**Test Position**

Test position is the position in which the part is placed by the examiner and held (if possible) by patient. It is the position used for the purpose of evaluating strength for most muscles.

The optimal test position is at the completion of range for one-joint muscles and for two or multijoint muscles that act like one-joint muscles. The optimal test position for other two or multijoint muscles is at midrange of overall length, in accordance with the length-tension principle (See classifications, p.13.)

Test position (as opposed to test movement) offers the advantages of precision in positioning and accuracy in testing. In addition, the examiner can determine immediately whether any limitations of motion exist by moving the part through the existing range of motion to the position.

Use of test position also the examiner to detect substitutions movement. When muscle weakness exits, other muscles immediately substitute to hold a position resembling the test position. The visible shift from the test position indicates a substitute movement.

Placing the part in the rest position expedites grading the muscle strength. As the effort is made to hold the test position, the ability or inability to hold the positions against gravity is at once established. If it fails to hold, the examiner test for strength below the fair grade: If the position is held, the examiner then applies pressure to grade above fair (See Key to Muscle Grading, p.23.)

**Test Movement**

Test movement is a movement of the part in a specified direction and though a specific are of motion. For strength tests of extremity muscles that are too weak to act against gravity (i.e., muscles that grade in the range of poor), tests are done in the horizontal plane. Test movement is also used when testing the trunk lateral flexors, upper abdominal flexors, back extensors, quadratus lumborum, serratus anterior (in standing), and gastrocnemius.

Test movement may be used for certain muscles, such as those that cross hinge joints, but it is not practical when a test requires a combination of two or more joint positions or movements. It is difficult for a patient to assume the exact position through verbal instruction or imitating a movement demonstrated by examiner. For accurate testing, the examiner should place the part in precisely the desired test position.

**Pressure and Resistance**

The term **pressure**\* is used throughout this text to refer to external force that is applied by the examiner to determine the strength of the muscle holding in the test position (i.e., for grades of F+ or better).

The term resistance refers to the external force that opposes the test movement. The resistance may be the force of gravity or a force that is supplied by the examiner. Resistance may vary according to body weight (i.e., back extensor test), arm position (i.e., upper abdominal test), or leg positions (i.e., lower abdominal test). Occasionally, the examiner may be offer resistance. An example of this is traction the examiner provides in the quadratus lumborum test.

The placement, direction, and amount of pressure are important factors when testing for strength above the grade of fair.

In the descriptions of muscle tests, pressure is specified as against or in the direction of. Against refers to the position of examiner’s hand in relation to the patient; in the direction of describes the direction of the force that is applied directly opposite the line of pull of the muscle or its tendon.

In some of the illustrations of muscle tests, the examiner’s hand has been held extended for the purpose of indicating, photographically, that the direction of pressure is perpendicular to palmar surface of hand. Pressure should be applied only the direction indicated. (It is not necessary that extended hand position be imitated during routine muscle testing.) An extended hand is not appropriate when applying pressure in a test that includes a rotation component.

Just as the direction of the pressure is an important part of accurate test performance, the amount of pressure is the determining factor in grading strength above fair. (See Grading, p.20), for further discussion related to amount of pressure).

The place at which the pressure is an important on muscle insertions, strength of intervening muscles and leverage. Generally, pressure is applied near distal end of the part on which the muscle is inserted. For example, pressure is applied near the distal end of the forearm during the biceps test. Exceptions to this rule occur when pressure on the bone of insersion does not provide adequate leverage to obtain discrimination for grading.

Both the length of the lever and the amount of pressure are closely related with respect to grading above fair. Using a long lever gives the examiner a mechanical advantage and allows more sensitive grading of muscle strength.

Test results might be more indicative of lack of strength of the examiner than of the subject if the examiner did not have the advantage of leverage.

When testing strong muscles like hip abductors, it is necessary to use a long lever (i.e., placing pressure just proximal to ankle). When testing hip adductors, however, it is necessary to use a shorter lever, with pressure just above the knee joint, to avoid strain on the anteromedial area of that joint.

Pressure must be applied gradually to determine the degree of strength above fair in muscles. the patient must be get set and hold the test position against the examiner’s pressure. The examiner can not gauge the degree of strength unless pressure is applied gradually, because slight pressure that applied suddenly can “break” the pull of a strong muscle. Grading strength involves a subjective evaluation based on the amount of pressure applied. Differences in strength so apparent, however, that on observer who understands grading can estimate the strength with a high degree of accuracy while watching the examiner apply pressure.

