To Evaluate Strength and Motion Range of Internal and External Rotational of the Arm in Even and Uneven Shoulder of Men Volleyball Players

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Abstract

Introduction: The shoulder joint is the most used joint in volleyball players. Performing repetitive movements and over-the-top attacks, the shoulder joint is under stress and leads to an asymmetrical shoulder and pain in the shoulder joint. The purpose of this study was to evaluate the strength and range of motion of internal and external rotating muscles in the asymmetric shoulder of the affected and non-volleyball players. **Methods and Materials**: This research is descriptive and causal-comparative. The statistical sample of this study was randomly assigned into two groups of affected and non-affected patients according to the research criteria. To measure the strength of the muscles of the rotator in two positions of zero and 45 degree shoulder from the dynamometer device (MMT), we used goniometer to measure the range of shoulder muscles and the scolymeter device was used as a symmetrical shoulder diagnostic tool. **Results:** There was a significant difference between the strength of internal (P=0/03) and external (P=0/02) rotating muscles in both non-diabetic and non-affected groups. Also, in this study, the internal (P=0/02) and external (P=0/03) spin amplitudes were significantly different in the two groups with and without asymmetric shoulder. **Conclusion**: The findings of this study showed that high muscle strength in asymmetric shoulder volleyball players is known as a risk factor in many studies. Limitations in the range of motion of the shoulder movements in the shoulder joint of asymmetric shoulder volleyball players require attention to preventive approaches by creating corrective strategies.

Keywords: Even Shoulder; External Rotation of the Arm; Internal Rotation of the Arm; Strength; Ueven Should

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Introduction

Optimal and fit body condition requires the coordination of different parts of the body, and one of the parts that play an essential role in maintaining the desired physical condition is the scapula. The role of scapula has been significantly considered in recent years, so that it is very important in the generation of soft coordinated movements of the shoulder girdle (1) Kibler acknowledges that the role of scapula in throwing and serves is to obtain appropriate movements and positions to facilitate shoulder function (2). In other words, proper shoulder movements are critical for normal shoulder mechanics and are effective during throwing (3). The position of scapula and its orientation in throwing athletes also have a clear difference with non-throwing athletes, which indicates that adaptations in these athletes are proportional to their activity (4). The inability of the scapula to perform these roles results in loss of physiological and biomechanical efficiency, so shoulder function will lose its effectiveness. This can lead to poor performance and increased shoulder injuries (5).

One of the main features of scapula is that it acts as a base for connecting muscles, and its displacement can affect the function of muscles around the shoulder girdle, especially the scapula stabilizers. In addition, it is stated that the position of scapulae is directly related to the production of muscle forces as well as the motion range of the shoulder girdle. Therefore, it seems that scapula displacement can affect the function and production of the muscular force of the shoulder girdle, especially the scapula's stabilizing muscles. In volleyball athletes, repetitive movements such as abduction and outward rotation, which are accompanied by extensions and turning in, as well as hitting the ball in maximal abduction, increase impingement force. In addition, it has been shown that muscle imbalance and rotational muscle weakness are risk factors for athlete's shoulder injury in athletes who exercise overhead (6). Regarding the main cause of changes in the distance of the scapula from the spine, some researchers have stated that the placement of the scapula is an inherited condition that some people are born with (7). However, others

Figure 1. Scoliometer to measure the degree of evenness

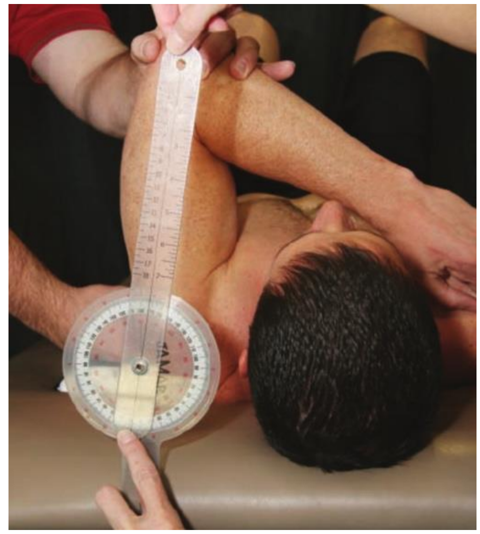

Figure 2. Goniometer for measuring range of motion

believe that if the scapula holding muscles do not have the necessary endurance, strength, and flexibility, there will be many changes in this area due to their important role in the position of scapulae relative to each other (8). Studies of previous research have shown that very little research has been done on the strength and range of motion of the muscles around the shoulder, as well as the power ratio between the muscles around the glenohyomral joint in elite athletes and the ratio of the external rotator muscles to the internal rotator muscles is mainly examined (9). On the other hand, another study deliberately compared female physical strength with that of male athletes, or examined and compared female athlete and non-athlete women, and concluded that male athletes had more physical strength than female athletes or female athletes have better condition compared to non-athlete women in terms of physical strength or other physical fitness factors (10). Therefore, due to the fact that the imbalance of power between the agonist and antagonist muscles of the glenohyomral joint can cause damage to the shoulder joint and shoulder impingement syndrome, it is necessary to conduct research in this regard (11).

