

Research Correlating MMT Outcomes With Other Instruments Measuring Muscle Function

Parallel comparison of grip strength measures obtained with a MicroFET 4 and a Jamar dynamometer, Bohannon RW.

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Abstract: Repeated measures of grip strength obtained bilaterally with a Jamar and a MicroFET 4 dynamometer were compared. Measurements obtained with the MicroFET 4 tended to be slightly (2.2-3.1 lb.) higher but were highly correlated ($r \geq .96$) with those obtained with the Jamar. Parallel reliability for the two devices was excellent (intraclass correlation coefficient $\geq .96$). Although clinicians should be cautious about using the devices interchangeably, the MicroFET 4 appears to be a legitimate alternative to the Jamar dynamometer.

Reliability of hand-held dynamometry in assessment of knee extensor strength after hip fracture, Roy, MA, Doherty, TJ.
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OBJECTIVES: To examine the reliability of hand-held dynamometry in assessing knee extensor strength in inpatients undergoing rehabilitation after hip fracture and to examine the discriminant validity of this measure. **DESIGN:** A total of 16 subjects (14 women; mean \pm SD, 79 \pm 7 yrs) undergoing inpatient rehabilitation after hip fracture volunteered to participate. Isometric knee extensor strength of the fractured and unfractured sides was determined with a hand-held dynamometer. Subjects were retested 1-2 days after the initial testing session. **RESULTS:** Test-retest intraclass correlation coefficients were high for both the fractured (0.91) and unfractured legs (0.90). A low coefficient of variation was observed for both the fractured (15.3%) and unfractured (14.7%) sides. The maximal knee extensor strength was significantly different when comparing the fractured (7.9 \pm 3 kg) and unfractured (15.6 \pm 4 kg) legs. When comparing test 1 and test 2 mean values for the fractured leg, the scores significantly differed ($t = 3.14$, $P < 0.01$), with 13 of 16 subjects scoring higher on test 2. **CONCLUSIONS:** Hand-held dynamometry is a reliable and valid tool for assessment of knee extensor strength after hip fracture. Reduced knee extensor strength in the fractured leg may be an important component limiting rehabilitation progress in these patients.

Hand-held dynamometry reliability in persons with neuropathic weakness, Kilmer DD, McCrory MA, Wright NC, Rosko RA, Kim HR, Aitkens SG.

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Arch Phys Med Rehabil. 2000 Nov;81(11):1538-9.

OBJECTIVE: To determine test-retest reliability of hand-held dynamometry (HHD) in measuring strength of persons with neuropathic weakness. **DESIGN:** Intratester and intertester reliability of HHD-measured strength over a 7- to 10-day period. In addition, HHD knee strength was compared with criterion standard of fixed dynamometry (FD). **SETTING:** Human performance laboratory of a university. **PARTICIPANTS:** Convenience sample of ambulatory outpatients with Hereditary Motor and Sensory Neuropathy, Type I (HMSN) ($n = 10$) and able-bodied controls (CTL) ($n = 11$). **MAIN OUTCOME MEASURE:** Maximal isometric torque. **RESULTS:** Intratester intraclass correlation coefficients (ICCs) were high, generally ranging from .82 to .96 for HHD- and FD-measured strength for both HMSN and CTL groups. There were no significant differences between sessions for HHD-measured strength, while FD-measured strength was only significantly different for knee extension ($p < .01$). Intertester reliability was generally good for both HHD- and FD-measured strength, with ICCs ranging from .72 to .97 for HMSN and CTL groups. Exceptions were knee extensors and ankle dorsiflexors for the CTL group. Knee extensor strength was significantly lower measured by HHD compared

