



Original Article

The Effect of the Loading on Dynamic Stability and Scapular Asymmetry

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ABSTRACT

Background: Scapular stabilization and neuromuscular control provide an important parameter to characterize shoulder function during dynamic activities. Many studies have confirmed the effect of the loading on scapular position and scapulohumeral rhythm. Therefore, the evaluation of stabilizer muscles involvement in scapular asymmetry may assist in the development of clinical examination and rehabilitation program. The aim of this study was to evaluate the effect of loading on dynamic stability and scapular asymmetry in basketball players.

Methods: Thirty healthy male basketball players aged between 20 to 31 years old were tested. The linear distance between scapular inferior angle and T7 spinous process was measured using a caliper in 90 degrees of unloaded scaption and with 1, 2 and 4 kg loading. The difference of distances of two sides in the above 4 positions was analyzed.

Results: The amount of distances difference in two sides with 1 kg loading was minimal (9.36 mm). This difference increased to 10.19 mm and 12.22 mm, with increasing the loading to 2 and 4 kg respectively; although the 4 positions of the test did not show significant differences in distances difference ($P > 0.05$).

Conclusion: This study shows that dynamic stability of the scapula is dependent on the role of muscles, so that with increasing load on the muscles, the scapular asymmetry is more pronounced.

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Introduction

Observation of the scapular posture is one of the most important portions of the physical examination in overhead athletes. The scapular asymmetry is suggested to be further accentuated in unilateral overhead athletes who use their dominant shoulder repetitively in forceful conditions. Despite the importance of the postural evaluation in the physical examination, research on postural scapular asymmetry is lacking [1].

Burkhart et al. theorized that scapular asymmetry is a sign of an underlying alteration in the muscle activation associated with various shoulder and scapular conditions, based on the assumption that the asymmetry is abnormal [2]. Scapular stabilization and neuromuscular control provide an important parameter to characterize shoulder function during dynamic activities [3]. More involved rotator cuff and scapular muscles causes more motor units to be recruited [4], therefore it seems that with loading on the scapular muscles, we can evaluate the role of muscles in scapular position more accurately and comprehensively.

Clinicians commonly assess scapular function by observing bilateral scapular motion during repeated motions of arm elevation and lowering. A few of the

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traditional clinical tests such as the lateral scapular slide test (LSST) categorize or quantify scapular dyskinesia [5]. The LSST is a clinical evaluation method used to identify scapular asymmetry, based on the idea that the asymmetry is an abnormality that needs to be identified and rehabilitated [1]. We hypothesized that the scapular asymmetry would be present in healthy overhead athletes from the repetitive use of the dominant shoulder. Identifying scapular asymmetry in healthy overhead athletes is important because it provides a basis for comparison with injured overhead athletes.

Additionally, the evaluation of scapula in resting position is a static measurement and may not reflect scapular kinematics during functional movements. Thus, when evaluating athletes with shoulder injuries, it is important to assess dynamic scapular kinematics.

Therefore, the main goal of the present study was to determine the effect of loading on dynamic stability and scapular asymmetry in scapular plane with various loading in the overhead healthy athletes.

Methods

This study was a cross sectional, study that was done in thirty healthy male basketball players who were recruited from three professional basketball teams. Subjects to be included in this study had to be able to actively perform 90 degrees of scaption and full internal rotation of the shoulder, aged between 20-40 years and a minimal 2 years of sport participation. Subjects were excluded if they had the following problems: previous shoulder surgery, a history of systemic disease, neuromuscular dysfunction and obesity (body mass index 32 or greater). Prior to participating in this study, all subjects signed an informed consent form. This study was approved by the ethics committee of Tehran University of Medical Sciences (TUMS). Demographic information includes age, weight, height and BMI were measured and related questions were answered.

A digital Vernier caliper (Mitotuyo Company, Japan) with an accuracy of 0.01 mm, a goniometer with extendable arm (Lafayette Instrument Company, USA) and 1, 2 and 4 kg dumbbell-like weights were used in the experiment.

The scapular plane was considered as 40 degrees anteriorly from the coronal plane [6]. To determine the scapular plane, the subjects stand across from the wall corner on a reference plate with signs for foot stands and a reference line on it. Azarsa et al. have showed the reliability of lateral scapular slide test in scaption in basketball players [7].

To determine the 90 degrees of shoulder scaption, we set different parts of a goniometer as follows: a fixed extendable arm was set along with external body line; shaft of the goniometer was under the external part of acromion with a distance of 2 cm and mobile arm parallel to subjects arm axis in 90 degrees [8] (Figure 1).