Because the researcher has not reached extensive research on athletes in this regard, and our research has shown that none of these studies have examined the effect of scapula placement on the strength of the shoulder girdle muscles in volleyball players, the present study investigates and compares the strength of shoulder muscles in male volleyball players according to the position of their shoulders and seeks to confirm or deny that the internal and external rotational power of the humerus as well as the range of motion in the internal and external rotation has a significant difference in volleyball players with even and uneven shoulders.

Methods and Materials

The present study was a retrospective study (strength and range of motion of internal and external rotation of the humerus) and it is applied in nature. The statistical population in this study were all male volleyball players in Mahabad who had at least 3 years of regular sports experience and exercised an average of 3 sessions per week. Statistical samples were selected through non-random convenient sampling method. Prior to the commencement of the investigation, all subjects signed the consent form for participation in the research tests and filled out a form for collecting individual information and the form related to injuries and sports experience. Before the tests were performed, the weight and height measurements were made and their body mass index was calculated. According to the inclusion and exclusion criteria, athletes entered the study in both suffering and non-suffering groups (15 people in each group). The subjects warmed up for 5 to 10 minutes before the test. It should be noted that the test was performed three times for each variable with a time interval of 30 seconds, the highest data in the measurement of power and the mean data in the range of motion was the basis of statistical work.

The shoulder was first measured by a scoliometer to determine the asymmetry of the shoulders, which required to identify the location of two bony marks. In this study, those with more than two degrees of deviation in their shoulders were included in the group of people with uneven shoulders (12). The strength of the internal and external rotating muscles was measured in neutral state (zero degree of shoulder abduction). Each test was performed three times for each of the dominant and non-dominant hands, and the highest value was recorded as the strength of each organ (Figure 1).

Table 1. Anthropometric characteristics of participants in both groups

Group	Number	Age (Years)	Height (cm)	Weight (Kg)
		Mean (SD)	Mean (SD)	Mean (SD)
Uneven shoulder (Degree)	15	23 (1.4)	176 (4.3)	72.7(4.1)
Even shoulders (Degree)	15	24 (2.1)	177.3 (3.1)	74.2(2.4)
***P*-value**	-	0.48	0.63	0.31

** Significance level P≤0.05*

Table 2. Independent t-test results, comparing internal and external rotational power of suffered and non-suffered groups [Mean (SD)]

Group	The suffered group	Non-suffered group	*T*-value	*P*-value
Internal rotational power of dominant hand (newton)	12.32 (4)	13.17 (3.1)	-3.87	0.03
Internal rotational power of non-dominant hand (newton)	13.75 (3.7)	14.40 (3.2)	۹۸	0.35
External rotational power of dominant hand (newton)	12.7 (4.55)	11.32 (2.3)	-3.77	0.02
External rotational power of non-dominant hand (newton)	11.41 (3.5)	13.23 (2.7)	۹٤	0.45

*** Significance level P≤0.05*

To assess the range of outward rotation, when the subject was lying on the bed in a supine position, he was told to keep the shoulder girdle muscles in a completely relaxed position. The shoulder was bent at 31 degrees abduction to the edge of the bed and the elbow was bent 31 degrees and perpendicular to the bed. By applying force to the subject's forearm, the examiner moved his shoulder joint passively around the frontal axis toward the external rotation, releasing the forearm slowly at the end of the range without applying additional force. The examiner placed the goniometer on the olecranon appendage so that the fixed arm was perpendicular to the ground and downward, and the movable arm was along the midline of the forearm. So the range of outward rotation of the shoulder around the frontal axis was calculated (13) (Figure 2).

