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Strength Measurements of the Intrinsic Hand Muscles: A Review of the Development and Evaluation of the Rotterdam Intrinsic Hand Myometer

Ton A.R. Schreuders, PT, PhD
Ruud W. Selles, PhD
Marij E. Roebroeck, PhD
Henk J. Stam, MD, PhD, FRCP
Erasmus MC—University Medical Center Rotterdam
Department of Rehabilitation Medicine
Rotterdam, The Netherlands

ABSTRACT: Numerous neurological diseases are accompanied by atrophy of the intrinsic muscles of the hand. Muscle strength testing of these muscles is frequently used for clinical decision making. Traditionally, these strength measurements have focused on manual muscle testing (MMT) or on grip and pinch strength dynamometry. We have developed a hand-held dynamometer, the Rotterdam Intrinsic Hand Myometer (RIHM), to measure this intrinsic muscle strength. The RIHM was designed such that it can measure a wide range of muscle groups, such as the abduction and adduction strength of the little finger and index finger, the opposition, palmar abduction (anteposition) and opposition strength of the thumb, and intrinsic muscles of the fingers combined in the intrinsic plus position. We found that the reliability of RIHM measurements in nerve injury patients was comparable to grip and pinch strength measurements and is appropriate to study the functional recovery of the intrinsic muscles of the hand in isolation. We have applied the RIHM in a recent study on the long-term outcome of muscle strength in patients with ulnar and median nerve injuries and found that while recovery of grip and pinch strength was relatively good, recovery of the ulnar nerve innervated muscles measured with the RIHM was poor. This poor recovery could not be detected with manual muscle strength testing or with grip and pinch dynamometry. We conclude that the RIHM provides an accurate clinical assessment of the muscle strength of the intrinsic hand muscles that adds valuable information to MMT and grip and pinch dynamometry.

J HAND THER. 2006;19:393–402.

Muscle strength measurements are an area of interest for those studying diseases that are accompanied by loss of muscle strength. In, for example, rehabilitation medicine and physical therapy, muscle strength testing is frequently used for clinical decision making and outcome evaluation. The purpose of this testing is diverse, including to diagnose diseases, to evaluate and compare treatments, to document progression of muscle strength, and to provide feedback during the rehabilitation process.[1–5] In addition, strength testing is often used in areas such as sports medicine and ergonomics.

Atrophy of the intrinsic hand muscles is a symptom in a large number of pathologies. For example, ulnar and median nerve injuries cause a strength deficit of the intrinsic muscles, resulting in loss of hand function. Similarly, plexus lesions, spinal cord lesions,[6] and neuromuscular diseases such as leprosy, poliomyelitis, hereditary motor and sensory neuropathy, Guillan Barré, and amytrophic lateral sclerosis may cause loss of intrinsic hand muscle strength.[7,8] In addition, intrinsic muscle loss can also be found in nerve compressions like carpal tunnel syndrome, cyclers palsy,[9–11] and in patients with cervical disk

The authors hereby state that they have no personal interest in the Rotterdam Intrinsic Hand Myometer.

Correspondence and reprint requests to Ton A.R. Schreuders, PT, PhD, Erasmus MC—University Medical Center Rotterdam, Department of Rehabilitation Medicine, Room H014, Dr. Molewaterplein 40, 3015 GD Rotterdam, The Netherlands; e-mail: <a.schreuders@erasmusmc.nl>.

doi:10.1197/j.jht.2006.07.024

herniation. Finally, hand-arm vibration syndrome[12–15] and diabetes might result in atrophy of the intrinsic muscles of the hand.[16] Strength measurements of the hand have generally focused on grip and pinch strength.[17–19] However, these grip and pinch strength measurements have the disadvantage of evaluating both the intrinsic and extrinsic hand muscles in combined action. In patients in whom the extrinsic muscles are not affected to the same extent as the intrinsic muscles, grip and pinch strength measurements may not be sensitive enough to detect deficits in intrinsic muscle strength due to the significant contribution of the extrinsic muscles to the total pinch and grip strength measurement.[20]

Over the last few years, we have developed and tested the Rotterdam Intrinsic Hand Myometer (RIHM*) to measure the strength of the intrinsic hand muscles. This article briefly reviews the traditional tools used to measure intrinsic hand muscle strength and introduces the RIHM. We review data on the repeatability of RIHM measurements of the intrinsic hand muscles and present patient data that indicate how specific measurement of the intrinsic hand muscles using an instrument like the RIHM adds to the understanding of intrinsic muscle loss.