	<p>with FD ($p < .01$), but knee flexor strength was similar for the two methods. CONCLUSION: HHD appears to be a reliable method to measure maximal isometric strength in persons with neurogenic weakness, and may be useful to quickly and objectively evaluate strength in the clinical setting.</p>
<p>Electromyographic responses of back and limb muscles associated with spinal manipulative therapy, Herzog, W., Scheele, D., Conway, P.J.</p>	<p><i>Spine</i>, 1999;24:146-152 http://www.spinejournal.com/pt/re/spine/abstract.00007632-199901150-00012.htm</p> <p>Study Design: Ten young, asymptomatic male subjects underwent 11 clinically relevant spinal manipulative treatments along the length of the spine to test the magnitude and extent of reflex responses associated with the treatments. Objectives: To determine the magnitude and extent of reflex responses elicited by spinal manipulative treatments. Summary of Background Data: Spinal manipulative treatments have been associated with a reflexogenic relief of pain and a loss of hypertonicity in muscles within the treatment area. However, there is no study in which results show the probability of occurrence or the extent of reflex responses during spinal manipulative treatments. Methods: Asymptomatic subjects received spinal manipulative treatments on the cervical, thoracic, and lumbar levels and on the sacroiliac joint. Reflex activities were measured using 16 pairs of bipolar surface electrodes placed on the back and proximal limb musculature. The percentage of occurrence and the extent of reflex responses in the back and proximal limb musculature were determined. Results: Each treatment produced consistent reflex responses in a target-specific area. The reflex responses occurred within 50-200 msec after the onset of the treatment thrust and lasted for approximately 100-400 msec. The responses were probably of multireceptor origin and were elicited asynchronously. Conclusions: This is the first study in which results show a consistent reflex response associated with spinal manipulative treatments. Because reflex pathways are evoked systematically during spinal manipulative treatment, there is a distinct possibility that these responses may cause some of the clinically observed beneficial effects, such as a reduction in pain and a decrease in hypertonicity of muscles.</p>
<p>EMG recordings of abdominal and back muscles in various standing postures: validation of a biomechanical model on sacroiliac joint stability, Snijders, C.J., Ribbers, M.T., de Bakker, H.V., Stoeckart, R., Stam, H.J.</p>	<p><i>J Electromyogr Kinesiol</i>, 1998;8:205-14</p> <p>Abstract: In a biomechanical model we described that for stability of the flat sacroiliac joints (SIJ) muscle forces are required which press the sacrum between the two hip bones (self-bracing). Shear loading of these joints is caused by gravity and longitudinally oriented muscles. Protection against shearing can come from transversely oriented muscles like the internal oblique (OI) abdominal muscles. For validation we used standing postures with significantly more or less OI activity compared to activity in a standardized erect standing reference posture. OI activity decreased significantly when (a) resting on one leg (the contralateral), as can be observed at bus stops, (b) tilting the pelvic backward and (c) applying a pelvic belt. We explain this decrease of OI activity by, respectively, decrease of gravity load, decrease of load from the psoas major muscles, and a substitute of self-bracing. The outcome of this study is in line with the biomechanical model on SIJ stability. Clinical relevance of this study regards aspecific low back pain and is found in the effect of the use of a pelvic belt, of a trunk position as adopted when wearing a small rucksack and of the benefit of exercising trunk muscles in extension and torsion.</p>
<p>Normative values for isometric muscle force measurements obtained with hand-held dynamometers, Andrews AW, Thomas MW, Bohannon RW.</p>	<p><i>Phys Ther</i>. 1996 Mar;76(3):248-59.</p> <p>BACKGROUND AND PURPOSE: The extent of a patient's impairment can be established by comparing measurements of that patient's performance with normative values obtained from apparently unimpaired individuals. Only a few studies have described normative values for muscle strength measured by hand-held dynamometry. The purpose of this study of older adults, therefore, was to obtain normative values of maximum voluntary</p>

