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Original Research Article

Anterior translation of humeral head in glenohumeral joint: Comparison between limb dominance and gender using ultrasonography

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ABSTRACT

Introduction: The anterior translation of humeral head (ATHH) in glenoid cavity is one of the commonly evaluated measures to diagnose glenohumeral joint (GHJ) disorders. It is not clear that limb dominance and gender affect the ATHH in glenoid cavity. An understanding on such effects is important for clinicians to evaluate shoulder disorders.

Aim: This study compares the ATHH between gender and limb dominance among healthy individuals.

Material and methods: A total of 20 participants (12 females and 8 males) with mean $\pm$SD of 34$\pm$5.4 years of age participated in this study. All of the participants reported no shoulder pain, shoulder injury over the past two years, and had full range of shoulder movements at the time of testing. Participants with a history of shoulder surgery and those involved in any forms of overhead sports were excluded. A real-time ultrasonography was used to measure the ATHH in GHJ during a force of 80 N applied to GHJ. Independent sample *t*-test and paired sample *t*-test were used to analyze the differences in ATHH between limb dominance and gender.

Results and discussion: The mean$\pm$SD of ATHH was 0.16$\pm$0.08 cm and 0.13$\pm$0.08 cm in dominant and non-dominant shoulder, respectively. There was no statistically significant difference in ATHH ($t_{19}=1.52$, $p=.14$, 95% CI -0.01 to 0.07) between dominant and non-dominant shoulders. There was no significant difference in ATHH between male and female participants ($t_{18}=1.90$, $p=.97$, 95% CI -0.08 to 0.84).

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Conclusions: ATHH of GHJ did not differ among genders and limb dominance in healthy participants.
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1. Introduction

Shoulder stability is characterized by the proper alignment of the humerus within the glenoid fossa.[23] The proper alignment of humerus within the glenoid fossa is determined by anterior translation of humeral head (ATHH) within the glenoid fossa.[23] In glenohumeral joint (GHJ), ATHH refers to the displacement of the humeral head (HH) relative to the glenoid due to an applied stress by the examiner.[18,22] Hawkins et al. proposed translation as a parallel movement of a particular object due to applied stress with reference to another fixed object.[18] An understanding of the direction of HH translation during an applied stress provides the clinician information regarding the direction and magnitude of the laxity at GHJ.

Palpation of HH position in relation to glenoid fossa during rest and functional activity is frequently done by the clinicians as part of shoulder evaluation.[9] It is believed that altered translation of HH in relation to glenoid fossa is one of the causes for shoulder problems.[9] Thus, the knowledge on the HH especially ATHH in glenoid becomes a variable of interest to clinicians. In practice, quantifying the direction and magnitude of the HH translation at GHJ aids practitioners towards decisions on surgery or rehabilitation for shoulder problems. However, it is not clear whether the ATHH differs between dominant and non-dominant extremities. It is also unknown whether a gender difference exists in ATHH when clinicians interpret the translation measurements in clinical practice of shoulder conditions. Therefore it is important to investigate whether the range of motion of ATHH differs between genders, dominant and non-dominant GHJ.

Limb dominance or handedness is one of the factors reported to affect the range of motion of the upper extremity.[3,4,11,15] It is defined as the ability of the individual to use one hand predominantly than the other hand during unimanual functional tasks.[3,4,17] Past studies had compared several clinical variables related to shoulder joint such as radiological shoulder balance,[2] range of motion,[5] rotational strength,[17] proprioception[1,30] and kinematic analysis of scapulohumeral-shoulder muscles,[33] between dominant and non-dominant arms in order to find out the effect of limb dominance. Other studies reported differences in the range of motion of active and passive movements in the internal and external rotation movements in the dominant shoulder in comparison to the non-dominant shoulder.[3,4,15] The dominant hand was suggested to produce more force than the non-dominant hand.[24] According to the 10% rule on limb dominance, it was suggested that the maximum strength was 10% higher in dominant hand than the non-dominant hand.[25] The above studies imply that limb dominance is one of the crucial factors that might influence the clinical outcome of the shoulder joint examination.

Gender is also another factor that may affect the ATHH in GHJ. Women seem to have smaller anthropometric dimensions compared to men.[31] It is reported that females have increased thoracic curve and greater cervical joint range of motion when compared to males.[10] A recent study on the MR imaging of the GHJ between genders reported higher size, height and weight of HH among men when compared to women.[27] Gender differences were also identified in the biomechanical data for the hip, knee and ankle, with females having greater hip flexion, anterior pelvic tilt and lesser knee extension.[8,20] It raises the scientific quest to inquire whether gender differences exist in the ATHH in GHJ. Therefore, the main aim of this study was to report on the differences in the ATHH of the GHJ between the genders and limb dominance among healthy participants. This study hypothesizes that ATHH does not differ between limb dominance and gender. This study was performed to develop an understanding on the effects of gender and limb dominance on ATHH in GHJ.

