[Physical Therapy]

Internal Rotation Behind-the-Back Angle: A Reliable Angular Measurement for Shoulder Internal Rotation Behind the Back

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Background: The hand-behind-back method is the accepted technique to evaluate shoulder internal rotation, is highly popular, and is endorsed by the American Academy of Orthopaedic Surgeons. It remains, however, subject to intra- and interexaminer discrepancy and has been challenged by several recent publications.

Hypothesis: Internal rotation behind the back can be evaluated with a measurable angle, which eliminates the need to estimate spinal level, decreases the effect of unrelated joints, and allows collection of numeric rather than categorical data.

Study Design: Descriptive laboratory study.

Methods: We defined the internal rotation behind-the-back (IRB) angle as that between the ulna and the line of gravity. A pendulum is attached to a standard goniometer. The patient is asked to reach the highest point along the midline of the back. The goniometer is centered over the pisiform, and the angle between the ulnar axis and the pendulum is measured. Two examiners assessed both shoulders of 60 volunteers with no shoulder pathology using this technique on 2 occasions. Both examiners were blinded to each other's values. We applied the paired Student *t* test and calculated Pearson correlation coefficients and weighted Cohen kappa values.

Results: The IRB angles ranged from 50° to 125°. The difference of the mean, as measured with the Student *t* test, was 0.6° (95% confidence interval: 0.1°, 1.3°) and 0.6° (95% confidence interval: -0.8°, 1.8°); the Pearson correlation coefficients were 0.98 and 0.92; and the weighted kappa values were 0.88 and 0.77 for interobserver and intraobserver analyses, respectively.

Conclusion: The IRB angle is easy to measure, is reproducible, and does not rely on determination of spinal level. It provides numeric data and may eliminate some of the uncertainty associated with the estimation of spinal level.

Clinical Relevance: The IRB angle may eliminate some of the uncertainty associated with the estimation of spinal level.

Keywords: shoulder; range of motion; internal rotation behind back; hand behind back; physical examination

Clinicians and investigators agree that a standardized method of assessing musculoskeletal function is a high priority for communication, documentation, and relay of outcome data to fellow physicians, health care administrators, and the general public.¹¹ In the realm of shoulder surgery, however, measurement of shoulder motion, specifically internal rotation, has proven difficult to standardize. The commonly accepted hand-behind-back (HBB) method—although highly popular, easy to use and teach, and endorsed by the American Academy of Orthopedic Surgeons⁶ and the American Shoulder

and Elbow Surgeons¹¹—remains a weak link in the examination of shoulder range of motion (Figure 1).

Several recent studies have challenged the accuracy and reproducibility of HBB measurements among examiners.^{2,4,8,9} Placing the hand behind the back incorporates shoulder extension, scapular retraction and downward rotation, elbow flexion, forearm supination, wrist radial deviation, and thumb extension reaching to the highest point up the spine. The motion of the aforementioned joints directly influences the interpretation of HBB, adding more variables to the evaluation.⁴

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The author reported no potential conflicts of interest in the development and publication of this manuscript.

DOI: 10.1177/1941738113502159

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Figure 1. Hand behind back is determined by the highest spinal level reached by the thumb.

Spinal deformity and truncal obesity may make accurate designation of the spinal level challenging.^{8,9} As such, the utility of HBB as a measure of shoulder internal rotation greatly underestimates the contribution from other joints.^{4,9}

Evaluating internal rotation behind the back (IRB) remains an important measurement of shoulder function, as reaching behind the back is an everyday function and loss of such motion is one of the early signs of pathology. Whereas the current standard for the evaluation of shoulder IRB relies on visual and tactile determination of spinal level and carries the effect of other joints, there is room for improvement in the way that it is measured. Our approach was to eliminate the use of the spine and thumb and replace them with the line of gravity and the ulna, respectively. This replacement converts a categorical measurement (spinal levels) into a numeric one (angles).

METHODS

This study was approved by the ethics committee of Stonewall Jackson Memorial Hospital, Weston, West Virginia. The IRB angle was defined as the angle between the long axis of the forearm and the line of gravity (Figure 2).

We attached a pendulum made of a K-wire and 2 Jurgan balls to the center of a standard goniometer. To measure the angle between a limb and the line of gravity, the goniometer arm is aligned along the limb, and the pendulum is let free (Figure 3).

To measure the IRB angle, the patient is asked to reach up the back to the highest point along the midline. The goniometer is centered over the pisiform, and the measuring arm is aligned along the ulna toward the olecranon (Figure 4). The angle is measured between the pendulum and the measuring arm, with

Figure 2. The internal rotation behind-the-back angle is defined between the forearm and a vertical line.