MANUAL MUSCLE TESTING OF THE INTRINSIC HAND MUSCLES

In clinical practice, the intrinsic hand muscles are most often evaluated using manual muscle testing (MMT),[21] which was first developed by Lowman in 1911, followed by Lovett[22] who introduced the testing grades based on gravity. In MMT, muscle contraction is graded on a scale from 0 to 5, which is known as the Medical Research Council (MRC) Scale or the Oxford Grading Scale.[23] At present, the MRC scale is most often used for MMT.[24] Within this grading scale, complete paralysis is graded as 0, grade 3 is when the limb segment can be moved actively against gravity, and grade 5 is normal strength. For evaluating the intrinsic hand muscle strength, a small modification to the standard MRC grading was suggested so that grade 3 indicates "full active range of motion" as compared to "movement against gravity."[4]

In the hand, the MRC scale has often been successfully used to assess the intrinsic hand muscles.[21,25] The hand of the examiner feels the muscle activity and gives resistance when grading the muscle (see Figure 1). It should be noted that, although textbooks usually present the tests as if it evaluates muscles in isolation, usually a group of muscles is tested rather

FIGURE 1. Illustration of manual muscle strength testing of the abduction strength of the little finger; the right hand of the examiner gives resistance to determine which grade the muscle can be given.

than just one muscle. Therefore, some authors[3,4] have suggested labeling the movement rather than the muscle. For example, the MMT should be interpreted as grading the palmar abduction movement of the thumb, sometimes called the anteposition of the thumb, instead of abductor pollicis brevis, since the abductor pollicis brevis is not the only muscle active during palmar abduction of the thumb.

Although indispensable in clinical practice, the MMT method has a number of limitations. One limitation is that while the MRC uses a 6-point numeric scale and seems to indicate a constant distance between grades, the MRC scale is in fact an ordinal scale with disproportional distances between grades; e.g., grade 4 is not twice as strong as grade 2. It might therefore be more appropriate to use terms such as normal, good, fair, trace, and paralyzed as compared to a grading of 0–5. The problem with using the ordinal MRC scale for muscle strength was illustrated by van der Ploeg et al.[26] who studied manual strength testing and dynamometry measurements of elbow flexion and found that the higher part of the scale (grades 4 and 5) occupies by far the largest part of total range (see Figure 2). As a result, in these ranges the MRC scale will not be able to detect clinically relevant changes in muscle strength.

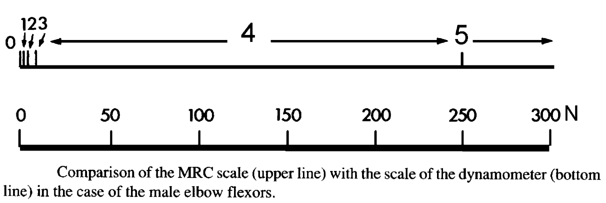

FIGURE 2. Graph published by van der Ploeg et al.,[26] indicating how the amount of force in the elbow measured with a dynamometer corresponds to the Medical Research Council grades 0–5. (Reprinted with kind permission from Springer Science and Business Media.)

*Information about the Rotterdam Intrinsic Hand Myometer (RIHM) can be found at www.erasmusmc.nl/rehabilitation.

Another limitation of the MRC scale is that the scoring depends on the examiner's ability to assess the pressure as a parameter for strength and therefore depends on the experience of the examiner. With the 6-point ordinal MRC scale it is difficult to identify relatively small but clinically relevant changes in muscle strength.[27] Based on these problems with the MRC scale, the American Society of Hand Therapists stated that while the MRC is appropriate to use in cases of extreme muscle deterioration (grades 0–3), it is not appropriate for higher-level muscle function due to a lack of sensitivity and precision.[28] Similarly, Dvir[29] demonstrated that even low levels of innervation can produce a grade 4 contraction and concluded that once reinnervation permits a grade 3 contraction, quantitative dynamometer measurement of muscle strength is required to effectively monitor further improvement.[30]

DYNAMOMETRY OF THE INTRINSIC HAND MUSCLES

As an addition to the MRC, a large variety of dynamometers have been developed to assess muscle strength. In contrast to the MRC scale, dynamometer measurements are more sensitive to change and render outcome on a continuous scale. An additional advantage of such measurements is that the strength of the contralateral hand can serve as the reference value for that person.

In clinical evaluation and research studies on patients with hand problems, muscle strength measurements are usually based on grip and pinch strength dynamometry.[17,18,31] As mentioned above, grip and pinch strength may not be able to detect changes in the intrinsic hand muscles due to the dominant contribution of the extrinsic hand muscles to these measurements.