To measure the scaption angle, we set the fixed goniometer arm on the body axis in frontal plane, and we put the axis of goniometer on the acromion tip and



Figure 1: The Goniometry method for measuring 90 degrees of shoulder elevation

the mobile arm parallel to subject arm axis [8] (Figure 2). Since, there may be some differences in subject's upper extremity length, we extended the extendable mobile arm of goniometer up the wall and marked crossing points by markers on it. It is done in 90 degrees of scaption for both upper extremities separately. All subjects were asked to keep upper extremities compatible with that cross from a line with these markers. These markers were positioned on the wall in a way that they made 40 degrees with frontal body plane to guide subject along with scapula plane.



Figure 2: The Goniometry method for measuring 40 degrees of shoulder scaption

The first position of the test (P1) was unloaded 90 degrees of scaption. In this position, the subjects were asked to keep their upper limbs in 90 degrees of scaption with full internal rotation of shoulders along with markers that put on the wall, then the examiner found T7 spinous process and scapula inferior angle by touching, he measured their least linear distance in 0.01 mm order using digital caliper (Figure 3a).

The second position of the test (P2) was 90 degrees of scaption with 1 kg loading. In this position, the subjects were asked to keep their upper limbs in 90 degrees of scaption with full internal rotation of shoulders along with mentioned markers, then the examiner measured mentioned linear distance using digital caliper (Figure 3b).

In the third position (P3), 2 kg dumbbell-like weights and in fourth position (P4), 4 kg dumbbell-like weights were given to subjects. Then examiner measured mentioned linear distance using digital caliper in same positions.

All of the above measurements were done by an expert examiner (M.Sc PT) who was qualified in surface anatomy and experienced for performing the test.



Figure 3: a) Unloaded scaption position, b) Loaded scaption position

Statistical Analysis

A 1-sample Kolmogorov-Smirnov goodness-of-fit test was done to determine normal distribution ($P > 0.05$), then distances difference of two sides in the 4 positions were analyzed using the one-way repeated measures ANOVA test. All data were analyzed using SPSS software version 20.

Results

The data were collected from 30 healthy male basketball players, aged between 20 to 31 years old. Mean, standard deviation (SD) and the range of demographic data of participants are showed in Table 1.

The mean of distances difference (difference of linear distance between scapular inferior angle to spinous process of T7 in left and right sides) with 1 kg loading was minimal (9.36 mm). The difference of distances increased to 10.19 mm and 12.22 mm, with increasing the load to 2 and 4 kg in both sides, respectively.

Table 2 shows the mean of distances difference, standard deviation and the range of measurements difference in the 4 positions.

Also, the distances difference of both sides in the 4 positions were not significant ($P > 0.05$). The observed power in this study was low (0.376).

Figure 4 shows the linear changes of the mean of distances difference in the 4 positions. This figure shows that with increasing of loading on the scapular muscles, distances difference from inferior angle of scapula to spinous process of T7-8 was increased in right and left sides.

Discussion

The purpose of this study was to evaluate the influence of applying the loads on the scapular stabilizer muscles and scapular asymmetry of healthy athletic men. Kibler has primarily applied the LSST to determine scapular asymmetry in athletes who do overhead throwing [9]. Therefore, the measurements of linear distance related to the scapula (linear distance between scapular inferior angle to spinous process of T7 in left and right sides) can be a reliable measurement for scapular assessment [10].

Our results showed that with increasing the loading on the scapular muscles, the difference of distances from inferior angle of scapula to spinous process of T7 increased in both right and left sides, although the differences were not statistically significant. It seems that increasing the loads on scapular muscles induced higher motor unit recruitment and internal torque of scapulohoracic joint and therefore the difference of distances of scapular

Table 1: Mean, standard deviation (SD) and range of demographic data of participants (n=30)

Demographics	Mean (SD)	Range
Age (years)	22.53 (3.72)	20-31
Height (cm)	187.33 (9.81)	170-210
Weight (kg)	84.17 (16.29)	54-130
BMI (kg/m ²)	23.83 (3.04)	18.68-30.26
Number of years of sport participation	8 (5.5)	2-20

Table 2: The mean (mm), standard deviation (SD) and range of distances difference in the 4 positions

Position	Mean of differences (SD)	Range (Min-Max)	P value
P1	9.94 (1.22)	(7.43-12.45)	0.229
P2	9.36 (1.12)	(7.06-11.65)	0.229
P3	10.19 (1.16)	(7.81-12.57)	0.219
P4	12.22 (1.52)	(9.12-15.33)	0.208

P1: Unloaded scaption position, P2: Loaded scaption position with 1-kg weight, P3: Loaded scaption position with 2-kg weight, P4: Loaded scaption position with 4-kg weight