**Substitution**

Substitution results from one or more muscles attempting to compensate for the lack of strength in another muscle or group of muscles. substitution is a good indication that tested muscle is weak, that adequate fixation has not been applied, or that the subject has not been given adequate instruction concerning how to perform test.

Muscle that normally act together in movements may act in substitution. These include fixation muscles, agonists and antagonist.

Substitution by fixation muscles occurs specifically in relation to movements of shoulder joint and the hip joint. Muscles that move scapula may be produce a secondary movement of the arm; muscles that move the pelvis may produce a secondary movement of the thigh.

These substitution movements appear similar to- but are not- movements of shoulder or hip joint.

The close relationship of muscles determines their action in substitution, assistance, and stabilization during tests of individual muscles. The grouping of muscles according to joint action, as seen in the charts on pages 254 and 255 and 366 and 367, has been done to aid the examiner in understanding the allied action of the muscles.

True abduction of the hip joint is accomplished by hip abductors with normal fixation by lateral trunk muscles. when the hip abductors are weak, apparent abduction may occur by the substitution action of lateral trunk muscles. When the hip abductors are weak, apparent abduction may occur by the substitution action of lateral trunk muscles. The pelvis is hiked up laterally, the leg is raised from the table, but no true hip joint abduction occurs. (See pp. 184 and 434).

**Antagonists** may produce movements like test movements. If fingerfleksor are weak, action of the wrist extensor may produce passive finger flexion by the tension placed on flexor tendons.

Substitution by other agonists results in either a movement of the part in direction of the stronger agonist or shift of the body in a way that favors the pull of that agonist. For example, during the gluteus medius test in side-lying, the thigh will tend to flex if the tensor fasciae latae is attempting to substitution for gluteus medius, or the trunk may rotate back to that tensor fascia latae can hold a position that appears to be the desired test position.

For accurate muscle examinations, no substitutions should be permitted. The position or movement described as the test should be done without shifting the body or turning the part. Such secondary movements allow other muscles to substitution for weak or paralyzed muscle.

An experienced examiner who is aware of the ease with which normal muscles perform tests will readily detect substitutions. When test position is employed instead of test movement, even an inexperienced examiner can detect the sudden shift of the body or the part that results from an effort to compensate for muscle weakness.

**Weakness**

Included with the descriptions of the muscles in this text is a discussion of the loss of movement or the position of deformity that results from muscle weakness or muscle shortness.

**Weakness** is used as an overall term that covers a range of strength from zero to fair in nonweight-bearing muscles but also includes fair+ in weight-bearing muscles. Weakness will result in loss of movement if the muscle cannot contract sufficiently to move the part through partial or complete range of motion.

A contracture or shortness will result in loss of motion if the muscle cannot be elongated through its full range of motion. **Contracture** refers to a degree of shortness that results in a marked loss of range of motion. Shortness refers to a degree of shortness that results in slight to moderate loss of range of motion.

A fixed deformity usually does not exist because of weakness unless contractures develop in the stronger opponents. In the wrist, for example, a fixed deformity will not develop result of wrist extensor weakness unless the opposing flexors maintain the position of wrist flexion.

A state of **muscle imbalance** exits when a muscle is weak and its antagonist is strong. The stronger of the two opponents tends to shorten, and the weaker of the two tends to elongate. Weakness permits a position of deformity, but shortness creates a position of deformity.

In some parts of the body, positions of deformity may develop results of weakness even though the opposing muscles do not become contracted. Gravity and body weight exert opposing forces. A kyphotic position of the upper back may result from weakness of the upper back muscles regardless of whether the anterior trunk muscles become contracted. A position of pronation of foot may exits if the inverters are weak because the body weight in standing will distort the bony alignment. If opposing peroneal muscles become contracted, a fixed deformity will result.

The word **tight** has two meanings. I may be used interchangeably with the term **short**, or it may be used to mean **taut**, in which case it may be applied to either a short or stretched muscle. On palpation, hamstrings that are short or a stretched and drawn taut will fell tight. From the standpoint of prescribing treatment, it is very important to recognize difference between stretched muscles and shortened muscles. In addition, some muscles are short and remain in what appears to be a state of semi-contraction. On palpation, they feel firm or even rigid without being drawn taut. For example, posterior neck and upper trapezius muscles often are tight in people with bad posture of upper back, head, and shoulders.

