Reliability of the Clinical Application of a Mechanical Inclinometer in Measuring Glenohumeral Motion

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Objective: Establish intra- and inter-examiner reliability of glenohumeral range of motion (ROM) measures taken by a single-clinician using a mechanical inclinometer. **Design**: A single-session, repeated-measure, randomized, counterbalanced design. **Setting**: Athletic Training laboratory. **Participants**: Ten college-aged volunteers (9 right-hand dominant; 4 males, 6 females; age=23.2±2.4y, mass=73±16kg, height=170±8cm) without shoulder or neck injuries within one year. **Interventions**: Two Certified Athletic Trainers separately assessed passive glenohumeral (GH) internal (IR) and external (ER) rotation bilaterally. Each clinician secured the inclinometer to each subject's distal forearm using elastic straps. Clinicians followed standard procedures for assessing ROM, with the participants supine on a standard treatment table with 90° of elbow flexion. A second investigator recorded the angle. Clinicians measured all shoulders once to assess inter-clinician reliability and eight shoulders twice to assess intra-clinician reliability. We used SPSS 14.0 (SPSS Inc., Chicago, IL) to calculate standard error of measure (SEM) and Intraclass Correlation Coefficients (ICC) to evaluate intra- and inter-clinician reliability. **Main Outcome Measures**: Dependent variables were degrees of IR, ER, glenohumeral internal rotation deficit (GIRD) and total arc of rotation. We calculated GIRD as the bilateral difference in IR (nondominant–dominant) and total arc for each shoulder (IR+ER). **Results**: Intra-clinician reliability for each examiner was excellent (ICC[1,1] range=0.90-0.96; SEM=2.2°-2.5°) for all measures. Examiners displayed excellent inter-clinician reliability (ICC[2,1] range=0.79-0.97; SEM=1.7°-3.0°) for all measures except nondominant IR which had good reliability(0.72). **Conclusions**: Results suggest that clinicians can achieve reliable measures of GH rotation and GIRD using a single-clinician technique and an inexpensive, readily available mechanical inclinometer.
Key Words: Shoulder, glenohumeral internal rotation deficit (GIRD), range of motion (ROM)

Reliably measuring range of motion (ROM) is an integral component of a comprehensive shoulder exam. Patients with shoulder pathologies often present with decreased glenohumeral (GH) ROM.[1,2] Measured values can be compared between clinicians, to normative data, and used to calculate measures that are associated with pathologies including glenohumeral internal rotation deficit (GIRD) and total arc of rotation. However, reliable techniques measuring ROM often lack practicality in use, requiring two clinicians or expensive instruments.

Establishing a standard patient position for measuring ROM allows the same or different clinician to reproduce the measurements later. The standard protocol for measuring rotational ROM, external (ER) and internal rotation (IR) with the arm in 90º abduction,[1-11] has an excellent Interclass Correlation Coefficient (ICC) for intra-clinician reliability when using a standard goniometer.[12] However, discrepancy exists on whether the patient should sit or lay supine, if the clinician should limit ROM by stabilization, or use visual investigation to prevent additional scapulothoracic motion. The end of glenohumeral rotation occurs when a firm capsular end point is felt or when the scapula appreciates.[1]

A variety of measurement tools are available to determine ROM of the GH joint, including a mechanical and digital inclinometer, goniometer, and computerized tracking analysis.[1,2,6-8,10,12] Goniometric methods have displayed fair to good reliability[5]; however, their applicability is limited in the clinical setting. Clinically, the examiner must efficiently be able to measure ROM without a second examiner present. Goniometric measurements often require two examiners; the first secures the goniometer and follows the movement of the forearm into rotation, while the second stabilizes the scapula.[5,8] Scapular stabilization, the application of a posterior force on the anterior coracoid and lateral clavicle to limit anterior tilt of the scapula, isolates glenohumeral rotation.[1,2-5,9,10]

A measuring instrument must be financially obtainable for clinical use. A computerized data tracking software with joint position sensors can be used to determine ROM, but is not practical to a high school or small setting. Therefore, the purpose of this study was to establish a reliable measure of internal and external ROM using a mechanical inclinometer. We hypothesize our results will be similar to goniometric reliability of fair to good.

Methods

Participants were 10 healthy college-aged volunteers (20 shoulders) (9 right-hand dominant; 4 males, 6 females; age=23.2±2.4 y, mass=73±16 kg, height=170±8 cm) with no shoulder or neck injuries within the past year. Clinicians were two Certified Athletic Trainers (PD and PM) with novice experience using an inclinometer to assess ROM. Each clinician practiced with the mechanical inclinometer for one week prior to testing to gain familiarization with the instrument.

