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Thumb to spinous process is a false metric for glenohumeral internal rotation

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Background: The measurement of internal rotation by noting the maximal vertebral level reached by the patient's thumb behind their back is an established physical examination technique, as outlined in the American Shoulder and Elbow Surgeons Shoulder Assessment Form.[7] The purpose of the present study is to correlate real-time glenohumeral internal rotation with thumb to spinous process movement to determine the accuracy of the technique.

Methods: Healthy volunteers with no previous history of shoulder injury or symptoms were recruited from the local medical school population. Ultrasound probe was placed over the anterolateral shoulder, and relevant anatomy was identified. Internal rotation was evaluated by measuring displacement of the peak of the medial aspect of the bicipital groove relative to the anterior glenoid rim with the arm held in defined positions of progressively increasing internal rotation. The difference in displacement between arm positions was calculated and recorded.

Results: A total of 20 participants (11 women/9 men, aged 22-42 years) were recruited for measurement. A mixed-model repeated-measures analysis of variance was used. The most significant differences in displacement, and therefore internal rotation, were observed between the neutral and anterior superior iliac spine (0.21 ± 0.39 mm, $P = .0269$) and between the anterior superior iliac spine and peak iliac crest (0.26 ± 0.44 mm, $P = .0163$). After the peak iliac crest, there was no further statistically significant change in rotation.

Conclusion: The present study suggests that most glenohumeral internal rotation occurs before reaching the arm behind the back. Although not directly studied, this supports the notion that the maximal vertebral level reached involves an interplay of various joint motions. While the thumb to spinous process maneuver remains a functional evaluation, our results suggest a different examination technique be used to more accurately test glenohumeral internal rotation.

There are many physical examination methods to evaluate shoulder rotation. Measuring internal rotation by noting the maximal vertebral level reached by the patient's thumb behind their back is among those that are widely used. It is referred to in multiple physical examination textbooks and is mentioned on the American Shoulder and Elbow Surgeons Shoulder Assessment Form.[7] Previous studies have attempted to test the accuracy and precision of this measurement either directly, using X-ray, or indirectly, using measuring tape and electrode tracking.[2,5,6,9] These studies have come to a general conclusion that the measurement provides an incomplete assessment of glenohumeral internal rotation (GHIR) as humeral extension, scapulothoracic, elbow, and wrist ranges of motion are also involved. The aim of our study is to use dynamic ultrasound to directly measure GHIR with the arm in various positions and correlate the measurements with thumb to spinous process position.

We hypothesize that most GHIR will occur prior the thumb reaching the spine.

Methods

The study protocol was approved by the Institutional Review Board of the State University of New York at Buffalo. Participants with healthy shoulders were recruited from the Jacobs School of Medicine and Biomedical Sciences medical student population. Healthy shoulders were defined as those without preexisting condition, previous injury, or mechanical/painful symptoms at time of evaluation. Only one shoulder per participant was measured. If the

Approval for this study was received from the University at Buffalo Institutional Review Board (STUDY00003367).

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participant reported any prior shoulder symptoms, the contralateral shoulder was used as the primary goal of the study was to observe only healthy shoulders. Informed consent was obtained from all willing participants before continuation with ultrasound measurement. Ultrasound measurements were carried out in the outpatient office of Dr. Ablove using a Phillips Sparq Ultrasound system (model 795090RA). Measurements were made by a single researcher and confirmed by two observers. Measurements were repeated when there was not a consensus between all three people.

Volunteers were instructed to sit and were provided appropriate clothing while leaving the shoulder exposed. The ultrasound probe was placed over the anterolateral shoulder identifying the bicipital groove and the glenoid rim. The distance from the peak of the medial aspect of the bicipital groove to the anterior glenoid rim, along the arc of the glenohumeral joint, was recorded with the arm held in various positions. The probe was held in one position on the anterior shoulder while the participants moved their arm, and measurements were recorded in real time. The plane of measurement was held constant by the measuring physician, with consensus from the other two researchers in the room. Arm positions included the following: (1) neutral rotation with the arm at side; (2) thumb to anterior superior iliac spine; (3) peak iliac crest; (4) posterior superior iliac spine; (5) lumbosacral junction; and (6) spinous processes from L5 until cessation of internal rotation.

Descriptive statistics were used to analyze patients' demographic data such as age, sex, and body mass index. Analysis of variance, two-way with pairwise comparison, was used to assess if there is a difference in mm displacement of bicipital groove and percent change across multiple categories of the arm position. A P value <.05 was considered statistically significant.

Results

We included in the study 20 participants, 11 women and 9 men, with an average age of 25.7 ± 5.0 years. All participants were right-hand dominant. Eleven right shoulders and 9 left shoulders were measured. (Refer to Table I for demographic data.)