In a recent article concerning measurement of health outcome in patients following tendon and nerve repair, MacDermid[32] acknowledged that relatively few studies include quantitative information on intrinsic muscle strength when reporting clinical outcomes and that few instruments are readily available to perform these measurements.

A number of studies have focused specifically on the dynamometer measurements of the intrinsic muscle strength. In 1966, Mannerfelt was one of the first to develop a dynamometer for measurement of the intrinsic muscle strength. In 1997, he used a newer device called the Intrins-o-meter[33,34] to study patients with ulnar nerve compression. He was able to measure pinch, grip, palmar adduction of the thumb, radial abduction of the index finger, and ulnar abduction of the little finger, before and after operation. The same instrument was also used by Necking et al.[13–15] in patients suffering from hand–arm vibration syndrome to measure the isometric strength of thumb palmar abduction, index finger abduction, and little finger abduction using specially designed jigs secured on a table. Trumble et al.[27] performed quantitative measurements of the intrinsic muscles using a hand-held device and showed that patients suffering from peripheral nerve injuries recovered to a median motor grade of 3, corresponding to a 32% recovery compared to the contralateral side. They concluded that dynamometer testing of muscle strength after peripheral nerve injuries enhances the sensitivity of evaluating nerve regeneration and facilitates the comparison of different nerve repair techniques.[27] To measure the abduction strength of the thumb in healthy subjects, Boatright et al.[35] used a strain gauge system and found that thumb abduction strength generally correlated with grip and pinch strength. After median nerve block, the thumb abduction strength decreased by 70–75%. Liu et al.[36] used a portable microprocessor-controlled hand-held device to obtain normative values for abductor pollicis brevis strength in 297 volunteers. No significant differences were found between the different age groups that were studied and between the dominant and nondominant hand. Recently, Jacquemin et al.[6] developed a device to measure the strength of the intrinsic muscles of the hand in patients with spinal cord injury (SCI). It was reported that abnormalities of the peripheral nervous system, such as peripheral nerve entrapments, often affect hand intrinsic muscle strength of SCI patients.

The above-mentioned studies indicate that measurement of the intrinsic muscle strength can provide useful information for clinical evaluation and research studies that can not be obtained using grip and pinch measurements. We decided that there is a need for an instrument to measure the intrinsic muscle strength that is hand held, portable, easy to use, that provides appropriate visual feedback about the direction of force, and that is able to measure the strength of all intrinsic hand muscles with a single device (see also[32]).

DESIGN OF RIHM

The RIHM was developed as a hand-held, ergonomically designed dynamometer and is made of a strong lightweight plastic, which contains the battery, the force sensor, and electronics (see Figure 3). The peak forces can be read from a digital display on top of the device. The grip is positioned at a 97° angle with the horizontal, allowing the tester to hold the wrist in a comfortable and stable position.

The device can store a maximum of 99 measurements, which can be downloaded to a PC using an USB cable for off-line analysis. The data can also be