2. Aim

The aims of the study were (1) to investigate any difference in ATHH in glenoid cavity between the dominant and non-dominant shoulder joints among healthy participants and (2) to compare ATHH in glenoid cavity between male and female participants with healthy shoulder joints.

3. Material and methods

3.1. *Subjects*

A total of 20 healthy participants (12 females and 8 males) participated in this study. The participants were recruited among the patient care givers who accompanied other patients to the hospital and as well as the staff from the hospital who volunteered to participate in the study. All the participants were selected based on pre-defined study criteria. In general, all the participants had full range of shoulder motions with no history of any symptoms in shoulder joint. Any participants with pregnancy, shoulder pathology, presence of pain on the shoulder or any shoulder injuries over the past 3 months, with any past history of shoulder surgery and participants more than 60 years of age were excluded. Participants who were involved in repetitive activities for the shoulder joints such as overhead sports were also excluded. The subjects were briefed about the study details and a written informed consent was obtained prior to their participation in the study. The ethical approval for this study was obtained from a University Hospital Ethical Committee with ethical code NN-181-2011.

3.2. Procedure

The resting position of HH (RPHH) and ATHH in the GHJ was measured using US imaging (real-time ultrasound system, model iU22 Philips, Netherlands) by B mode through a linear transducer of 3.5 MHz based on the established protocol.[12,21,32] The real-time ultrasonography method has the advantage that it does not have any radiation hazards when compared to other radiological measures such as X-ray and CT scan. After getting the consent, the participants were asked to expose the shoulder joints and they were positioned on a chair with a backrest with both legs resting on the floor. The shoulder was kept in medial rotation in an adducted position alongside of the trunk with the forearm facing the body and the elbow flexed and supported with another hand. This position was chosen to relax the shoulder muscles during the procedure. Additionally, general instructions were given to the participants to relax the shoulder during the procedure.

US imaging of the shoulder translation was performed by a qualified radiologist from anterior GHJ. During testing, the linear transducer with an aquasonic gel was placed on the anterior aspect on the shoulder and three well defined bony landmarks – greater tubercle of the humerus, coracoids process of the scapula and anterior-superior part of the neck of scapula – were identified and captured by the radiologist. In this position, the placement of the transducer on the skin was marked. The RPHH was measured by placing the cursor on the coracoids process of scapula, neck of scapula and top of the greater tubercle in the captured image. The distance between neck of scapular and the top of greater tubercle was measured as shoulder resting distance (d_1). A total of three trials were carried out and the average of the three readings was taken as final measurement.

The detail of ATHH measurement was defined as following. After the measurement of RPHH, the investigator (LJ) stood in a walk stance position behind the side of the tested shoulder of the participant. Acromion process and HH were palpated and the joint line was identified. The shoulder girdle was stabilized by the investigator (LJ) to prevent subjects from leaning forward or rotating the trunk during application of the translation force. Using a push-pull dynamometer, the first investigator applied a translator force of 80 N to the posterior part of HH to passively translate the HH anteriorly to the point of end feel. The force of 80 N was kept constant for all the participants in order to prevent variation in the translator force between genders and individuals. The bony landmarks of shoulder post-translation were measured again using ultrasonography by placing the cursor on the coracoid process of scapula, neck of the scapula and top of the greater tubercle. The distance between the neck of scapula and the top of the greater tubercle after the translator force was measured and recorded as post-translation distance (d_2). An average of three measures was taken for final reading of d_2. The ATHH was calculated through the difference between distance measured during a passive anterior translation (d_2) and at rest (d_1) (Fig. 1). The US images of ATHH are shown in Fig. 2. The same radiologist captured the US images of rest of the positions of HH and ATHH throughout the study. Thus, the measurement of ATHH was performed first on one shoulder and then on the other shoulder in a random manner. The intra-rater reliability of the ATHH measurement was performed prior to data collection, which demonstrated an acceptable reliability of measurements (intra-class correlation coefficient of 0.94 with standard error of measurements (SEMs) of 0.01 cm and coefficient of variation of 5.10%).

3.3. Statistical analysis

The data was analyzed using statistical software package for Windows (SPSS version 20.0). Examination of the normality of data using Shapiro–Wilk test showed that APHH and RPHH for both limb dominance and gender were normally distributed. Hence, paired sample-*t*-test was used to analyze the difference in APHH between dominant and non-dominant shoulder joints. The differences in APHH between genders were analyzed using independent sample-*t*-test. The level of significance was set at .05 for all tests.

