

Relationship between Passive Glenohumeral Rotation and Strength of Internal and External Rotator Muscles in Young Healthy Adults

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ABSTRACT

Introduction: Increased range of motion at glenohumeral joint makes it susceptible to injury and instability. It was found that subjects with total glenohumeral rotation $>165^{\circ}$ had less isometric external rotation and internal rotation muscle strength than those with glenohumeral rotation was $<165^{\circ}$. Beyond normal 180° of shoulder range of motion indicates joint instability hence aim was to find out the muscle strength difference of internal rotation and external rotation with total arc of glenohumeral rotation.

Material and Methods: 50 young healthy subjects (43 females, 7 males) of 18 to 25 years were included. Initially dominant shoulder internal and external rotation passive range of motion was recorded with help of universal goniometer as well by motion analyzer in supine position. Shoulder rotator muscle strength was measured using hand held dynamometer in supine position in neutral and at end range of rotation motions.

Data analysis and Results: Karl Pearson's correlation was used to evaluate correlation between strength and shoulder range of rotation for right side. Out of 50, 37 females and 6 males showed $>180^{\circ}$ whereas 6 females and 1 male showed $<180^{\circ}$ of total shoulder internal and external range of motion. It was observed that subjects with $<180^{\circ}$ shoulder rotation showed moderate correlation with muscle strength where as those with $>180^{\circ}$ shoulder rotation range showed no or weak correlation with rotator muscle strength.

Conclusion: As the total arc of glenohumeral rotation increases beyond normal limits of $0-180^{\circ}$ there is a decreased strength of internal rotator and external rotator muscles as compared to total arc of glenohumeral rotation less than 180° .

Keywords: Range, Goniometer, Glenohumeral Rotation, Strength, Dynamometer, Young Healthy.

INTRODUCTION

The glenohumeral joint (GH) is characterized foremost by its mobility and large range of motion (ROM).^[1] The GH joint is a multiaxial, ball and socket, synovial joint that depends primarily on the muscles and ligaments rather than bones for its support, stability and integrity.^[2] Shoulder muscles contribute to both mobility and stability of the GH joint.^[2] Increased ROM at the GH joint makes it susceptible to injury and instability.^[2]

Stability is provided to GH joint by static and dynamic stabilizers.^[3] Static stability to GH joint is provided by the rotator interval capsule, the line of gravity and negative intra-articular pressure.^[3] The rotator interval capsule consists of superior capsule, superior GH ligament and coracohumeral ligament.^[3] Dynamic stability to GH joint is provided by the rotator cuff which is composed of supraspinatus, infraspinatus, teres minor and subscapularis muscles.^[3] The inserting

tendons of these muscles blend with and reinforce the GH joint capsule and significantly contribute to the dynamic stability of GH joint. [3] Clinically, the stabilizing role of the rotator cuff is evident in those with rotator cuff tear injuries where a damaged rotator cuff contribute to GH joint instability. [4,5] Thus assessing the total arc of GH rotation as well as the strength of the rotator cuff muscles is important, however, whether the two are related remains unknown. [4]

The internal rotation of the GH joint is brought about by anterior fibers of deltoid, subscapularis and teres major and external rotators are the posterior fibers of deltoid, infraspinatus and teres minor. [6] The normal range of GH internal rotation (IR) and GH external rotation (ER) is 0⁰-90⁰ according to American Medical Association (AMA). [7] Cyriax J noted that a joint with capsular laxity, whose stability is not under full muscular control often displays excessive passive ROM hence too much joint movement can lead joint susceptible to glenoid labrum lesions, subluxation, and dislocation. [8] In functional activities shoulder external rotation is required in, hand to mouth in feeding, reaching behind head for activities such as grooming the hair, positioning a necktie, fastening a dress zipper, combing hair on left side of head with right hand and vice versa whereas internal rotation is required in reaching hand into a back pocket, to reach behind the back for tasks such as dressing the upper body, tucking in a shirt and to perform toilet hygiene, pushing a car door open from inside. [7,9,10]

Passive ROM of GH internal and external rotation can be measured by a universal half circle goniometer which is a valid with reliability good to excellent (Intrarater ICC 0.88 to 0.93 and interrater ICC 0.85 to 0.80). [10] A motion analyser can also be used to measure accurate rotation range of motion at GH joint [11] with interrater reliability ICC 0.68 to 1.00. [12] Many researchers have examined the strength of shoulder IR and ER isometric

strength by using a hand held dynamometer (HHD) which demonstrates excellent interrater and intrarater reliability ($\rho = 0.79-0.92$). [12-14]