The order in which muscles are tested is largely a matter of choice but generally arranged to avoid any unnecessary changes of position for the subject. Muscles that are closely related in position or action, tend to appear in sequence to distinguish test differences. When a specific order of tests is important, it is so indicated in the text. Generally, length testing precedes strength testing.

**SUGGESTED ORDER OF MUSCLE TESTS**

1. **Supine**

Toe extensors

Toe flexors

Tibialis anterior

Tibialis posterior

Peroneals

Tensor fasciae latea

Sartorius

Iliopsoas

Abdominals

Neck flexors

Finger flexors

Finger extensors

Thump muscles

Wrist extensors

Wrist flexors

Supinators

Pronators

Biceps

Brachioradialis

Triceps (supine test)

Pectoralis major, upper part

Pectoralis major, lower part

Pectoralis minor

Medial rotators of shoulder (supine test)

Teres minor and infraspinatus

Lateral rotators of shoulder (supine test)

Serratus anterior

Anterior deltoid (supine test)

**2. Side-Lying**

Gluteus medius

Gluteus minimus

Hip adductors

Lateral abdominals

**3. Prone**

Gastrocnemius and plantaris

Soleus

Hamstrings, medial and lateral

Gluteus maximus

Neck extensors

Back extensors

Quadratus lumborum

Latissimus dorsi

Lower trapezius

Middle trapezius

Rhomboids

Posterior deltoid (prone test)

Triceps (prone test)

Teres major

Medial rotators of shoulder (prone test)

Lateral rotators of shoulder (prone test)

**4. Sitting**

Quadriceps

Medial rotators of hip

Lateral rotators of hip

Hip flexors (group test)

Deltoid, anterior, middle, and posterior

Coracobrachialis

Upper trapezius

Serratus anterior (preferred test)

**5. Standing**

Serratus anterior

Ankle planter flexors

**GRADING**

Grade represent an examiner’s assessment of the strength or weakness of a muscle or a muscle group. In manual muscle testing, grading is based on a system in which the ability to hold the tested part in a given position against gravity establishes a grade referred to as fair or the numerical equivalent (depending on the grading symbols being used). The grade of fair is the most objective grade because the pull of gravity is a constant factor.

For grades above fair, pressure is applied in addition to the resistance offered by gravity. A break test is a muscle strength test to determine the maximal effort exerted by a subject who is performing an isometric contraction as the examiner applies a gradual build up of pressure to the point that the effort by the subject is overcome. It is used determining grades of fair+ through good+.

No effort is made to break the subject’s hold if the examiner has determined the strength is normal. To continue exerting force to make the muscle yield by performing a break test is unnecessary and may even be injurious.

The symbols used in grading vary and include the use of words, letters, number, or other signs. To avoid listing the equivalents each time this text refers to a grade, the symbols are used in the descriptions of grades below.

Gravity is a form of resistance that is basic to manual muscle testing, and it is used in tests of the trunk, neck, and extremity muscles. It is a factor, however, only in approximately 60% of the extremity muscles. It is not required in tests of finger and toe muscles, because the weight of the muscle that the effect of gravity on the part is negligible. Supination and pronation of the forearm are movements of rotation in which the effect of gravity is also not a significant factor.

Testing muscles that are very weak involves movements in the horizontal plane on a supporting surface where the resistance by gravity is decreased. To avoid use of phrases such as “gravity-lessened”, “gravity-decreased”, or “minimized-gravity”, the text and the key to muscle grading (see p.23) will refer to movements in the horizontal plane.

Detailed grading of muscle strength is more important in relation to prognosis than to diagnosis. The extent of involvement may be determined by such simple grading as zero, weak and normal. On the other hand, more precise grading helps to establish the rate and degree of return of muscle strength and is also useful in determining a prognosis. A muscle might appear to be “weak” for months, even though the record shows that it has progressed from poor- to fair during this same period.

