
CHAPTER 6

Testing the Muscles of the Lower Extremity

Hip Flexion

Hip Flexion, Abduction, and External Rotation With Knee Flexion

Hip Extension

Hip Extension Test to Isolate Gluteus Maximus

Hip Extension Tests Modified for Hip Flexion Tightness

Supine Hip Extension Test

Hip Abduction

Hip Abduction From Flexed Position

Hip Adduction

Hip External Rotation

Hip Internal Rotation

Knee Flexion

Hamstring Muscles in Aggregate

Medial Hamstring Test (Semitendinosus and Semimembranosus)

Lateral Hamstring Test (Biceps Femoris)

Knee Extension

Ankle Plantar Flexion

Gastrocnemius and Soleus Test

Foot Dorsiflexion and Inversion

Foot Inversion

Foot Eversion With Plantar Flexion

Hallux and Toe MP Flexion

Hallux MP Flexion

Toe MP Flexion

Hallux and Toe DIP and PIP Flexion

Hallux and Toe MP and IP Extension

Hip Flexion

(*Psoas Major and Iliacus*)

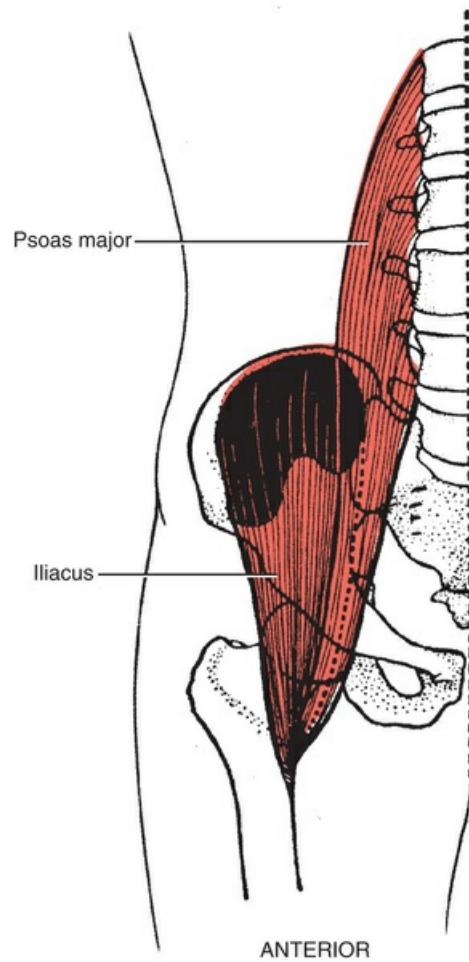


FIGURE 6.1

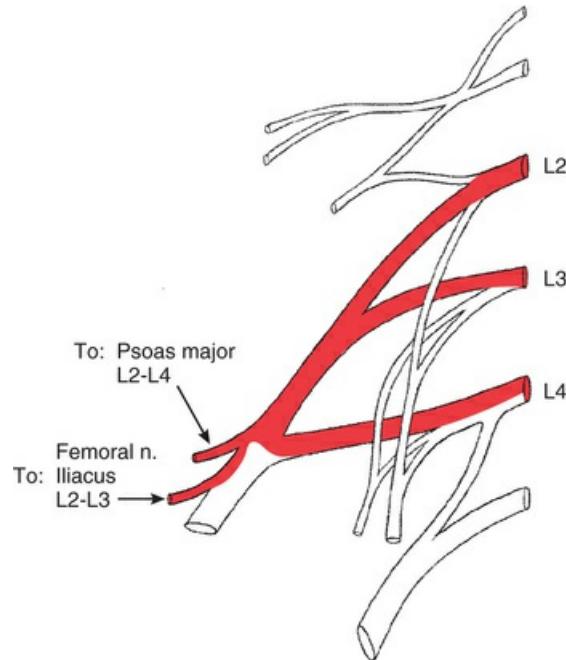


FIGURE 6.2

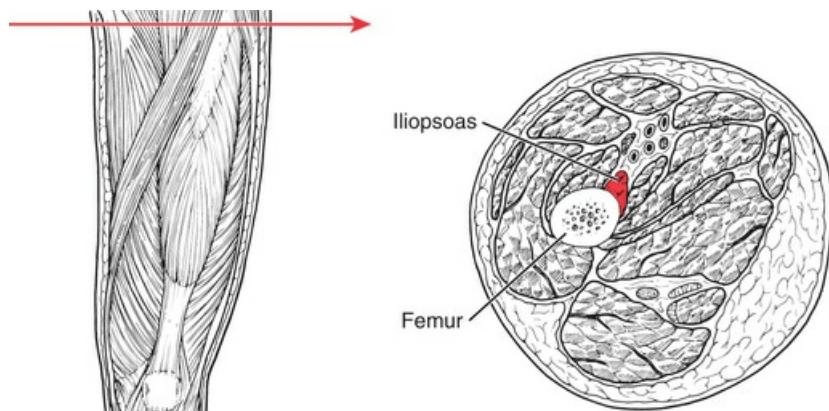


FIGURE 6.3 Arrow indicates level of cross section.

Range of Motion

0°–120°

Table 6.1
HIP FLEXION

I.D.	Muscle	Origin	Insertion	Function
176	Iliacus	Ilium (superior of iliac fossa Iliac crest (inner lip) Anterior sacroiliac and iliolumbar ligaments Sacrum (upper lateral surface)	Femur (lesser trochanter via insertion on tendon of the psoas major) Femoral shaft below lesser trochanter	Hip flexion up to 110° ¹ Internal rotation ¹ Abduct femur in external rotation ¹ Flexes pelvis on femur
174	Psoas major	L1-L5 vertebrae (transverse processes) T12-L5 vertebral bodies (sides) and their intervertebral discs	Femur (lesser trochanter)	Hip flexion with origin fixed Trunk flexion (sit-up) with insertion fixed (These two functions occur in conjunction with the iliacus) Hip external (lateral) rotation Flexion of lumbar spine (muscles on both sides)

			Lateral bending of lumbar spine to same side (muscle on one side)
<i>Others</i>			
196	Rectus femoris		Hip flexion
195	Sartorius		Hip flexion (combined with ER and abduction)
185	Tensor fasciae latae		Hip flexion Hip abduction
177	Pectenueus		Accessory in hip flexion
183	Gluteus medius (anterior)		Accessory (if femur is moving from extension toward flexion)

The iliopsoas muscle is a compound muscle consisting of the iliacus and the psoas major, which join in a common tendon of insertion on the lesser trochanter of the femur. The iliopsoas contributes to hip compressive forces in walking and running, but relatively little to the gait cycle. Although the iliopsoas and rectus femoris are necessary for initiation of leg swing, they only contribute approximately 10% of the net metabolic cost of walking.² Hip flexion strength was found not to be a significant predictor of maximum walking speed.³ The function of the iliopsoas may be more important in transfer activities and stair climbing as well as in uphill running.⁴

Grade 5, Grade 4, and Grade 3

Position of Patient:

Short sitting with thighs fully supported on table and legs hanging over the edge. Patient may use arms to provide trunk stability by grasping table edge or with hands on table at each side ([Fig. 6.4](#)).



FIGURE 6.4

Instructions to Therapist:

Stand next to limb to be tested. Ask the patient to lift the thigh off the table. If adequate range is present (thigh clears the table), proceed to apply maximum resistance at midrange (Grade 5) over distal thigh just proximal to the knee joint, being careful not to grasp the thigh (see [Fig. 6.4](#)).

Test:

Patient flexes hip to end of range, clearing the table and maintaining neutral rotation. The patient then brings the hip to midrange and holds that position against the therapist's resistance, which is given in a downward direction toward the floor.

Instructions to Patient:

"Sit tall and hold your thigh up. Don't let me push it down."

Grading

Grade 5:

Patient holds test position against maximal resistance.

