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INNOVATIVE APPROACH IN THE STUDY OF MUSCLE STRENGTH - THEORETICAL ANALYSIS

Assoc. Prof. Stefka Mindova, PhD
Department of Public Health,
University of Ruse
E-mail: smindova@uni-ruse.bg

Assoc. Prof. Irina Karaganova, PhD
Department of Public Health,
University of Ruse
E-mail: ikaraganova@uni-ruse.bg

Abstract: *The assessment of a patient's muscle strength is one of the most important vital functions that is typically monitored. Specifically, strength assessment is necessary for deter-mining distribution of weakness, disease progression, and/ or treatment efficacy. Several assessment techniques and tools are currently available to the healthcare provider and/or researcher, yet each has its unique attributes. Nevertheless, as outcomes-based medical practice becomes the norm, the need for quantitative outcomes assessment of muscle strength will become even more important.*

Standardized strength-testing procedures are important regardless of whether MMT or HHD are used. MMT is simple, easy to use, and therefore clinically practical. However, the reliability and responsiveness of MMT is uncertain for strength greater than 3/5. HHDs potentially quantify strength numerically by recording force output. Because of the portability of HHDs, they are useful in the clinical/bedside environments for tracking strength changes.

Keywords: *muscle testing, muscle strength, measurement of muscle strength, dynamometers, hand-held dynamometry, HHD, MMT*

JEL Codes:

INTRODUCTION

The simplest and most common method of assessing muscle strength is the manual muscle test (MMT). Manual muscle testing is a procedure for evaluating strength and function of an individual muscle or a muscle group in which the patient voluntarily contracts the muscle against gravity load or manual resistance, (Clarkson HM, 2000; Florence PK, McCreary EK, Province PG, Rodgers MM, Romani WA, 2005).

It is quick, efficient, and easy to learn, however, it requires total cooperation from the patient and learned response levels by the assessor.

The technique of MMT began with Lovett in 1912, (Clarkson HM, 2000; Florence PK, McCreary EK, Province PG, Rodgers MM, Romani WA, 2005).

A system for grading the strength of postural muscles using the MMT for disability evaluation in polio and other neuromuscular diseases was presented by the Kendalls in 1936, with the first text based on this work published in 1949, (Clarkson HM, 2000).

Kendall and Kendall's second book were called *Posture and Pain* (1952), and it was already realized that the theoretical construct of the MMT should be expanded far beyond the "polio syndromes" that the MMT was originally designed to evaluate, (Kendall FP, McCreary EK, Province PG, 1993).

Goodheart introduced this method of testing into the chiropractic profession in 1964, and he and the International College of Applied Kinesiology (I.C.A.K.) developed methods for treating the muscle inhibitions found using manual methods since that time, (Green BN, Gin RH, 1997).

Methods for the objective evaluation of the effects of neuromuscular impairment and the measurement of changes in neuromuscular functioning must be developed in parallel with advances in therapy, and the MMT may be a tool for measuring this, (Florence PK, McCreary EK, Province PG, Rodgers MM, Romani WA, 2005; Walter H Schmitt Jr, S., 2008).

EXPOSITION

Muscle testing is a procedure for evaluating the function and strength of individual muscles and muscle groups, based on effective performance of a movement in relation to the forces of gravity and manual resistance through available range of motion, (Popov, N., 2012).

Manual grading of muscle strength is based on palpation or observation of muscle contraction, ability to move the limb through its available ROM against or without gravity, and ability to move the limb through its ROM against manual resistance by the examiner. Manual resistance is applied by the examiner using one hand with the other hand stabilizing the joint. Exact locations for applying resistive force are specified and must be followed exactly to obtain accurate MMT results, (Clarkson HM., 2000).

The purposes of muscle test:

✓ To overcome the limitations of the MMT, dynamometers have been developed to aid therapists in clinics. With our research we aim to acquaint the audience with the types of dynamometers, we joined them in several groups according to the type and application. To provide information that may be of assistance to a number of health professionals in differential diagnosis, treatment planning and prognosis. It has limitations in the neurological disorders, where there is an alteration in muscle tone if reflex activity is altered or if there is a loss of cortical control due to lesions of the central nervous system.

