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Reliability and precision of measuring strength of extrinsic muscles of the hand with the Rotterdam Intrinsic Hand Myometer

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Dear Editor,

There are few selective and responsive measures of strength for radial and median nerve innervated extrinsic muscles. Pinch and grip dynamometry are objective, quantitative assessments of hand strength, but they do not isolate the strength-specific intrinsic or extrinsic muscles, and manual muscle testing is not responsive to change when strength is Medical Research Council Grade 4 or 5 (Schreuders et al., 2004).

An alternative to pinch or grip dynamometry and manual muscle testing is myometry. The Rotterdam Intrinsic Hand Myometer (RIHM) is a digital myometer that measures the maximal isometric forces associated with isolated hand movements and reports to the tenth of a Newton. The RIHM has been validated for use in measuring intrinsic hand muscle strength and has excellent inter-rater reliability (McGee, 2017). It has acceptable criterion validity when compared with the manual muscle testing and excellent interrater reliability in healthy children and adults with ulnar and median nerve injuries (Schreuders et al., 2006). Additionally, the RIHM is reported to have greater sensitivity in detecting change in the thenar muscles than grip and pinch testing (Schreuders et al., 2004). The purpose of this study was to assess the reliability and precision of the RIHM when measuring extrinsic muscle strength in healthy adult hands.

Ten men and 19 women participated. Their ages ranged from 18 to 48 years, with a mean of 25 years and standard deviation of 8.5 years) Twenty-eight participants were needed for sufficient statistical power (beta = 0.20; alpha = 0.05). Institutional review board approval

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Ethical approval This study was approved by and underwent annual reviews by the University of Minnesota's Institutional Review Board (IRB # 1204M12262).

Informed consent Participants provided written and verbal informed consent prior to participation.

Supplemental Material Supplemental material is available for this article online.

was granted and informed consent was given by all participants. This study included four right-handed raters, who ranged in experience from novice to experienced.

Each participant completed three trials of maximal voluntary isometric contractions in four movement patterns intended to assess the strength of selected extrinsic muscles of both hands. The RIHM recorded the peak forces achieved at the time where the limb segment could no longer resist the force applied by the tester in a manner similar to that of a manual muscle testing 'break test' (Schreuders et al., 2004). Each participant was evaluated during a single 30-minute appointment by four raters who were blinded to the results of the other raters.

The four movements tested were thumb interphalangeal (IP) extension (presumably extensor pollicis longus), thumb IP joint flexion (presumably flexor pollicis longus), thumb carpometacarpal (CMC) joint abduction (presumably abductor pollicis longus) and third finger metacarpophalangeal (MP) joint extension (presumably extensor digitorum) for a total of 2784 measurements (four measurements per hand, two hands per adult, 29 adults, four raters per adult, three trials per rater). However, the specific muscles used during each movement were not confirmed via electromyography; therefore, the methods and analysis herein will focus on these four movements rather than on isolated muscles. See online Appendix S1 for details on the standardized procedures.

The mean, standard deviation, maximum and minimum force values were calculated for each movement by rater. In order to determine the intra-rater reliability of these four RIHM measures, the agreement among the three trials of each evaluator was assessed by calculating the intraclass correlation coefficient ($ICC_{3,1}$) for each movement. The 95% confidence interval (CI) of the ICC values were used to evaluate differences in the intra-rater reliability across all raters to determine if experience influenced rater consistency. Overlapping ICC CIs across raters indicates similar intra-rater reliability. Once it was confirmed that each rater had high intra-rater reliability, the agreement among all raters, or interrater reliability, was tested by calculating the $ICC_{3,4}$ for the mean scores of the three trials of each movement.

The standard error of the measurement (SEM) was used to quantify the precision of the RIHM measurements both within and across raters. The minimum detectable change (MDC) was also used to analyse the precision of RIHM measurements within and across raters. The MDC represents the smallest amount of meaningful change in scores that can be detected by a statistical test and can be interpreted clinically. The MDC was then divided by the mean force value of each movement (within and across raters) to calculate the 'MDC%'. This new value illustrates the measurement error relative to the average value one might expect for a particular measure.

The ICCs for intra-rater and inter-rater reliability values for all four raters were all greater than 0.75, which is excellent reliability. When comparing the inter-rater reliability of extrinsic hand manual muscle testing (Jepsen et al., 2004) to that of our findings, manual muscle testing yields lower Kappa values. For intra-rater reliability, the precision (SEM) of the three trials ranged from 1.8 N (0.4 lb) for non-dominant thumb IP extension to 7.4 N (1.7

lb) for dominant thumb IP flexion. For inter-rater reliability, precision ranged from 0.76 N for dominant long finger to 4.9 N for non-dominant thumb CMC joint abduction. The precision of these extrinsic measures within and across raters is acceptable (MDC% < 30) in all instances and excellent (MDC% of 10 or less) for all measures except thumb CMC joint abduction across raters. All reliability and precision data are presented in Online Table S1 (intra-rater) and Online Table S2 (inter-rater).

We conclude from this study that the Rotterdam Intrinsic Hand Myometer is a reliable tool for use by multiple raters with variable expertise to collect selected measures of extrinsic hand strength in persons without known hand impairments. This tool is appropriate to be used in defining population-based norms for research and clinical assessment. Our findings provide evidence that, within and across raters and regardless of expertise, use of the RIHM for measuring the strength of select extrinsic muscles of the hand will yield adequately precise and highly repeatable results within and across raters. Further testing in clinical populations that experience extrinsic hand muscle weakness is necessary.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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