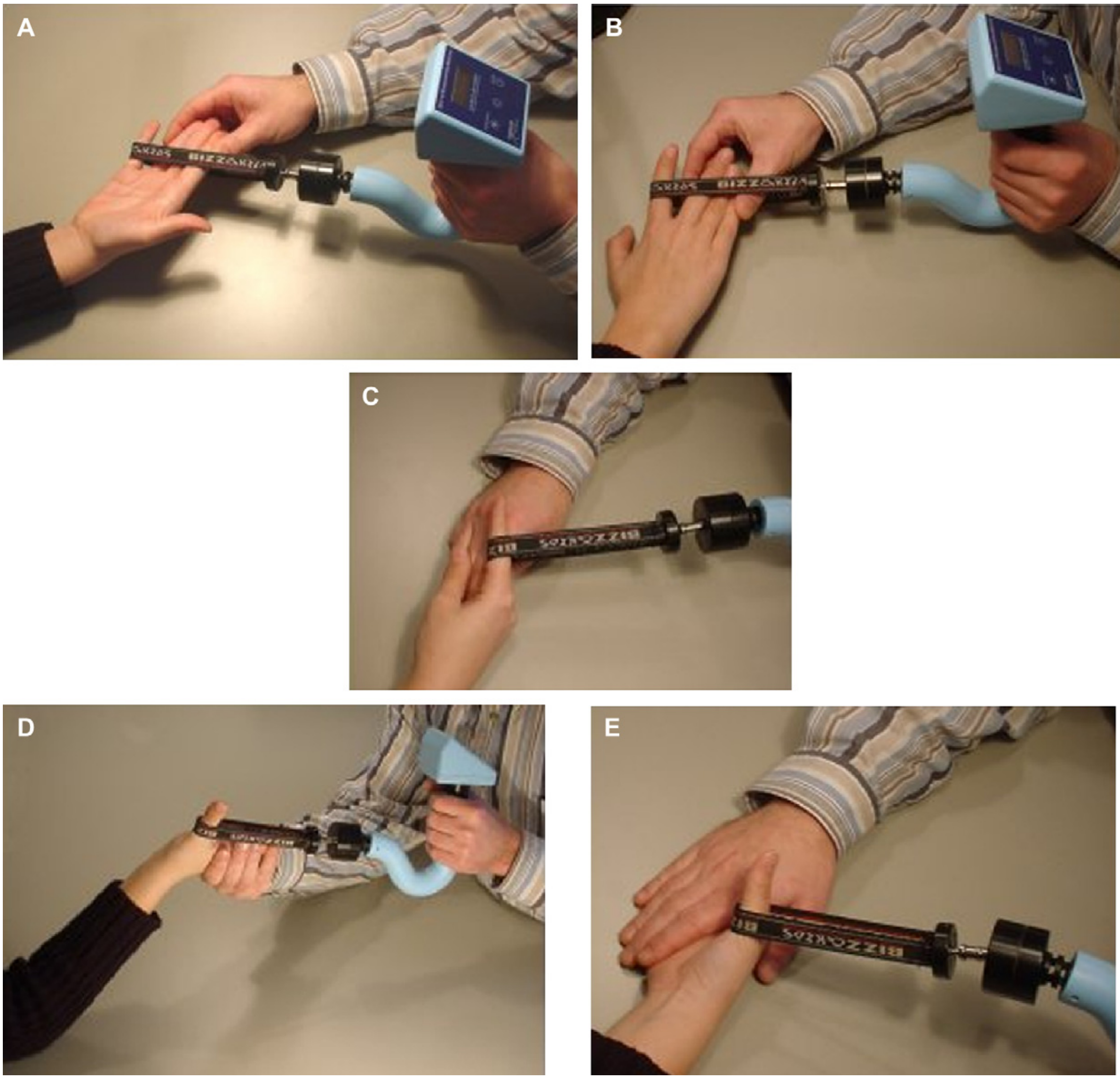

FIGURE 3. *Illustration of five measurements with the Rotterdam Intrinsic Hand Myometer, that is (**A**) abduction of the little finger; (**B**) abduction of the index finger; (**C**) intrinsic plus position of the index finger, assessing the interosseous, and lumbrical muscles; (**D**) palmar abduction of the thumb; and (**E**) opposition of the thumb.*

exported to other software packages such as MS Excel and SPSS. To minimize erroneous forces introduced by the tester, a small cylindrical part is connected to the handgrip of the instrument by means of a ball joint containing the button load cell (type BC301 from DS Europe). This construction, together with a rotating handgrip, ensures loading perpendicular to the load cell and prevents the examiner from introducing torques.

An important difference compared with other intrinsic muscle strength dynamometers mentioned above is the pulling technique of the RIHM, whereby the forces are measured by pulling on a leather band placed on the digit. An advantage of this pulling technique is that the examiner can pull toward their own body while supporting the upper arm against the side of the thorax, enabling better force control than pushing. For practical reasons (e.g. hand size) a 15-cm long leather band is used, allowing visual control of the direction of force application.

Due to its design, the RIHM can be used to measure all the intrinsic muscle groups in the hand using an approach that is similar to MMT measurement of the intrinsic hand muscles (compare, for example, Figures 1 and 3A). More specifically, the RIHM can measure the abduction and adduction of the little finger and index finger as well as the opposition, palmar abduction (anteposition), adduction and flexion of the metacarpophalangeal (MCP) joint of the thumb, allowing measurement of both median and ulnar nerve innervated intrinsic muscles. In addition, the intrinsic plus position of each finger can be measured to assess a combination of the interosseous and lumbrical muscle strength by pulling at the proximal

TABLE 1. **Reliability Study of Strength Measurements in Patients with Hand Injuries**

		Mean (N)	*SD (N)*	*ICC*	*SEM (N)*	*SDD (N)*	*SDD/SD Ratio*
Ulnar and median nerve injuries ($n = 27$)	Abduction little finger	22	14	0.97	2.2	6.1	0.4
	Abduction index finger	28	18	0.98	2.3	6.3	0.4
	Abduction thumb	55	24	0.94	5.8	16	0.7
	Opposition thumb	87	25	0.95	5.5	15.3	0.6
Hand injuries ($n = 33$)	Grip strength (second handle position)	250	123	0.97	22	61	0.5
	Grip strength (fourth handle position)	231	110	0.95	25	70	0.6
	Tip pinch strength	39	17	0.93	4	12	0.7
	Key pinch strength	64	22	0.97	4	11	0.5