<p>-- University of North Carolina Hospitals, Chapel Hill, 27514, USA.</p>	<p>isometric force using hand-held dynamometers. SUBJECTS: One hundred fifty-six asymptomatic adults (77 men, 70 women) participated in this study. The subjects' mean age was 64.4 years (SD=8.3, range=50-79). The male subjects' mean age was 64.5 years (SD=8.4, range=50-79), and the female subjects' mean age was 64.3 years (SD=8.2, range=50-79). METHODS: Gender, age, dominant side, height, weight, and activity level were recorded. Eight upper-extremity movements (shoulder flexion, extension, abduction, and medial and lateral rotation; elbow flexion and extension; and wrist extension) and five lower-extremity movements (hip flexion and abduction, knee flexion and extension, and ankle dorsiflexion) were resisted by one of three experienced testers using a strain-gauge hand-held dynamometer. RESULTS: Gender, age, and weight were identified as independent predictors of force for all muscle actions on both the dominant and nondominant sides. These variables were used, therefore, to create regression equations and normative values for the force of each muscle action. CONCLUSION AND DISCUSSION: The reference values provided may allow clinicians who follow the described testing protocol to estimate the severity of force-generating impairments in patients aged 50 to 79 years.</p>
<p>Evaluation of neck muscle strength with a modified sphygmomanometer dynamometer: reliability and validity, Vernon HT, Aker P, Aramenko M, Battershill D, Alepin A, Penner T.</p> <p>-- Canadian Memorial Chiropractic College, Toronto, Ontario.</p>	<p><i>J Manipulative Physiol Ther.</i> 1992 Jul-Aug;15(6):343-9.</p> <p>OBJECTIVE: Determine test-retest reliability, normative data and clinical validity of isometric muscle strength testing in the neck with a modified sphygmomanometer dynamometer (MSD). DESIGN: Analytic survey. Paired trials of various muscle strength tests were conducted on convenience samples of normal subjects and consecutive samples of symptomatic subjects. SETTING: Outpatient chiropractic research clinic. PATIENTS/SUBJECTS: For study 2, 40 normal male subjects, average age 25 +/- 2 yr, were studied for reliability and normative data. For study 3, 24 symptomatic patients, 12 males and 12 females, average age 39 +/- 7 yr, were studied, 8 with "whiplash"-type injuries (average duration 22.5 wk) and 16 with nontraumatic chronic neck pain (average duration 110 wk). INTERVENTION: No therapeutic intervention is reported. MAIN OUTCOME MEASURE: Pressure levels generated by subjects against a modified sphygmomanometer-type dynamometer as measured in kilopascals. RESULTS: Study 1. Repeated paired trials of a standardized weight column (20 lbs) produced a coefficient of variation of 0.84% and virtually no difference between the means of the first vs. second trials. Study 2. High test-retest correlation coefficients were found for all ranges of motion (.79-.97). Right-to-left asymmetry in rotation and lateral flexion was within 6-8%. The flexion/extension ratio was .57:1, indicating that in normal subjects, flexion was approximately 40% lower than extension. Lower cutoffs were established as the mean--1 SD as follows (in kPa): flexion--3300, extension--5800, rotation--5200 and lateral flexion--6200. Coefficients of variation ranged from 25 to 29%. Study 3. Differences between paired trials were analyzed by intraclass coefficients, which were very high (.95-.99), and by percentages, which ranged from 4 to 10.4%, with an average of 7%, indicating a high degree of test-retest consistency. The mean values for all symptomatic subjects for flexion, extension, right rotation and right lateral bending were all well below the normal cutoff values as found in study 2. The flexion/extension ratio for whiplash subjects was 0.25:1.00, which is half of that of normal subjects. CONCLUSIONS: The MSD has been found to be a reliable instrument for the evaluation of isometric muscle strength in the neck in normal and symptomatic subjects. Normative values for absolute test levels, bilateral symmetry and flexion/extension ratios have been determined. A symptomatic group demonstrated significant deviations from these norms in the form of reduced strength levels and reduced flexion/extension ratios, while still maintaining very high levels of test-retest consistency and bilateral symmetry. The MSD appears very promising in the evaluation of neck-injured patients.</p>
<p>Reliability of Manual Muscle Testing with a Computerized</p>	<p><i>Journal of Manipulative and Physiological Therapeutics.</i> 1990; 13:72-82.</p>