Grade 4:

Patient holds test position against strong to moderate resistance. There may be some "give" with maximum resistance, making the grade a 4.

Grade 3:

Patient completes test range and holds the position without resistance ([Fig. 6.5](#)).



FIGURE 6.5

Helpful Hint

The position of the pelvis influences the action of the hip flexors. An anterior or posterior pelvic tilt influences the length tension of the hip flexors, thereby making them appear stronger or weaker. To eliminate the influence of the pelvis, the pelvis and spine should be in neutral as in [Fig. 6.4](#).

Grade 2

Position of Patient:

Side-lying with limb to be tested uppermost and supported by therapist ([Fig. 6.6](#)). Trunk in neutral alignment. Lowermost limb may be flexed for stability. A powder board under the upper limb may also be used to decrease friction.

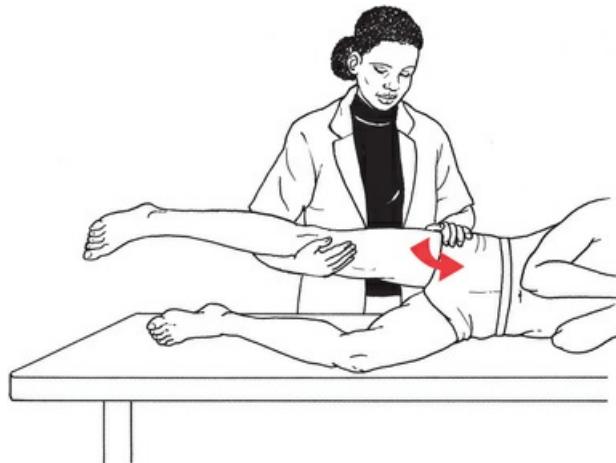


FIGURE 6.6

Instructions to Therapist:

Stand behind patient. Cradle test limb in one arm with hand support under the slightly flexed knee. Opposite hand maintains trunk alignment at hip (see [Fig. 6.6](#)).

Test:

Patient flexes hip with supported limb. Knee is permitted to flex to prevent hamstring tension.

Instructions to Patient:

“Bring your knee up toward your chest.”

Grading

Grade 2:

Patient completes the range of motion in side-lying position.

Grade 1 and Grade 0

Position of Patient:

Supine.

Instructions to Therapist:

Stand at side of limb to be tested. Test limb is supported under calf with hand behind knee. Free hand palpates the muscle just distal to the inguinal ligament on the medial side of the sartorius ([Fig. 6.7](#)).



FIGURE 6.7

Test:

Patient attempts to flex hip.

Instructions to Patient:

"Try to bring your knee up to your nose."

Grading

Grade 1:

Palpable contraction but no visible movement.

Grade 0:

No discernable palpable contraction of muscle.

Substitutions

- Use of the sartorius will result in external rotation and abduction of the hip. The sartorius, because it is superficial, will be seen and can be palpated along its entire length ([Fig. 6.8](#)).

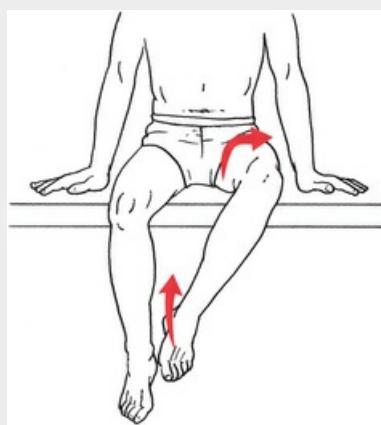


FIGURE 6.8

- If the tensor fasciae latae substitutes for the hip flexors, internal rotation and abduction of the hip will result. The tensor may be seen and palpated at its origin on the anterior superior iliac spine.

- Patient may try to flex trunk as effort is made to flex hip or lean back to enhance length tension or the hip flexors.

Helpful Hint

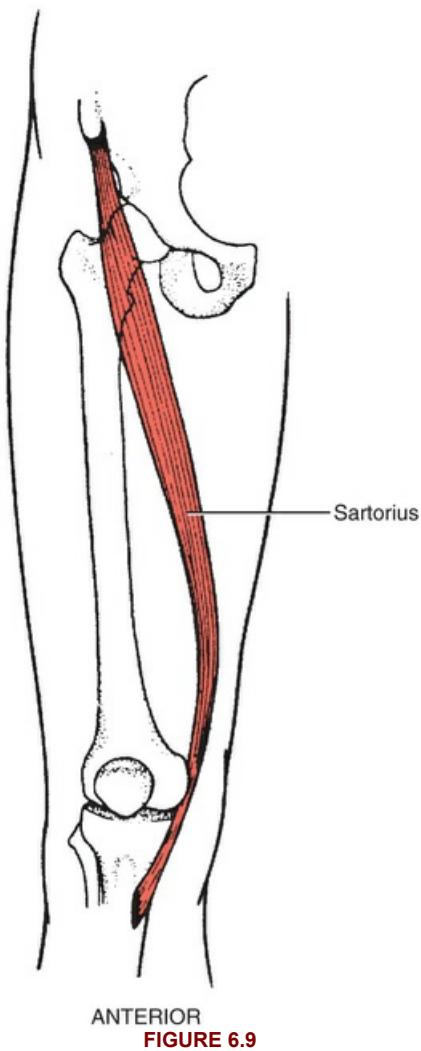
The hip flexors are rather small muscles (see Fig. 6.3) and therefore do not provide a lot of force, especially as compared with the quadriceps or gluteus maximus. Therefore a negative break test is rarely achieved if using a straight arm technique. Consequently, Fig. 6.4 shows the therapist with a bent arm while providing resistance. Experience is necessary to appreciate what constitutes a normal level of resistance.

Suggested Exercises for Iliopsoas

- Straight leg raise
- Marching (High Knees)
- Standing straight leg raise (SLR)
- V-situp

Hip Flexion, Abduction, and External Rotation With Knee Flexion

(*Sartorius*)



ANTERIOR
FIGURE 6.9

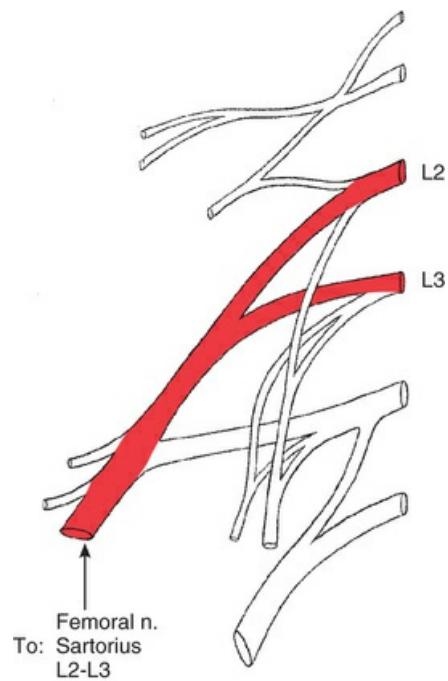


FIGURE 6.10

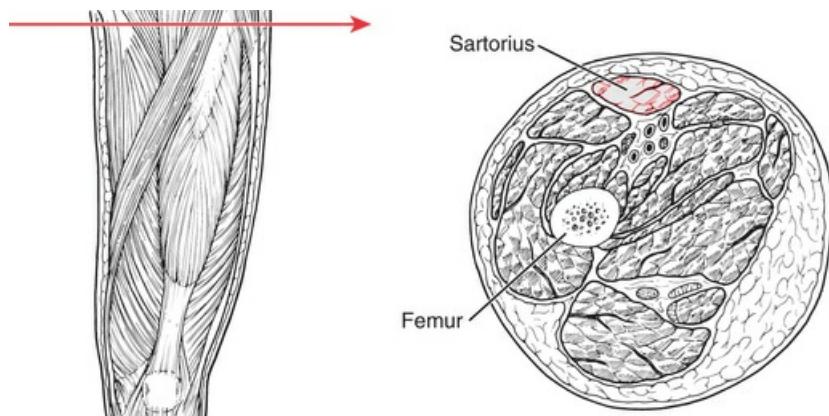


FIGURE 6.11 Arrow indicates level of cross section.