Data indicate the intraexaminer repeatability using an experienced examiner (T.A.S.), comparing repeated RIHM measurements of the intrinsic hand muscles of 27 patients with peripheral nerve injuries with grip and pinch measurements of 33 patients with traumatic hand injuries.[43] To compare the SDD between measurements, we scaled the SDD to the SD.
Abbreviations: N = Newton, SD = standard deviation; ICC = intraclass correlation coefficient; SEM = standard error of measurement; SDD = smallest detectable difference.

interphalangeal (PIP) joint level and giving resistance to MCP flexion and PIP extension. Five of these measurements are illustrated in Figure 3.

Testing Procedure

Assessments with the RIHM are performed as a "break" test.[37] To do so, the examiner pulls with increasing force while verbally encouraging the patient to hold the finger or thumb in place. The force will be increased such that after approximately 1 second, the subject will not be able to maintain the position (the resistance will "break") and the pulling is ended so that the subject can relax. The RIHM stores the maximum force that is recorded during this period. Within our measurement protocol, the break test is repeated three times for each muscle group and the average of three values is reported, similar to the American Society of Hand Therapists recommendations for evaluating grip and pinch force.[28,38]

The examiner and patient were seated at opposite sides of a table. The procedure was explained to the patient. In the tests, the patient was told how to hold the finger or thumb and instructed that he or she should try to keep the finger or thumb in that position with maximum strength. The force on the finger or thumb was slowly increased while the examiner verbally encouraged the patient to hold the finger or thumb in place, which is known as a break test.[37] The places at which the force was applied were similar to the anatomical reference points of the MMT as described by Brandsma et al.[4,25] For example, for ulnar abduction of the little finger, the hand of the patient is held in supination while the second, third, and fourth fingers are fixated by the examiner's hand. Then, the little finger is placed in maximum abducted position with the MP joint in slight flexion and the patient is asked to maintain that position. The sling of the dynamometer is applied at the PIP joint of the little finger and the pull is performed perpendicular to the little finger in a straight line with the palm of the hand until the resistance of the patient breaks.

RELIABILITY OF THE RIHM

To assess the test–retest reliability of the RIHM, we performed repeated measurements with the RIHM in 27 patients with ulnar and/or median nerve injuries.[1] Results show that the intraclass correlation coefficients (ICCs) of the intrarater repeatability were 0.94 or higher for the intrinsic hand muscles (see Table 1).

In addition to the ICC, we calculated the standard error of measurements (SEMs) as well as the smallest detectable difference (SDD), indicating the difference between measurements that is needed to conclude that a real change has occurred.[39] We found that the SEMs were 2.2 and 2.3 N, and the SDDs were 6.1 and 6.3 N, for the abduction of the little finger and the abduction of the index finger, respectively (see Table 1). For the two median nerve innervated movements of the thumb, SEMs were 5.8 and 5.5 N, and SDDs 16 and 15.3 N, for the abduction and the opposition of the thumb, respectively. To compare the SDD between the RIHM measurement and between the grip and pinch measurements, we calculated the SDD/SD (standard deviation) ratio by dividing the SDD by the between-subject SD of the measurements and found that the outcomes were similar to those reported in grip and pinch strength measurements. Therefore, we conclude that the reliability of RIHM measurements is comparable to grip and pinch strength measurements and is appropriate to study the recovery and function of the intrinsic muscles of the hand in individual subjects.

