International Journal of Yoga, Physiotherapy and Physical Education
ISSN: 2456-5067
Impact Factor: RJIF 5.24
www.sportsjournal.in
Volume 3; Issue 2; March 2018; Page No. 180-183

Analysis of scapular contribution in shoulder complex extension

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Abstract
Scapulothoracic joint may have a role in shoulder complex extension and addition of scapular movements to glenohumeral joint may increase the total shoulder complex range. 79 healthy subjects (20 males, 59 females) were enrolled for the study. On first day shoulder complex extension range of motion was measured and on day two glenohumeral extension range of motion was measured. For both the measurements three trials were done and best of them was used for further analysis. Scapular contribution was calculated by subtracting glenohumeral extension from shoulder complex extension range of motion. Paired t test was applied to compare the differences between means of glenohumeral and shoulder complex extension angles. The results of the present study showed glenohumeral extension to be 34.92 ±9.66 (mean±SD), shoulder complex extension 55.20 ± 11.30 (mean±SD) and scapular contribution 20.27± 8.50 (mean±SD). Results of our study show shoulder complex extension is significantly higher than glenohumeral extension.

Keywords: shoulder complex, glenohumeral joint, scapulothoracic rhythm, shoulder extension range of motion

1. Introduction

The shoulder complex, composed of the clavicle, scapula, and humerus, is an intricately designed combination of three joints that links the upper extremity to the thorax. Shoulder complex consists of acromioclavicular (AC) joint, scapulothoracic (ST) joint and glenohumeral (GH) joint. The shoulder complex has 3 degrees of freedom [1]. Full range of motion (ROM) of the shoulder requires humeral, scapular, and clavicular motion at the glenohumeral, sternoclavicular, acromioclavicular, and scapulothoracic joints [2]. Motion of the scapula on the thorax normally contributes about one third of the total shoulder complex motion necessary for arm elevation, whereas the glenohumeral joint contributes about two thirds of the total motion [3, 4]. According to Inman [4] overhead movements of the shoulder complex such as flexion and abduction can be described as scapulohumeral rhythm where GH: ST joint movement ratio varies from 1.25:1 to 2.69:1 [5-8].

Although the role of ST joint is clearly described in flexion and abduction, minimal studies have measured extension of shoulder complex [9-10]. According to Neuman [11] full extension of the shoulder occurs to a position of about 45 to 55 degrees behind the frontal plane. The extremes of this motion stretch the anterior capsular ligaments, causing a slight forward tilting of the scapula. This forward tilt may enhance the extreme of a backward reach. According to Kapandji [12] rhomboids and middle trapezius have a role in shoulder extension. So far in our knowledge no one has described application of scapulohumeral rhythm for shoulder extension as well as amount of contribution of scapulothoracic joint into shoulder complex extension.

The current study hypothesized that scapulothoracic joint may have a role in shoulder complex extension and addition of scapular movements to glenohumeral joint may increase the total shoulder complex range. Furthermore if such addition occurs, the study is aimed to measure ratio of contribution of glenohumeral to scapulothoracic joints.

2. Material and methods

Cross sectional, single blinded study on 79 healthy physiotherapy students (mean age 21 years, 20 males, 59 females) at Government Physiotherapy College Jamnagar, Gujarat was conducted. Total 158 data were collected from both shoulders of 79 subjects. Any subjects with history of shoulder pain or trauma or pathology which may affect shoulder range of motion were excluded.

Ethical clearance was taken from Institutional Ethical committee. Written consent was signed by all the subjects. Familiarization was done about the procedure to all the subjects. On first day shoulder complex extension range of motion (without stabilization) was measured and on day two glenohumeral extension range of motion (with stabilization) was measured. This was done to minimize the risk of recall bias. For both the measurements three trials were done and best of them was used for further analysis. In this study Extension was defined as the range of extension beyond frontal plane. Materials used were 180 degrees universal goniometer, plinth, pen and paper. Standard guidelines as explained by Cynthia [2] were followed for range of motion assessment.

Shoulder complex extension range of motion - Subjects lied in prone lying position with goniometer fulcrum was aligned to greater tuberosity. Stable and movable arms were parallel to the arm. The scapula was not stabilized during this measurement. As the subjects raised their shoulder into

extension, movable arm was moved along with arm and final shoulder complex extension angle was calculated. Any substitution pattern of spine were avoided.
Glenohumeral extension range of motion - Subjects lied in prone lying position with goniometer fulcrum was aligned to greater tuberocity. Stable and movable arms were parallel to the arm. One therapist stabilized the scapula and clavicle firmly to prevent their movement. As the subjects raised their shoulder into extension, movable arm was moved along with arm and final glenohumeral extension angle was calculated.