Table 6.2

HIP FLEXION, ABDUCTION, AND EXTERNAL ROTATION

I.D.	Muscle	Origin	Insertion	Function
195	Sartorius	Ilium (anterior superior iliac spine [ASIS]) Iliac notch below ASIS	Tibia (shaft, proximal medial surface) Capsule of knee joint (via slip) Aponeurosis	Hip external rotation, abduction, and flexion Knee flexion Knee internal rotation Assists in "tailor sitting"
<i>Others</i>				
	Hip and knee flexors			
	Hip external rotators			

The sartorius is the longest muscle in the body crossing the hip and the knee. The word sartorius comes from the Latin sartor, meaning tailor and the sartorius allows the movement of crossing one leg over the other one, as in a "tailor sit" (cross-legged sitting).

Grade 5, Grade 4, and Grade 3

Position of Patient:

Short sitting with thighs supported on table and legs hanging over side. Arms may be used for support.

Instructions to Therapist:

Stand lateral to the leg to be tested. Ask the patient to flex, abduct, and externally rotate the hip, with the knee flexed. If adequate range is present, place one hand on the lateral side of the knee, the other hand over the medial-anterior surface of the distal leg ([Fig. 6.12](#)). Apply appropriate resistance with both hands, resisting hip flexion and abduction (in a down and inward direction) with the proximal hand and hip external rotation and knee flexion (up and outward) with the hand at the distal leg.



FIGURE 6.12

Test:

Patient flexes, abducts, and externally rotates the hip while maintaining knee flexion (see [Fig. 6.12](#)).

Instructions to Patient:

Therapist may demonstrate the required motion passively and then ask the patient to repeat the motion, or the therapist may place the limb in the desired test position.

"Hold it! Don't let me move your leg or straighten your knee."

Alternate instruction: "Slide your heel up the shin of your other leg."

Grading

Grade 5:

Holds test position against maximal resistance, limb does not "give."

Grade 4:

Tolerates moderate to strong resistance while maintaining position.

Grade 3:

Completes movement and holds test position without resistance ([Fig. 6.13](#)).

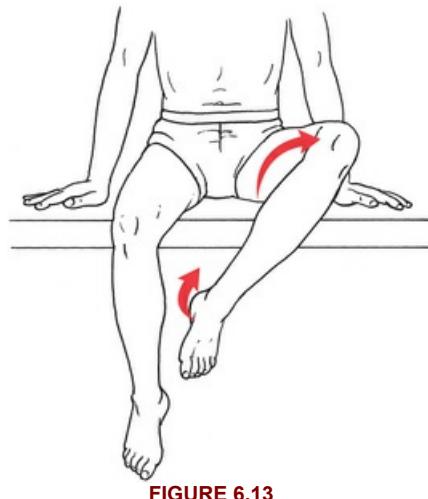


FIGURE 6.13

Grade 2

Position of Patient:

Supine. Heel of limb to be tested is placed on contralateral shin (Fig. 6.14).



FIGURE 6.14

Instructions to Therapist:

Stand at side of limb to be tested. Support limb as necessary to maintain alignment.

Test:

Patient slides test heel upward along shin to knee.

Instructions to Patient:

“Slide your heel up to your knee.”

Grading

Grade 2:

Completes desired movement.

Grade 1 and Grade 0

Position of Patient:

Supine.

Instructions to Therapist:

Stand on side to be tested. Cradle test limb under calf with hand supporting limb behind knee. Opposite hand palpates sartorius on medial side of thigh where the muscle crosses the femur (Fig. 6.15). Therapist may prefer to palpate near the muscle origin just below the anterior superior iliac spine (ASIS).



FIGURE 6.15

Test:

Patient attempts to slide heel up shin toward knee.

Instructions to Patient:

"Try to slide your heel up to your knee."

Grading

Grade 1:

Therapist can detect slight contraction of muscle; no visible movement.

Grade 0:

No discernable palpable contraction.

Substitution

Substitution by the iliopsoas or the rectus femoris results in pure hip flexion without abduction and external rotation.

Helpful Hints

- The therapist is reminded that failure of the patient to complete the full range of motion in the Grade 3 test is not an automatic Grade 2. The patient should be tested in the supine position to ascertain whether the correct grade is 2 or less.
- The abdominal muscles must generate a posterior pelvic tilt of sufficient force to neutralize the strong anterior pelvic tilt potential of the hip flexors.⁵
- In the presence of weakness, patients will attempt to substitute using the knee flexors, external

rotators, and tensor fascia lata but the movement would deviate out of the expected plane.

Suggested Exercises for the Sartorius Muscle

- Multidirectional lunge (forward, side, lateral)
- High box step ups
- Closed stance squats
- Leg lifts with hip externally rotated

Hip Extension

(Gluteus maximus and hamstrings)