Accuracy in grading depends on many factors: the stable position of the patient, fixation of the part proximal to the part being tested, the precision of the test position, and the direction and amount of pressure. The amount of pressure varies with the age and the size of patient, the part being tested and leverage. If one extremity is unaffected, the examiner may use the strength in the unaffected extremity as an index for the patient’s normal strength when testing the affected extremity.

An examiner must build a basis for comparison of test results through experience in muscle testing. Such experience is necessary when testing both paralytic and normal individuals. For many, however, experience in muscle testing has been limited to the examination of patients with disease or injury. As a result, these examiner’s idea of normal strength tends to be a measure of what appears to be good functional recovery following weakness.

The authors recommend that an examiner try to test individuals, both male and female, of various ages and those with good posture as well as those faulty posture. If it is not possible to examine many normal individuals, an effort should be made to examine the trunk and unaffected extremities in cases involving only one or two extremities.

Testing and grading procedures are modified during examination of infants and children to the age of 5 or 6 years. The ability to determine a child’s muscle strength up to the grade of fair is usually not difficult, but grading strength above fair depends on the cooperation of the child in holding against resistance or pressure. Young children seldom cooperate in strong test movements. Very often, tests must be recorded as “apparently normal” which indicates that although the strength may, in fact, be normal, one cannot be sure.

**Grades Above Fair**

Standardization of muscle testing techniques related to grading strength above fair requires a specific place in the arc of motion where the part is held by the subject as manual pressure is applied.

Muscle strength is not constant throughout the range of motion, and in manual muscle testing, it is not practical to try to grade the strength at various points in the arc of motion. (For the place in the arc used as the position for grading, see p.13.)

**Whether the part is placed in the test position or actively moves to that position, grading above fair is determined by the ability to hold the part in the test position against varying degrees above fair.**

If the position is used, the part is placed in the specific position by the examiner, and then pressure is applied. For there to be standardization of testing techniques and grading, when test movement is used, the movement must proceed to the same place in the arc of motion as that established as the test position. For this reason, the movement factor is omitted in the Key to Muscle Grading (see p.23) when defining grades above fair.

**Normal Grade**

The grade of normal means that the muscle can hold the test position against strong pressure. This grade is not intended to indicate the maximum strength of the subject but, rather, the maximum pressure that the examiner applies to obtain what might be termed a “full” strength of the muscle. In terms of judgment, it might be described as strength that is adequate for ordinary functional activities. To become component in judging this full strength, an examiner should test normal individuals of various ages and sizes and both sexes.

**Good Grade**

The grade of good means that the muscle can hold the test position against moderate pressure.

**Fair Grade**

The grade of fair indicates that a muscle can hold the part in test position against the resistance of gravity but cannot hold if even slight pressure is added. In tests such as those for the triceps and quadriceps, the examiner should avoid a “locked” position of the joint that could give undue advantange to a muscle that was slightly less than fair in strength.

In the area of the fair grade, the question arises of whether the strength to hold the test position is equivalent to the position. With some exceptions, the general rule is that the test movement can be performed if the test position can be held.

In some muscle tests, the bone on which the muscle is inserted moved from a position of suspension in the vertical axis toward the horizontal plane. The quadriceps, deltoid, and hip rotators tested in the sitting position and the triceps and shoulder rotators tested in the prone position compose this group. The leverage exerted by the weight of the part increases as the part moves toward completion of the arc, and the muscle strength required to hold the test position against gravity usually is sufficient to perform the test movement. This occurs during tests of hamstrings when tested by knee flexion in the prone position and tests of hamstrings when tested by knee flexion in the prone position and tests of the elbow fleksor when examined in the supine position.

**Poor Grade**

The ability to move through a partial arc of motion in the horizontal plane is graded as poor-. The grade of poor means that the muscle can complete the range of motion in the horizontal plane. The grade of poor+ denotes the ability to move in the horizontal plane to completion of the range of motion against resistance or to hold the completed position against pressure. It also means that the muscle is can moving through a partial arc of motion in the antigravity position.

The ranges of strength within the grade of poor are significant enough to deserve these subclassifications for purpose of more definitive grading. The ability to perform the full of range motion in the horizontal plane is not close to the ability to perform the against gravity for most muscles, notably those of the hip joint. Adding pressure or resistance to the element of movement in the horizontal plane provides the added force that approaches that of gravity in the antigravity position.

