

C H A P T E R

I

Principles of Manual Muscle Testing

Grading System
Overview of Test
Procedures
Criteria for Assigning a
Muscle Test Grade
Screening Tests

Preparing for the
Muscle Test
Exercises
Prime Movers
Summary

GRADING SYSTEM

Grades for a manual muscle test are recorded as numeric ordinal scores ranging from zero (0), which represents no discernable muscle activity, to five (5), which represents a maximal or best-possible response or as great a response as can be evaluated by a manual muscle test. Because this text is based on actions (e.g., elbow flexion) rather than tests of individual muscles (e.g., biceps brachii), the grade represents the performance of all muscles contributing to that action.

The numeric 0 to 5 system of grading is the most commonly used muscle strength scoring convention across health care professions. Each numeric grade (e.g., 4) can be paired with a word grade (e.g., good) that describes the test performance in qualitative, but not quantitative, terms. (See table.) Use of these qualitative terms is an outdated convention and is not encouraged because these terms tend to misrepresent the strength of the tested action. For knee extension, forces that are less than 50% of average and therefore not “normal” are often graded 5.¹ Knee extension actions graded as 4 may generate forces as low as 10% of maximal expected force, a level clearly not described appropriately as “good.” For this reason, the qualitative terms have largely been removed from this book. The numeric grades are based on several factors that will be addressed later in this chapter.

Numeric Score	Qualitative Score
5	Normal (N)
4	Good (G)
3	Fair (F)
2	Poor (P)
1	Trace activity (T)
0	Zero (no activity) (0)

OVERVIEW OF TEST PROCEDURES

Break Test

Manual resistance is applied to a limb or other body part after it has actively completed its test range of motion against gravity. The term *resistance* is always used to denote a concentric force provided by the tester that acts in opposition to contracting muscles. Manual resistance should always be applied opposite to the muscle action of the participating muscle or muscles. The patient is asked to hold the body segment at or near the end of the available range, or at the point in the range where the muscle is most strongly challenged. At this point, the patient is instructed to not allow the therapist to “break” the hold while the therapist applies manual resistance. For example, a seated patient is asked to flex the elbow to its end range (Grade 3); when that position is reached, the therapist applies resistance just proximal to the wrist, trying to “break” the muscle’s hold and thus allow the forearm to move downward into extension. This is called a break test, and it is the procedure most commonly used in manual muscle testing nowadays. However, there are

alternatives to the break test for grading specific muscle actions.

As a recommended alternative procedure, the therapist may choose to place the muscle or muscle group to be tested in the end or test position, after ensuring that the patient can complete the available range (Grade 3), before applying additional resistance. In this procedure the therapist ensures correct positioning and stabilization for the test.

Make Test

An alternative to the break test is the application of manual resistance against an actively contracting muscle or muscle group (i.e., opposite the direction of the movement) that matches the patient’s resistance but does not overcome it. During the maximum contraction, the therapist gradually, over approximately 3 seconds, increases the amount of manual resistance until it matches the patient’s maximal level. The make test is not as reliable as the break test, therefore making the break test the preferred test.

Active Resistance Test

Resistance is applied opposite the actively contracting movement throughout the range, starting at the fully lengthened position. The amount of resistance matches the patient’s resistance but allows the joint to move through the full range. This kind of manual muscle test requires considerable skill and experience to perform and is not reliable; thus its use is not recommended as a testing procedure but may be effective as a therapeutic exercise technique.

Application of Resistance

The principles of manual muscle testing presented here and in all published sources since 1921 follow the basic tenets of muscle length–tension relationships, as well as those of joint mechanics.^{2,3} In the case of the elbow flexion, for example, when the elbow is straight, the biceps are long but the lever is short; leverage increases as the elbow flexes and becomes maximal at 90°, where it is most efficient. However, as flexion continues beyond that point, the biceps are short and their lever arm again decreases in length and efficiency.

In manual muscle testing, external force in the form of resistance is applied at the end of the range or after backing off slightly from the end of range in the direction opposite the actively contracting muscle. For some muscle actions (e.g., knee flexion), this backing off is considerable—to the point that the primary muscles tested are at what may be considered mid-range. Two-joint muscles are typically tested in mid-range where length-tension is more favorable. Ideally, all muscles and muscle groups should be tested at optimal length-tension, but there are many occasions in manual muscle testing where the therapist is not able to

distinguish between Grades 5 and 4 without putting the patient at a mechanical disadvantage. Thus the one-joint brachialis, gluteus medius, and quadriceps muscles are tested at end range and the two-joint hamstrings and gastrocnemius muscles are tested in mid-range.