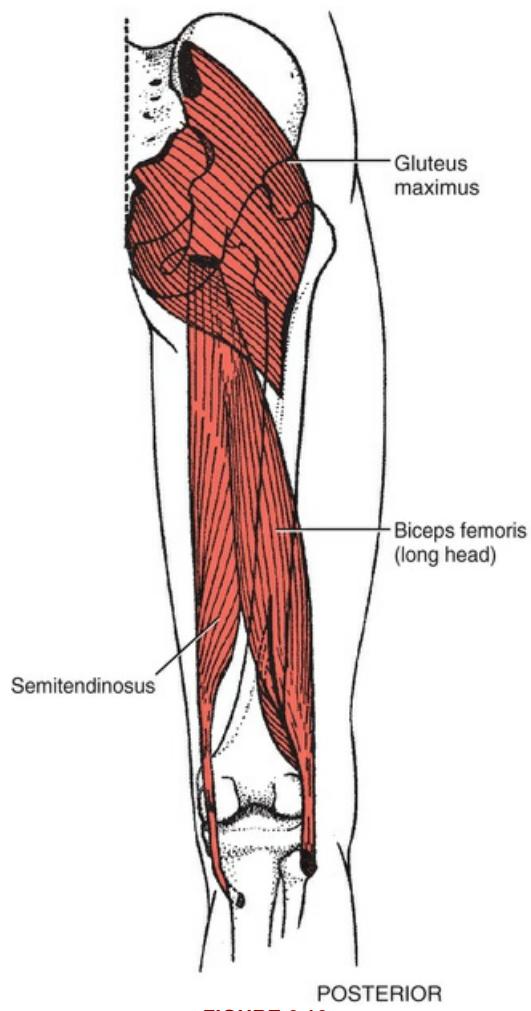


FIGURE 6.16

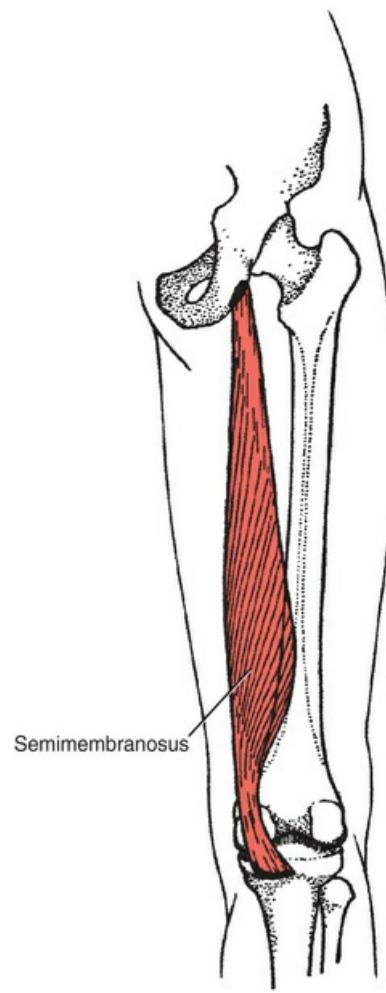


FIGURE 6.17

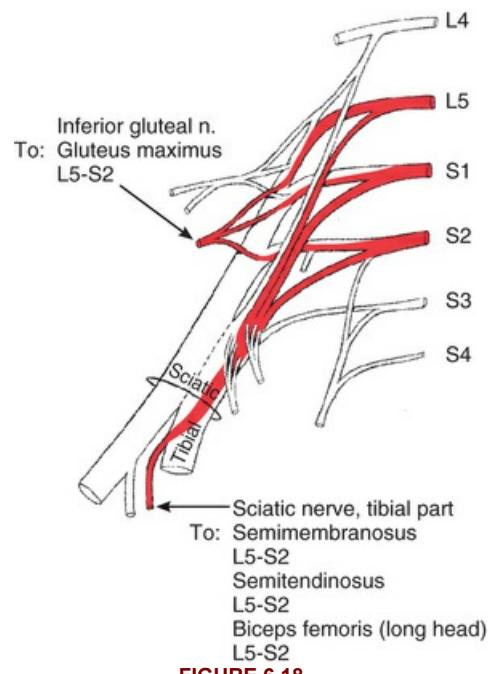


FIGURE 6.18

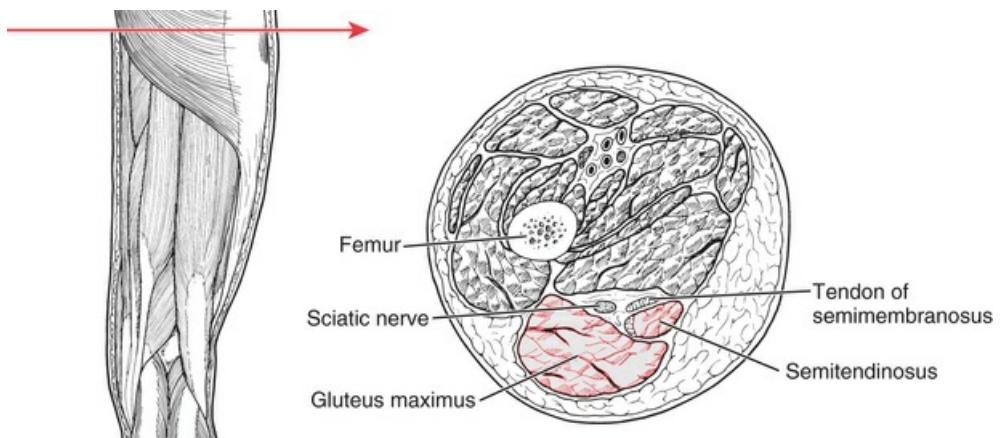


FIGURE 6.19 Arrow indicates level of cross section.

Range of Motion

0°–20°

Some authors say as low as 0°–5°.

Table 6.3
HIP EXTENSION

I.D.	Muscle	Origin	Insertion	Function
182	Gluteus maximus	Ilium (posterior gluteal line) Iliac crest (posterior medial)	Femur (gluteal tuberosity)	Hip extension (powerful) Hip external (lateral) rotation Hip abduction (upper fibers) Hip adduction (lower fibers) Through its insertion into the iliotibial band it stabilizes the knee
		Sacrum (dorsal surface of lower part) Coccyx (side) Sacrotuberous ligament Aponeurosis over gluteus medius	Iliotibial tract of fascia lata	
193	Semitendinosus	Ischial tuberosity (upper area, inferomedial impression via tendon shared with biceps femoris) Aponeurosis (between the two muscles)	Tibia (proximal medial shaft) Pes anserinus	Knee flexion Hip extension Hip internal rotation (accessory)
194	Semimembranosus	Ischial tuberosity (superolateral impression)	Tibia (medial condyle, posterior aspect) Oblique popliteal ligament of knee joint Aponeurosis over distal muscle (variable)	Knee flexion Hip extension Hip internal rotation (accessory)
192	Biceps femoris (long head)	Ischial tuberosity (inferomedial impression via tendon shared with semitendinosus) Sacrotuberous ligament	Fibula (head) Tibia (lateral condyle) Aponeurosis	Hip extension and (weak) external rotation
<i>Others</i>				
181	Adductor magnus (inferior)			When the femur is flexed this muscle can be a powerful extensor. In earlier anatomy texts this muscle was classified as a fourth hamstring
183	Gluteus medius (posterior)			

The gluteus maximus is the largest muscle in the body, accounting for 16% of the total cross-sectional area of the lower extremity.⁶ Eighty percent of the gluteus maximus inserts into the iliotibial band. It has at least six regions within the muscle that respond to different movements. The gluteus maximus is most effective in near full extension. Its pennate structure and long muscle length suggest it produces both high levels of force at low speeds through small ranges of motion and low levels of force at high speeds through large ranges of motion. It is a mix of slow and fast twitch fibers. It is often used to accelerate the body upward and forward from a position of hip flexion ranging from 40° to 60° (as in sprinting, squatting, and climbing a steep hill).⁷

Grade 5, Grade 4, and Grade 3 (Aggregate of All Hip Extensor Muscles)

Position of Patient:

Prone. Arms may be at the side of the body or abducted to hold sides of table. (Note: If there is a hip flexion contracture, immediately go to the test described for hip extension modified for hip flexion

tightness [see [page 240](#).])

Instructions to Therapist:

Stand at level of pelvis on side of limb to be tested. (Note: [Fig. 6.20](#) shows therapist on opposite side to avoid obscuring activity.) Ask the patient to lift the leg off the table as high as possible, while keeping the knee straight. If sufficient range is achieved, place the hand providing resistance on the posterior leg just above the ankle. The opposite hand may be used to stabilize or maintain pelvis alignment in the area of the posterior superior spine of the ilium (see [Fig. 6.20](#)). This is a demanding test because of the size of the muscle and the length of the lever arm.



FIGURE 6.20

Alternate Position:

The hand that gives resistance is placed on the posterior thigh just above the knee ([Fig. 6.21](#)). This alternate position is a less demanding test. Optimal resistance cannot be applied because of the shorter lever arm and thus, the highest grade a patient can attain is a Grade 4. This test is not recommended unless absolutely necessary (e.g., unstable, painful knee, above-knee amputee).



FIGURE 6.21

Test:

Patient extends hip through entire available range of motion. Resistance is given straight downward toward the floor.

Instructions to Patient:

"Lift your leg off the table as high as you can without bending your knee. Hold it" (see [Fig. 6.20](#)).

Grading

Grade 5:

Patient holds test position against maximal resistance.

Grade 4:

Patient holds test position against strong to moderate resistance.

Grade 3:

Completes range and holds the position without resistance ([Fig. 6.22](#)).



FIGURE 6.22

Helpful Hint

Knowledge of the ranges of hip motion is imperative before manual tests of hip strength are conducted. If the therapist does not have a clear idea of hip joint ranges, especially tightness in the hip flexor muscles, test results will be inaccurate. For example, in the presence of a hip flexion contracture, the patient must be standing and leaning over the edge of the table to test hip extension strength. This position (described on [page 240](#)) will decrease the influence of the flexion contracture and will allow the patient to move against gravity through the available range. The supine hip extensor test can also be used (see [page 242](#)).

Grade 2

Position of Patient:

Side-lying with test limb uppermost. Knee straight and supported by therapist. Lowermost limb is flexed for stability.

Instructions to Therapist:

Stand behind patient at thigh level. Therapist supports test limb just below the knee, cradling the leg ([Fig. 6.23](#)). Opposite hand is placed over the pelvic crest to maintain pelvic and hip alignment.



FIGURE 6.23

Test:

Patient extends hip through full range of motion.

Instructions to Patient:

"Bring your leg back toward me. Keep your knee straight."