However, very few literature is available evaluating relationship between shoulder muscle strength and GH joint ROM [4] which showed that subjects whose total GH rotation exceeded 165⁰ had less isometric external rotator (ER) and internal rotator (IR) muscle strength than those whose has GH rotation less than 165⁰. [4] Normal shoulder ROM for rotation is 180⁰ hence, ROM more than 180⁰ should be considered abnormal and any range beyond 180⁰ indicates joint instability. As there is dearth of literature to find out the difference in shoulder muscle strength in those subjects whose total GH rotation exceeded 180⁰ than those with GH rotation was less than 180⁰ hence, the present study aimed at finding out relationship between the shoulder muscle strength of IR and ER with total arc of GH rotation in asymptomatic young healthy population.

MATERIALS & METHODS

An observational comparative study was performed on young healthy subjects of age group 18 to 25 years (mean 21.32 \pm 3.68 years). Total 50 subjects of both genders were selected (43 females, 07 males), individuals with right hand dominance, [15] without any muscular or neurological deficit were included whereas subjects with previous shoulder surgery in the past three years, any shoulder, neck or arm pain, subjects unable to tolerate the supine position or any history of chronic shoulder dislocations [4] were excluded from study.

Procedure

Requisite permission from ethical committee and head of institution was obtained. Selection of subjects was on basis of inclusion by simple randomize method. The procedure was explained in detail and written consent was obtained form study

subjects. The comparative data was collected and analyzed.

Material used for shoulder rotators muscle strength measurement was Jammer hand held dynamometer (HDD) and isometric strength of IR and ER muscles measured by using HDD in pounds(lbs) [4] (Figure 1 A,B,C,D), soft cushion pad was used under arm to avoid friction during evaluation, universal half circle goniometer

was used to measure shoulder active and passive internal and external rotation range in degrees [4,7] (Figure 2 A,B,C) and motion analyzer with RM Ingenierie SyCoMoRe version 8.52.0, (bioval sensors) was also used to measure shoulder active and passive internal and external rotation range electronically in degrees. (Annexure) (Figure 3)



Fig: 1A



Fig: 1B



Fig:1C



Fig:1D

Figure 1: Strength Assessment Of Shoulder Rotators Using Hand Held Dynamometer.

- (1A) Strength of shoulder Internal Rotators in neutral position using dynamometer
- (1B) Strength of shoulder Internal Rotators at end range using dynamometer
- (1C) Strength of shoulder External Rotators in neutral position using dynamometer
- (1D) Strength of shoulder External Rotators at end range using dynamometer



Fig: 2A- Initial Position



Fig: 2B- Internal Rotation



Fig: 2C-External Rotation

Figure 2: Range Of Shoulder Internal And External Rotation Using Half Circle Universal Goniometer.



Figure 3: Starting Position Of Shoulder For Measuring Rotation Range Of Motion Using Motion Analyzer Sensors With Motion Analyzer Software: R M ingenierie Sy Co Mo Re version 8.52.0 And Bioval sensors.

Statistical Analysis

Descriptive statistics: Data was analyzed in statistical software version 14.0. Descriptive statistics like mean and standard deviation were calculated to summarize quantitative variables like range of motion of total arc of rotation at shoulder joint. Quantitative variable gender was summarized by frequency and percentage.

Inferential statistics: Karl Pearson's correlation was used to evaluate relation between shoulder rotator muscle strength at neutral and end range internal rotation and external rotation at right side.

Reliability: For intra-rater reliability of goniometry and motion analyzer for shoulder range of motion was determined by using the ICC to be 0.95 on the right side. The guidelines for the interpretation of reliability based on ICC's as: < 0.4 = poor, 0.4 to < 0.75 = moderate, 0.75 to < 0.9 = good, and > 0.9 = excellent reliability values.