Critical to the accuracy of a manual muscle test are the location of the applied resistance and the consistency of application across all patients. The placement of resistance is typically near the distal end of the body segment to which the tested muscle attaches. There are exceptions to this rule. One exception is when resistance cannot be provided effectively without moving to a more distal body segment. In the case of shoulder and hip internal and external rotators, this involves applying resistance through the hand placed on the distal forearm or lower leg. Another exception involves patients with a shortened limb segment as in an amputation. Take for example a patient with a transfemoral amputation. Even if the patient could hold against maximum resistance while abducting the hip, the weight of the lower limb is so reduced and the therapist's lever arm for resistance application is so short, that a grade of 5 cannot be assumed regardless of the resistance applied. A patient holding against maximum resistance may still struggle with the force demands of walking with a prosthesis. If a variation is used, the therapist should make a note of the placement of resistance to ensure consistency in testing.

The application of manual resistance should never be sudden or uneven (jerky). The therapist should apply resistance with full patient awareness and in a somewhat slow and gradual manner, slightly exceeding the muscle's force as it builds over 2 to 3 seconds to achieve the maximum tolerable intensity. Applying resistance that slightly exceeds the muscle's force generation will more likely encourage a maximum effort and an accurate break test.

The therapist also should understand that the weight of the limb plus the influence of gravity is part of the test response. Heavier limbs and longer limb segments put a higher demand on the muscles that move them. Therefore lifting the lower limb against gravity can demand more than 20% of the "normal strength" of the hip muscles.⁴ In contrast, lifting the hand against gravity requires less than 3% of the normal strength of the wrist muscles.⁴ When the muscle contracts in a parallel direction to the line of gravity, it is noted as "gravity minimal." It is suggested that the commonly used term "gravity eliminated" be avoided because, of course, that can never occur except in a zero-gravity environment.

Weakened muscles are tested in a plane horizontal to the direction of gravity with the body part supported on a smooth, flat surface in such a way that friction force is minimal (Grades 2, 1, and 0). A powder board may be used to minimize friction. For stronger muscles that can complete a full range of motion in a direction against the pull of gravity (Grade 3), resistance is applied perpendicular to the line of gravity (Grades 4 and 5). Acceptable variations to antigravity and gravity-minimal positions are discussed in individual test sections.

Stabilization

Stabilization of the body or segment is crucial to assigning accurate muscle test grades. Patients for whom stabilization is particularly important include those with weakness in stabilizing muscles (e.g., scapular stabilizers) when testing the shoulder muscles and those who are particularly strong in the tested muscle action.

Numerous muscles, some seemingly remote, can contribute as stabilizers to the performance of tested muscle actions. However, muscle test performance is not meant to be dependent on muscles other than the prime movers. To give an extreme example, shoulder abduction on the left side should not be dependent on the trunk muscles on the right side. Therefore a patient with weak trunk muscles and limited sitting balance should be supported and stabilized either through patient positioning or by a stabilizing hand on the right shoulder.

A muscle or muscle group that is particularly strong may also require patient stabilization if the full capacity of a muscle group is to be accurately tested.⁵ For example, a tester may not be able to break the knee extension action of a patient who is allowed to rise off of a support surface during the performance of a break test. However, the same patient, properly stabilized by the tester, an assistant, or a belt during testing, may not be able to hold against maximum tester resistance and thus break the muscle contraction, indicating that the patient has a muscle test grade of 4 rather than 5.

CRITERIA FOR ASSIGNING A MUSCLE TEST GRADE

The grade given on a manual muscle test comprises both subjective and objective factors. Subjective factors include the therapist's impression of the amount of resistance given during the actual test and then the amount of resistance the patient actually holds against during the test. Objective factors include the ability of the patient to complete a full range of motion or to hold the test position once placed there, the ability to move the part against gravity, or an inability to move the part at all. All these factors require clinical judgment, which makes manual muscle testing a skill that requires considerable practice and experience to master. An accurate test grade is important not only to establish the presence of an impairment but also to assess the patient's longitudinal status over time. Clinical reasoning is necessary for the therapist to determine the causes for the lack of ability to complete the full range or hold the position, ascertain which is most applicable, and decide whether manual muscle testing is appropriate.