✓ To assess muscle strength, the therapist must have a sound knowledge of anatomy (joint motions, muscle origin, insertion and function) and surface anatomy (to know where a muscle or its tendon is best palpated).

✓ The therapist must be a keen observer and be experienced during testing to detect minimal muscle contraction, movement and/or muscle wasting and substitutions or trick movements.

✓ A consistent method of manually testing muscle strength is essential to assess accurately a patient's present status, progress, and the effectiveness of the treatment program, (Clarkson HM., 2000; Neustadt M., Croteau E., 1998).

Conventional method for measuring muscle strength:

Manual grading of muscle strength is based on three factors:

- *Evidence of contraction:* No palpable or observable muscle contraction (grade 0) or a palpable or observable muscle contraction and no joint motion (grade 1).
- *Gravity as a resistance:* The ability to move the part through the full available range of motion with gravity eliminated (grade 2) or against gravity (grade 3) the most objective part of test.
- *Amount of manual resistance:* The ability to move the part through the full available range of motion against gravity and against moderate manual resistance (grade 4) or maximal manual resistance (grade 5). Adding (+) or (-) to the whole grades to denote variation in the range of motion. Movement through less than half of the available range of motion is denoted by a (+) (outer range). Movement through greater than half of the available range of motion by (-) (inner range).

A common alternative to motion based MMT is the isometric MMT in which the limb is held in a fixed position while the examiner gradually applies an increasing resistance force. The instructions to the patient are, don’t let me move you. While not entirely accurate, MMT scores do correlate well with results from handheld dynamometers, (Bohannon RW., 1986) implying that both are valid measures of muscle strength.

However, all tests based on voluntary activation of a muscle are prone to artifact because of patient motivation and examiner encouragement, (W.K. Durfee P.A. Iaizzo).

Table 1. Conventional grading Scale Range: 0 to 5 modified from 1993 Florence P. Kendall. Author grants permission to reproduce this chart [http://www.scottsevinsky.com/pt/mmt.html]

Zero	0	Non of the available ROM, no visible or palpable contraction
Trace	**1**	**Visible or palpable contraction (No ROM)**
Trace+	1+	Less than one half of the available ROM, gravity eliminated
Poor$^-$	2^-	Partial ROM, gravity eliminated
Poor	**2**	**Full ROM, gravity eliminated**
Poor$^+$	2^+	Gravity eliminated/slight resistance or < 1/2 range against gravity
Fair$^-$	3^-	> 1/2 but < Full ROM, against gravity
Fair	**3**	**Full ROM against gravity**
Fair$^+$	3^+	Full ROM against gravity, slight resistance
Good$^-$	4^-	Full ROM against gravity, mild resistance
Good	**4**	**Full ROM against gravity, moderate resistance**
Good$^+$	4^+	Full ROM against gravity, almost full resistance
Normal	**5**	**The full available ROM against gravity, maximal resistance, with hold at the end of ROM** (Hold for about 3 seconds)

Hand-held dynamometer (HHD) has been developed which can measure the strength of most upper and lower body muscle groups. Dynamometers Standardized protocols exist for isometric measurement of muscle strength. However, when using a HHD, this position requires considerable observer strength in order to stabilize the HHD and maintain the isometric positioning, (Wikholm JB, Bohannon RW, 1991; Wiles CM, Karni Y., 1983).

When examining muscle strength using dynamometers, we must consider two relationships. The first is the length-tension relationship of the muscle. This relationship is between the maximum tension in a muscle versus its length. Ideally, the muscle strength should be tested in its optimal length-tension position. When using an HHD for strength testing, the examiner must determine the testing point in the ROM based on the functional demands of the subject. Above all, the position in the ROM identified for strength testing must be standardized for all measurement intervals for a given patient, (Sue Ann Sisto, Trevor Dyson-Hudson, 2007).