RESULT

Out of 50 subjects, 43 (37 Female, 06Male) i.e. 86% showed shoulder range of rotation more than 180 degrees. Out of 43 female subjects in study 37 (i.e. 86.04%) showed shoulder range more than 180 degrees and 13.96 % showed less than 180 degrees. Whereas among males, out of 7 subjects 6 (i.e. 85.7%) showed shoulder rotation range more than 180 degrees. It was found that both gender showed nearly equal percent of subjects having more than 180 degrees of shoulder rotation range of motion. Hence, the mean and standard deviation of total arc of shoulder rotation range of motion using goniometer and motion analyzer is more than 180 degrees for shoulder joint among subjects. (Table 1)

Table 1: Mean and standard deviation of shoulder internal and external rotation range of motion (Goniometer and motion analyzer) in degrees and shoulder internal and external rotators muscle strength in pounds (lbs).

	ROM by Goniometer (IR+ER) (Degrees)	ROM by Motion analyzer (IR+ER) (Degrees)	Strength (End range IR) (lbs)	Strength (End range ER) (lbs)	Strength Neutral IR (lbs)	Strength Neutral ER (lbs)
Mean±SD	193.26±18.55	202.22±15.49	4.48±1.25	5.54±2.36	11±4.88	12.49±4.73

Abbr.: Standard Deviation (SD), Range of Motion (ROM), Internal Rotators (IR), External Rotators (ER)

Table 2: Mean And Standard Deviation Of Internal And External Rotation Range Of Motion Using Goniometry And Motion Analyzer

	ROM by Goniometer IR	ROM by Goniometer ER	ROM by Motion analyzer IR	ROM by Motion analyzer ER
Mean±SD	93.76±7.405	99.50±16.790	96.38±9.866	105.84±10.977

Abbr.: Standard Deviation (SD), Range of Motion (ROM), Internal Rotators (IR), External Rotators (ER)

In female subjects, with total arc of glenohumeral rotation more than 180°, exhibited decreased strength of external rotator muscles, than subjects with total arc less than 180°. There was no significant difference found in strength of IR and ER in neutral and at end range in females who had total arc of GH rotation more than 180° hence showed weak correlation.(Table 3)

The male subjects having more than 180° of total arc of glenohumeral rotation, exhibited decreased strength of internal rotators in both neutral and end range positions. No significant difference was found between the total arc of glenohumeral rotation and the strength of external rotators in neutral position as well as at the end range in male subjects with total arc of GH rotation more than 180°. The strength of IR

and ER in the neutral position and strength of internal rotators in end range was compared in male subjects with total arc more than 180° it was found that the

strength was more in neutral position as compared to end range, showed moderate correlation. (Table 3)

Table 3: Correlation between strength of shoulder internal and external rotators at neutral, end range external rotation and end range internal rotation among females (n=37) and males (n=06) with total rotation arc more than 180 degrees.

Gender	Shoulder Strength of rotator muscles at angle of rotation	Pearson correlation (r-Value)	Pearson correlation (IR/ER Strength at neutral Vs IR/ER strength at end range) (r- Value)
Female (n=37)	Neural IR	0.19*	}0.36*
	End range IR	0.15*	
	Neural ER	0.09*	}0.43*
	End range ER	-0.14*	
Males (n=6)	Neural IR	-0.73**	}-0.72**
	End range IR	-0.53**	
	Neural ER	-0.09*	}-0.54**
	End range ER	0.17*	

Abbr.: Internal Rotators (IR), External Rotators (ER)
Status of correlation: X*=No correlation, X**=Moderate correlation, X***=Strong correlation

Among female subjects with total arc of glenohumeral rotation less than 180°, exhibited decreased strength of external rotator muscles at neutral and at end range showed moderate negative correlation. There was significant difference found in strength of ER in neutral and at end range in females who had total arc of GH rotation less than 180°, showed strong positive correlation. (Table 4)

Table 4: Correlation between strength of shoulder internal and external rotators at neutral, end range external rotation and end range internal rotation among females (n=06) with total rotation arc less than 180 degrees.

Gender	Shoulder Strength of rotator muscles at angle of rotation	Pearson correlation (r-Value)	Pearson correlation of (IR-ER Strength at neutral Vs IR-ER strength at end range) (r- Value)
Females (n=6)	Neural IR	-0.69**	}-0.10*
	End range IR	-0.05*	
	Neural ER	-0.78**	}0.92***
	End range ER	-0.66**	

Abbr.: Internal Rotators (IR), External Rotators (ER)
Status of correlation: X*=No correlation, X**=Moderate correlation, X***=Strong correlation.

The reliability between goniometer and motion analyzer was evaluated and found acceptable internal consistency between the goniometry and the motion analyzer to measure range of motion with Cronbach's Alpha value 0.743 (Moderate Reliability).