Consistent with a typical orthopedic exam, the patient is first asked to perform the active movement of the muscle to be tested. Active movement is performed by the patient without therapist or mechanical assistance. This active movement informs the therapist of the patient's willingness and ability to move the body part, of the available range

TESTING THE MUSCLES OF THE NECK

Table 3.1 CAPITAL EXTENSION

I.D.	Muscle	Origin	Insertion	Function
56	Rectus capitis posterior major	Axis (spinous process)	Occiput (inferior nuchal line laterally)	Capital extension Rotation of head to same side Lateral bending of head to same side
57	Rectus capitis posterior minor	Atlas (tubercle of posterior arch)	Occiput (inferior nuchal line medially)	Capital extension
60	Longissimus capitis	T1-T5 vertebrae (transverse processes) C4-C7 vertebrae (articular processes)	Temporal bone (mastoid process, posterior surface)	Capital extension Lateral bending and rotation of head to same side
58	Obliquus capitis superior	Atlas (transverse process)	Occiput (between superior and inferior nuchal lines)	Capital extension of head on atlas (muscle on both sides) Lateral bending to same side (muscle on that side)
59	Obliquus capitis inferior	Axis (lamina and spinous process)	Atlas (transverse process, inferior-posterior surface)	Capital extension of head on atlas (muscle on both sides) Lateral bending to same side (muscle on that side)
61	Splenius capitis	Ligamentum nuchae C7-T4 vertebrae (spinous processes)	Temporal bone (mastoid process) Occiput (below superior nuchal line)	Capital extension Rotation of head to same side (debated) Lateral bending of head to same side
62	Semispinalis capitis (distinct medial part often named Spinalis capitis)	C7-T6 vertebrae (transverse processes) C4-C6 vertebrae (articular processes)	Occiput (between superior and inferior nuchal lines)	Capital extension (muscles on both sides) Rotation of head to opposite side (debated) Lateral bending of head to same side
63	Spinalis capitis	Medial part of Semispinalis capitis, usually blended inseparably	Occiput (between superior and inferior nuchal lines)	Capital extension