2.1 Outcome measures

Primary outcome was extension range of motion of glenohumeral joint and extension range of motion of shoulder complex. Scapular contribution was calculated by subtracting glenohumeral extension from shoulder complex extension range of motion.

2.2 Data analysis

Mean, range, and other descriptive statistics were calculated for glenohumeral extension and shoulder complex extension. Paired t test was applied to compare the differences between means of glenohumeral and shoulder complex extension angles. Level of significance was kept at 0.05. If the differences were found significant, mean, range, and other descriptive statistics were calculated for scapulothoracic contribution also. Frequency distribution as well as histograms were analysed for normal distribution analysis. SPSS version 20 was used for statistical analysis.

3. Results

Table 1: Descriptive statistics of subjects

N = 158	Age	Glenohumeral Extension	Shoulder Complex Extension	Scapular Contribution
Mean	21.2278	34.9241	55.2025	20.2785
Std. Error of Mean	.04743	.76857	.89898	.67689
Std. Deviation	.59615	9.66084	11.30005	8.50842
Variance	.355	93.332	127.691	72.393
Skewness	.609	.065	-.080	.212
Std. Error of Skewness	.193	.193	.193	.193
Kurtosis	.922	.925	-.116	-.252
Std. Error of Kurtosis	.384	.384	.384	.384

Figure 1 to 3 shows frequency distribution of glenohumeral extension, shoulder complex extension and scapular contribution amongst the subjects.

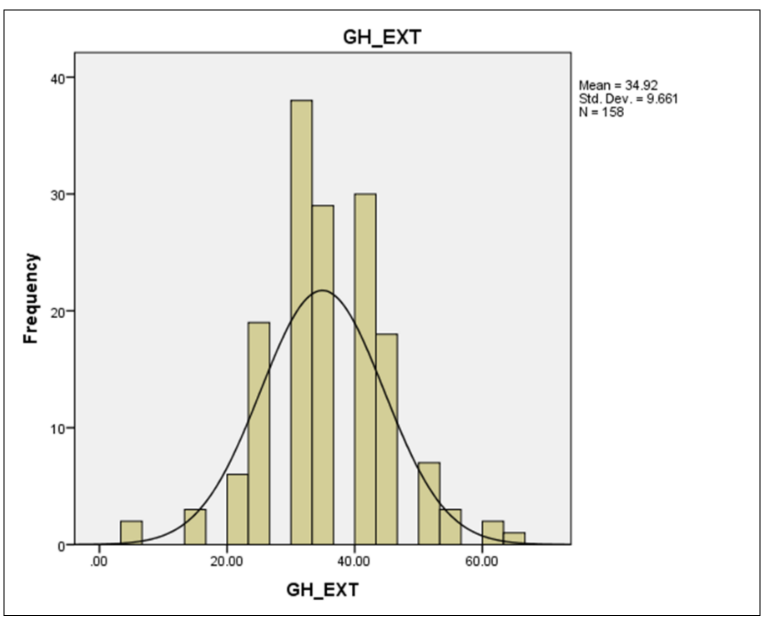

Fig 1: Frequency distribution of glenohumeral extension range (GH_EXT) with overlapping normal distribution curve

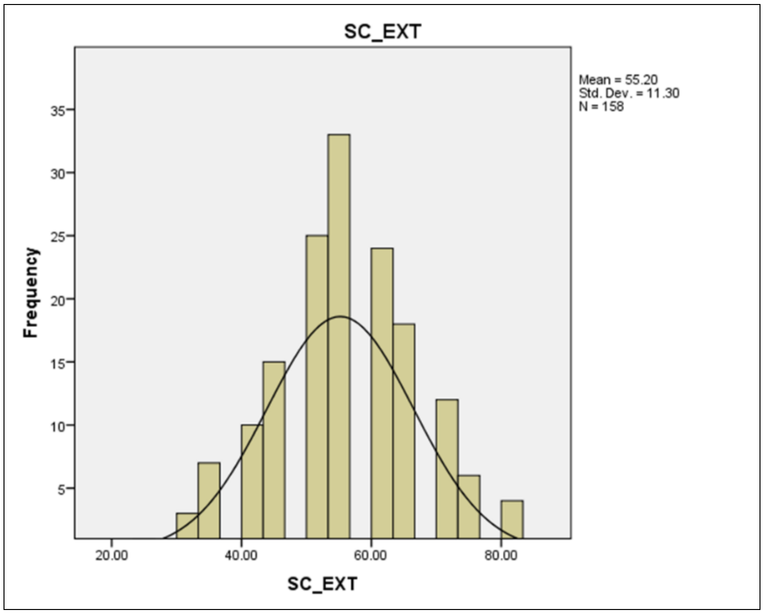

Fig 2: Frequency distribution of shoulder complex extension range (SC_EXT) with overlapping normal distribution curve

