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Analysis of Reference Range of Glenohumeral Rhythm During Flexion and Abduction - An Analytical Study

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ABSTRACT

Background and need of research: Many research studies have established a goniometric range of motion reference values for normal joints which also includes the Shoulder complex. As the shoulder complex consists of glenohumeral (GH) and scapulothoracic (ST) joints, there exists considerable variability in glenohumeral joint range of flexion and abduction in different populations, but its values in the Indian population are not yet known. Contribution of scapulothoracic joint in shoulder extension has been evaluated for the Indian population recently which suggests that reference values for Scapulothoracic flexion and abduction should also be evaluated. Knowledge of such reference values can be important in clinical decision making for treatment applications and outcome measure evaluations.
Method: 243 healthy subjects (123 girls and 120 boys) between the age group 18-23 years were enrolled for the study. Range of motion of flexion and abduction of the glenohumeral joint and shoulder complex was measured bilaterally with universal goniometer. 3 measurements were done for each movement and best of 3 was used for the further analysis.
Result: MedCalc statistical software was used for analysis. Reference range for the ratio between GH and ST joint is 0.80:1 to 2:1 for left abduction, 0.80:1 to 2.6:1 for right abduction, .0.71:1 to 2.27:1 for bilateral flexion.
Conclusion: There is varying reference range for flexion and abduction at GH joints in the Indian population. The therapists in India should consider current values while evaluating GH and ST flexion and abduction range of motion.

***Key words*:** Glenohumeral joint, Reference range, Shoulder complex, Scapulohumeral rhythm, Scapulothoracic joint

INTRODUCTION

The shoulder complex, which consists of the clavicle, scapula, and humerus, is a complicated arrangement of three joints that connects the upper extremities to the thorax. The shoulder complex consists of four joints: acromioclavicular (AC), sternoclavicular, scapulothoracic (ST), and glenohumeral (GH). The shoulder complex possesses three degrees of freedom.[1]

The shoulder's full range of motion (ROM) needs humeral, scapular, and clavicular mobility at the glenohumeral, sternoclavicular, acromioclavicular, and scapulothoracic joints.[1] The scapula on the thorax generally provides about one-third of the total shoulder complex motion required

for arm elevation, whereas the glenohumeral joint contributes around two-thirds of the entire motion. [2,3]

Inman et al. discovered an uneven amount and type of scapular motion in response to GH-motion during the first 60°.[3] In the early phase (0-60), motion is largely at the GH joint, however straining the arm could increase the scapular contribution.[4]

In the literature Scapulohumeral rhythm is described like a ratio of humeral elevation and scapulothoracic rotation. The overall ratio of 2:1 during arm elevation is commonly used. According to the 2-to-1 ratio frame-work, flexion or abduction of 90° in relation to the thorax would be accomplished through approximately 60° of GH and 30° of ST motion. [3]

Ratios are often described as nonlinear indicating changing ratios during ROM. The 2 to 1 ratio substantially varies in scapular and humeral contributions at different points in the ROM and among individuals.

Sorani D et al analysed scapular contribution in shoulder complex extension ROM and suggested that 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.[5]

Objectives of the study is to measure shoulder complex and GH flexion range of motion and to measure shoulder complex and GH abduction range of motion.

Aim of the study is to find reference range value for GH and Scapulothoracic flexion and abduction and find glenohumeral rhythm for shoulder complex flexion and abduction range of motion.

As the shoulder complex consists of glenohumeral and scapulothoracic joints, there exists considerable variability in glenohumeral joint range of flexion and abduction in different populations, but its values in the Indian population are not yet known. Contribution of scapulothoracic joint in shoulder extension has been evaluated for the Indian population recently [5] so the need of the study is to evaluate reference values for Scapulothoracic flexion and abduction. Knowledge of such reference values can be important in clinical decision making for treatment applications and outcome measure evaluations.