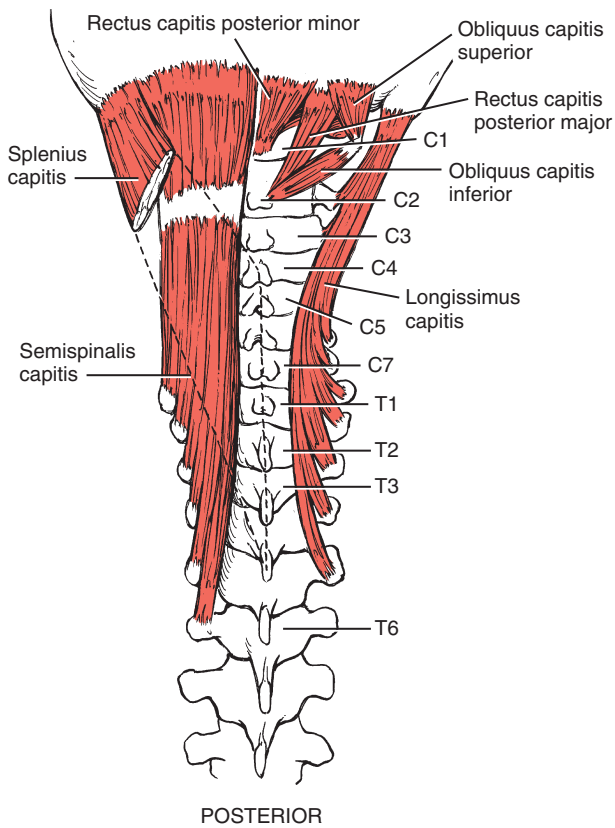


FIGURE 3.1

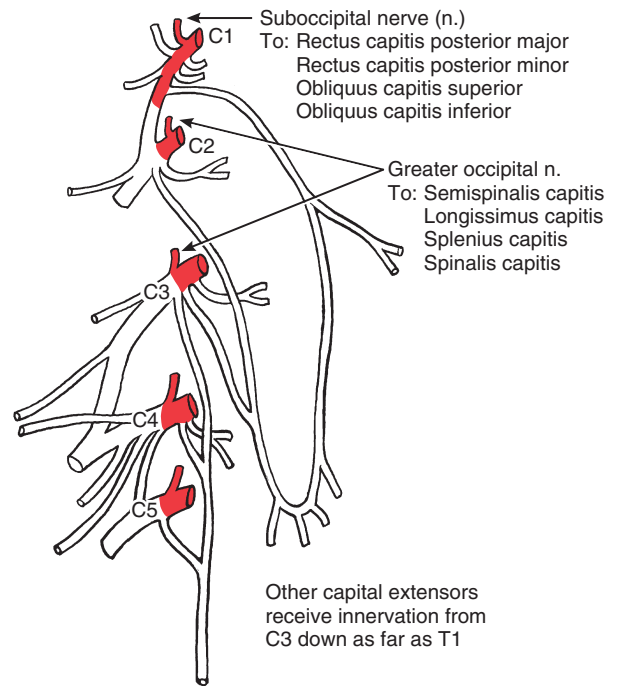


FIGURE 3.2

Range of Motion
0°–25°

CAPITAL FLEXION (CHIN TUCK)

(Deep cervical flexors)

Grade 5 and Grade 4

Position of Patient: Supine with head on table. Arms at sides.

Instructions to Therapist: Stand at head of table, facing patient. Ask patient to tuck chin. If sufficient range is present, place cupped hands under the mandible to give resistance against chin tuck, in an upward direction (Fig. 3.16).

Test: Patient tucks chin into neck without raising head from table. No motion should occur at the cervical spine. This is the motion of nodding.

Instructions to Patient: “Tuck your chin and keep your eyes straight ahead. Don’t lift your head from the table. Hold it. Don’t let me lift up your chin.”

Grading

Grade 5: Patient holds test position against maximum resistance. These are very strong muscles.

Grade 4: Patient holds test position against moderate resistance.

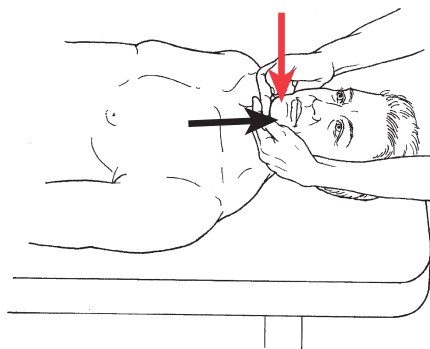


FIGURE 3.16

Grade 3

Position of Patient: Supine with head supported on table. Arms at sides.

Instructions to Therapist: Stand at head of table, facing patient.

Test: Patient tucks chin without lifting head from table (Fig. 3.17).

Instructions to Patient: “Tuck your chin into your neck. Do not raise your head from the table.”

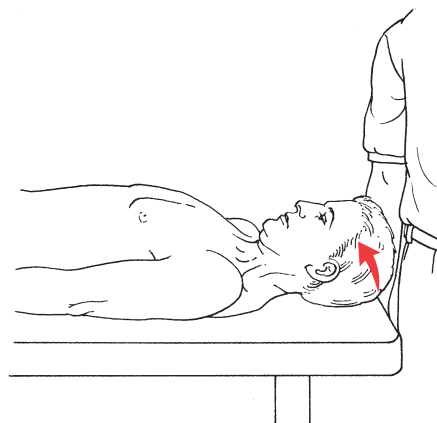
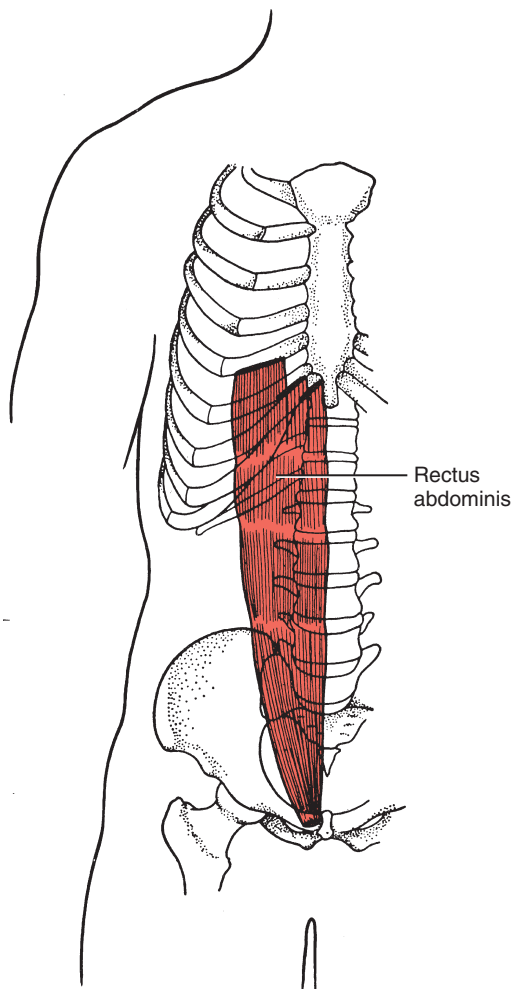


