Introduction

This 10th edition presents manual muscle testing within the context of strength testing. Classic muscle testing is a fundamental skill of every physical therapist and is essential to the diagnosis and assessment of movement impairments. However, as manual muscle testing has come under scientific scrutiny, it is obvious that its use to evaluate and assess strength as a component of functional movement patterns and tasks is inadequate. Therefore, in addition to the classic presentation of manual muscle testing, this edition presents methods of strength testing that are valid, objective, and applicable across various settings.

A number of noteworthy changes have been made in the new edition. First and foremost, it is a modern 21st century text that has been thoroughly researched. Each test presented is backed by evidence, and the utility of each muscle testing approach is presented in context with alternative options. Throughout the text there are updated testing methods. Origins, insertions, and actions of key muscles for each manual muscle test are now included and precede the description of most test procedures. Additionally, for each specific muscle (e.g., serratus anterior, tibialis anterior), there are exercises that the therapist can use to strengthen weak muscles in patients. Each recommended exercise has been demonstrated, in most instances, to elicit at least 40% of maximum voluntary strength. Thus exercises are sufficiently rigorous to induce genuine strength increases in patients.

Chapter 7 presents a variety of strength testing methods using common equipment. Although this chapter was introduced in the previous edition, additional tests have been added to it and modifications to other tests were made. Additional normative values have been included and values for reliability, validity and specificity are now part of the text, when these values exist. Chapter 8 describes functional tests that have a significant strength component. Age-based norms are included when available, and patient scenarios are presented that provide the rationale for each recommended approach to strength testing. Finally, there is a new Chapter 9 on handheld dynamometry, an emerging technology that offers an additional means of distinguishing between limbs that have subtle strength differences and an opportunity for more precise testing. Normative values for handheld dynamometry have also been included when normative values exist. We believe that you will find this a very different text from Edition 9 and a welcome addition to your library.

Muscle strength is a critical component of functional movement. Assessment must include accurate measurement of the quantity of strength within the context of functional tasks and movement. Especially for the lower extremities, methods that allow the expansion of the findings of manual muscle testing from an impairment to a function level are needed. Quantitative assessment promotes accurate assessment of progress and patient performance within the context of age-based normative values. Although few “hard numbers” of threshold strength levels exist for specific functional movements, we have identified the known muscles that have been correlated with a specific task and, in some cases, have suggested values that may serve as a target for the minimum strength required for a specific functional task.

The manual muscle testing portion of this book, as in previous editions, directs its focus on manual procedures. For the most part, joint motions (e.g., hip flexion) rather than individual muscles (e.g., iliopsoas) are the focus of this text because of the contributions of more than one muscle to a movement. Although prime movers of a movement can be identified, secondary or accessory movers may be equally important and should not be overlooked or underestimated. Rarely is a prime mover the only active muscle, and rarely is it used under isolated control for a given movement. For example, knee extension is the prerogative of the five muscles of the quadriceps femoris, yet none of these five extend the knee in isolation from its synergists. Regardless, definitive activity of any muscle in a given movement can be precisely detected by electromyography, and such studies, when they exist, are now included as important pieces of evidence in this updated text.

Range of motion in this book is presented only to illustrate the range required to test a movement correctly. A consensus of typical ranges is presented with each test, but the techniques of measurement used are not within the scope of this text.

Brief History of Muscle Testing

Wilhelmine Wright and Robert W. Lovett, MD, Professor of Orthopedic Surgery at Harvard University Medical School, were the originators of the muscle testing system that incorporated the effect of gravity.[1,2] Janet Merrill, PT, Director of Physical Therapeutics at Children's Hospital and the Harvard Infantile Paralysis Commission in Boston, an early colleague of Dr. Lovett, stated that the tests were used first by Wright in Lovett's office gymnasium in 1912.[3] The seminal description of the tests used largely today was written by Wright and published in 1912[1]; this was followed by an article by Lovett and Martin in 1916[4] and by Wright's book in 1928.[5] Miss Wright was a precursor of the physical therapist of today, there being no educational programs in physical therapy in her time, but she headed Lovett's physical therapeutic clinic. Lovett credits her fully in his 1917 book, *Treatment of Infantile Paralysis*,[6] with developing the testing for polio. In Lovett's book, muscles were tested using a resistance-gravity system and graded on a scale of 0 to 6. Another early numerical scale in muscle testing was described by Charles L. Lowman, MD, founder and medical director of Orthopedic Hospital, Los Angeles.[7] Lowman's system (1927) covered the effects of gravity and the full range of movement on all joints and was particularly helpful for assessing extreme weakness. Lowman further described muscle testing procedures in the *Physiotherapy Review* in 1940.[8]