Grading

Grade 2:

Completes available range of motion in side-lying position.

Grade 1 and Grade 0

Position of Patient:

Prone.

Instructions to Therapist:

Stand at level of pelvis on side to be tested. Palpate hamstrings (deep into tissue with fingers) at the ischial tuberosity (Fig. 6.24). Palpate the gluteus maximus with deep finger pressure over the center of the buttocks including the upper and lower fibers.



FIGURE 6.24

Test:

Patient attempts to extend hip in prone position or tries to squeeze buttocks together.

Instructions to Patient:

"Try to lift your leg from the table." OR "Squeeze your buttocks together."

Grading

Grade 1:

Palpable contraction of gluteus maximus but no visible joint movement. Contraction of gluteus maximus will result in narrowing of the gluteal crease.

Grade 0:

No discernable palpable contraction.

Substitutions

Rotation of pelvis. Having the patient turn his or her head to the opposite side will help prevent trunk rotation.

Flexion of the knee to substitute hamstrings for gluteus maximus. The gluteus maximus (page 238) and hamstrings (page 266) isolation tests may be a better indicator of specific muscle action.

Helpful Hints

- Because of the strength of the gluteus maximus, it is imperative that the therapist achieve an optimal position for himself or herself, such as using a straight arm technique to apply as much force as the muscle can bear. Shorter therapists may need to step up on a stool or lower the plinth if it is adjustable to apply adequate resistance. See hip extensor test to isolate the gluteus maximus on page 242.
- The therapist should be aware that the hip extensors are among the most powerful muscles in the body, and most therapists will not be able to "break" a Grade 5 hip extension. Care should

be taken not to overestimate a Grade 4 muscle.

Hip Extension Test to Isolate Gluteus Maximus

Grade 5, Grade 4, and Grade 3

Position of Patient:

Prone with knee flexed to 90°, hip abducted and externally rotated. The abducted and externally rotated hip positions are difficult to visualize in Figs. 6.25 and 6.26. (Note: In the presence of a hip flexion contracture, do not use this test but refer to the test for hip extension modified for hip flexion tightness [see page 240].)



FIGURE 6.25

Instructions to Therapist:

Stand at the level of the pelvis on the side to be tested. (Note: The therapist in the illustration is shown on the wrong side to avoid obscuring test positions.) Ask the patient to lift the thigh off the plinth as high as possible, while bending the knee. If sufficient range is achieved, place the hand for resistance over the posterior thigh just above the knee. The opposite hand may stabilize or maintain the alignment of the pelvis (see Fig. 6.25).

For the Grade 3 test, the knee may be supported in flexion (by cradling at the ankle) if needed because of hamstring weakness.

Test:

Patient extends abducted and externally rotated hip through available extension range, maintaining knee flexion. Resistance is given in a straight downward direction (toward floor).

Instructions to Patient:

"Lift your foot to the ceiling." OR "Lift your leg, keeping your knee bent."

Grading

Grade 5:

Holds test position against maximal resistance.

Grade 4:

Holds test position against strong to moderate resistance.

Grade 3:

Completes available range of motion and holds test position but without resistance (see Fig. 6.26).



FIGURE 6.26

Grade 2

Position of Patient:

Side-lying with test limb uppermost. Knee is flexed and supported by therapist. Lowermost hip and knee should be flexed for stability (Fig. 6.27). Therapist provides stabilization and alignment through the uppermost hip by assuring that the pelvis and hip are in line with the shoulder.

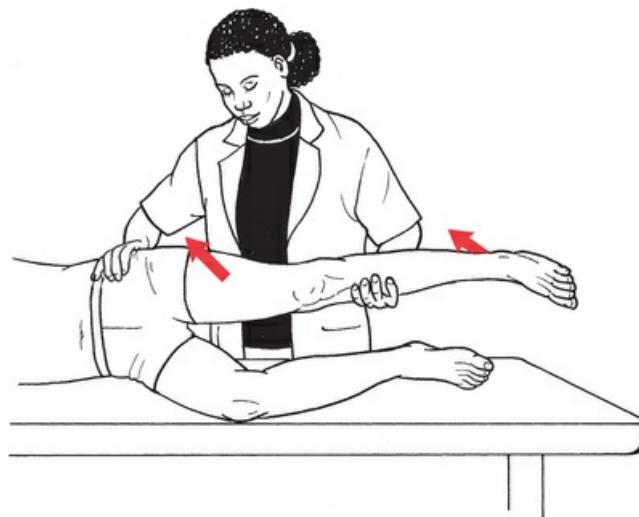


FIGURE 6.27

Instructions to Therapist:

Stand at the level of the pelvis behind the patient. Therapist cradles uppermost leg with forearm. Other hand stabilizes pelvis in neutral alignment at the iliac crest.

Test:

Patient extends hip with supported knee flexed.

Instructions to Patient:

"Move your leg back toward me."

Grading

Grade 2:

Completes available range of motion in side-lying position.

Grade 1 and Grade 0

This test is identical to the Grades 1 and 0 tests for aggregate hip extension (see Fig. 6.24). The patient is prone and attempts to extend the hip or squeeze the buttocks together while the therapist palpates the gluteus maximus.

Helpful Hints

- Hip extension range is less when the knee is flexed because of tension in the rectus femoris. A diminished hip extension range may be observed, therefore, in tests that isolate the gluteus maximus.
- Often, cramping of the hamstrings will occur when the patient performs this test. The authors have found that decreasing knee flexion to 70° or applying resistance in the middle of the muscle belly during the test will decrease the likelihood of a cramp.
- Hip extension torque increases with hip flexion (increase of 41% with 15° hip flexion and 112% with 45° hip flexion [average of 1.9 Nm per degree of flexion]).⁸

Hip Extension Tests Modified for Hip Flexion Tightness

Grade 5, Grade 4, and Grade 3

Position of Patient:

Patient leans over the table with hips flexed so that the ASIS is “hooked” on the end of table (Fig. 6.28). The arms are used to “hug” the table for support. The knee of the non-test limb should be flexed to allow the test limb to rest on the floor at the start of the test.



FIGURE 6.28

Instructions to Therapist:

Stand at side of limb to be tested. (Note: Fig. 6.28 shows the therapist on the opposite side to avoid obscuring test positions.) Ask the patient to lift his leg toward the ceiling. If sufficient range is achieved, place the hand used to provide resistance over the posterior thigh just above the knee.

The opposite hand stabilizes the pelvis laterally to maintain hip and pelvis posture (see Fig. 6.28). The therapist's stabilizing hand may need to be placed over the hip to prevent the pelvis from rising (not shown).

Test:

Patient extends hip through available range, but hip extension range is less when the knee is flexed. Keeping the knee in extension will test all hip extensor muscles; with the knee flexed, the gluteus maximus will be evaluated in isolation.

Resistance is applied downward (toward floor).

Instructions to Patient:

"Lift your foot off the floor as high as you can."

Grading

Grade 5:

Holds test position against maximal resistance.

Grade 4:

Holds test position against strong to moderate resistance.