Hip abductors, for example, may complete the movement of abduction in a supine position (i.e., horizontal plane) which would give a grade of poor. As strength improves, the patient can hold against more and more pressure in the abducted position or can move to abducted position against increasingly greater resistance. Experience will disclose the amount of pressure or resistance that must be applied in the supine position to exhibit strength that approaches the ability to perform to completion of range in antigravity position. With hip abductors, it requires that the muscles tolerate moderate to strong resistance or pressure in the supine position before being able to hold for a fair grade in the antigravity position.

It is important to record the changes in strength that occur during time that it takes to move from the grade of poor minus (P-) to poor (P) and to poor plus (P+). Testing for the various grades of poor is justified and meaningful when used appropriately. In the rehabilitation of persons with severe neuromuscular and musculoskeletal involvement, the minute but visible changes that show improvement are very important. Maintaining a record of these significant changes, however slight, is important to the morale and continuing motivation of the patient and is necessary in determining his or her progress. In the board scope of rehabilitation, these small changes at one end of the spectrum can be more significant than the 10, 20, or even 30 (or more) pounds of force that can be gained by a recovering athlete at the other end of spectrum.

After all that explanation, it may also be said that the overall grade of poor can be “assumed” without the unnecessary changes of position that are required for tests in the horizontal plane. If it has been determined that the muscle does not grade more than are required for tests in the horizontal plane. If it has been determined that the muscle does nor grade a fair minus (F-) by the test in the antigravity position but does grade more than a trace (which can be established in almost any position), then the overall grade of poor exits without any need for further testing.

There are some instances in which assuming the grade of poor may be justified: if there is no need for more specific grading than normal, good, fair, poor, and trace; if the patient has extensive weakness and is easily fatigued; or if the condition is long-standing, with no appreciable change.

Establishing the grade of poor often requires that the patient be moved from one position to another. In practice, frequent change of position or repetition of the test in various positions is tiring for the patient and time-consuming for the examiner. It is also possible that those patients with the most weakness would be subjected to the most changes of position. Patients should not be subjected to unnecessary procedures during examination if the results obtained are not meaningful.

Tests in the horizontal plane include several variables. The partial range of motion for the poor- grade is not specific, because there is no indication of where in arc of motion the partial range should be. It may be at the beginning of range of motion, within the midrange, or near the end.

With respect to partial arc of motion in antigravity position for a poor+ grade, it may mean starting from the suspended (i.e., vertical) position for quadriceps. For the hamstrings, it may mean that in the prone position, the subject can flex the last few degrees required to bring the leg to vertical position.

When testing hip extensors or flexors in the side-lying position, a horizontal movement through the range of motion furnishes a means to obtain an objective grade of poor. The surface of table, smooth or rough, changes the amount of friction and resistance. The strength of hip adductors (if the under-neath leg is being tested) may make a material difference in the results of the flexor and extensor tests. If the adductors are paralyzed, the full weight of the extremity will tend to raise the extremity so that the full weight does not rest on the table, thereby reducing the friction, and the flexion and extension movements will thus be easier.

**Trace Grade**

The grade of trace means that a feeble contraction can be felt in a muscle that can be palpated or that the tendon becomes slightly prominent; however, no movement of the part visible. When testing muscles that are very weak, the examiner usually moves the part into test position, trying to help the patient to feel the movement and elicit a muscle response. The examiner should be sure that the movement starts from a relaxed position. If the part is carried to beginning of range of motion and slight tension is put on the muscle, there are may be a rebound or springing back, which can be confused with active movement.

**Zero Grade**

The grade of zero means that no evidence of any muscle contraction is visible or palpable.

**GRADING SYMBOLS**

Robert W. Lovett, M.D., introduced a method of testing and grading muscle strength using gravity as resistance (15). A description of the Lovett system was published in 1932 and listed the following definitions:

**Gone**- no contraction felt.

**Trace**- muscle can be felt to tighten but cannot produce movement.

**Poor-** produces movement with gravity eliminated but cannot function against gravity.

**Fair-** can raise the part against gravity.

**Good**- can raise the part against outside resistance as well as against gravity.

**Normal-** can overcome a greater amount of resistance than a good.

The symbols used may vary, but the movement and weight factors set forth by Lovett form the basis of most current muscle testing. The Kendalls introduced the use of numbers for computing the amount of change in muscle strength when doing research with patients recovering from poliomyelitis. They had used the word and letter symbols previously and, for the most part, it was possible to translate grades from one scale to the other.