Most displacement, and by extension GHIR, occurred between arm at neutral and thumb at anterior superior iliac spine (0.21 ± 0.39 mm, $P = .0269$) and between thumb at anterior superior iliac spine and peak iliac crest (0.26 ± 0.44 mm, $P = .0163$). After peak iliac crest, the difference in displacement between positions was not found to be statistically significant (refer to Table II).

Discussion

Shoulder internal rotation is an important part of activities of daily living, with injuries or restriction causing morbidity. Accurate diagnosis of causation is potentially important in helping plan therapeutic intervention. One of the most popular techniques is the hand-behind-back (HBB) vertebral-level test.

Table I
Patient demographic characteristics, N = 20.

Demographics (mean ± SD for continuous; n(%) for categorical variables)	
Age in yr	25.7 ± 5.0
Gender	
Male	9 (45)
Female	11 (55)
Hand dominance	
Right	20 (100)
Laterality	
Right	11(55)
Left	9 (45)

Table II
Comparison between 6 positions and displacement measurements (cm) of glenohumeral internal rotation, N = 20.

Arm/Thumb positions	Differences in displacement (cm)	P value*
Neutral rotation with the arm at side vs. the thumb to anterior superior iliac spine (ASIS)	0.21 ± 0.39	.0269*
Thumb to ASIS vs. peak iliac crest (PIC)	0.26 ± 0.44	.0163*
PIC vs. posterior superior iliac spine (PSIS)	−0.04 ± 0.51	.7507
PSIS vs. lumbosacral junction (LS jxn)	−0.04 ± 0.35	.5992
LS jxn vs. spinous processes from L5 until cessation of internal rotation (level to level)	0.09 ± 0.25	.1107

* The P values were estimated with mixed-model repeated-measures ANOVA. P value <.05 was considered statistically significant.

Numerous studies have discovered the reliability of indirectly measuring internal rotation with HBB and measuring distance from posterior superior iliac spines or C7 to maximal vertebral level, which prove that the technique is reliable when performed in a specific manner.[2,5,8] How closely this corresponds with internal rotation is not known.

While studies have attempted to test the reliability of numerous GHIR measuring techniques in various ways, few have tested the accuracy of the hand-behind-back method. Mallon et al[6] have demonstrated the HBB method oversimplifies joint mechanics because other joints are involved in recreation of the specific movement. Elbow and shoulder joint angles were measured in five positions using X-ray imaging while patients lay prone. Other studies used standing or supine positions.[4] The authors concluded further investigation was necessary, but they established the precedent the HBB method does not measure GHIR solely, and the movement of reaching behind the back involves more than just the glenohumeral joint.

Wakayabashi et al[9] attempted to study using internal rotation using electromagnetic tracking devices placed at key joints and measuring their relationships to each other while the participant moved their arm in space. This, once again, is an indirect measure of GHIR. Although they ultimately came to the same conclusions, they pointed out that subdivision of the arm position along the iliac crest and sacrum was needed in further investigation.

We attempted to directly measuring the shoulder joint using ultrasound while the patient's arm and thumb assume multiple positions in accordance with suggestion of previous experiments. Our results suggest that most GHIR occurs most significantly from neutral position to peak iliac crest and less so as the arm reaches behind the back. This suggests this commonly used technique is not a valid measurement of internal rotation specifically. In multiple studies, after testing the HBB method against direct goniometric measure in 90° abduction, researchers suggested that goniometric methods are a more reliable measure of GHIR.[1-3] However, the measurement can still be a valuable global functional assessment of the shoulder as it seems to involve not only GHIR.[6] As such, a difference in thumb to spinous process measurement between a normal and pathologic shoulder within the same patient may be observed.

There are several limitations to our study. This was a study with relatively small sample size with an average age of 26 years and healthy shoulders, which may not be representative of the population as a whole. The exclusion of real patients with shoulder complaints was intentional as we felt that including such patients would confound results. The decision was made to include only healthy shoulders as to be able to identify normal anatomy and eliminate potential for limited shoulder range of motion based on preexisting shoulder pathology. In addition, the study design relied on the operator of the ultrasound to correctly

identify anatomic landmarks and perform measurements at rest and during movement, while maintaining the probe's position constant. Not knowing humeral diameter at the measured level prevented us from measuring rotation in degrees, causing us to use displacement from position to position to quantify the percentage of internal rotation occurring between the described positions. However, we were able to easily and reproducibly identify very small internal rotations occurred with the thumb on the spine in any position.

Conclusion

Our study findings corroborate previous research in concluding that thumb to maximal spinous process measurement for GHIR is an oversimplification of a complicated interplay of joints. By using ultrasound, we have found a noninvasive and safe modality for real time measurement with promising future implications. Ultimately, although thumb to spinous process test is still useful as a functional metric, it may be an inaccurate measurement of GHIR.

Disclaimers

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Supplementary data

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