Grade 3:

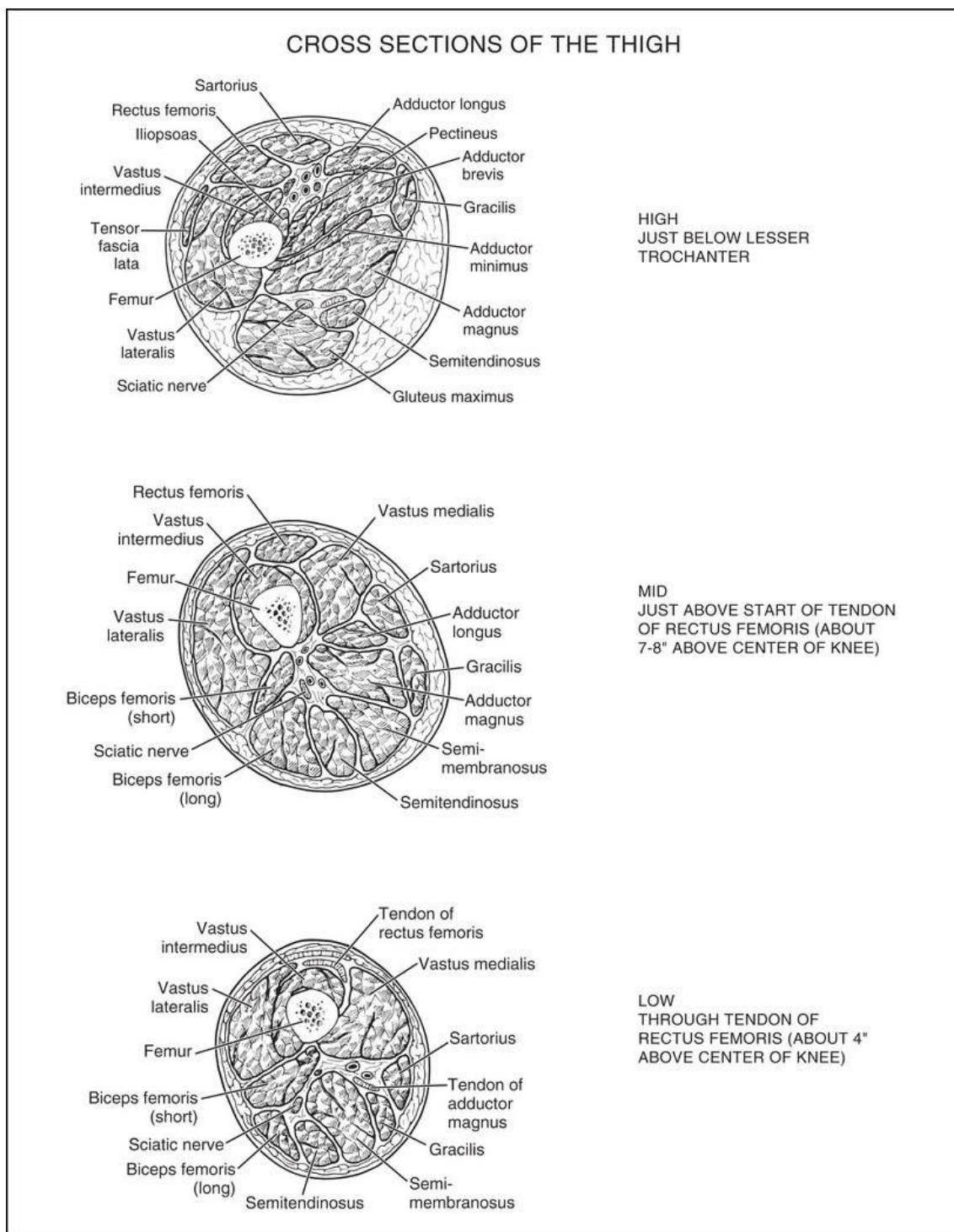
Completes available range and holds test position without resistance.

Grade 2, Grade 1, and Grade 0

Do not test the patient with hip flexion contractures who has less than Grade 3 hip extensors in the standing position. Position the patient side-lying on the table. Conduct the test as described for the aggregate of extensor muscles (see page 239) or for the isolated gluteus maximus (see page 238).

Helpful Hint

The modified hip extensor test is the preferred test for people who are not able or are unwilling to lie prone. This test may elicit a greater effort than the alternate supine hip extensor test.



Supine Hip Extension Test

An alternate hip extensor test is the supine hip extension test. This supine test may be substituted to eliminate change of patient position or for those who cannot lie prone. Grades 5, 4, 3, and 2 have been validated in this position ($n = 44$ subjects) by measuring maximum hip extension torques recorded via a strain gauge dynamometer.⁹

Grade 5, Grade 4, Grade 3, and Grade 2

Position of Patient:

Supine with heels off end of table. Arms folded across chest or abdomen. (Do not allow patient to push into table with upper extremities.)

Instructions to Therapist:

Stand at end of table. Lift patient's leg to at least 65° of flexion. Determine patient's hip range by measuring from the heel to the table ([Fig. 6.29](#)). Approximately 35 inches from heel to table (approximately 65° of flexion) is necessary to perform this test and is the distance the leg should be lifted during the test. In a squat position (knees and hips bent and elbows straight), cup both hands under the heel and ask patient to push into therapist's hands, keeping the knee straight and hip locked ([Fig. 6.30](#)). Try to raise the limb to the height measured initially. The therapist will need excellent body mechanics to be able to resist this typically very strong muscle ([Fig. 6.31](#)). (Note: Ideally, the table should be lower than the one shown in these figures to allow for optimal therapist advantage and body mechanics.)



FIGURE 6.29

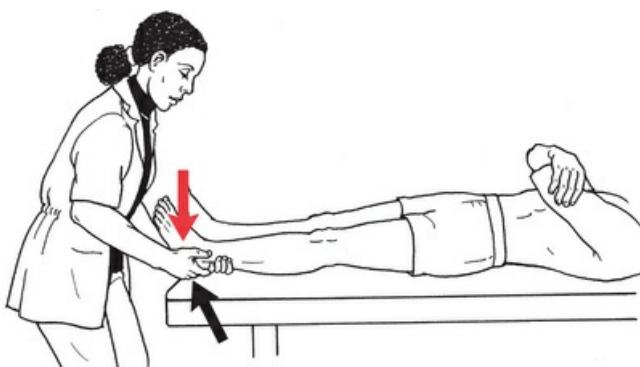


FIGURE 6.30



FIGURE 6.31

Test:

Patient presses heel into therapist's cupped hands, attempting to maintain full extension of the limb as the therapist raises the limb approximately 35 inches from the table. No instructions are given for the opposite leg except to relax.

Instructions to Patient:

"Don't let me lift your leg from the table. Keep your hip locked tight (don't let it bend)."

Grading

Grade 5:

Hip locks in neutral (full extension) throughout this test. Pelvis and back elevate as one locked unit as the therapist raises the limb (see Fig. 6.31). The opposite limb will rise involuntarily, illustrating a locked pelvis.

Grade 4:

Hip flexes before pelvis and back elevate and lock as the limb is raised by the therapist. Hip flexion should not exceed 30° before locking occurs (Fig. 6.32). The other leg will rise involuntarily, but will have some hip flexion because the pelvis is not fully locked.

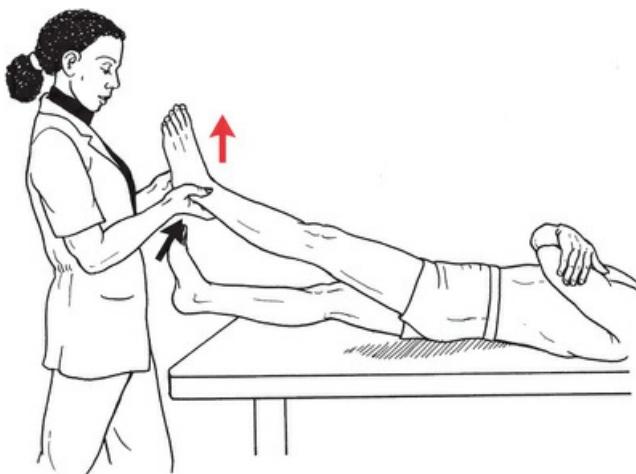


FIGURE 6.32

Grade 3:

Full flexion of the hip to the end of the straight-leg raising range (65° of hip flexion) with little or no elevation of the pelvis, demonstrated by the other leg remaining on the table. Therapist feels strong resistance throughout the test (Fig. 6.33).



FIGURE 6.33

Grade 2:

Hip flexes fully with only minimal resistance felt (therapist should check to ensure that the resistance felt exceeds the weight of the limb; see Fig. 6.33).

There is no Grade 1.