MATERIALS & METHODS

Cross sectional, single blinded study on 243 healthy physiotherapy students in which 120 are males and 123 females at Government Physiotherapy College Jamnagar, Gujarat was conducted. Total 486 data were collected from both shoulders of 243 subjects.

Both male & female subjects with age group between 18-23 years and who showed willingness to participate were included for the study. Any subject with history of shoulder pain or trauma or pathology which may affect shoulder ROM were excluded from study.

Convenient sampling technique was used to collect data. 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 flexion and abduction range of motion (without stabilization) was measured and on day two glenohumeral flexion and abduction 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. Materials used were 180 degrees universal goniometer, plinth, pen and paper. Standard guidelines as explained by Cynthia were followed for range of motion assessment.[1]

Shoulder complex flexion range of motion (without stabilization) - Subjects was in supine 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 flexion, movable arm was moved along with arm and final shoulder complex flexion angle was calculated. Any substitution pattern of spine was avoided.

Shoulder complex abduction range of motion (without stabilization) - Subjects was in supine lying position with goniometer fulcrum was aligned to anterior aspect of acromion process. Stable arm was parallel to the midline of anterior aspect of sternum and movable arms was parallel to the arm. The scapula was not stabilized during this measurement. As the subjects raised their shoulder into abduction, movable arm was moved along with arm and final shoulder complex abduction angle was calculated. Any substitution pattern of spine was avoided.

Glenohumeral flexion range of motion (with stabilization) - Subjects was in supine lying position with goniometer fulcrum was aligned to greater tuberosity. Stable and movable arms were parallel to the arm. One therapist stabilized the scapula firmly with hypothenar aspect of one hand to prevent their movement. As the subjects raised their shoulder into flexion, movable arm was moved along with arm and final glenohumeral flexion angle was calculated.

Glenohumeral abduction range of motion (with stabilization) - Subjects was in supine lying position with goniometer fulcrum was aligned to acromion process. Stable arm was parallel to the midline of anterior aspect of sternum and movable arms was parallel to the arm. One therapist stabilized the scapula firmly with hypothenar aspect of one hand to prevent their movement. As the subjects raised their shoulder into abduction, movable arm was moved along with arm and final glenohumeral abduction angle was calculated.

Figure 1: GH abduction ROM with stabilizing scapula

Figure 2: GH flexion ROM with stabilizing scapula

Primary outcome was flexion and abduction range of motion of glenohumeral joint and flexion and abduction range of motion of shoulder complex. Scapular contribution was calculated by difference of GH and shoulder complex.

STATISTICAL ANALYSIS

After data was collected, analysis was done to find percentage of scapular contribution and ratio of glenohumeral and scapular contribution using MS excel (version: excel 2013). Also to generate reference range for all parameters MedCalc (Version: 23.0.6) was used.

RESULT

Table 1 - Descriptive statistics of subjects

	Male	**Female**	**Total**
Number of population (N)	120	123	243
Age(years)	20.08(1.82)	20.44(1.86)	20.26(1.30)
Weight(kg)	60.34(10.71)	51.62(9.65)	55.92(11.06)
Height(meters)	1.69(0.06)	1.57(0.06)	1.63(0.08)
BMI(kg/m^2)	21.10(3.51)	20.79(3.76)	20.94(3.63)

Mean (SD) is expressed for all parameters

As shown in Table 1 both male and female are similar in age as well as in BMI.

Table 2: Mean, Percentile and Reference range for GH, Shoulder complex and Scapular contribution of left and right flexion.

	Flexion							
	Left				**Right**			
	GH	**Shoulder complex**	**Scapular contribution**	**Percentage of Scapular Contribution**	**GH**	**Shoulder complex**	**Scapular Contribution**	**Percentage of Scapular Contribution**
Mean± SD	99.50± 11.08	180	80.49± 11.08	0.44±0.06	98.02± 10.43	180	81.97± 10.43	0.45±0.05
25th Percentile	95		75	0.42	90		76	0.42
50th Percentile	100		80	0.44	95		85	0.47
75th Percentile	105		85	0.47	103		90	0.50
95th Percentile	115		95	0.53	120		96	0.54
Reference Range	75 - 125		55 - 105		75.5-125		55-104.5	

Degree is expressed for all parameters.