To assess the range of inward rotation, the subject was explained to keep the muscles of the shoulder girdle in a completely relaxed position as he laid in a supine position. The shoulder was bent at 31 degrees to the edge of the bed and the elbow was bent 31 degrees and perpendicular to the bed. By applying force to the subject's forearm, the examiner moved his shoulder joint passively around the frontal axis toward the internal rotation, placing the other hand on the acromioclavicular joint. Since the goal was to examine the range of internal rotation of the glenohumeral joint, as soon as the feeling motion in the acromioclavicular joint, the internal rotation is stopped and the patient's hand was hold by another person. (Receiving verbal feedback) The examiner placed the goniometer axis on the elbow appendage so that the fixed arm was perpendicular to the ground and the movable arm were along the midline of the forearm. This range of inward rotation was calculated around the frontal axis. To increase the accuracy of the measurement and reduce the error rate of the test, the evaluation steps of the rotation range outward and inward the shoulder joint were repeated three times and the mean of three results was recorded. All steps were performed for the dominant as well as the non-dominant shoulder (Figure 2).

Result analysis

Descriptive and inferential statistics were used to analyze the data. Data normalization was performed in a Kolmogorov-Smirnov test due to the sample size over 30 people. To calculate the mean and standard deviation, descriptive statistics and to compare the strength and range of motion of even and uneven shoulders of volleyball players, the independent t-test were used and to compare each of the suffered and non-suffered groups, paired t-test was used. All tests were performed at a significance level of $P \leq 0.05$ with SPSS version 20. (Tables 1 to 5)

Results

Table 1 shows the mean and standard deviation of age, height and weight of the subjects for two groups with even and uneven shoulders.

Table 3. Paired t-test results of internal and external rotational power of the dominant and non-dominant hand [**Mean (SD)**]

Group	Dominant hand	Non-dominant hand	*T*-value	*P*-value
Suffered internal rotational power (Newton)	16.32±4	13.75±3.7	2.98	0.004
Internal rotational power of non-suffered (Newton)	13.17±3.1	14.40±3.2	7.3	0.031
Suffered external rotational power (Newton)	14.55±2.7	11.41±3.5	2.12	0.04
Non-suffered external rotational power (Newton)	11.32±2.3	12.23±2.7	٨٤	0.45

** Significance level P≤0.05*

Table 4. Independent t-test results, comparison of the range of motion of internal and external rotation of suffered and non-suffered groups [Mean (SD)]

Group (degree)	Suffered group	Non-suffered group	*T*-value	P-value
Internal rotational range of motion of the dominant hand	82.15±8.2	72.5±7.4	-0.77	0.03
Internal rotational range of motion of the non-dominant hand	85.7±1.2	85.58±6.4	٩٠	0.41
External rotational range of motion of the dominant hand	107.10±6.1	100.9±7.02	-6.87	0.02
External rotational range of motion of the non-dominant hand	109.7±8.10	98.45±5.1	٧١	0.10

** Significance level P≤0.05*

Table 5. The results of paired t-test of range of motion of the internal and external rotation of the dominant and non-dominant hand

Group (degree)	Dominant hand	Non dominant hand	*T*-value	*P*-value
The range of motion of suffered internal rotation	72.15 (8.2)	82.91 (7.5)	-9.77	0.02
The range of motion of non-suffered internal rotation	98.47 (5.8)	85.58 (6.4)	101	0.50
External rotation range of motion of non-suffered	99.05 (4.7)	98.45 (5.1)	65	0.38
External rotation range of motion of suffered	107.1 (6.2)	101.8 (7.9)	-15.84	0.04

** Significance level P≤0.05*

Table 2 shows the independent t-test results, which compared the internal and external rotational power means of the dominant and non-dominant shoulders of both the suffered and non-suffered groups as out group. The data in this table show that there is a significant difference between the strength of the internal rotating muscles of the dominant hand in even and uneven shoulder groups (*P*=0.03), so that the even shoulder group shows an increase of 12.1% compared to uneven shoulder group. There is no significant difference between the strength of the external rotating muscles in the dominant hand of even and uneven shoulder groups (*P*=0.02), so that the even shoulder group increased by 8.6. There is no significant difference between the strength of the internal rotating muscles of the non-dominant hand in even and uneven shoulder groups.

Table 3 shows the results of paired t-test, which compared the internal and external rotational power means of the dominant and non-dominant hands of both the even and uneven shoulder groups as intragroup. The data in this table show that there is a significant difference between the strength of the internal rotating muscles of the dominant and non-dominant hand in the group with uneven shoulder (*P*=0.004). The strength of the internal rotating muscles of the dominant hand is increased by 14.76% compared to the non-dominant hand. However, there is no significant difference between the strength of the internal rotating muscles of the dominant and non-dominant hands of the non-suffered group. There is a significant difference between the strength of the dominant and non-dominant external rotating muscles in the uneven shoulder group (*P*=0.004). The strength of the internal rotating muscles of the dominant hand has increased by 17.30% compared to the non-dominant hand. But there is no significant difference between the strength of the internal rotating muscles of the dominant and non-dominant hands of the non-suffered group.