H.S. Stewart, a physician, published a description of muscle testing in 1925 that was very brief and was not anatomically or procedurally consistent with what is done today.[9] His descriptions included a resistance-based grading system not substantially different from current use: maximal resistance for a normal muscle, completion of the motion against gravity with no other resistance for a grade of fair, and so forth. At about the time of Lowman's book, Arthur Legg, MD, and Janet Merrill, PT, wrote a valuable small book on poliomyelitis in 1932. This book, which offered a comprehensive system of muscle testing, was used extensively in physical therapy educational programs during the early 1940s; muscles were graded on a scale of 0 to 5, and a plus or minus designation was added to all grades except 1 and zero.[10]

Among the earliest clinicians to organize muscle testing and support such testing with sound and documented kinesiologic procedures in the way they are used today were Henry and Florence Kendall. Their earliest published documents on comprehensive manual muscle testing became available in 1936 and 1938.[11,12] The 1938 monograph on muscle testing was published and distributed to all Army hospitals in the United States by the U.S. Public Health Service. Another early contribution came from Signe Brunnström and Marjorie Dennen in 1931; their syllabus described a system of grading movement rather than individual muscles as a modification of Lovett's work with gravity and resistance.[13]

The first comprehensive text on muscle testing was written by Lucille Daniels, MA, PT; Marian Williams, PhD, PT; and Catherine Worthingham, PhD, PT, published in 1946.[14] These three authors prepared a comprehensive handbook on the subject of manual testing procedures that was concise and easy to use. It remains one of the most used texts the world over and is the predecessor for all subsequent editions of *Daniels and Worthingham's Muscle Testing* including this edition.

The Kendalls (together and then Florence alone after Henry's death in 1979) developed and published work on muscle testing and related subjects for more than 6 decades[15-17] Their first edition of *Muscles: Testing and Function* appeared in 1949.[15] Earlier, the Kendalls had developed a percentage system ranging from 0 to 100 to express muscle grades as a reflection of normal; they reduced the emphasis on this scale, only to return to it in the latest edition (1993), in which Florence again advocated the 0 to 10 scale.[17] The contributions of the Kendalls should not be considered as limited to grading scales, however. Their integration of muscle function with posture and pain in two separate books[15,16] and then in one book[17] is a unique and extremely valuable contribution to the clinical science of physical therapy.

Muscle testing procedures used in national field trials that examined the use of gamma globulin in the prevention of paralytic poliomyelitis were described by Carmella Gonnella, Georgianna Harmon, and Miriam Jacobs, all physical therapists.[18] The later field trials for the Salk vaccine also used muscle testing procedures.[19] The epidemiology teams at the Centers for Disease Control were charged with assessing the validity and reliability of the vaccine. Because there was no other method of accurately "measuring" the presence or absence of muscular weakness, manual muscle testing techniques were used.

A group from the D.T. Watson School of Physiatrics near Pittsburgh, which included Jesse

Wright, MD; Mary Elizabeth Kolb, PT; and Miriam Jacobs, PT, PhD, devised a test procedure that eventually was used in the field trials.[20] The test was an abridged version of the complete test procedure but did test key muscles in each functional group and body part. It used numerical values that were assigned grades, and each muscle or muscle group also had an arbitrary assigned factor that corresponded (as closely as possible) to the bulk of the tissue. The bulk factor multiplied by the test grade resulted in an "index of involvement" expressed as a ratio.