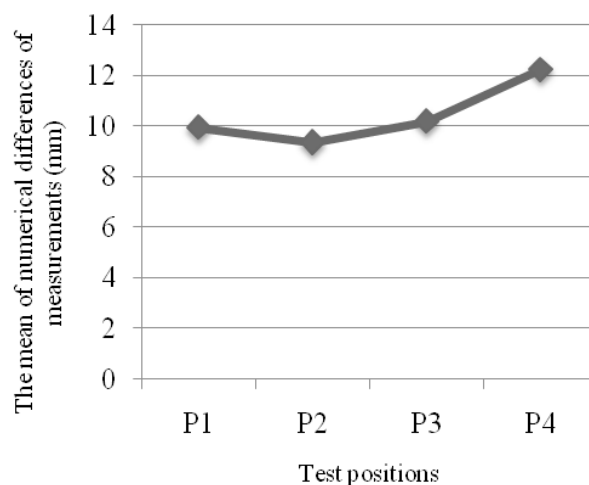


Figure 4: The trend of the mean of distances difference in the 4 positions. P1: Unloaded scaption position, P2: Loaded scaption position with 1-kg weight, P3: Loaded scaption position with 2-kg weight, P4: Loaded scaption position with 4-kg weight

asymmetry increased. On the other hand, with increasing the loading and more activity of muscles, the scapular asymmetry was pronounced. These changes in scapular positioning are accompanied by alterations in activity of the rotator cuff and stabilizer muscles of the scapula. Increased moment of inertia of the upper extremity due to holding a weight may result in greater stress at the shoulder [4]. However, further biomechanical analysis of these overhead athletes is needed to examine this hypothesis. Also, the fatigue of shoulder muscles induces a modification of scapula motion during humeral elevation (mainly an increased scapular upward rotation), which alters the scapulohumeral rhythm [5]. Decker et al. state a fatigued serratus anterior muscle will reduce scapular rotation and protraction [11]. Therefore, applying more loadings to the scapula may have an influence on the fatigue of these muscles and changes in movement rhythm or asymmetry. The difference of distances in both sides, from unloaded scaption to scaption with 1 kg loading decreased show that the 1 kg loading represents the most appropriate load selection to correct the asymmetry. However, this decrease of the difference of distances in both sides in P2 was not significant.

It should be mentioned here that we consider the condition of scaption without loading as the standard condition then we observed that the application of 1-kg loading has resulted in the decreasing of the difference of distances of the two sides. In this position (P1) the scapular asymmetry was at the minimum. It seems that applying a minimum load (1-kg) may involve the stabilizer muscles and improve scapular stability.

Oyama et al. quantify the differences in resting scapular posture between the dominant and non-dominant sides in 3 groups of healthy overhead athletes (baseball pitchers, volleyball players, and tennis players) using an electromagnetic tracking device [1]. Their results showed that in all overhead athletes, the scapula in the dominant side was more internally rotated and anteriorly tilted compare to the non dominant side. In our study, also, all participants were overhead athletes therefore the loading on the scapular muscles may increase the differences in the measurements of the two sides.

Oyama et al. indicated that clinicians evaluation of overhead athletes need to recognize that scapular posture asymmetry in unilateral overhead athletes may be normal [1]. Their study showed that scapular asymmetry does not necessarily suggest pathology and could also be seen in healthy people. The scapular asymmetry in above studies has not been evaluated in functional scaption and loading position, therefore may show different results in the positions. In the present study, based on the pathologic range of asymmetry (1.5 cm), we did not observe any asymmetry.

Gibson et al. reported no differences in scapular position of the dominant and non-dominant extremities based on the side-to-side distance measurements obtained by the LSST, and means for the absolute values of scapular difference measurements were larger in the subjects without shoulder dysfunction than in the subjects with shoulder dysfunction [12].

Thus, a clinical assessment method based on the assumption that posture in a healthy population is symmetric (such as the lateral scapular slide test) must be performed with the knowledge that some level of asymmetry may exist, but it is not necessarily problematic.

In the study of Kon et al. with 3 kg loading on scapular muscles, the mobility of scapulothoracic decreased and its stability increased [3]. They reported that it is simple to check a patient's shoulder function and scapular stability with observation of scapular motion during active scaption with external manual resistance.

The low statistical power observed in this study is probably due to the small sample size of our research. This was a major limitation of our study and could be, in all likelihood, the reason of yielding a non-significant difference in the two sides measurement ($P < 0.05$) However, this pilot study showed a direct relation between loading scapular stabilizer muscles and scapular asymmetry.

Conclusion

Increasing the loads on scapular muscles during the test induced higher motor unit recruitment and internal torque of scapulothoracic joint and therefore the difference

of distances of scapular asymmetry was pronounced. Unilateral overhead athletes and non-overhead athletes need to be investigated in the future studies.

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