Table 4 shows the results of independent t-test that compared the mean range of internal and external rotation of the dominant and non-dominant hand of both even and uneven shoulder groups as out-group. The data in this table show that there is a significant difference between the range of motion of the internal rotating muscles of the dominant hand in even and uneven shoulder groups (*P*=0.03) and the even shoulder group showed a decrease of 9.8% compared to the uneven shoulder group. There is a significant difference between the range of motion of the external rotation muscles of the even and uneven shoulder groups (*P*=0.02) and the uneven shoulder group showed an increasing difference of 15.4% compared to the even shoulder group.

Table 5 shows the results of paired t-test, which compared the mean range of motion of internal and external rotation of the dominant and non-dominant hand of both suffered and non-suffered groups as an intragroup. The data in this table show that there is a significant difference between the range of motion of the internal rotating muscles of the dominant and non-dominant hand in the uneven shoulder group (*P*=0.02) and in the dominant hand group compared to the non-dominant hand group showed an increase of 14.15%. There is a significant difference between the range of motion of the external rotating muscles of the dominant and non-dominant hand in the group with uneven shoulder (*P*=0.04). The dominant hand group showed a 7.90% increase compared to the non-dominant group.

Discussion

According to the results of this study, there was a significant difference between the strength of the internal rotating muscles of the dominant hand in even and uneven shoulder groups (*P*=0.03), so that the even shoulder group increased by 12.01% compared to the uneven shoulder group. The results are consistent with the results of Meyer et al., Cole et al., Favre et al., who found that throwing athletes with uneven shoulders were more powerful (3, 18, 19). However, it is inconsistent with the results of Nodehi, Wilk, and Wang, who showed that the strength of the internal rotating muscles on the dominant hand in volleyball players with uneven shoulders was significantly lower than in healthy individuals (15, 16, 17). The reason for this can be attributed to the frequent movements of volleyball players with the dominant hand during training and competitions, especially hit and serve techniques, which strengthens the shoulder muscles on the dominant hand, and creates a lack of evenness in the strength of the hand and shoulder muscles on both sides and this over time leads to an increase in shoulder unevenness.

Throwing or hitting, especially at a high level, requires the shooter to repeatedly expose his shoulder to strong, repetitive rotational movements. This repetition of movements leads to neuromuscular training, and this improves performance and strength. The reason is that athletes' movements over their head are delicate and precise, and the dominant shoulder in volleyball players is repeatedly exposed to more intense rotational movements than the non-dominant shoulder due to the repeated blows of the hits and repetitive single-handed serves. These repetitive movements are likely to lead to neuromuscular adaptation, thereby improving muscle strength. There is a significant difference between the strength of the external rotating muscles of the superior hand in groups with or without even shoulder and a significant difference is also seen between the strength of the external rotating muscles of the dominant and non-dominant hand in the uneven shoulder group. The results are consistent with the results of Marcelino et al., who confirmed the significant difference in external rotators in one-way sports. (21) However, it is inconsistent with Wang's results showing that the strength of the external rotating muscles on the dominant side of the uneven shoulders of volleyball players was significantly lower than in healthy individuals. (9) One of the possible reasons for this is the fact that over-head throwing athletes apply frequent and remarkable eccentric forces to the shoulder, especially during the throwing slowing acceleration phase, which may reduce the external power of the athlete's shoulder at 90 degrees abduction.

The rotating muscles act as the depressors and stabilizers in the head and arms, allowing the deltoid to ascend the Humerus in abduction, extension positions interiorly while maintaining the Glenohumeral joint center of rotation. Chronic repetitive activities and minor injuries increase the instability of the Glenohumeral and increase the need for rotating muscles to maintain the center of rotation. If the strength of the rotating muscles is insufficient, head and arms move anteriorly and upward, leading to impingement, pain, and brachial plexus stimulation. With severe recurrent movements of tendons, pain, and rotational inflammation spread and can eventually lead to rupture. Because volleyball players use the dominant limbs and one side of the body more during sports such as hit and serve, the muscles of the dominant limbs are affected by the exercises and lead to uneven shoulders, it is accompanied by an increase in muscle strength possibly due to repeated use of the shoulder joint. Unilateral exercises such as volleyball cause adaptive changes in muscle strength in the dominant arm. (10) These changes are due to certain exercises that increase the strength of the muscles on this side of the body. Therefore, training to increase muscle strength on the non-dominant side also seems necessary to prevent muscle imbalance and consequently injury. There was a significant difference between the range of motion of the internal rotating muscles in the dominant hand of even and uneven shoulder groups, and there was also a significant difference between the range of motion of the dominant and non-dominant hand internal rotating muscles in even and uneven shoulder group. Based on the results of this study, it was observed that the affected group has less internal rotation than in uneven shoulder volleyball players.