Table 2 describes mean, percentile and reference range of glenohumeral joint, shoulder complex and scapular contribution of right and left flexion range of motion. As shown in table there is similar scapular contribution in both right and left side flexion and reference range is also similar for both right and left flexion.

Table: 3: Mean, Percentile and Reference range for GH, Shoulder complex and Scapular contribution of left and right abduction.

	Abduction							
	Left				**Right**			
	GH	**Shoulder complex**	**Scapular contribution**	**Percentage of Scapular Contribution**	**GH**	**Shoulder complex**	**Scapular contribution**	**Percentage of Scapular Contribution**
Mean± SD	100.28±9.36	180	79.71±9.36	0.44±0.05	101.35±10.90	180	78.64±10.90	0.43±0.06
25th Percentile	95		75	0.42	95		75	0.42
50th Percentile	100		80	0.44	100		80	0.44
75th Percentile	105		85	0.47	105		85	0.47
95th Percentile	115		95	0.53	120		95	0.53
Reference Range	80-120		60 - 99.5		80 – 130		50 - 100	

Degree is expressed for all parameters.

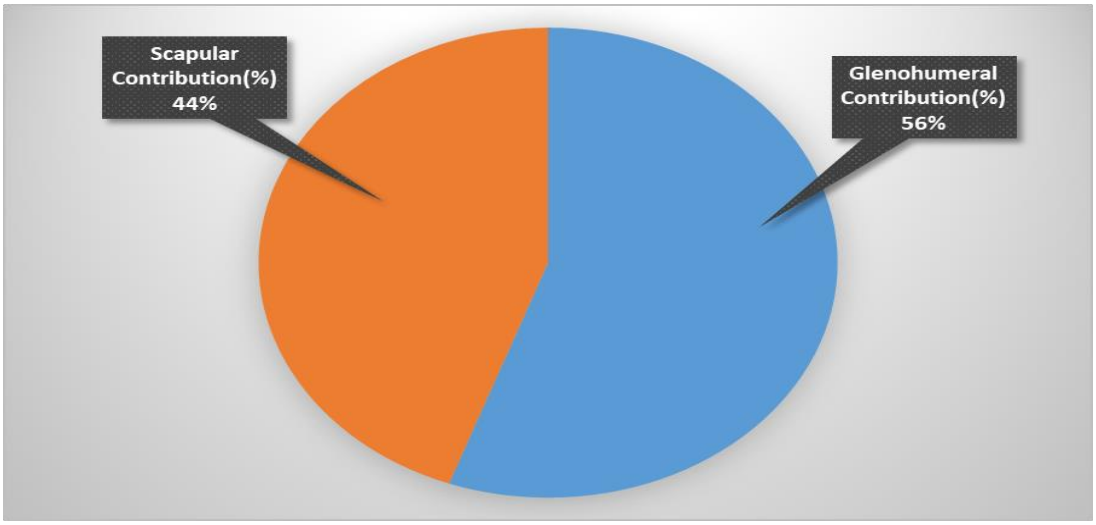
Table 3 describes mean, percentile and reference range of glenohumeral joint, shoulder complex and scapular contribution of right and left abduction range of motion. As shown in table there is similar scapular contribution in both right and left side abduction and reference range is also similar for both right and left side abduction.