Before the trials, Kolb and Jacobs were sent to Atlanta to train physicians to conduct the muscle tests, but it was decided that experienced physical therapists would be preferable to maintain the reliability of the test scores.[20] Lucy Blair, then the Poliomyelitis Consultant in the American Physical Therapy Association, was asked by Catherine Worthingham of the National Foundation for Infantile Paralysis to assemble a team of experienced physical therapists to conduct the muscle tests for the field trials. Kolb and Jacobs trained a group of 67 therapists in the use of the abridged muscle test.[20] This work of determining the presence or absence of weakness and paralysis had enormous impact on the eventual approval of the Salk vaccine. A partial list of participants was appended to the Lilienfeld paper in the *Physical Therapy Review* in 1954.[19]

How to Use This Book

The general principles that govern manual muscle testing are described in Chapter 1. Chapter 2 describes the purposes and limitations of manual muscle testing, placing manual muscle testing in the context of strength testing across settings. Chapters 3 through 7 present traditional and updated techniques for testing motions of skeletal muscle groups in the body region covered by that chapter. Chapter 4 reflects additional changes to practice through the expansion of the trunk muscle strength testing section, particularly trunk endurance; the pelvic floor muscle testing section; and the respiratory muscle section. Chapter 7 describes methods of strength testing using equipment and instruments, and Chapter 8 is devoted to functional tests, which have become critical for successful documentation. Students should learn manual muscle testing within the context of strength testing to avoid some of the limitations described in Chapter 2. Chapter 9 is completely new and describes manual testing using a handheld dynamometer and includes normative values where they exist. Chapter 10 provides case studies to describe different methods of strength testing in various patient populations and settings.

For instant access to anatomical information without carrying a large anatomy text to a muscle testing session, see the Ready Reference Anatomy section on Evolve. This chapter is a synopsis of muscle anatomy, muscles as part of motions, muscle innervations, and myotomes.

To assist readers, each muscle has been assigned an identification number based on a regional sequence, beginning with the head and face and proceeding through the neck, thorax, abdomen, perineum, upper extremity, and lower extremity. This reference number is retained throughout the text for cross-referencing purposes. Two lists of muscles with their reference numbers are presented, one alphabetical and one by region, to assist readers in finding muscles in the Ready Reference section. These can also be found on the inside front and back covers of the book.

Names of the Muscles

Muscle names have conventions of usage. The most formal usage (and the correct form for many journal manuscripts) is the terminology established by the Federative International Committee on Anatomical Terminology (FCAT) in 1998. However, common usage often neglects these prescribed names in favor of shorter or more readily pronounced names. The authors of this text make no apologies for not keeping strictly to formal usage. Most of the muscles cited follow Terminologia Anatomica. Others are listed by the names in most common use. The alphabetical list of muscles (see the inside front cover of the book) gives the name used in this text and the correct Terminologia Anatomica term, when it differs, in parentheses.

Anatomical Authorities

The authors of this book relied on both the American and British versions of *Gray's Anatomy* as principal references for anatomical information, as well as Sabotta's *Atlas of Human Anatomy*. Because proficiency in muscle testing can only be achieved if the practitioner has a thorough understanding of anatomy, anatomical drawings are presented throughout the book, many in cross-section format, and descriptions of origins and insertions and functions are provided in multiple places, in detail and in abbreviated form.

The Convention of Arrows in the Text

Red arrows in the text denote the direction of movement of a body part, either actively by the patient or passively by the examiner. The length and direction of the arrow indicates the relative excursion of the part.

Black arrows in the text denote resistance by the examiner.

It is important to remind the reader that mastery of muscle testing, whether performed manually or using a strength-testing device, requires substantial practice. The only way to acquire proficiency in clinical evaluation procedures is to practice over and over again. As experience with patients matures over time, the nuances that can never be fully described for the wide variety of patients encountered by the clinician will become as much intuition as science. Muscle testing continues to be among the most fundamental skills of the physical therapist and others who are concerned with abnormalities of human motion. The skill of manual muscle testing is a critical clinical tool that every physical therapist must not only learn but also master. A physical therapist who aspires to be recognized as a master clinician will not achieve that status without acquiring exquisite skills in manual muscle testing and precise assessment of muscle performance.

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