FIGURE 3.17



ANTERIOR
FIGURE 4.15

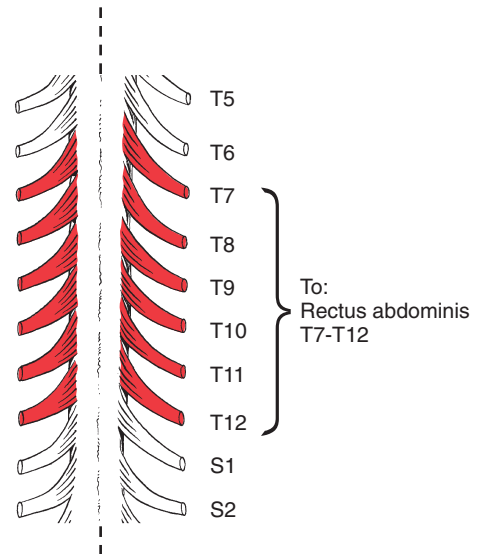


FIGURE 4.16

Range of Motion
0°–80°

Alternate Form of Plank Testing

For a patient not able to do a full plank, ask the patient to flex the knees and hips and lift the body onto forearms and knees. The elbows should be in line below the shoulders. The patient must keep the buttocks in line with the spine, forming a straight line from neck to buttocks while on knees. Time the effort. This alternate form should be scored as a Grade 2. Hint: Make sure the pelvis and buttocks are not hiked but in line with the spine. The body must come forward onto the forearms to do this Grade 2 test properly.

Side Bridge Endurance Test

Purpose: Strength test for core. Quadratus lumborum oblique and transverse muscles are elicited without generating large compression forces on the lumbar spine.^{36,37}

Position of Patient: Side-lying with legs extended, resting on the lower forearm with the elbow flexed to 90°. Upper arm is crossed over chest (Fig. 4.37).

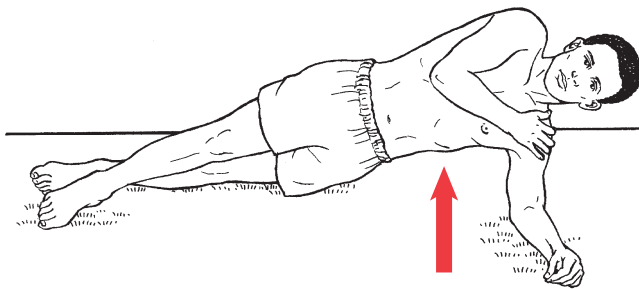


FIGURE 4.37

Instructions to Therapist: Stand or sit in front of patient. Ask patient to lift the hips off the table, keeping the body in a straight line with the contracted core. Time the effort, observing for quality and quantity of effort. Give patient feedback regarding posture; hips and trunk should be level throughout the test (see Fig. 4.37).

Test: Patient lifts hips off the table, holding the elevated position in a straight line with the body on a flexed elbow. This position is maintained until the patient loses form, fatigues, or complains of pain. The therapist times the effort.

Instructions to Patient: “When I say ‘go!’ lift your hips off the table, keeping them in a straight line with your body for as long as you can. I will be timing you.”

Scoring: Record the best time of two trials.

Mean scores for men and women:³⁸

Men: 95(±32)s

Women: 75(±32)s

Helpful Hints

- Despite the high reliability of the side bridge test, significant changes in hold times must be observed to confidently assess a true change in strength. Therefore the patient’s rating of perceived exertion (RPE) would help to inform clinical decision-making.³³
- Mean hold times ranged from 20 to 203 seconds (mean, 104.8 seconds) for the right side bridge test and from 19 to 251 seconds (mean, 103.0 seconds) for the left side bridge test.³³
- Exercisers held the side bridge test nearly double the time nonexercisers did (64.9 vs. 31.8 seconds).³⁹

CORE TESTS

Timed Partial Curl Up Test⁴⁰

The timed partial curl up test is a standard in the fitness industry and is included here, even though it uses the hook lying position and thus encourages hip flexor activation.