Table 4: Mean, Percentile and Reference range of Ratio of GH to shoulder complex during abduction and flexion

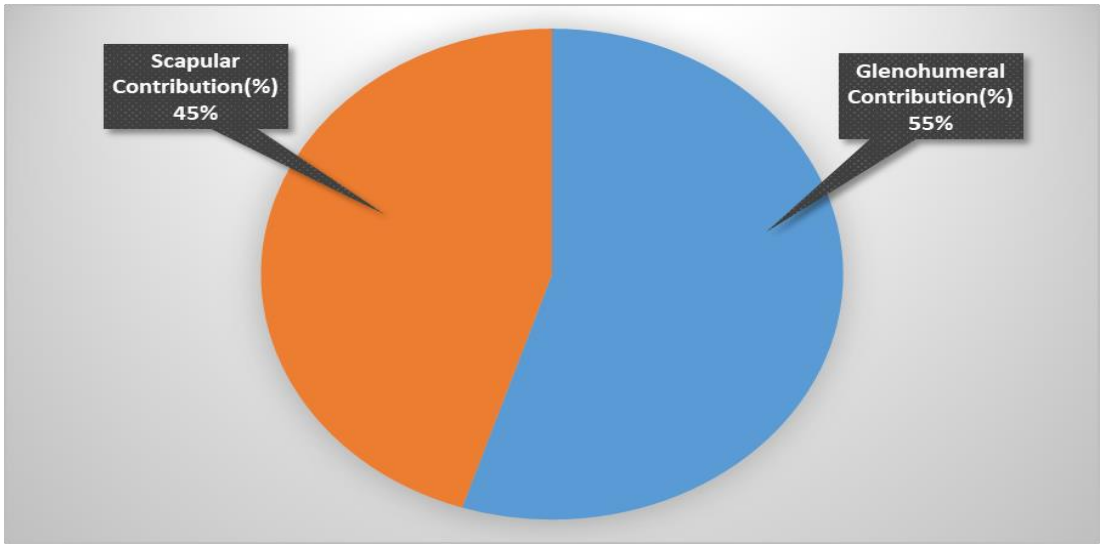
	Abduction		**Flexion**	
	Left	**Right**	**Left**	**Right**
Mean (SD)	1.29: 1(0.31:1)	1.34:1(0.44:1)	1.28:1(0.40:1)	1.23:1(0.33:1)
25th Percentile	1.12	1,12	1.12	1
50th percentile	1.25	1.25	1.25	1.11
75th Percentile	1.4	1.4	1.4	1.36
95th Percentile	1.77	2	1.77	2
Reference range	0.80 – 2	0.80 – 2.6	0.71 – 2.27	0.71 – 2.27

Degree is expressed for all parameters.

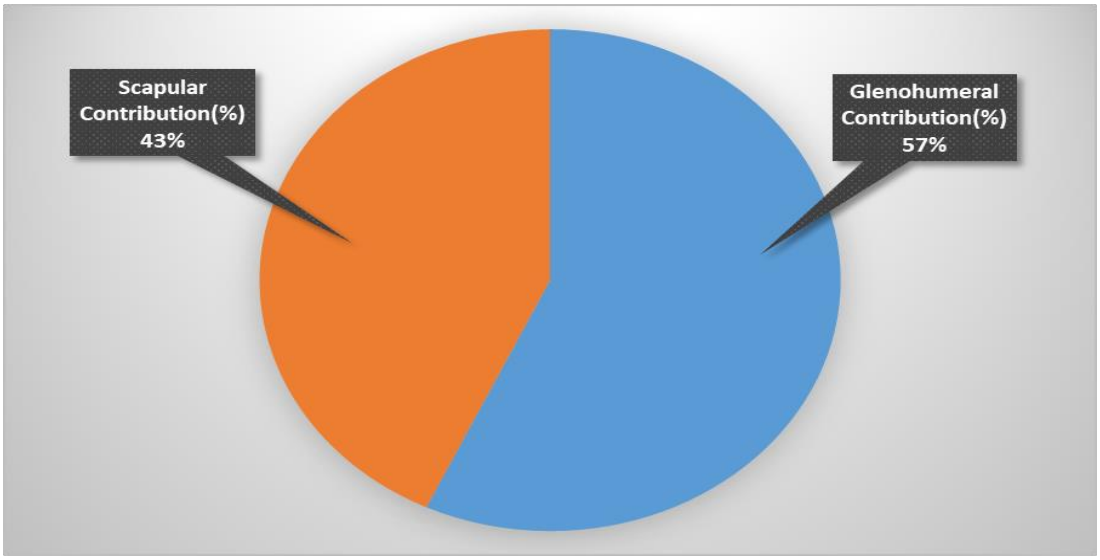
Table 4 shows that glenohumeral to scapulothoracic ratio means and reference range value is similar in both right and left as well as in flexion and abduction.