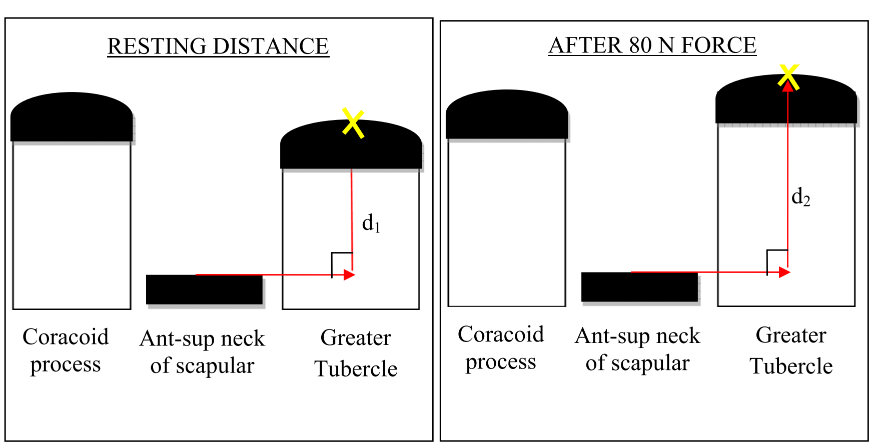

Fig. 1 – Measurement of ATHH: distance between highest parts of greater tubercle perpendicular to imaginary line of anterior-superior neck of scapular during resting (d_1); distance between highest part of greater tubercle perpendicular to imaginary line of anterior-superior neck of scapular during resting (d_2); ATHH (d_2–d_1).

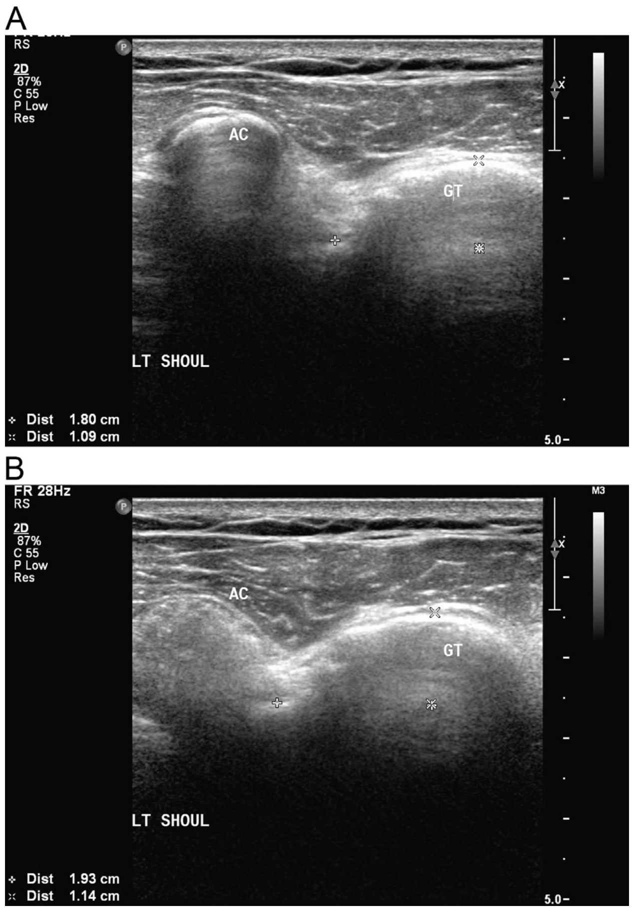

Fig. 2 – US images of ATHH at rest (A) and after 80 N translatory force (B).

Table 1 – Demographic characteristics of the subjects.

	Gender		P-value
	Male	Female	
Age, years	32.8 ± 3.6	36.7 ± 7.3	.13
Height, cm	162 ± 7.7	158 ± 6.4	.03
Weight, kg	71.7 ± 16.2	64.7 ± 14.0	.04
BMI	25 ± 5.9	25 ± 4.8	.52

4. Results

4.1. *ATHH between dominant and non-dominant shoulder joints*

The mean ±SD of the age, weight, height and body mass index (BMI) of the participants are shown in Table 1. The mean ±SD of ATHH of both dominant and non-dominant shoulder joints is demonstrated in Table 2. The results from the paired sample-t-test shows that there was no statistically significant difference in ATHH ($t_{19}=1.52$, $p=.14$, 95% CI -0.01 to 0.07) between dominant and non-dominant shoulders.

4.2. *ATHH between male and female shoulder joints*

Table 3 shows the mean ±SD of ATHH among both male and female participants. A comparison of the mean ATHH using independent sample-t-test with $\alpha=.05$ between males and female participants showed that there were no differences in ATHH between genders in both dominant $t_{0.03}=18$, $p=.97$ and non-dominant $t_{1.10}=18$, $p=.25$ shoulder joint.