Purpose: Strength test for abdominals.

Position of Patient: Supine in hook lying position on a mat with arms at sides, palms facing down, and the middle fingers touching a piece of tape affixed to the surface parallel to the hand. A second piece of tape is affixed 12 cm (4.7 in) further than the initial tape for those younger than 45 years and 8 cm (3.1 in) further for those 45 years and older (Fig. 4.38).

Instructions to Therapist: Stand to the side of patient. Ask patient to perform a slow, controlled sit up in time, lifting head and scapulae off the mat, while the middle finger reaches to the second tape. If successful, use a metronome set to 40 beats/min to time repetitions. Ask patient to curl up as many times as possible keeping time with the metronome. The low back should be flattened before curl up.

Test: The individual does as many curl ups as possible without pausing, to a maximum of 75.

Scoring: Refer to ACSM Norms for partial curl up (Table 4.8).

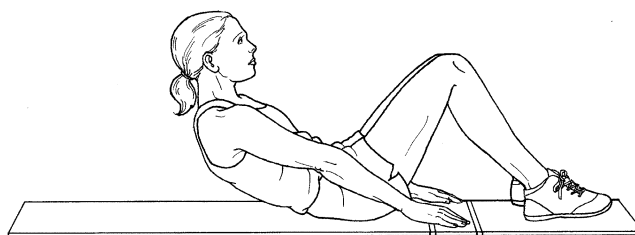


FIGURE 4.38

Table 4.8 ACSM NORMS For PARTIAL CURL UP

	AGE									
	20-29		30-39		40-49		50-59		60-69	
Sex	Male	Female	Male	Female	Male	Female	Male	F Female	Male	F Female
90th percentile	75	70	75	55	75	55	74	48	53	50
80	56	45	69	43	75	42	60	30	33	30
70	41	37	46	34	67	33	45	23	26	24
60	31	32	36	28	51	28	35	16	19	19
50	27	27	31	21	39	25	27	9	16	13
40	24	21	26	15	31	20	23	2	9	9
30	20	17	19	12	26	14	19	0	6	3
20	13	12	13	0	21	5	13	0	0	0
10	4	5	0	0	13	0	0	0	0	0

ACSM, The American College of Sports Medicine.

Data from Pescatello LS, Ross A, Riebe D, et al. *ACSM's Guidelines for Exercise Testing and Prescription*. 9 ed. Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins; 2014.

Isometric Trunk Flexor Endurance Test²²

Purpose: Measure isometric core endurance.

Position of Patient: Sitting on table with wedge supporting the back at angle of 60° to the table. Hips and knees flexed to 90°, with feet stabilized with a strap. Arms are folded across the chest (Fig. 4.39).

Instructions to Therapist: Ask patient to hold test position when the wedge is pulled back 10 cm. Time effort as soon as wedge is pulled back. Terminate test when the patient can no longer maintain the 60° angle independently.

Scoring: Ages 18 to 55 years (mean, 30 years), mean hold time = 178 seconds.³⁹ Exercisers held the test 3 times as long as nonexercisers (186 s vs. 68.25 s).³⁹

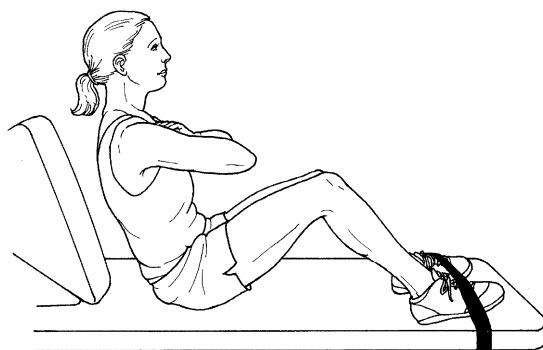


FIGURE 4.39

Front Abdominal Power Test

Purpose: Assess the power component of core stability prestability and poststability training.

Position of Patient: Supine on a mat with arms at sides, feet shoulder width apart, and knees bent to 90° (Fig. 4.40A).