<p>Dynamometer, Hsieh, C.Y., Phillips, R.B.</p>	<p>Abstract: The purpose of this study was to investigate the reliability of manual dynamometry. Three testers participated and performed the doctor-and-patient-initiated testing methods as described in the applied kinesiology literature. Three muscles from each subject were tested. Fifteen normal volunteer adults had their muscles tested by the doctor-initiated method and another and another 15 had their muscles tested by the patient-initiated method. Each tester took two observations per muscle. The testing procedures were repeated 7 days later. The results showed that the intratester reliability coefficients were 0.55, 0.75 and 0.76 for testers 1, 2 and 3, respectively, when the doctor-initiated method was used; 0.96, 0.99 and 0.97 when the patient-initiated method was used. The intertester reliability coefficients were 0.77 and 0.59 on day 1 and day 2, respectively, for the doctor-initiated method; 0.95 and 0.96 for the patient-initiated method. It is concluded that manual dynamometry is an acceptable procedure for the patient-initiated method and is not acceptable for the doctor-initiated method.</p> <p>Comment: Numerous hand-held dynamometers have been developed to quantify the manual muscle test. These are units that are interposed between the examiner's hand and the subject's limb being tested. There is a constant effort to upgrade the hand-held units. These units can measure many aspects of the manual muscle test, but none of them has all of the measuring capacities that are in each of them separately. To date none of these units have been capable of measuring the manual muscle test as used in applied kinesiology with consistent reliability. This study does show a correlation, but it does not validate the complete system of manual muscle testing as used in AK. It appears that the major difference between testing against fixed transducers – whether isometric or concentric – is that the muscle is required to simply produce power; in manual muscle testing, the muscle is required to adapt to the changing pressure of the examiner's force. This requires effective functioning in the gamma system adjusting the neuromuscular spindle cell, and proper interpretation of its afferent supply and response by the nervous system.</p>
<p>Intrarater reliability of manual muscle testing and hand-held dynamometric muscle testing, Wadsworth CT, Krishnan R, Sear M, Harrold J, Nielsen DH.</p>	<p><i>Phys Ther</i>, 1987 Sep;67(9):1342-7.</p> <p>Abstract: Physical therapists require an accurate, reliable method for measuring muscle strength. They often use manual muscle testing or hand-held dynamometric muscle testing (DMT), but few studies document the reliability of MMT or compare the reliability of the two types of testing. We designed this study to determine the intrarater reliability of MMT and DMT. A physical therapist performed manual and dynamometric strength tests of the same five muscle groups on 11 patients and then repeated the tests two days later. The correlation coefficients were high and significantly different from zero for four muscle groups tested dynamometrically and for two muscle groups tested manually. The test-retest reliability coefficients for two muscle groups tested manually could not be calculated because the values between subjects were identical. We concluded that both MMT and DMT are reliable testing methods, given the conditions described in this study. Both testing methods have specific applications and limitations, which we discuss.</p>
<p>Clinical and electromyographical course of sciatica: prognostic study of 41 cases, Negrin P, Fardin P.</p>	<p><i>Electromyogr Clin Neurophysiol</i> 1987;27:125-127</p> <p>Abstract: The study of the clinical and EMGraphical course of patients with sciatica may help us to decide between a simple symptomatic treatment and an admission to hospital for neuroradiological tests and possible surgery. 41 patients with acute lumbosciatalgia and EMGraphically proven monoradicular denervation were studied: the root affected was L5 in 39 cases (78%), L4 in 7 cases and S1 in 2 cases. 19 of these cases were then submitted to surgical treatment of disc protrusion removal, the other 22 were treated medically. 3 to 8 years later, the following parameters were tested: pain, motor impairment, EMG denervation and degree of patient's subjective judgment. We concluded that urgent hospital admission is indicated only in the case of severe and/or recent (within 1 month) paralysis or in the case of intolerable painful symptomatology. The diagnostic and prognostic role of EMG is hence confirmed: this examination yields information on the identity of the root</p>