The authors of this text believe it is in the best interest of those who engage in manual muscle testing that an effort be made to standardize (as much as possible) the descriptions of the tests and the symbols used. Numerals are being used increasingly, and such used is needed for research that involves muscle test grades.

The Key to Muscle Grading on the facing page is basically the same as the Lovett system, but with added definitions for the minus and plus grades. The poor+ grade provides for movement in the horizontal plane and for partial arc gravity. Both methods for grading poor+ are in common use.

In this next, the normal minus (N-) grade has been eliminated, and the scale has been changed from 0 to 10. Leaving zero as 0 and trace as T, the word and letter symbols translate directly as indicated by the Key to Muscle Grading. No movement is involved with the 0 and T grades, and the numerals 1 to 10 refer to test movement and test position grades.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| KEY TO MUSCLE GRADING | | | | | | |
|  | **Function of Muscle** | **Muscle Grades and Symbols** | | | | |
| No movement | No contraction felt or seen in the muscle. | Zero | 0 | 0 | 0 | 0 |
| Tendon becomes prominent or feeble contraction felt in muscle with no visible movement | Trace | T | 1 | T |  |
| Supported in the Horizontal Plane\* | Movement through partial range of motion | Poor- | P- | 2- | 1 | + |
| Movement through complete range of motion for the muscle being tested. | Poor | P | 2 | 2 |  |
| Holds against slight pressure in test position\*\* | Poor+ | P+ | 2+ | 3 |  |
| Test in the Antigravity Position | Moves through partial range of motion against gravity | Poor+ | P+ | 2+ | 3 |  |
| Gradual release from test position occurs | Fair- | F- | 3- | 4 |  |
| Holds test position (no added pressure) | Fair | F | 3 | 5 | ++ |
| Holds test position against slight pressure | Fair+ | F+ | 3+ | 6 |  |
| Holds test position against slight to moderate pressure | Good- | G- | 4- | 7 |  |
| Holds test position against moderate pressure | Good | G | 4 | 8 | +++ |
| Holds test position against moderate to strong pressure | Good+ | G+ | 4+ | 9 |  |
| Holds test position against strong pressure | Normal | N | 5 | 10 | ++++ |

\* Support of the part being tested should ideally be provide by a firm, smooth surface that minimizes resistance to movement in the horizontal plane, such as powder board.

\*\* Testing for a Poor+ grade in the horizontal plane requires that the muscle being tested 1) be able to move the part through the muscle’s range of motion without resistance (Poor grade), then 2) be able to hold against slight pressure in the test position where it exhibits greatest strength (e.g. Class I and II muscles should be tested at completion of range, while Class III and IV muscles should be tested at midrange of overall length of muscle. (See p.13).

According to the Key, the highest test movement grade in the antigravity position is a 3, or Poor+. Test movements for lateral trunk fleksor, upper and lower abdominal muscles, and back extensors are exceptions. See individual tests (pages 181, 185, 202, 212) for grading of these muscles.

Testing of the muscles of the fingers and toes does not depend on gravity. See Chapter 6, page 295.

**USE OF THE TERM NORMAL IN RELATION TO MUSCLE GRADING**

Term normal has a variety of meanings. It may mean average, typical, natural, or standard. As used in various methods of muscle grading, it has been defined as the degree of strength that will perform a movement against gravity and hold against strong resistance.

If one adheres to the usage in this sense, then a grade of poor will be recorded for a small child who cannot lift the head in flexion from a supine position. Knowing that it is natural for small children to exhibit weakness of the anterior neck muscles, an examiner might say this child’s neck is normal, using normal in the sense that it is natural. On administering a leg-lowering test for abdominal strength in a large group of adolescent children and finding that a grade of fair+ or good- is the average strength is normal for this age. Thus, we have three different uses of normal applied rather freely in muscle testing: as standard, as natural, and as average.

Because normal is defined as a standard when used in the scale of grading, grades of strength should relate to that standard, and appropriate terms other than normal should be used in the interpretation of results.

One of the advantages of using numerical grades is that leaves the term normal free for use in the interpretation of those grades. In the following discussion, this term will be employed in this manner.