5. Discussion

5.1. *Effects of gender and limb dominance in ATHH*

This study investigated the ATHH in shoulder joints among male and female participants as well between dominant and non-dominant shoulder joints. The study found that ATHH did not differ between dominant and non-dominant shoulders which imply that limb dominance had no effect on the ATHH in shoulder joints. The effects of gender and limb dominance on ATHH from the current study were comparable with the previous available literatures. The evidence from literatures did support a unified conclusion on the effects of gender on GHJ mobility. Past studies reported that there were no significant differences in translation and GHJ stiffness between male and female subjects.[6,16] Ellenbecker et al. after comparing ATHH using manual and stress radiography reported no statistical side to side differences in ATHH between dominant and non-dominant throwing shoulder.[14] Sauers et al. studied generalized joint laxity at GHJ and found no significant differences in the displacement of HH even at different force levels.[26] However, few other studies reported greater anterior glenohumeral laxity among female subjects when compared to male subjects.[5,6,7] Although past studies have tried to quantify translational laxity in GHJ,[14,19,28,29] only few studies have compared the HH translation between genders and limb dominance.

The measurement of HH translation was not well controlled and monitored in many of the past studies. In the study by Ellenbecker et al.,[14] ATHH was performed by a manual technique where it was not possible to control and quantify the translatory force given by the applicator. The measurement of ATHH through an instrumented device employed by Sauers et al.[26] might not be available in all clinical practice. In addition, monitoring of the correct ATHH during the applied force was not possible. In the clinical examination of the shoulder joint, laxity was measured commonly by clinicians through feeling the HH translation using manual tests. In our opinion, such manual method might be subjective in nature to quantify HH translation. In addition, the manual technique might lack preciseness to displace the HH and the clinicians may differ in their skills to accurately feel the translation of HH. The variation in the force given by different clinicians might produce different amount of HH translation as the force was not quantified in manual tests usually. All the above said factors might influence the examination findings and decision making of the clinicians.

Therefore, a rigorous method was employed in the current study to measure HH translation using ultrasonography. In the current study, the force of 80 N to produce ATHH displacement

Table 2 – HH translation between dominant and non-dominant shoulder joints.

	Limb dominance		Mean difference	CI of difference		P-value
	Dominant	Non-dominant		Lower	Upper	
ATHH, cm	0.16±0.08	0.13±0.08	0.03	−0.01	0.07	.14

Table 3 – Humeral head translation between gender.

Anterior translation of humeral head, cm	Gender		Mean difference	CI of difference		P-value
	Male	Female		Lower	Upper	
Dominant shoulder	0.15±0.08	0.15±0.09	0.001	−0.08	0.08	.97
Non-dominant shoulder	0.15±0.07	0.11±0.08	0.040	−0.03	0.11	.25

was controlled using a force transducer and the researchers were able to monitor the moment of HH translation clearly in ultrasonography. We opine that the ultrasonography evaluation of the ATHH provides a visual feedback to the clinician in the ultrasound monitor which assists in the precise translation of the HH. Thus, the measurement of ATHH using ultrasonography might be more applicable and appropriate for clinical practice where the translation of the HH could be visibly seen and monitored.

5.2. *Importance of ATHH in clinical practice*

The measurement of GHJ laxity and its importance in clinical decision making warrants that the amount of glenohumeral translation required to be more objectively defined.[26] To our knowledge, our study might also be the first study that had investigated the differences on ATHH among genders and limb dominances using a real time ultrasonography in the clinical environment. The novelty of the study is related with the quantification method of ATHH as the whole translator force and changes in the GHJ translation was completely monitored by ultrasonography by the researchers. In terms of clinical implication, the non-differences observation in the ATHH between dominant and non-dominant shoulder joint add further biomechanical knowledge to clinical reasoning and interpretation of ATHH during shoulder examination. Thus, the technique and the findings of the current study are clinically feasible as the method of measuring ATHH was well controlled with a reliable procedure in an clinical environment. Also, it may assist the clinicians in the examination and treatment of shoulder problems such as shoulder instability, stiff shoulder, shoulder impingement syndrome and to evaluate the outcomes of both surgical and non-surgical treatment programs.

5.3. *Limitation*

One of the limitations of the current study was that all the participants in the study were with right hand dominance. Hence, the true effects of left hand dominance could not be inferred from the current study. However methodologically as all of the subjects were right handed, the classification of dominant and non-dominant shoulders were controlled and distributed equally. In addition, the ATHH in the study was evaluated only among healthy participants. Perhaps, we would like to recommend that the ATHH could also be studied among patients with different shoulder problems such as shoulder instability and shoulder impingement where the position of HH was reported to be altered.[13]

6. Conclusions

The evaluation of HH translation using ultrasonography supported no differences in ATHH among genders and limb dominance in healthy participants. The findings of the study and the measurement procedure of HH translation using ultrasonography could be a useful referencing method for clinicians in clinical practice to evaluate shoulder disorders.

Conflict of interest

Nothing to declare.

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