Grade 0:

Hip flexes fully with no active resistance felt by the therapist as limb is raised. Therapist perceives that resistance is due to leg weight only.

Helpful Hints

- To optimize the therapist's body mechanics and ability to generate sufficient force to resist this strong muscle, the therapist should start in a squat position to enable elbows to be straight, necessitating the patient to be positioned on a low table or mat table.
- The supine hip extensor test was found to have higher hamstring activation than the unilateral bridge test.¹⁰
- When the trunk is held relatively stationary, contraction of the hip extensors and abdominal muscles function as a force-couple to posteriorly tilt the pelvis.⁵

Suggested Exercises for the Gluteus Maximus

Exercises are over 40% MVIC in order of increasing MVIC.⁷ Exercises producing the greatest gluteus maximus EMG amplitude will be those that place the gluteus maximus in a shortened position (pull-throughs, glute bridges, hip thrusts, horizontal back extensions).

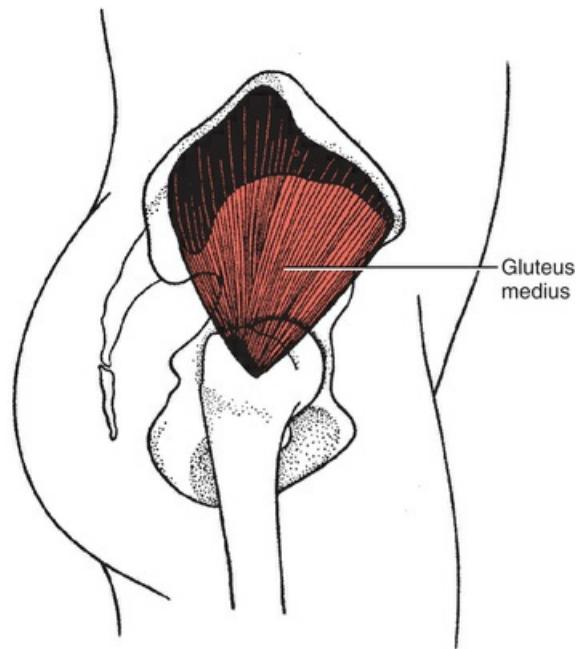
- Sideways lunge
- Lateral step up
- Transverse lunge
- Quadruped with contralateral arm/leg lift
- Unilateral mini-squat

- Retro step up
- Wall squat
- Single-limb squat
- Single-limb deadlift
- Forward step up

EMG, Electromyography; *MVIC*, maximum voluntary isometric contraction.

Hip Abduction

(Gluteus medius and gluteus minimus)



LATERAL
FIGURE 6.34

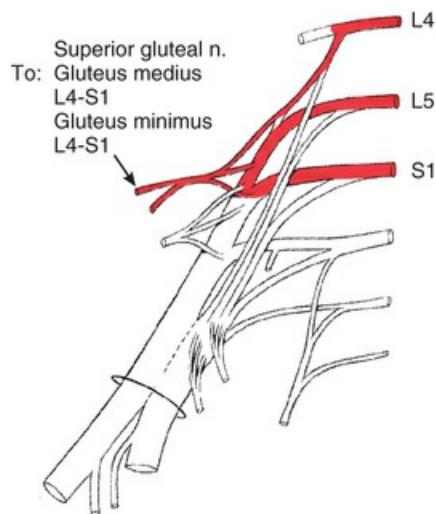


FIGURE 6.35

Range of Motion

0°–45°

Table 6.4
HIP ABDUCTION

I.D.	Muscle	Origin	Insertion	Function
183	Gluteus medius	Ilium (outer surface between crest and anterior and posterior gluteal lines) Fascia (over upper part)	Femur (greater trochanter, lateral aspect)	Pelvic stabilizer Hip abduction (in all positions) Hip internal rotation (anterior fibers) Hip external (lateral) rotation (posterior fibers) Hip flexion (anterior fibers) Hip extension (posterior fibers) as accessory functions
184	Gluteus minimus	Ilium (outer surface between anterior and inferior gluteal lines) Greater sciatic notch	Femur (greater trochanter, anterolateral ridge) Anterior and superior capsule of hip joint	Hip abduction Hip internal (medial) rotation
<i>Others</i>				
182	Gluteus maximus (upper fibers)			
185	Tensor fasciae latae			
187	Obturator internus (thigh flexed)			
189	Gemellus superior (thigh flexed)			
190	Gemellus inferior (thigh flexed)			
195	Sartorius			

The primary role of the gluteus medius is to stabilize the pelvis in the frontal plane and control femoral motion during dynamic limb motion. The greatest percentage of maximum voluntary contraction (MVC) in the gluteus medius was recorded during single limb stance when the subject was simultaneously abducting the opposite leg. This finding validates the gluteus medius as a pelvic stabilizer.^{11,12} The gluteus medius is functionally divided into three parts: (1) anterior, (2) middle, and (3) posterior, each with separate branches from the superior gluteal nerve. Consequently, the three parts have different actions of rotation with abduction, dependent on the degree of hip flexion. The test below captures all three parts during hip abduction. Functionally, the gluteus medius generates an exceptional amount of force, given its size.⁷

Grade 5, Grade 4, and Grade 3

Position of Patient:

Side-lying with test leg uppermost. Start test with the hip slightly extended beyond the midline and the pelvis rotated slightly forward (Fig. 6.36). Lowermost leg is flexed for stability.



FIGURE 6.36

Instructions to Therapist:

Stand behind patient. Ask patient to lift the leg as high as possible, giving verbal and tactile clues as necessary to keep the pelvis from rotating and the hip from flexing. If sufficient range is achieved, place hand used to give resistance at the ankle (Fig. 6.37). Applying resistance at the ankle creates a longer lever arm, thus requiring more patient effort to resist the movement. If the patient cannot hold the limb against resistance at the ankle, then apply resistance at the lateral knee (Fig. 6.38). The

therapist is reminded always to use the same lever in a given test sequence and in subsequent comparison tests.

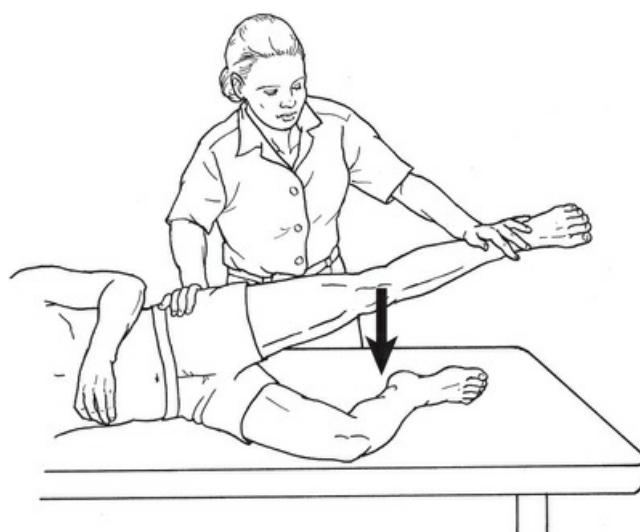


FIGURE 6.37

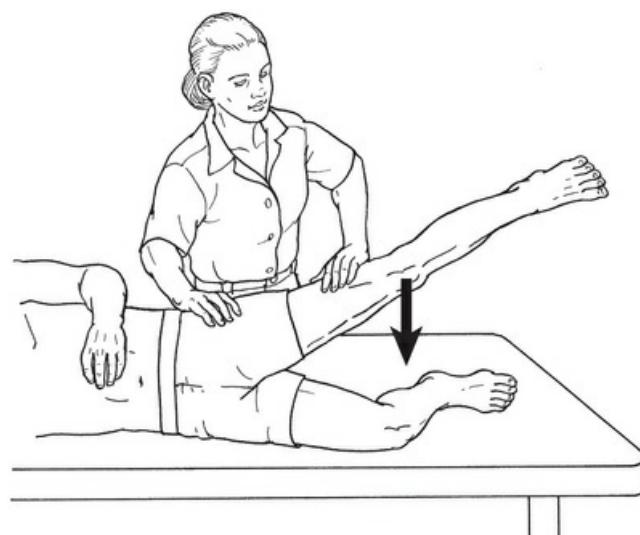


FIGURE 6.38

Test:

Patient abducts hip through the available range of motion without flexing the hip or rotating it in either direction. Resistance is given in a straight downward direction.

