endpoint when the coracoid tends to move against the palpating thumb. For external rotation, the fixating hand is placed gently over the shoulder top, and the shoulder is moved into

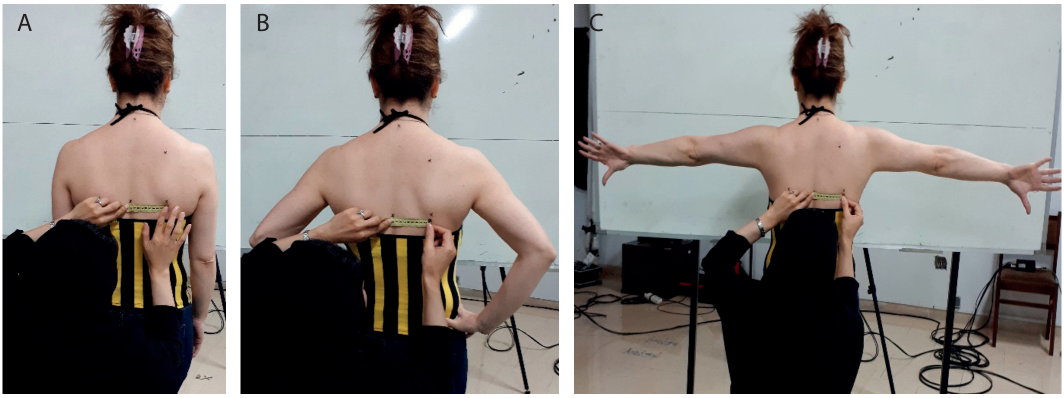

Figure 1. Lateral scapular slide test. A) both arms at the sides in glenohumeral joint neutral. B) with hands on hips and with thumbs posterior. C) with arms abducted 90 degrees with full shoulder internal rotation

external rotation, aligning the goniometer with the forearm (Cools et al., 2015). In addition, the measurements were performed in the dominant hand of the subjects.

Exercise program: The protocol used included the exercise protocol of Moura et al. 2016 (Table 1), which was performed by the experimental group to repeat three sessions of exercise per week with moderate intensity for eight weeks. The training protocol consisted of three stages. Phase 1 consisted ROM and periscapular muscular strengthening training, Phase 2 focused on periscapular muscular strengthening and initiation of sensory motor training and phase 3 on advanced sensory motor training. All exercises were dosed at 3 sets of 15 repetitions throughout the protocol, and this intermediate dosage was chosen in order to focus on muscular strength and endurance (Moura, Monteiro, Lucareli, & Fukuda, 2016). The rest between each set was gradually reduced until the end of the period. Activity intensity was monitored using the Borg scale PRE (Borg, 1998) and OMNI resistance exercise scale (Colado et al., 2012). The Borg scale is a numerical scale that ranges from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion" (Borg, 1998). When measured, a number is chosen from the following scale by an individual that best describes their level of exertion during physical activity; and according to OMNI-resistance exercise scale, by increasing the separation between the hands gripping the elastic band, the intensity decreases.

Table 1. Selected exercise protocol

Phase 1 (week 1&2)	Phase 2 (week 3–5)	Phase 3 (week 6–8)
Sleeper stretch (60°, 90°, 120°)	Sleeper stretch (60°, 90°, 120°)	
Sitting, arms in neutral position, pull their shoulder blades back and down	Punch with dumbbells	Standard push-up plus with the Swiss ball
Punch exercise	One-hand push-up plus exercise	Modified prone Cobra on Swiss ball with dumbbells
Wall push-up plus exercise	Modified prone Cobra with dumbbells	Prone horizontal abduction exercise on the Swiss ball with dumbbells
Modified prone Cobra	Prone horizontal abduction exercise	Prone V-raise exercise on the Swiss ball with dumbbells
	Prone V-raise exercise	Low row exercise with theraband
	Prone row	Rotator cuff exercise with theraband
	Rotator cuff exercise	

1-sample K-S statistical test was used to check the normality of data distribution. According to the normality of data distribution, Independent t-test was used to compare the mean variables of IR, ER and SD between the experimental and control groups before and after exercise. Analysis was performed with IBM SPSS statistics version 22 and α <0.05 was considered.

RESULTS

The demographic information of the samples is presented in Table 2.

Table 2. The Demographic Characteristics of the Two Groups[a]

Variable	Groups	Mean±SD	P-Value
Age (year)	Experimental	21.59±2.63	0.163
	Control	22.85±2.1	
Height (cm)	Experimental	165.66±3.58	0.511
	Control	164.92±4.35	
Weight(kg)	Experimental	62.48±7.25	0.110
	Control	62.88±5.51	

[a]Values are expressed as mean ± SD and analyzed by 1-sample K-S test.