Each clinician measured one subject at a time on two separate examination tables in an Athletic Training research laboratory. We measured maximal passive GH IR and ER bilaterally using an inexpensive mechanical inclinometer (Sears, Roebuck & Co., Chicago, IL). The inclinometer uses a pendulum to determine its angular relation to horizontal, accurate to 0.5°. We strapped the inclinometer firmly to each subject's forearm at the distal radius using two 1" elastic straps with hook-and-loop closures. Each measurement followed standard procedures for assessing GH rotational ROM, with subjects lying supine on a standard treatment table with 90° of elbow flexion wearing a t-shirt or sports bra. This protocol for patient positioning is reported as a valid and reliable measure of isolated glenohumeral motion.[12] The clinician controlled scapular motion through visual inspection and patient positioning, with the scapula on the table. Clinicians considered maximal motion achieved when rotation ceased with a firm capsular end-feel and before they appreciated scapular motion. Clinicians then prompted a second investigator to record the angle indicated by the inclinometer. The two clinicians were blinded to each measure to remove bias. We measured each rotation twice, recording the average. We calculated GIRD as the difference between nondominant total arc and dominant total arc measures. Each clinician measured all 20 shoulders once to assess inter-examiner reliability and measured eight shoulders twice to assess intra-examiner reliability. Participants rested for 5 minutes between measures to allow any affects of the measure to diminish before the next measurement. We used SPSS 14.0 (SPSS Inc., Chicago, IL) to calculate standard error of measure (SEM) and evaluate intra- and inter-examiner reliability of dependent measures through ICC.

Results

Listed in Table 1 are mean and standard deviation (SD) for each motion measured. For clinician 1, mean measure of dominant IR was 53.7±5.4º, dominant ER 87.4±12.7º, with total arc measurements of 151±12.5º for dominant shoulder. For clinician 2, mean measures of dominant IR was 66.7±5.7º, dominant ER 85.0±11.9º, with total arc measurements of 151±11.0º for dominant shoulder. .

ICC values of >0.75 are regarded as excellent, 0.40-0.75 as fair to good, and 0-0.40 as poor.[12]. Intra-clinician reliability for each clinician was excellent (ICC[1,1] range=0.90-0.96; SEM=2.2°-2.5°) for all measures (Table 2). Clinicians displayed excellent inter-clinician reliability (ICC [2,1] range=0.79-0.97; SEM=1.7°-3.0°) for all measures except nondominant IR which had good reliability (0.72) (Table 3).

Discussion

The results of this study indicate our clinicians displayed good to excellent reliability when measuring GH rotation with a mechanical inclinometer. All measures were excellent for both intra- and inter-examiner reliability, except nondominant IR with good reliability. Our measures are comparable to other non-overhead throwing measures. Mean measures for ROM are IR 48.7º and ER 81.6º in non-overhead throwing athletes.[13] The average ROM for throwing athletes is, however, greater in both ER with 113º- 141º and IR with 56.6º-65º in the dominant shoulder.[3,14] The specific cause in the change of ROM is unknown; associations are made with osseous adaptations and soft tissue adaptations due to the repetitive stress of throwing.

Patients with shoulder pathologies often have a change in their affected shoulder's ROM. In measuring shoulder ROM, the method must be reliable so that when compared across time the method is exact, and the results are comparable. The amount of rotational ROM measured can determine the severity of the pathology. Athletes with internal impingement have shown a decrease in IR, that is not met with gains in ER.[1] With results comparable over time, the clinician can determine the progress of an intervention or the continuation of a pathology.[15] Our results demonstrate that using a mechanical inclinometer to measure rotational motion at the GH joint is both intra- and inter-examiner reliable.

Our study is limited to healthy college-aged population. Our results apply only to the use of the mechanical inclinometer for measuring range of GH rotation.

Conclusions

This demonstrates that novice clinicians can achieve reliable measures of GH rotation and GIRD using a single-clinician technique and an inexpensive, readily available mechanical inclinometer. Further investigation is needed to determine the validity of measuring rotation at the GH joint using a mechanical inclinometer compared to motion analysis software and a standard goniometer, and if a mechanical inclinometer is reliable when measuring patients with pathology.

Table 1. Mean Values for IR, ER, Total Arc, and GIRD

	D IR		D ER		ND IR		ND ER	
Clinician	1	2	1	2	1	2	1	2
Mean	63.7	66.7	87.4	85.0	66.8	66.8	87.1	85.8
SD	5.4	5.7	12.7	11.9	5.9	4.7	10.1	9.0
	D Arc		ND Arc		GIRD			
Clinician	1	2	1	2	1	2		
Mean	151	151	154	153	3.1	0.1		
SD	12.5	11.0	9.1	7.7	4.3	4.5		

Legend. D, dominant; ND, nondominant.

Table 2. Intra-clinician Reliability Measures

	ICC	SEM
Clinician 1	0.962	2.24
Clinician 2	0.942	2.53

Table 3. Inter-clinician Reliability Measures

	ICC	SD	SEM
D IR	0.790	5.6	2.57
D ER	0.941	12.1	2.94
ND IR	0.720	5.2	2.75
ND ER	0.968	9.3	1.66
D ARC	0.937	11.5	2.89
ND ARC	0.870	8.2	2.96

Legend. D, dominant; ND, nondominant.

Figure 1. Technique used to measure range of passive glenohumeral external rotation.

Figure 2. Technique used to measure range of passive glenohumeral internal rotation

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