Most grades are based on adult standards, so it is necessary to acknowledge what is normal for children of a given age. This is particularly true regarding the strength of the anterior neck and anterior abdominal muscles. the size of the head and trunk in relation to the lower extremities as well as the long span and normal protrusion of the abdominal wall affect the relative strength of these muscles. Anterior neck muscles may grade about poor+ in a 3-year-old child, about fair in a 5-year-old child, and gradually increase up to the standard of performance for adults by 10 or 12 years of age. Many adults will exhibit no

more than fair+ strength.

The prime example of a standard that is infant rather than an adult accomplishment is that of toe flexor strength. In general, children have more strength in their toe flexors than many adults do. It is not uncommon to narrow-toed shoes have weakness of toe flexors in which the grade is no more than fair-.With the standard being the ability to flex the toes and hold against strong resistance or pressure, the adult must be graded against that standard; however, this weakness of the toe flexor weakness among adults that a degree of weakness might be assumed to be normal in the sense that “normal” is average. Marked weakness of the toe flexors is almost invariably associated with some degree of disability of the foot. However, the term normal should not apply to such weakness unless one is ready to accept the disability itself as being normal.

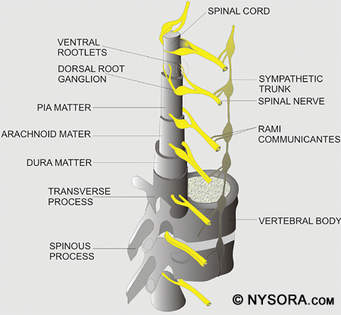
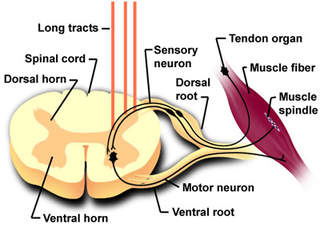
This toe flexor weakness represents a loss of strength from childhood to adulthood, and it should be regarded as an unnatural, acquired weakness. This type of weakness may be present in other muscles because of stretch activities or faulty posture. Acquired weakness usually does not drop below the grade of fair, but fair and fair+ grades of strength might be interpreted as neurogenic it one were not aware that such degrees of weakness can result from stretch and strain of the muscles.

**DEFINITIONS**

The term **plexus** comes from the Latin word that means a braid. A **nerve plexus** results from the dividing, reuniting, and interwining of nerves into a complex network. When describing the origins, components, and terminal branches of a plexus, the terms **nerve,** **roots,** and **cord** are used with dual meanings. There are spinal nerves and peripheral nerves, roots of the spinal nerves and roots of plexus, and spinal cord and cords of plexus. To avoid confusion, appropriate modifying words are used in the descriptions below.

The **spinal cord** lies within the vertebral column, extending from the first cervical vertebra to the level of the second lumbar vertebra. Each of the 31 pairs of **spinal nerves** arises from the spinal cord by two **spinal nerve roots.** The **ventral root,** which is composed of motor fibers, and **dorsal root,** which is composed of sensory fibers, unite at the intervertebral foramen to form the spinal nerve (See p. 144 at top). A **spinal segment** is the part of the spinal cord that gives rise to each pair of spinal nerves. Each spinal nerve contains motor and sensory fibers from a single spinal segment.

Shortly after the spinal nerve exits through the foremen, it divides into a **dorsal primary ramus** and a **ventral primary ramus.**

****

The dorsal rami are directed posteriorly, and the sensory and motor fibers innervate skin and extensor muscles of the neck trunk. The ventral rami, except those in the throcic region, contain the nerve fibers that become part of the plexuses.

Plexus illustrations have been included with the appropriate chapters: cervical with neck, page 145; brachial with upper extremity, page 249; and both lumbar and sacral with lower extremity, pages 362 and 363. Trunk muscles receive innervation directly from the thoracic nerves, plus a branch from the lumbar plexus.

Periferal nerves emerge from the plexuses at various levels or as terminal branches. As a result of the interchange of fiber within the plexus, peripheral nerves contain fibers from at least two and, in some instances, as many as five spinal segments.