1-sample K-S statistical test was used to evaluate the normality of data distribution. Regarding that the sig factor is greater than 0.05 in all variables, the data distribution is normal. The results of Independent t-tests indicated that there was no significant difference between the two groups in terms of height, weight, age (table 2), IR ROM, ER ROM and SD (table 3) and the two groups were homogeneous ($P < 0.05$).

Table 3. Mean and SEM of IR, ER and SD and the Changes Between Two Groups[a]

Variable	Time	Experimental	Control	p-value
Internal rotation range of motion (degrees)	Pre	46.59±4.90	47.18±10.37	0.628
	Post	52.74±5.18	47.66±5.00	0.001*
External rotation range of motion (degrees)	Pre	97.07±10.37	95.03±9.18	0.890
	Post	95.77±10.14	95.77±9.22	0.628
Scapular Dyskinesis (cm)	Pre	1.80±0.32	1.75±0.30	0.653
	Post	1.60±0.25	1.75±0.28	0.001*

[a] Values are expressed as mean ± SEM and analyzed by IR, ER and SD t-test.

Independent t-test was used to compare the mean variables of IR, ER and SD between the experimental and control groups before and after exercise (Table 3). Table 3 presents the pre- and post-mean, SEM of the IR, ER and SD between the two groups. The IR increased significantly after eight weeks of exercises in the experimental group (P= 0.001), whereas there was no significant increase in the control group (P= 0.628). The SD decreased significantly in the experimental (p= 0.001), while the changes in ER were not significant.

DISCUSSION

Results of the study showed that the exercises protocol significantly increased the IR ROM and significantly reduced the SD of the mentioned athletes. It can also reduce the ER ROM, although this reduction was not significant.

The repetitive overhead motions which usually involve excessive ER with a maximally abducted position (cocking phase) and the subsequent phases of acceleration/deceleration and follow-through place a high amount of stress on the static and dynamic stabilizers of the shoulder, including the rotator cuff, joint capsule, and labrum. This repetitive overuse load will ultimately lead to a failure in these structures to absorb arm energy, predisposing them to injury, which generates pain and posterior shoulder tightness (Borsa, Laudner, & Sauers, 2008). Posterior inferior capsular and rotator-cuff tightness have been suggested as the main contributing factors to the loss of GIR for most athletes (Lintner, Mayol, Uzodinma, Jones, & Labossiere, 2007).

In the present study, GIR in the experimental group increased significantly after exercise (IR_{pre}= 46.59±4.90, IR_{post}= 52.74±5.18, P= 0.001). Stretching has been proposed as an effective approach for the management of GIRD, restoring shoulder ROM, and reducing the incidence of shoulder injury and muscle soreness (Burkhart et al., 2003a; W. Kibler & Chandler, 2003). Burkhart et al. (2003) and Launder at al. (2008) examined the effect of the Sleeper Stretch on GROM and found that the sleeper stretch group improved significantly in IR compared to the control stretching group (Burkhart et al., 2003a; Laudner, Sipes, & Wilson, 2008). Moura et al. (2016) presented a rehabilitation training program to amateur athletes with SD to reduce subacromial pain, increase ROM, periscapular muscular strengthening, and SA activation. The authors also attributed the increase in ROM to the posterior capsule structures stretching (sleeper stretch) (Moura et al., 2016). In the present study, it seems that the increase in IR is due to the stretching (sleeper stretch) of the posterior shoulder structures. This finding confirms the reports of other authors who attribute this deficiency in the IR ROM to joint capsule stiffness disturbance and SD (3, 37, 47). Sajadi et al. (2019) also reported a significant increase in GIR in swimmers with SD following the training protocol of Moura et al. (2016) According to the results of this study, performing sleeper stretching at three angles of 60, 90 and 120 degrees increased the GIR in swimmers with SD (Sajadi, Alizadeh, Barati, & Minoonejad, 2019). The results of a systematic review study suggest that the rehabilitation program for subjects with shoulder dysfunction should focus on periscapular muscular strengthening and rotator cuff, joint mobilization techniques, and posterior capsule stretching (Kuhn, 2009).