DISCUSSION

The study aims to find the relationship between passive glenohumeral total rotation and the strength of internal and external rotator muscles in young healthy adults. Subjects were divided into two groups based on those with total arc of GH rotation more than 180° and those with total arc of GH rotation less than 180°. [7] In present study total number of subject were 50 out of which 43 were females and 07 were males. In present study out of 50, 37 females and 6 males showed total arc of GH

rotation more than 180°. Clarke GR et al found that females had greater GH range of motion for ER and total rotation [16] but in present study, males also showed higher incidence of arc of shoulder motion more than 180° which might be observed due to small sample size of male subjects.

In female subjects, with total arc of glenohumeral rotation more than 180°, exhibited decreased strength of external rotator muscles, than subjects with total arc less than 180° which is consistent with the results of the study conducted by Cibulka MT et al which showed that subjects with an increased total arc of GH rotation (more than 165°) had less isometric muscle strength than the subjects with arc less than 165°. [4] Scheper M et al concluded that individuals with generalized joint hypermobility have reduced muscle

strength. [17] There was no significant difference found in strength of IR and ER in neutral and at end range in females who had total arc of GH rotation more than 180° . The male subjects who had total arc of glenohumeral rotation more than 180° , exhibited decreased strength of internal rotators in both neutral and end range positions which is consistent with the findings of Cibulka MT et al who found that those with an increased total arc of glenohumeral rotation had less isometric muscle strength. [4]

There was no significant correlation was found between the total arc of glenohumeral rotation and the strength of external rotators in neutral position as well as at the end range in male subjects with total arc of GH rotation more than 180° . Miller AE et al concluded that the greater strength of males as compared to females is primarily due to larger muscle fiber. [18] It was also found that gender difference in upper body strength can be attributed to the fact that females tend to have a lower proportion of their lean tissue distributed in the upper body. [18] When the strength of IR and ER in the neutral position and strength of internal rotators in end range was compared in male subjects with total arc more than 180° it was found that the strength was more in neutral position as compared to end range which is consistent with results of study conducted by Cibulka MT, found that IR and ER muscles were found to be weakest when placed in a position of shortest muscle length, while the neutral and mid range positions were the strongest positions. [19,20]

On comparing the ranges obtained by half circle goniometer with the ranges taken on motion analyzer, it was found that there is acceptable internal consistency (Chronbach 'α' value =0.743) implying that the ranges taken by universal half circle goniometer and motion analyzer were nearly same as well as comparable. As the total arc of glenohumeral rotation increases beyond normal limits of 0° - 180° there is a decreased strength of internal rotator and

External rotator muscles as compared with those with total arc of glenohumeral rotation less than 180° irrespective of the gender. Goniometry and motion analysis system can be conjointly used for the assessment of glenohumeral rotation range of motion can be stated.

Future studies could be performed on a larger population with equal distribution of both genders. Correlation studies can also be performed on different joints with hypermobility and strength among both adult and paediatric population. From the result of present study, strengthening program can be implemented on the subjects exhibiting increased shoulder rotation range beyond normal limits. Non dominant side was not evaluated for correlation of muscle strength and range of motion at glenohumeral joint which can be part for future scope.

CONCLUSION

As the total arc of glenohumeral rotation increases beyond normal limits of 0 - 180° there is a decreased strength of internal rotator and external rotator muscles as compared with those with total arc of glenohumeral rotation less than 180° irrespective of the gender. Goniometry and motion analysis system can be conjointly used for the assessment of glenohumeral rotation range of motion.

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ANNEXURE

Range of Motion (ROM) by Motion Analyzer R M Ingenierie SyCoMoRe version 8.52.0

- I. The range of motion of GH joint was also measured by motion analyzer, the subject lying supine on a treatment table, with the glenohumeral joint positioned at 90 degree flexed and forearm pronated. Sensor was placed at ulnar styloid process at wrist of subject.
- II. A soft pad was placed under the subjects distal humerus so that it remained parallel to the treatment table surface.
- III. The subject was positioned supine on a treatment table, with the arm being tested in 90⁰ shoulder abduction, forearm perpendicular to supporting surface and in 0 degree of supination and pronation. [7]
- IV. The GH joint was rotated into the direction of IR or ER until a firm end feel was met, as a firm end feel represents the end passive range of motion for each movement.

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