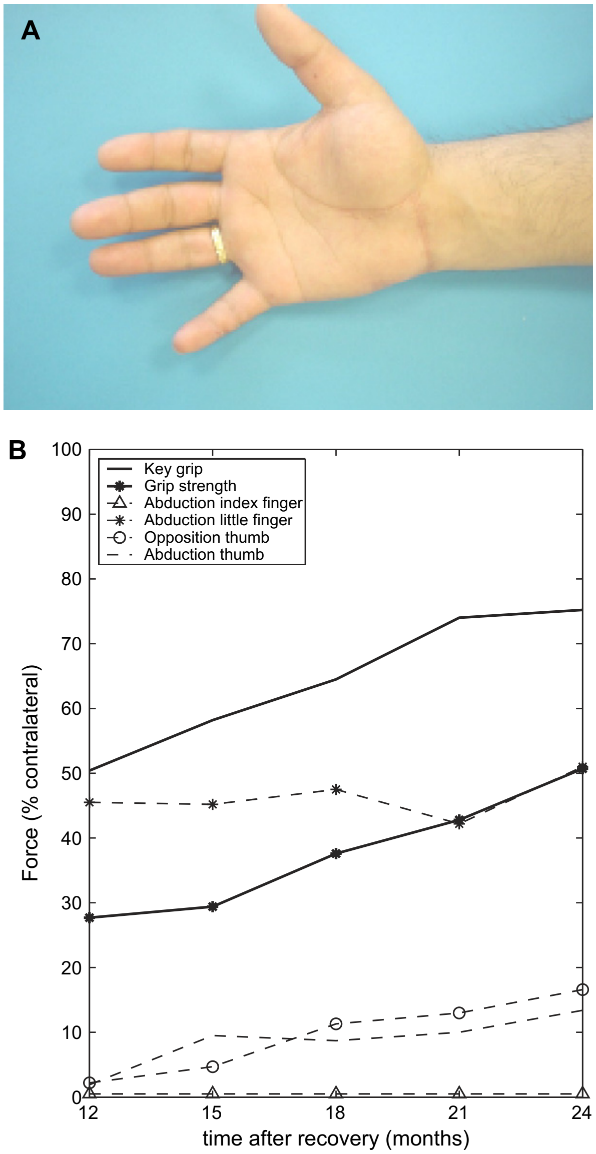

FIGURE 4. (A) Case study illustrating the use of Rotterdam Intrinsic Hand Myometer measurements in addition to grip and pinch strength measurements in a patient with a combined ulnar and median nerve injury. The hand of the patient is shown one year after the nerve injury at wrist level. Besides a Wartenberg sign (abducted little finger), only little atrophy of the intrinsic muscles can be seen. (B) Recovery of grip, pinch, and intrinsic muscle strength as percentage of the uninvolved hand of the same patient. The graph presents the muscle strength from one year up to almost two years after injury. The muscle strength of the little finger abduction recovered similar to that of the pinch strength. Although the median nerve innervated thumb muscles showed some small improvements during the year, after two years the strength was only 13–17% of the uninvolved hand. Grip and pinch strength increased further two years after injury.

Validity

The validity of a measure can be established by comparing the measure's results with that of the truth or gold standard.[40] For muscle strength testing of the intrinsic muscles, traditionally, the golden standard has been MMT using MRC grading of muscle strength between 0 and 5. To determine the criterion validity of the RIHM measurements, we have tested the hands of 34 patients more than two years after an ulnar and/or median nerve injury[41] and compared the RIHM measurements of intrinsic muscle strength with the MMT. For all four muscle groups tested, we found a significant Spearman correlation coefficient between MMT and the RIHM dynamometry measurements between 0.56 and 0.85, indicating that the RIHM has an acceptable criterion validity to assess intrinsic muscle strength.

Convergent validity examines the extent to which a measure's result is consistent with the result of another measure that is believed to be assessing the same attribute.[40] In a recent study on strength measurements of the arm and hand in HMSN (hereditary motor and sensory neuropathy) (Selles RW, Van Ginneken BTJ, Schreuders TAR, Janssen WGM, Stam HJ. Dynamometry of intrinsic hand muscles in patients with Charcot-Marie-Tooth disease. Accepted) we compared grip and pinch, and RIHM measurements and related the outcomes with upper extremity function, measured with selected items of the Sollerman hand dexterity test.[17,42] We found that the RIHM measurements (abduction of the thumb, abduction of the index finger, and abduction little finger) were both correlated with the Sollerman and the grip and pinch measurements, however, the RIHM measurements were more strongly related. The correlation coefficients between the RIHM measurements and the Sollerman ranged between 0.62 and 0.65.

THE NEED TO SPECIFICALLY MEASURE INTRINSIC HAND MUSCLES; TWO CASE STUDIES

Case 1

A 21-year-old man suffered a deep cut at his wrist while washing his jeans in a ceramic washing basin which broke, creating very sharp edges which lacerated all his flexor tendons and both the ulnar and median nerves (see Figure 4A). All structures were surgically repaired the same day. After 12 months, when the MRC grading of the abduction strength of the little finger had reached grade 3, repeated intrinsic measurements were performed with the RIHM in addition to grip and pinch strength dynamometry (see Figure 4B). We found that his grip strength doubled during this year and his (key) pinch improved 57%. However, measurements with the RIHM showed that the abduction strength of the little finger did not improve during the second year and remained stable at 13 N, which was 45% of his uninjured hand (29 N). Throughout the same period, abduction