For example, to measure the strength of the biceps, we should position the elbow at approximately 90°, which would put the muscle at its optimal length and generate the greatest tension. However, since the biceps is a two-joint muscle, standardizing the position of the shoulder is important as well.

When an HHD is used, different rates of force application against the dynamometer will produce variable force production. Standardizing the time expected to get to a maximum contraction may reduce this variability, (Wikholm JB, Bohannon RW, 1991).

Table 2. Subject Position, Placement of Dynamometer, and Location of Stabilization Provided for Each Tested Muscle Action, (Williams A., Michael W Thomas and Richard W Bohannon, 1996)

Muscle Action	***Limb/Joint Positions***	***Dynamometer Placemen***	***Stabilization of Subject***
Shoulder flexion	Shoulder flexed 90˚; elbow extended	Just proximal to epicondyles of humerus	Axillary region
Shoulder extension	Shoulder flexed 90˚; elbow flexed	Just proximal to epicondyles of humerus	Superior aspect of shoulder
Shoulder abduction	Shoulder abducted 45˚; elbow extended	Just proximal to lateral epicondyle of humerus	Superior aspect of shoulder
Shoulder lateral rotation	Shoulder abducted 45˚; elbow at 90˚	Just proximal to styloid processe	Elbow
Shoulder medial rotation	Shoulder abducted 45˚; elbow at 90˚	Just proximal to styloid processes	Elbow
Elbow flexion	Shoulder at neutral; elbow flexed 90˚; forearm supinated	Just proximal to styloid processes	Superior aspect of shoulder or arm
Elbow extension	Shoulder at neutral; elbow flexed 90˚; forearm in neutral	Just proximal to lateral styloid process	Anterior aspect of shoulder or arm
Wrist extension	Shoulder at neutral; elbow flexed 90˚; wrist at neutral fingers relaxed	Just proximal to metacarpophalangeal joints	Distal forearm
Hip flexion	Hip flexed 90˚; knee relaxed; contralateral limb in neutral	At femoral condyles	Pelvis
Hip abduction	Both lower limbs in neutral	At lateral femoral condyles	Contralateral lower limb held in neutra
Knee flexion	Hips and knees flexed 90˚; hands resting in lap	Just proximal to malleoli	Stabilized at shoulders by assistant
Knee extension	Hips and knees flexed 90˚; hands resting in lap	Just proximal to malleoli	Stabilized at shoulders by assistant
Ankle dorsiflexion	Hip, knee, and ankle at 0˚	Just proximal to metatarsophalangea joints	Knee maintained in full extension; leg supported with foot off table

HHDs, also known as myometers, have several advantages over other types of dynamometers, including lower cost, greater ease of use, and better acceptability in clinical settings. Researchers and clinicians are evaluating the benefits of HHDs for strength measurement, (Bohannon, R., 2005; Burns SP, Spanier DE., 2000; Wikholm JB, Bohannon RW, 1991).

When strength testing is performed with an HHD, guidelines for optimal repeatability should be followed. The examiner should perform three trials and allow the subject adequate rest between trials, (Agre JC, Magness JL, Hull SZ, et al., 1987; Hyde SA, Goddard CM, Scott OM, 1983).

Repeating trials allows the examiner to take an average that will be more representative of a maximum effort. Additionally, the examiner can eliminate outliers or extremely high or low values caused by a subject's inconsistent effort or an examiner's inadequate resistance. The examiner needs to stabilize him or herself so that the counterforce is in the required direction. The examiner should avoid providing counter resistance across two joints and must pay attention to strategies a patient may use to compensate for muscle weakness. When such compensation is observed, the examiner should terminate the test and the patient should be instructed to avoid compensatory maneuvers, (Sue Ann Sisto, Trevor Dyson-Hudson, 2007).

CONCLUSION

Our studies have focused on the development and implementation of clinical trials to measure and objectively evaluate muscle strength in people with disabilities in different age groups. These new methods of muscle strength research for Bulgaria have a great interest in physiotherapy. The studies will be published in the next reports.

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