Figure 3. Gravity goniometer made from 1 goniometer and a pendulum. The pendulum is made from a K-wire and 2 Jurgan balls.

Figure 4. Internal rotation behind-the-back angle measured using the gravity goniometer.

Figure 5. Distribution of internal rotation behind-the-back angle values. Gray bars, measurements made by examiner 1; black bars, measurements made by examiner 2.

the 0 angle defined where the forearm is perfectly vertical and pointing inferiorly.

Sixty volunteers were recruited for evaluation. Inclusion criteria were as follows: adults aged 18 to 80 years who were willing to participate and available on 2 visits for repeat examination by 2 examiners. All volunteers completed screening questionnaires related to shoulder, elbow, forearm, or wrist pathology. We excluded all who had a history of injury, therapy, injection, or surgery to any of the above. All volunteers provided written consent to participate. Demographic information was collected as well. The test was performed on both shoulders by 2 examiners: the primary investigator and a certified athletic trainer. Both examinations were done independently, and both examiners were blinded to the results. The volunteers presented for repeat examination 2 weeks later. On the second visit, each volunteer was asked whether there had been any changes in the condition of the upper extremities.

All measurements were made to the nearest 5°. At the conclusion of the study, we utilized the paired Student *t* test, Pearson correlation coefficient, and weighted Cohen kappa to evaluate inter- and intraobserver reliability. We set the *P* value at 0.05.

RESULTS

Mean patient age was 43 years (range, 18-87 years), mean weight was 83.9 kg (range, 47-118 kg), and mean height was 166.2 cm (range, 124-193 cm). Twenty-four recruits were men, and 55 were right-hand dominant.

The measured IRB angles ranged between 50° and 125° (mean, 95°; 95% confidence interval [CI]: 59°, 131°) (Figure 5). Interobserver analysis based on the Student *t* test showed a difference of the mean of 0.6° (95% CI: 0.1°, 1.3°). The Pearson correlation coefficient was 0.98, and the weighted Kappa coefficient was 0.88. The majority of measurements (97.4%) were within 5° (Figure 6).

Intraobserver analysis based on the Student *t* test showed a difference of the mean of 0.6° (95% CI: -0.8°, 1.8°). The

Figure 6. Interobserver analysis.

Figure 7. Intraobserver analysis.

Pearson correlation coefficient was 0.92, and the weighted Kappa coefficient was 0.77 (Figure 7).

DISCUSSION

The guidelines and reference range for shoulder range of motion were set in 1958, when the American Medical Association published “A Guide to the Evaluation of Permanent Impairment of the Extremities and Back,”¹ and were further established in 1965, when the American Academy of Orthopedic Surgeons issued its recommendations for range of motion evaluation and introduced shoulder IRB.^{6,10} Since then, the HBB method has become the standard for measuring active internal rotation of the shoulder.¹¹ In 1994, the American Shoulder and Elbow Surgeons published its Standardized Shoulder Evaluation Form, which also measured shoulder internal rotation by noting the highest segment of spinal anatomy reached with the thumb, further establishing the HBB assessment as the standard for measuring shoulder internal rotation.¹¹

Despite limitations, examining IRB is important, as it relates to personal functions such as toileting and dressing.⁴ HBB examination is easy and convenient and does not require dedicated tools. There is, however, room for improvement. Some of the variability in administration and documentation of the HBB may be due to the need to determine the spinal level.² The HBB method is influenced by several unrelated joints distal to the shoulder and, at its best, provides only categoric data.

The inter- and intraobserver agreements of this study, both above 0.75, were excellent. The interobserver reliability was higher than the intraobserver reliability. Previous reports showed opposite results.^{2,4,5} Our results may be related to the ease of reading the angle; observer-related factors may be less influential.

The use of the gravity-referenced goniometers in the upper extremities was first described by Flowers et al³ to measure pronation and supination. Their reported intertester coefficient ranges between 0.86 and 0.98.^{3,7} There is value in relieving the tester of the dual responsibility of aligning both arms while reading the angle as required in conventional goniometry.⁷ Green et al⁵ employed the Plurimeter-V gravity inclinometer to measure shoulder range of motion, but he did not apply it for IRB.

CONCLUSION

We believe that the IRB angle provides a simple numeric measure of shoulder IRB that is easy to use.

ACKNOWLEDGMENT

I would like to acknowledge the contribution of Ericka Bell, ATC, for her assistance in the study.

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