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Measuring shoulder external and internal rotation strength and range of motion: comprehensive intra-rater and inter-rater reliability study of several testing protocols

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Background: Shoulder range of motion (ROM) and strength measurements are imperative in the clinical assessment of the patient's status and progression over time. The method and type of assessment varies among clinicians and institutions. No comprehensive study to date has examined the reliability of a variety of procedures based on different testing equipment and specific patient or shoulder position. The purpose of this study was to establish absolute and relative reliability for several procedures measuring the rotational shoulder ROM and strength into internal (IR) and external (ER) rotation strength.

Methods: Thirty healthy individuals (15 male, 15 female), with a mean age of 22.1 ± 1.4 years, were examined by 2 examiners who measured ROM with a goniometer and inclinometer and isometric strength with a hand-held dynamometer (HHD) in different patient and shoulder positions. Relative reliability was determined by intraclass correlation coefficients (ICC). Absolute reliability was quantified by standard error of measurement (SEM) and minimal detectable change (MDC). Systematic differences across trials or between testers, as well as differences among similar measurements under different testing circumstances, were analyzed with dependent *t* tests or repeated-measures analysis of variance in case of 2 or more than 2 conditions, respectively.

Results: Reliability was good to excellent for IR and ER ROM and isometric strength measurements, regardless of patient or shoulder position or equipment used (ICC, 0.85-0.99). For some of the measurements, systematic differences were found across trials or between testers. The patient's position and the equipment used resulted in different outcome measures.

Conclusions: All procedures examined showed acceptable reliability for clinical use. However, patient position and equipment might influence the results.

The Gent University Ethics Committee approved this study (Approval No. B67020109775).

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Clinicians and researchers routinely evaluate changes in the status of patients over time. The assessment of range of motion (ROM) and muscle strength is important in (1) the diagnosis of glenohumeral disorders and pathologies, (2) the assessment of treatment progression and effectiveness, and (3) for quantifying the amount of change in movement quality and force development occurring over time.[30-32] In addition, establishing objective measurements of ROM and strength is essential to the identification of risk factors for shoulder pain, particularly in an athletic population.[3,28] It is, therefore, important for clinicians and researchers to have accurate and reliable examination tools to objectively assess the functional status of the shoulder joint.[19,25] In general, ROM and strength assessment are considered to be necessary outcome measures of shoulder function besides self-report outcome scores and subjective clinical examinations.[11,24,26]

The method and type of functional shoulder assessment, including the patient's position and testing equipment, varies among clinicians and institutions by factors such as time, the clinician's educational background, availability of equipment, and the specific movement or muscle being assessed. Goniometry has been used widely for ROM assessment because of its low cost and portability. However, in the assessment of shoulder external (ER) and internal (IR) rotation ROM, the clinician is required to use both hands, which makes stabilization of the trunk and the scapula more difficult and thus often leads to increased risk for measurement errors or the need for a second assessor.[35]

Inclinometry is another practical alternative in which gravity is used as a reference point for ROM measurements. Digital inclinometers are portable and lightweight but are more costly than goniometers. In addition, ROM measurements with an inclinometer can only be performed in a vertical plane because the tool depends on gravity for interpretation of ROM measurements.[17]

A variety of methods have been used for the assessment of shoulder rotational strength, including manual muscle testing (MMT), hand-held dynamometry (HHD), and isokinetic testing. Although considered to be the gold standard, isokinetic testing is not always user-friendly because of the high costs and the laboratory setting required.[30] HHD is a more objective evaluation method and far more superior to subjective MMT when evaluating changes in muscle strength after injury.[27]

Numerous studies[30,32] have examined the reliability of one specific testing protocol or novel equipment[4,6,14,16,29] or have compared testing positions or equipment.[15,18,20] In general, the following conclusions may be drawn: First, intra-rater and inter-rater reliability for the measurement of the passive movements of the shoulder varies with the method of measurement and the equipment used.[32] Universal goniometers, as well as inclinometers, are recommended for the assessment of shoulder ROM.[32] Standardized trunk and scapula fixation, as well as standardization of the amount of overpressure at the end ROM, increase reliability.[12,35]

Second, considering HHD's ease of use, portability, cost, and compact size, the HHD can be regarded as a reliable and valid instrument for shoulder muscle strength assessment in a clinical setting.[30] However, results are prone to error that might arise from the strength of the investigator, the testing position, and the stabilization of the patient.[30]

In clinical practice, the minimal detectable change (MDC) is one of the most important values to consider when using objective outcome measurements.[5] The MDC is the minimum amount of change in a patient's score that ensures the change is not the result of measurement error. The MDC is calculated in terms of confidence of prediction; for example, MDC_{90} is based on a 90% confidence interval. However, only a few studies[16,17] have mentioned MDC results in the interpretation of their data regarding shoulder ROM and strength evaluation.

Although measurement techniques for shoulder rotation ROM and strength have been reported using supine, prone, and sitting procedures, as well as using varying shoulder positions from neutral rotational position up to 90° of abduction, to our knowledge, no study has combined all of these variables into one comprehensive reliability study performed by the same team of examiners. This condition mimics optimally the clinical reality in which often a team of health professionals—medical doctors and paramedic assistants—performs a set of tests using the available assessment tools. In addition, the study design allows statistical analysis including all measurements, and in particular, stating the MDC, which is known to be very relevant in clinical practice. Moreover, providing a variety of measurement protocols, based on established norms and potential functional requirements of the patient, this study may improve the quality of the patient's assessment over time.

The purpose of this study was to examine the intra-rater and inter-rater reliability and the MDC for clinical goniometric, inclinometric, and HHD dynamometry measurements of shoulder passive ROM into ER and IR, and