Findings related to internal rotation in this study, which showed that there was a significant difference between the range of motion of internal rotating muscles of even and uneven shoulder groups, were in line with the results of Shanley et al. (2012) showing the mean internal rotation of shoulder in healthy volleyball players less than those suffered from uneven shoulder, but not consistent with the results of the study by Andrade et al. [2013]. Because throwing athletes exert frequent microtraumatic pressures on the tissues around their shoulder joint as a result of the throw, this factor constantly challenges the tissues and leads to certain adaptive changes including in the range of motion of the joint that the shoulder makes them prone to injury and subsequently disrupts the performance of the professional throw. This is one of the reasons for the pain and unevenness of shoulder, followed by the need for shoulder rehabilitation in throwing athletes. Therefore, preventive recognition of these changes and efforts to control them is necessary. In (2011) Wilk et al., in a research found that overhead throwing athletes repeatedly applied eccentric forcers to the shoulder, especially during the slowing acceleration phase, which reduced muscle flexibility and that reduced internal rotation range in athletes' shoulders. (16) The results of the present study showed that there was a significant difference between the range of motion of the external rotating muscles in the dominant hand of even and uneven shoulder groups. Based on the results of this study, it was observed that the affected group had a greater range of external rotation than volleyball players with no uneven shoulders. The results of the present study was consistent with the results of Safran et al., (2001) suggesting that athletes applied repeated stress to the anterior-inferior part of the capsule during a throwing movement due to excessive external rotation at 90 degrees of shoulder abduction. (14) But it was inconsistent with the results of Wilk et al., who reported the same maximum range and external rotational force of the launchers' shoulders during the season. (16) For a possible interpretation of the reduction in internal rotation and the increase in external rotation, it can be said that in the case of the posterior capsule contracture and posterior ligament band condition of the lower glenohumeral ligament, which is caused by repeated microtraumas during the negative acceleration phase of throwing, the main possible cause is internal and external rotation defects. However, another possible cause could be a bone compliance that results in a retroversion of the humerus. In this case, the humerus center of rotation obtains the upper posterior displacement and reduces the contact area of the head and the lower anterior view of the capsule, which can lead to differences in the range of motion of the even and uneven shoulders of volleyball players. The study said uneven shoulder volleyball players have limited range of motion, and frequent microtraumas can cause this change by creating contractures in the tissues surrounding the joint, inserting the shoulder joint into a vicious cycle that, if left unstopped, it can lead to pain, injury, followed by inability to perform professionally and the need for maintenance training in shoulder rehabilitation. Lack of overall range of motion is associated with a higher risk of injury. Therefore, it is important to maintain a general range of motion during the competition season with a regular stretching program.

Limitations

Only male volleyball players from Mahabad with at least 3 years of regular sports experience were included in the study, therefore the effect of gender on the results could not be investigated. On the other hand, due to the lack of control over the participants' activities outside the test time, the effect of the subjects' physical fitness level on the results could not be controlled. The lack of previous experience of the subjects in relation to the performance of the strength and range of motion tests, training the subjects was not the same.

Research recommendations for future works

1. It is recommended that in addition to assessing the strength and range of motion of the internal and external rotation of the shoulder in uneven shoulder volleyball players, other variables such as shoulder and arm abductors and eductors should be measured.
2. In addition to assessing the strength and range of motion of the internal and external rotation of the shoulder in uneven shoulder volleyball players, it is recommended to measure other overhead throwing sports as well.
3. In addition to assessing the strength and range of motion of the internal and external rotation of the shoulder of volleyball players with uneven shoulder, it is recommended to measure other abnormalities as well.
4. Given the specific biomechanics of repetitive volleyball movements and to prevent imbalances in muscle strength and range of motion, coaches and athletes are recommended to emphasize on strengthening and stretching the muscles that support and oppose the shoulder girdle and consider muscles undergoing strengthening or flexibility exercises when exercising.

Conclusion

The results showed that high muscle strength in uneven shoulder volleyball players was known to be a risk factor in many studies. It can also be considered a long-term cause of injury in volleyball players. Volleyball, like any other sport, involves repetitive patterns of movement in which the hand moves over the head, and in the long run can lead to uneven shoulder of the dominant hand and that might lead to muscle imbalance and restrictions in range of motion of shoulder rotating muscles of these athletes so it is necessary to pay attention to preventive approaches by creating corrective solutions.

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