Instructions to Therapist: Place a 2-kg medicine ball into the patient's hands. Then ask patient to lift arms overhead and explosively project the medicine ball forward keeping the arms straight. Feet and buttocks should remain on the floor throughout the test. (Note: Feet may be secured manually or with a strap [not shown].) Measure the distance the ball was projected from the tips of the feet to the point where the ball landed. Patient should be sitting upright after the ball is thrown (Fig. 4.40B).

Scoring: 1.5 to 2 m was recorded in a group of 20-year-old men and women (standard error of the mean [SEM], 24 cm).^{41,42}

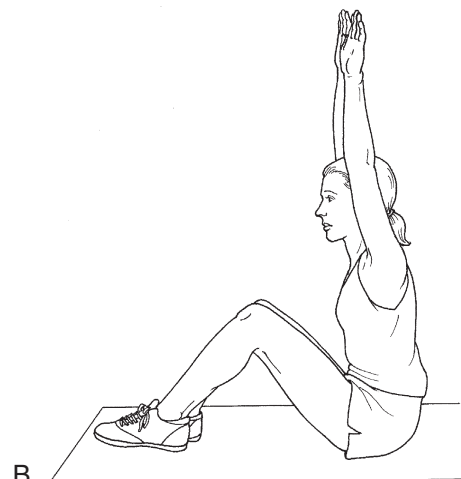
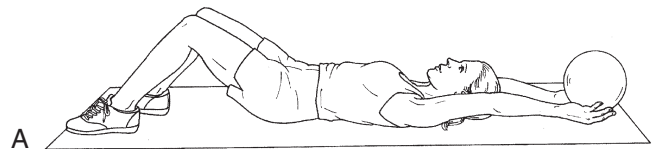


FIGURE 4.40

KNEE FLEXION

(All hamstring muscles)

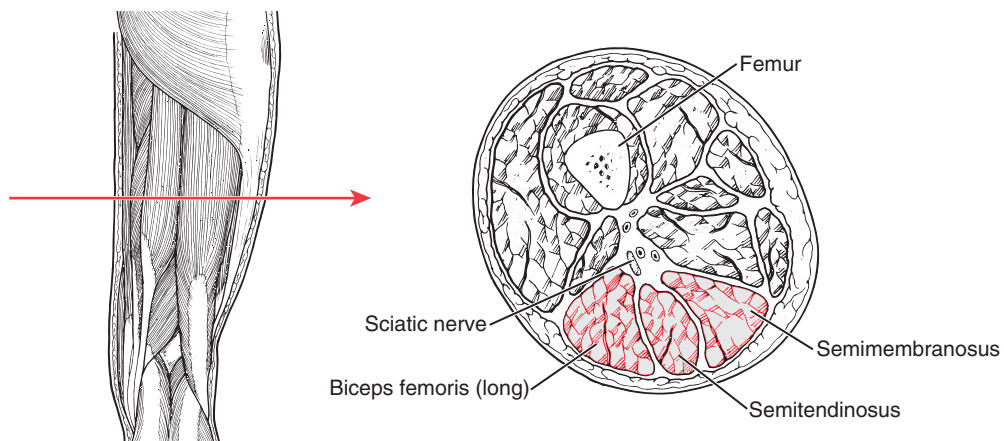
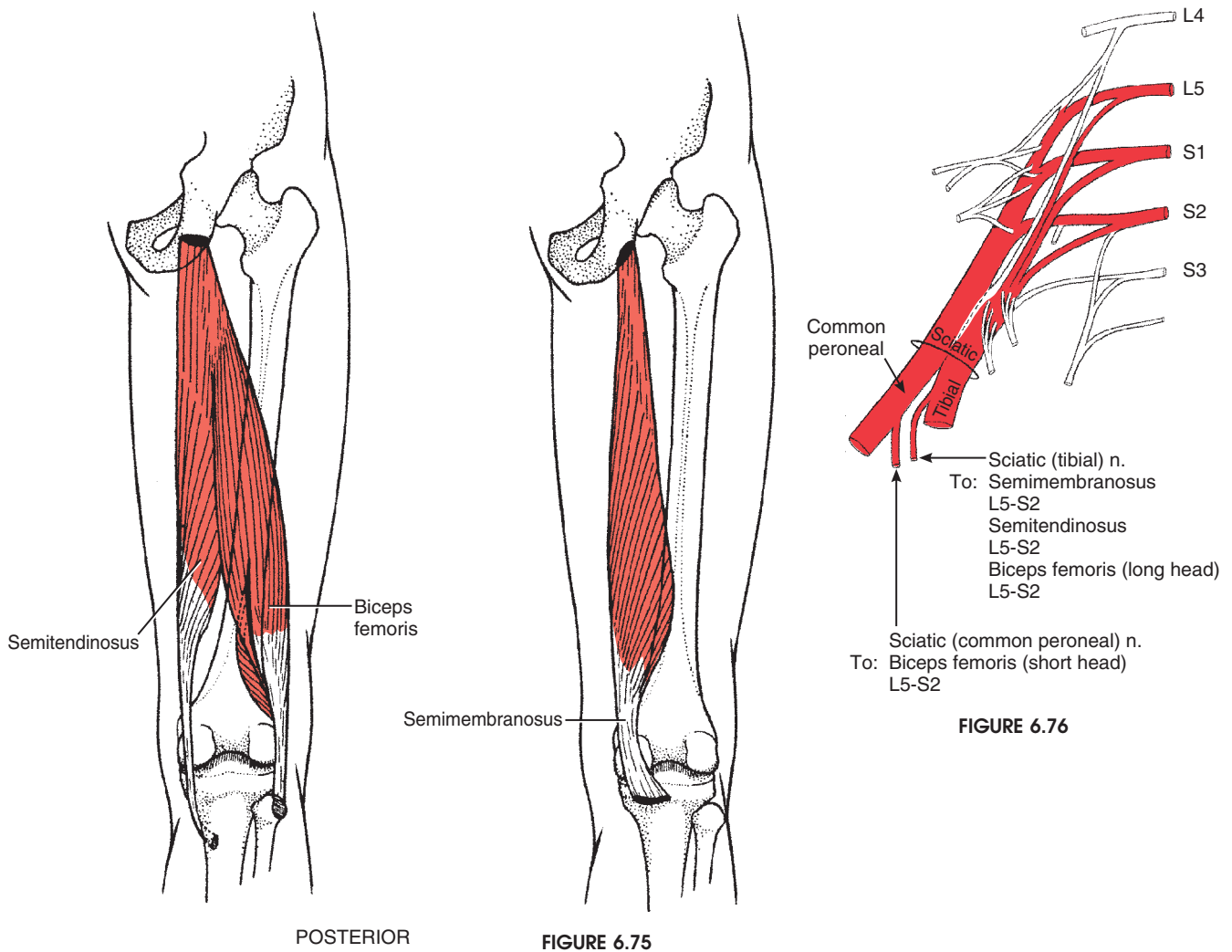