**SPINAL SEGMENT DISTRIBUTION TO NERVES AND MUSCLES**

For anatomists and clinicians, the determination of spinal segment distribution to peripheral nerves and muscles has proven to be a difficult test. The pathway of the spinal nerves is obscured by the interwining of nerve fibers as they pass through the nerve plexuses. Since it is almost impossible to trace the course of an individual nerve fiber through maze of its plexus, information regarding spinal segment distribution has been derived mainly from clinical observation. The use of this empirical method has resulted in a variety of findings regarding the segmental origins of these nerves and the muscles they innervate. An awareness of possible variations is important in the diagnosis and location of a nerve lesion. To focus on the range of variations that exits, the Kendalls tabulated information from six well known sources.

The chart in appendix shows the spinal segment distributions to nerves; the charts in appendix show the distribution to muscles.

The symbols used in tabulating the reference material were: a large X to denote a major distribution, a small x to denote a minor distribution, and a parenthetical (x) to denote a possible or infrequent distribution.

The recording of test results is an important part of muscle examinations. Records are valuable from the standpoints of diagnosis, treatment, and prognosis. An examination performed without recording the details can be of value now, but one has an obligation to patient, to the institution (if one is involved), and to oneself to record the findings.

Charts used for recording the findings of muscle examinations should permit complete tabulation of test results. In addition, the arrangement of the information should facilitate its interpretation.

There are two charts in this category: one for the neck, diaphragm, and upper extremity (see facing page) and other for the trunk and lower extremity (see p. 29). These charts have been designed especially for use as an aid in the differential diagnosis of lesion of the spinal nerves. The motor involvement, as determined by manual muscle tests, can aid in determining whether a lesion of the nerve exits at the root, plexus, or peripheral level. The chart may also be useful in determining the level of spinal cord lesion. In the upper and lower extremity charts, the names of the muscle appear in the left column and are grouped, as indicated by heavy black lines, according to their innervations, which are listed to the left of the muscle names. The space between the column of muscle names and the nerve is used to record the grade of the muscle strength.

The sternocleidomastoid and the trapezius muscles are listed on the *Spinal Nerve* and *Muscle Chart* (see facing page) and on the *Cranial Nerve* and *Muscle Chart* (see p. 125). These muscles received their motor innervation mainly from the spinal portion of the 11th cranial nerve (accessory), but additional spinal nerve branches are distributed to them: C2, C3, C4 to trapezius. Clinical findings in cases of pure accessory nerve lesions have led neurologists to assume that these spinal nerve fibers are chiefly concerned with innervation of the fibers are chiefly concerned with innervation of the caudal part of the trapezius, with the cranial and middle parts, as well as the sternocleidomastoid, being supplied predominantly by the accessory nerve (16). Some authors report that these cervical nerves supply the upper part of the trapezius. In other reports, it appears that these nerve fibers do not contribute any motor fibers to the trapezius, with the motor innervation of the entire muscle being dependent on the spinal portion of the accessory nerve. Apparently, considerable individual variations exit in the innervation of the trapezius (17).

**PERIPHERAL NERVE SECTION**

Peripheral nerves and their segmental origins are listed across the top of the center of the chart and follow the order of proximal- distal branching insofar as possible. For the peripheral nerves that arise from cords of the brachial plexus, the appropriate cord is indicated. The key at the top of the charts explains the abbreviations used.

Below this section, in the body of the chart, the dots indicate the peripheral nerve supply to each muscle (See Appendix) for sources of material for this section.).

**SPINAL SEGMENT SECTION**

In this section, a number denotes the spinal segment origin of nerve fibers innervating each of the muscle listed in the left column (See Appendix) for sources for material for this section.)

In the accompanying spinal nerve and muscle charts and subsequent text, distribution is indicated by numbers. Major distribution is indicated by a number in bold type, a small distribution by a number in a regular type, and a possible or infrequent distribution by a number in parenthesis.

**SENSORY SECTION**

On the right side of the charts are diagrams showing the dermatomes and distribution of cutaneous nerve for the upper extremity on one and for the trunk and lower extremity on the other. The dermatome illustrations are redrawn from Keegan and Garret on the extremity charts and from Gray on the cranial chart, see p. 125.)

It is possible to use the illustrations for charting areas of sensory involvement by shading or using a colored pencil to outline the areas of the involvement for ant given patient. Only drawings of the right extremity are used on the extremity charts, but labeling can indicate, when necessary, that the recorded information pertains to the left side.