	involved, the severity of the denervation, its course and the degree of final improvement expected.
Clinical biomechanical correlates for cervical function: Part II. A myoelectric study, Vorro J, Johnston W.	<p><i>J Am Osteopath Assoc</i> 1987;87:353-367</p> <p>Part 1 of this study compared cervical motion ranges for two groups of human subjects classified as symmetric or asymmetric on the basis of a single clinical test for cervical sidebending. Data from the asymmetric group revealed limited mobility in all primary rotations and in secondary deviations. Part 2 reports on the concurrent, bilateral measurement of electromyographic activity for 12 selected muscle sites during the movements executed. Data revealed that muscles in the asymmetric group were slower to initiate action and were reduced in time and strength of contraction. Because muscles provide the motive forces for the reduction in range previously reported, these myoelectric data expand understanding of the disturbance in physiologic function that is indicated when a clinical test for response to motion in a spinal region is positive for asymmetry.</p>
Manual muscle test scores and dynamometer test scores of knee extension strength, Bohannon RW.	<p><i>Arch Phys Med Rehabil.</i> 1986 Jun;67(6):390-2.</p> <p>The knee extension force of 50 patients was investigated using traditional manual muscle testing and hand-held dynamometry. The relationship between manual muscle test word scores and dynamometer force scores was determined using Kendall tau, as was the relationship between manual muscle test percentage scores and dynamometer scores expressed as a percentage of "normal." Percentage scores were also compared to determine if a significant difference existed. Manual muscle test scores and dynamometer test scores were significantly correlated (p less than .001). Percentage manual muscle test and dynamometer test scores were significantly different (p less than .001). These results suggest that the two procedures measure the same variable-strength. Manual muscle test percentage scores of knee extension may, however, overestimate the extent to which a patient is "normal."</p>
Predictive value of manual muscle testing and gait analysis in normal ankles by dynamic electromyography, Perry, J.P. et al	<p><i>Foot Ankle.</i> 1986 Apr;6(5):254-9.</p> <p>Eight muscles about the ankle of seven normal subjects were assessed by electromyography (EMG) during manual muscle testing (MMT) and walking. Three strength levels (normal, fair, trace) and three gait velocities (free, fast, slow) were tested. The muscles studied included the gastrocnemius, soleus, posterior tibialis, flexor digitorum longus, flexor hallucis longus, anterior tibialis, extensor digitorum longus, and extensor hallucis longus. Relative intensity of muscle action was quantitated visually (using an eight-point scale based on amplitude and density of the signal). The data showed that EMG activity increased directly as more muscle force was required during the different manual muscle test levels and increased walking speeds. No MMT isolated activity to the specific muscle though being tested. Instead, there always was a synergistic response. Both the gastrocnemius and soleus contributed significantly to plantarflexion regardless of knee position. The intensity of muscle action during walking related to the manual muscle test grades. Walking at the normal free velocity (meters/min) required fair (grade 3) muscle action. During slow gait the muscle functioned at a poor (grade 2) level. Fast walking necessitated muscle action midway between fair and normal, which was interpreted as good (grade 4).</p>
Effects of manipulation on gait muscle activity: preliminary electromyographic research, Hibbard D.	<p><i>J Am Chiro Assoc</i> 1983;17:49-51</p> <p>This study analyzed the effect of chiropractic manipulation of the extremities on gait muscles.</p>
The efficacy of manual	<i>Am J Sports Med.</i> 1982 Nov-Dec;10(6):360-4