FIGURE 6.77 Arrow indicates level of cross section.

Range of Motion
0°–135°

Table 6.9 KNEE FLEXION

I.D.	Muscle	Origin	Insertion	Function
192	Biceps femoris			Knee flexor Hip extensor Knee external rotation
	Long head	Ischium (tuberosity) Sacrotuberous ligament	Aponeurosis (posterior) Fibula (head, lateral aspect) Fibular collateral ligament	Hip extension and external rotation (long head)
	Short head	Femur (linea aspera and lateral condyle) Lateral intermuscular septum	Tibia (lateral condyle)	Knee flexion
193	Semitendinosus	Ischial tuberosity (inferior medial aspect) Tendon via aponeurosis shared with biceps femoris (long)	Tibia (proximal shaft) Pes anserinus Deep fascia of leg	Knee flexion Knee internal rotation Hip extension Hip internal rotation (accessory)
194	Semimembranosus	Ischial tuberosity Sacrotuberous ligament	Distal aponeurosis Tibia (medial condyle) Oblique popliteal ligament of knee joint	Knee flexion Knee internal rotation Hip extension Hip internal rotation (accessory)
Others				
178	Gracilis			
185	Tensor fasciae latae (knee flexed more than 30°)			
195	Sartorius			
202	Popliteus			Knee flexion Knee internal rotation (proximal attachment fixed) Hip external rotation (tibia fixed)
205	Gastrocnemius			
207	Plantaris			

Hamstring muscle strain injuries have the highest prevalence in sport and especially in track and field. One of the proposed risk factors for acute hamstring injuries in track and field athletes is muscle weakness during concentric and/or eccentric contractions. The hamstring

muscles act as hip extensors and knee flexors during both stance and swing phase of sprinting, the most common mechanism of injury in track and field athletes. They work eccentrically during the late stance phase of gait and during the late swing phase of overground running.²⁶