Another finding of this study was a significant reduction in SD in the experimental group following eight weeks of exercises (SD_{pre}= 1.80±0.32, SD_{post}= 1.60±0.25, P= 0.001*). Due to relationship of GIRD in the incidence of SD (L Ghanbari et al., 2019; Ben W Kibler & McMullen, 2003), performing corrective exercises by increasing IR ROM can reduce the rate of SD. In their study, Kibler et.al cited the posterior capsule stiffness as one of the causes of SD and recommended stretching and flexibility exercises to treat it (Ben W Kibler & McMullen, 2003). According to studies, in overhead athletes with GIRD, the protracted scapula was associated with SD, and increasing IR deficiency lead to increase the rate of SD (Borich et al., 2006; Thomas, Swanik, Swanik, & Kelly, 2010). In interpreting the relationship between GROM and SD, it can be stated that during the Follow through phase of the throw, the scapula helps to release energy by protracted on the chest (Thomas, Swanik, Swanik, & Kelly IV, 2010; Thomas, Swanik, Swanik, & Kelly, 2010). In case of IR deficiency, protracting the scapula increases in order to compensate the IR deficiency and also to maintain the overhead acceleration. At this time, this constant pressure causes soft tissue adaptation and weakness in the scapular stabilizers (Shimpi et al., 2015; Thomas, Swanik, Swanik, & Kelly IV, 2010; Thomas, Swanik, Swanik, & Kelly, 2010). Therefore, the scapula cannot provide a stable surface to support the rotator cuff muscles. This reduces its efficiency and increases the pressure on the dominance shoulder static structures (Cools et al., 2015). Thus, the rotator cuff pushes the scapula outward rather than putting pressure on the head of humerus in the glenoid fossa, causing further external protrusion and rotation of the scapula, altering the scapulohumeral rhythm, and disrupting the scapular movement (W. B. Kibler et al., 2013). According to the explanations provided, the relationship between the shoulder rotation ROM and SD was well explained. Therefore, it seems that increasing the shoulder rotation ROM was one of the reasons for reducing the SD in the subjects.

On the other hand, SD is associated with muscle imbalance (Ben W Kibler & McMullen, 2003). According to a study by Seitz et al. (2015). Athletes with SD had less upward rotation of scapula and GER, and weaker LT muscles than athletes without SD. Weakness of SA and LT strengthening was associated with lack of upward rotation of scapula (Seitz, McClelland, Jones, Jean, & Kardouni, 2015). Also, due to the importance of the SA role in the stability of the scapula, its disorder and imbalance in each of the SA, UT, LT muscles can change the natural three-dimensional movement of the scapula and its asymmetry (Ludewig & Cook, 2000). While pointing out that the asymmetry of the scapula (Ben Kibler, 1998) and its abnormal movement can be referred to as SD (B. W. Kibler et al., 2012; W. B. Kibler et al., 2013), many researchers have recommended targeted exercises by conducting electromyographic studies and with regard to the prevalence of imbalance in scapulothoracic muscle activation and also the presence of muscle imbalance in the force couples of UT with LT and SA in patients with SD (B. W. Kibler et al., 2012; Park et al., 2014). Therefore, in shoulder rehabilitation exercises, the focus should be on increasing the SA and LT activity (Pirauá et al., 2014), reducing the UT activity (Cools et al., 2007; B. W. Kibler et al., 2012), reducing the ratio of UT to SA, ratio of UT to LT and the ratio of UT to middle trapezius and strengthen the rotator cuff muscles (Cricchio & Frazer, 2011). Exercises such as Push-up plus, dynamic hug and punch are recommended, which can also amplify the SA muscle via production of the largest electrical signal (Pirauá et al., 2014). As Moura et.al commented on interpreting the results of their study, one of the reasons for the decrease in the symptoms of SD can be attributed to the increased level of SA muscle activity following participation in the rehabilitation exercise protocol (Moura et al., 2016). This finding is consistent with the view of some authors that the

SA is an important muscle that participates in three scapular movements during arm elevation and also usually decreases in activity during shoulder injuries (B. W. Kibler et al., 2012; Ludewig & Reynolds, 2009). Therefore, it can be stated that one of the reasons for the reduction of SD in the subjects of the present study was as a result of sensory motor training of the present training protocol. It is suggested to study the effect of the present protocol on the strength of shoulder rotator cuff muscles and electromyographic activity of scapulothoracic muscles in athletes with SD in other studies. Also, among the limitations of the present study is the lack of control over the effect of other protocol exercises on variables related to SD such as the strength of shoulder rotators and periscapular muscular activity.

CONCLUSION

According to the results of the study, the exercises protocol of the present study, responds well in volleyball players with SD, so that caused a significant increase in the GIR and a decrease in SD in volleyball players. It is recommended to consider it as a part of their routine exercises.

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