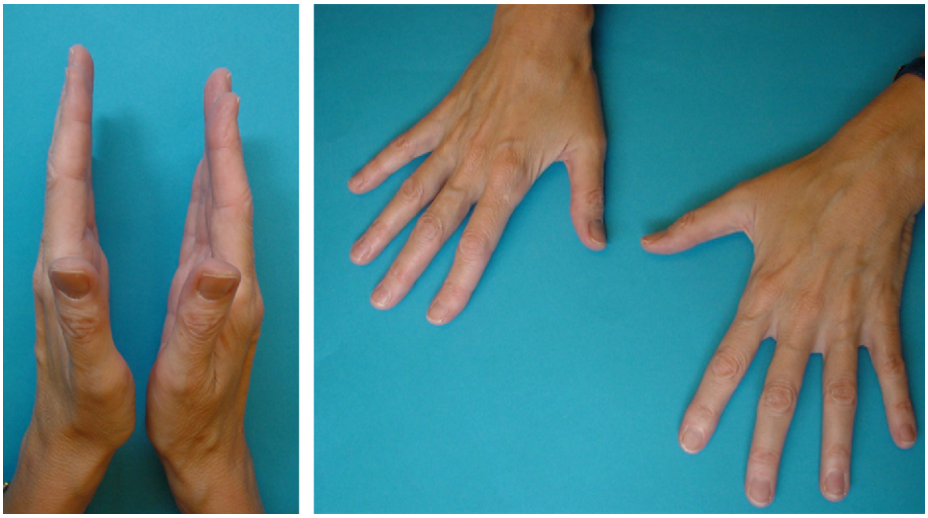

FIGURE 5. Case study illustrating the use of the Rotterdam Intrinsic Hand Myometer measurements in a patient with hereditary motor and sensory neuropathy. The subject was able to almost fully extend her fingers and had only minimal atrophy of the intrinsic muscles of the thumb web. Strength measurements in this subject are reported in Table 2.

strength of the index finger remained zero. The strength of the opposition of the thumb increased from 2 to 13 N, which was still only 17% of the uninjured hand (96 N), while the strength of the abduction of the thumb increased from 1.2 to 9.3 N, which was 13% of the uninjured hand (70 N). The implication of these findings is that while the grip and pinch measurements are often used to assess these kinds of nerve injuries, the improvement in these measurements did not reflect the fact that his intrinsic hand muscle strength remained very weak and showed little improvement during the follow-up.

Case 2

A 49-year-old woman with hereditary motor and sensory neuropathy reported difficulty with cooking, lifting heavy objects, and opening jars. Her hands showed minimal clawing of her middle and ring finger of her right hand and the middle finger of her left hand (see Figure 5). Normal sensation (filament 2.83) was assessed with the Semmes Weinstein filament test in the tips of the thumb and fingers, while some loss of residual protective sensation (filament 4.31) was measured at the base of the little and index fingers of both hands.

MMT grades were similar for both hands, with grade 4 for all movements tested (see Table 2). Grip and pinch strength were approximately 50% of the values found in a healthy population. Despite the grade 4 that was scored for the intrinsic muscle strength using the MRC scale, the RIHM measurements indicated that intrinsic strength was severely reduced to 18%, 44%, and 7% of that of a healthy population for the abduction of the index finger, palmar abduction, and opposition of the thumb, respectively.

THE NEED TO SPECIFICALLY MEASURE INTRINSIC HAND MUSCLES; A COHORT STUDY ON THE RECOVERY AFTER PERIPHERAL NERVE INJURY

The usefulness of using an instrument like the RIHM in evaluation of the strength of hand muscles was recently illustrated in a study on long-term outcome of muscle strength in 34 patients more than two years after an ulnar and/or median nerve

TABLE 2. **Force Measurements of the Patient with Hereditary Motor and Sensory Neuropathy (Case 2)**

	RIHM Measurements				
	Abduction Index Finger	*Abduction Thumb*	*Opposition Thumb*	*Grip Strength*	*Pinch Strength*
MRC scale	4	4	4		
Muscle strength (N)	7.3	23.3	5.8	127	18.3
Norm values (N)	40	53	82	269	37
Percentage of norm	18%	44%	7%	47%	50%

Mean values of the left and the right hand are presented since the strength of both hands was very similar. The outcomes are compared to norm values collected with the same instrument in our institute from a population of 270 women (grip and pinch strength) and 11 women (RIHM) measurements.