Graph: 1: Left side Flexion and Abduction glenohumeral rhythm



Graph: 2: Right side Flexion glenohumeral rhythm



Graph: 3: Right side Abduction glenohumeral rhythm

DISCUSSION

The current study assessed 243 subjects (120 males, 123 females) for scapular contribution in shoulder complex flexion and abduction range of motion analysis. The results of the present study showed 44 % and 45% scapular contribution in left and right side shoulder complex flexion respectively and 44 % and 43% scapular contribution in left and right side shoulder complex abduction respectively.

Results of our study show that in shoulder complex flexion and abduction there is some amount of scapular contribution to complete total range of shoulder complex flexion and abduction.

Scapular contribution mean is 80.49±11.08 (mean± SD) for left and 81.97±10.43 (mean± SD) for right flexion and 79.71±9.36 (mean± SD) for left and 78.64±10.90 (mean± SD) for right abduction.

Literature suggested that in elevation movement of the shoulder 2:1 ratio is followed but our study suggested that when considering the Indian population, we should consider separate values for shoulder flexion and shoulder abduction. For shoulder flexion 1.23:1 and for shoulder abduction 1.25:1 ratio should follow. This variation in range might be due to geographical areas that will affect individual's range of shoulder flexion and abduction.

We recommend to use reference range in assessment (diagnosis) purpose rather than considering a single value.

The result of our study found reference range value of scapular contribution of right side and left side abduction range of motion is different. This difference may be seen because of the dominant side difference. But in contrast for the flexion both right and left side reference range is similar.

According to Luciana, mean GH flexion is 47±14 (mean± SD) and GH abduction is 91±17 (mean± SD); for shoulder complex flexion is 192±11 (mean± SD) and shoulder complex abduction is 190±10 (mean± SD) which is in contrast to our findings. This contrast is due to difference in methodology of this two study.[6]

According to Kapandji, Trapezius and serratus anterior can contribute to shoulder flexion and abduction range of motion. During abduction the middle and inferior bands of the glenohumeral ligament become taut, while the superior band and the coraco-humeral ligament relax and during flexion tension develops mainly in the posterior band in coracohumeral ligament.[7]

During abduction, when the scapula is taken as the fixed base of reference, the following can be seen:(1)10 degree elevation of the medial extremity of the clavicle (2)70 degree widening of the scapuloclavicular angle and (3)45 degree axial rotation of the clavicle posteriorly and during flexion the elementary movements are similar though the widening of the scapuloclavicular angle is less marked. As these movements are not studied so far, electromyography or ultrasonographic analysis may be done to confirm this hypothesis.[7]

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 flexion and abduction is thus suggested.

Knowledge of such reference values can be important in clinical decision making for treatment application and outcome measure evaluation.

CONCLUSION

The results of this study confirm the definite contribution of scapulothoracic joint movement into shoulder flexion and abduction. While improving shoulder flexion and abduction range of motion in shoulder stiffness patients, this contribution must be taken into account. There is varying reference range for flexion and abduction at GH joints in the Indian population. The therapists in India should consider current values while evaluating GH and ST flexion and abduction ROM.

Declaration by Authors
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