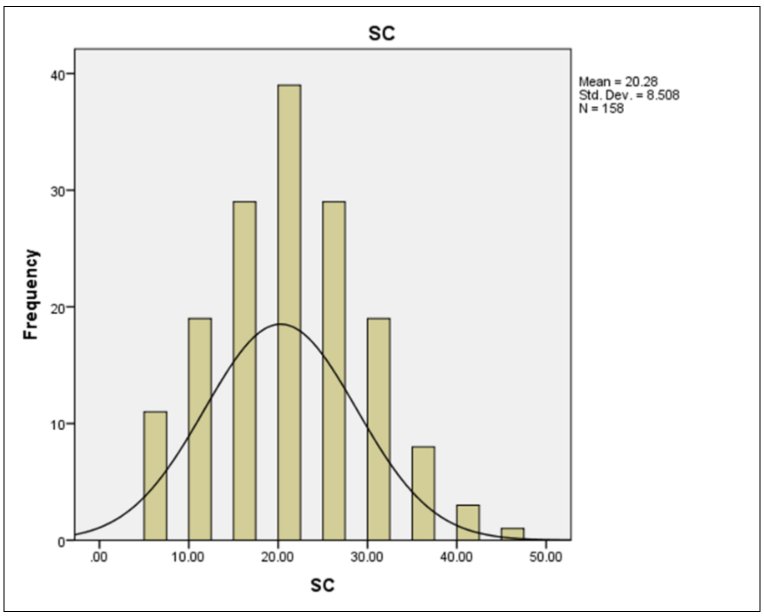

Fig 3: Frequency distribution of scapular contribution (SC) with overlapping normal distribution curve

Table 2: Paired samples t-test between Glenohumeral extension and shoulder complex extension

	Paired Differences			t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean			
GH_EXT - SC_EXT	-20.27848	8.50842	.67689	-29.958	157	.000

Glenohumeral extension, shoulder complex extension and scapular contribution were studied for right to left differences as well as gender based differences, however no significant differences were found between right and left side as well as between males and females (p>0.05)

4. Discussion

The current study assessed 158 shoulders of 79 subjects (20 males, 59 females) for extension range of motion analysis. The results of the present study showed glenohumeral extension to be 34.92 ±9.66 (mean±SD), shoulder complex extension 55.20 ± 11.30 (mean±SD) and scapular contribution 20.27± 8.50 (mean±SD). Results of our study show shoulder complex extension is significantly higher than glenohumeral extension thus supporting our hypothesis. So when scapula is allowed to move during extension movement, total shoulder complex extension definitely increases. The mean increase of about 20.27± 8.50 (mean±SD) can be attributed to scapular movements. According to Boone (9)mean shoulder complex extension range is about 57.3±8.1(mean ± SD) which supports our measurements of shoulder complex extension 55.20 ± 11.30 (mean±SD). In contrast to Lannan [13] glenohumeral extension range in current study is more.

Frequency distribution of glenohumeral and shoulder complex extension as well frequency distribution of scapular contribution in shoulder complex extension follows normal distribution with minimal skewness.

According to Kapandji [12] rhomboids and middle trapezius can contribute to shoulder extension range of motion. Neumann [11] stated that at the end of glenohumeral extension anterior ligamentous structures are stretched pulling scapula into frontal plane rotation i.e. anterior tipping. Pectoralis minor is one such muscle along with coracobrachialis and short head of biceps brachii which may have the ability to pull coracoid process anterior and inferior and produce anterior tipping of scapula. As humerus moves into extension passive elongation of coracobrachialis and short head of biceps brachii may enhance such force along with active muscular tension produced from pectoralis minor. As these movements are not studied so far, electromyography or ultrasonographic analysis may be done to confirm this hypothesis.

As with overhead movements 2:1 ratio of glenohumeral versus scapular movement is also maintained in shoulder complex extension. Though complete kinematic study is not performed in this analysis, additional contribution of acromioclavicular and sternoclavicular joints could not be studied. Further detailed kinematic as well as kinetic analysis of shoulder complex extension is thus suggested.

4. Conclusion

The 2:1 ratio of glenohumeral versus scapular movement is also maintained in shoulder complex extension.The results of this study confirm the definite contribution of scapulothoracic joint movement into shoulder extension. While improving shoulder extension range of motion in shoulder stiffness patients, this contribution must be taken into account.

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