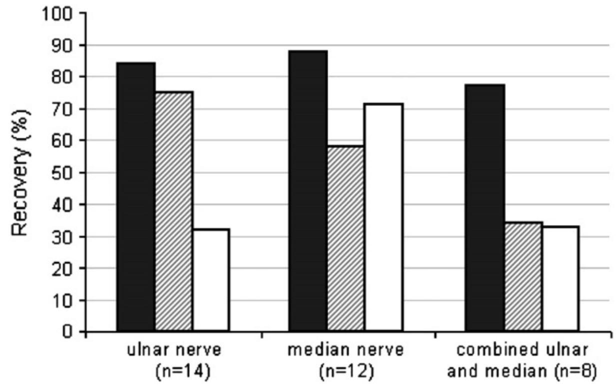

FIGURE 6. Recovery of grip (black), pinch (shaded), and intrinsic (white) muscle strength measured with the Rotterdam Intrinsic Hand Myometer of three groups of patients: ulnar nerve, median nerve, and combined nerve injury. Outcomes are presented as a percentage of the contralateral side hand to indicate the amount of discovery.

injury. Recovery of muscle strength was assessed using MMT, grip and pinch strength dynamometers, as well as measurements of the intrinsic muscles with the RIHM.[1] For the MMT, we found that most muscles recovered to grade 3 or 4. Average grip strength recovery was 83% of the uninjured hand, while pinch strength recovery was 75%, 58%, and 39% in patients with ulnar, median, and combined nerves injuries, respectively (see Figure 6). The RIHM measurements revealed a poor recovery of, especially, the ulnar nerve innervated muscles (26−37%). No significant correlation was found between the measurements of the RIHM and grip strength, while pinch strength was only significantly correlated with the RIHM measurement of the thumb abduction ($R = 0.55$) and opposition ($R = 0.72$).

Future studies will, amongst others, focus on the application of RIHM measurements in other patient groups, as well as the establishment of norm values in a large population.

CONCLUSION

In this review, we introduce the RIHM as a tool to quantify strength of the intrinsic hand muscles. We have shown that the RIHM dynamometer provides an accurate clinical assessment of the muscle strength of the intrinsic hand muscles with excellent intrarater reliability. An advantage of the presented dynamometer is that the intrinsic muscle strength is measured directly, in contrast to grip and pinch strength measurements in which many muscles are tested in addition to the intrinsic muscles. We found evidence for the validity of measurements with the RIHM in some respects, i.e., in relation to MMT and tasks of dexterity tests of the Sollerman. The RIHM provides more quantitative results than MMT, especially in the range of the MRC grades 4 and 5. We have shown in two case studies and in a clinical cohort study in patients with HMSN, that the use of the RIHM can indicate intrinsic muscle strength deficits in peripheral nerve injury patients that may not be detected using more regularly used grip and pinch force measurements.

Acknowledgments

The authors thank Mr. Arie den Ouden and Mr. Rob den Ouden for their contributions in the development of the RIHM.

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JHT Read for Credit

Quiz: Article #041

Record your answers on the Return Answer Form found on the tear-out coupon at the back of this issue. There is only one best answer for each question.

#1. THE ASHT recommends when doing a MMT that:
- a. all scores from 0 to 5 be used.
- b. only the scores of 0-3 be used because higher muscle strengths are not appropriately tested with this scale.
- c. an EMG must also be used to confirm validity.
- d. standard scoring technique is appropriate, except for thumb intrinsics which are unreliable.

#2. The RIHM devise is:
- a. mounted on the table and made of durable aluminum.
- b. ergonomically appropriate because it is constructed of materials that mold to the hand.
- c. recommended for home use by the patient as a form of biofeedback.
- d. hand held and made of light weight plastic.

#3. The RIMH:
- a. is a far different approach to testing the intrinsics than MMT.
- b. is considered by the ASHT to be the Gold Standard for testing the strength of the intrinsics.
- c. uses an approach similar to MMT & can be used to test all the intrinsics of the hand.
- d. eliminates the need for EMG studies in evaluating the intrinsics.

#4. The reliability of the RIMH was:
- a. 94 for interrater.
- b. 94 for intrarater.
- c. 74 for both intra & interrater.
- d. not reported in this study.

#5. The study suggests as illustrated in the 1st case study that:
- a. while grip & pinch scores may improve, intrinsic strength may not improve at a similar rate.
- b. intrinsic strength routinely improves at a similar rate to grip & pinch.
- c. intrinsic strength often improves at a greater rate than grip & pinch.
- d. lumbricals typically improve at a faster rate than the interossei.

When submitting to the HTCC for recertification, please batch your JHT RFC certificates in groups of three or more to get full credit.