<p>assessment of muscle strength using a new device, Marino M, Nicholas JA, Gleim GW, Rosenthal P, Nicholas SJ.</p>	<p>Abstract: The purpose of this study was to compare the manual assessment of muscle strength with a small, handheld (by the examiner) force-measuring device developed by the Institute of Sports Medicine and Athletic Trauma (ISMAT). One hundred twenty-eight patients presented with a known lower extremity orthopaedic pathology. All patients were clinically evaluated for hip abductor and hip flexor weakness in standard positions using the "break test" technique. All 128 patients were then evaluated with the ISMAT Manual Muscle Tester, a small, hand-held device which recorded the peak force (kg) required to break a muscle contraction. Three bilateral measures of hip abduction and hip flexion were recorded, averaged, and compared to the subjective clinical evaluation using a chisquare analysis. Bilateral values which were within 5% of each other were not considered significant and therefore not included in the calculations. The average hip abduction and hip flexion scores measured by the ISMAT tester were consistent with the examiner's perception of muscle weakness (P less than 0.001). The results demonstrate consistent detection of muscle weakness by the ISMAT Manual Muscle tester over a broad range of testing conditions.</p>
<p>Electromyographic analysis following chiropractic manipulation of the cervical spine: a model to study manipulation-induced peripheral muscle changes, Rebechini-Zasadny H, Tasharski C, Heinze, W.</p>	<p><i>J Manipulative Physiol Ther</i> 1981;4:61-63</p> <p>This study showed the effects of chiropractic manipulation upon the musculature, specifically an increase in finger strength after cervical adjusting.</p>
<p>Usefulness of electrophysiological studies in the diagnosis of lumbosacral root disease, Tonzola R, Ackil A, Shahani B, Young R.</p>	<p><i>Ann Neurol</i> 1981;9:305-308</p> <p>Abstract: Clinical, electrophysiological, and myelographic findings were correlated in 57 patients with the clinical diagnosis of lumbosacral root disease. Conventional motor and sensory (including sural nerve) conduction studies were normal in all patients. Electromyography, late response studies in different muscles of the lower extremity, the myelogram, or combinations of these tests were abnormal in 44 patients (77%). Of 36 patients (63%) with abnormal myelograms, 14 had normal electrophysiological studies. Twenty-nine (51%) had an abnormal electrophysiological or myelographic finding; although 8 patients in this group had a normal myelogram, 2 had an abnormal discogram and 1 an abnormal epidurogram. Electrophysiological or myelographic findings, in some cases both, correlated well with clinical signs and symptoms in 41 patients (72%). H-reflex and F response studies, when abnormal, helped in localizing a lesion in the appropriate root distribution.</p> <p>Comment: This study demonstrates that EMG shows better correlation with neurological examinations than CT scans or myelograms for nerve root disturbances in the lumbosacral spine. In other words, muscle dysfunction correlates better with lumbosacral nerve root injuries than CT scans or myelograms.</p>
<p>Factors influencing manual muscle tests in physical therapy, Nicholas JA, Sapega A, Kraus H, Webb JN.</p>	<p><i>J Bone Joint Surg Am.</i> 1978 Mar;60(2):186-90</p> <p>Abstract: To determine whether it is the amount or the duration of the force applied manually by the tester, or both, that determines the tester's perception of the strength of the hip flexor or abductor muscles, an electromechanical device was designed which was placed between the tester's hand and the subject's limb. With the device we measured the force applied to the limb, the time interval during which it was applied, and the angular position of the limb during the entire test. In 240 such tests, the testers' ratings of the differences in strength between the right and left sides were correlated with seven variables involving force and time. It was found statistically that the impluse--that is, the duration of</p>

	<p>the tester's effort multiplied by the average applied force during each test--was the factor that most influenced the tester in the ratings.</p> <p>Comment: The skills of the examiner related to conducting tests and interpreting the derived information will affect the usefulness of muscle performance data. The examiner is obliged to follow a standardized protocol that specifies patient position, verbal instructions or demonstration to the patient, alignment of the muscle and direction of examiner resistance to insure precise, repeatable, and reliable MMT results. When a muscle is tested in voluntary isometric contraction, EMG testing reveals that additional muscle fibers contract at low forces; when the force increases, the rate of firing becomes the predominant mechanism to increase strength. Tension, velocity, and electrical activity are interdependent and indicate the importance of proper neurologic control for the muscle to meet the changing pressure demands of the MMT. This requires effective function of the gamma system adjusting the neuromuscular spindle cell, and proper interpretation of its afferent supply by the central nervous system. Thus it is patient or more precisely the patient's neuromuscular adaptive capacity that is being examined during a proper MMT.</p>
<p>Discogenic radiculopathy: use of electromyography in multidisciplinary management, Lane M, Tamhankar M, Demopoulos J.</p>	<p><i>NY State J Med</i> 1978;78:32-36</p> <p>This study demonstrated an 85% agreement between EMG evaluation and neurological work-up, evidencing nerve root compromise. There is evidence offered that EMG readings may be equivalent to subluxation determination. This study shows that changes in muscle electrical activity measured in distinct myotomes revealed nerve root disturbance. The study concludes that a positive EMG finding, indicating the presence of a lesion at the level of the root or proximal in the spinal cord, should alert the clinician.</p>