Instructions to Patient:

"Lift your leg up and back. Hold it. Don't let me push it down."

Grading

Grade 5:

Holds test position against maximal resistance at the ankle.

Grade 4:

Holds test position against strong to moderate resistance at the ankle (the limb cannot hold the position) or with maximum resistance given at the knee.

Grade 3:

Completes range of motion and holds test position without resistance ([Fig. 6.39](#)). Hip should not flex into frontal plane or rotate.

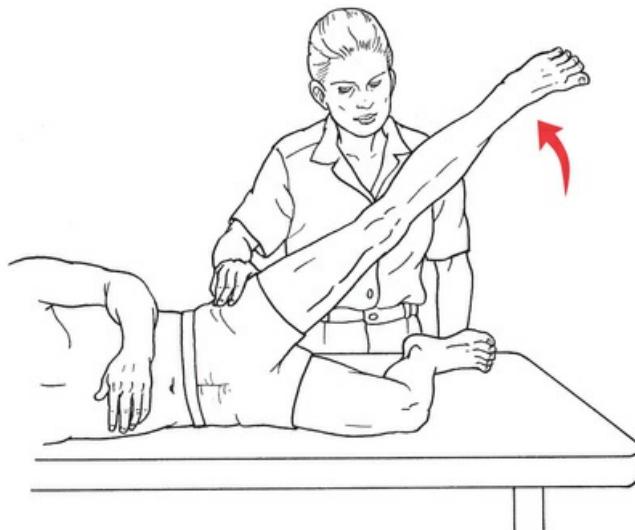


FIGURE 6.39

Grade 2

Position of Patient:

Supine.

Instructions to Therapist:

Stand on side of limb being tested. One hand supports and lifts the limb by holding it under the ankle to raise limb just enough to decrease friction. This hand offers no resistance, nor should it be used to offer assistance to the movement. On some smooth surfaces, such support may not be necessary ([Fig. 6.40](#)). (Note: [Figs. 6.40](#) and [6.41](#) show therapist on opposite side of patient to avoid obscuring test positions.)

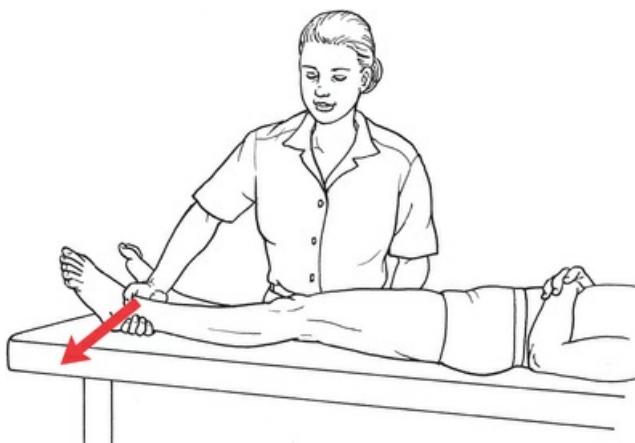


FIGURE 6.40



FIGURE 6.41

The other hand palpates the gluteus medius just proximal to the greater trochanter of the femur (see Fig. 6.41).

Test:

Patient abducts hip through available range.

Instructions to Patient:

"Bring your leg out to the side. Keep your kneecap pointing to the ceiling."

Grading

Grade 2:

Completes range of motion supine with no resistance and minimal to zero friction.

Grade 1 and Grade 0

Position of Patient:

Supine.

Instructions to Therapist:

Stand at the side of the limb being tested at level of thigh. One hand supports the limb under the ankle just above the malleoli. The hand should provide neither resistance nor assistance to movement (see Fig. 6.40). Palpate the gluteus medius on the lateral aspect of the hip just above the greater trochanter. The weight of the opposite limb stabilizes the pelvis. It is not necessary therefore to use a hand to manually stabilize the contralateral limb.

Test:

Patient attempts to abduct hip.

Instructions to Patient:

"Try to bring your leg out to the side."

Grading

Grade 1:

Palpable contraction of gluteus medius but no movement of the part.

Grade 0:

No discernable contractile activity.

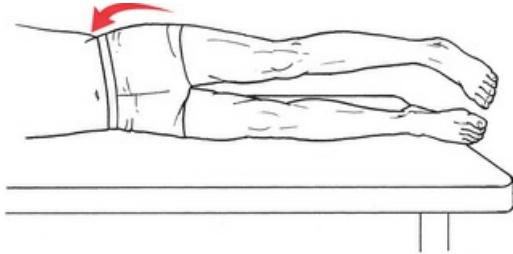


FIGURE 6.42

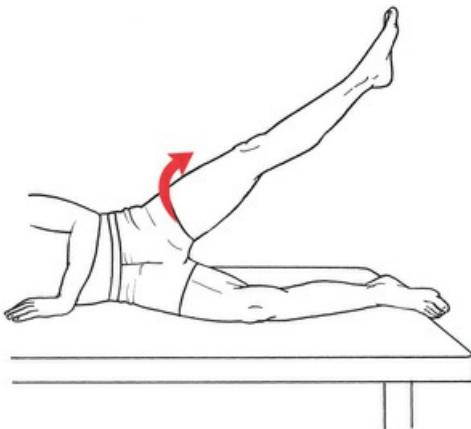


FIGURE 6.43

Substitutions

- Hip-hike substitution: If testing in the supine position, the patient may “hip hike” by approximating pelvis to thorax using the lateral trunk muscles, which moves the limb through partial abduction range (Fig. 6.42). This movement may be detected by observing the lateral trunk and hip (move clothing aside) and palpating the gluteus medius above the trochanter.
- External rotation and flexion (sartorius) substitution: The patient may try to externally rotate during the motion of abduction (Fig. 6.43). This could allow the oblique action of the hip flexors to substitute for the gluteus medius.
- Tensor fasciae latae substitution: If the test is allowed to begin with active hip flexion or with the hip positioned in flexion, there is an opportunity for the tensor fasciae latae to abduct the hip.

Helpful Hints

- The therapist should not be able to “break” a Grade 5 muscle (resistance applied at the ankle) and most therapists will not be able to “break” a Grade 4 muscle. The force required to stabilize the body is about $2\times$ the body weight, the majority produced by the hip abductors.⁵ The therapist should be able to generate at least 100 pounds of push force for a valid test.
- A grade of 4 often indicates significant weakness because of the tremendous intrinsic strength of these muscles. Giving resistance at the ankle rather than at the knee is helpful in overcoming this problem. However, respect the long lever arm and apply resistance carefully, assessing whether the patient can adequately resist the movement through the long lever arm.
- A patient should be able to stand on one leg keeping the pelvis level with a muscle grade of 4

or 5. The inability to do so results in a gluteus medius limp, whereby the pelvis drops on the opposite side of the weakness. In gait, a pelvic drop would occur in every step. If weakness is bilateral, you will see the equivalent of a “waddling” gait where the pelvis drops on each side, with each step. This is a sign of marked gluteus medius weakness.

- When a hip flexion contracture of 30° or more is present, the gluteus medius is compromised as an abductor, as its anterior fibers are now in the plane of flexion instead of abduction.
- Hip abductor and lateral rotator weakness can lead to knee valgus, hip adduction, and hip internal rotation, a position that can put undue stress on lower extremity joints.
- Gluteus medius strength is associated with stair ascend/descend and 5-chair rise test performance. In the presence of gluteus medius weakness, patients will display a gluteus medius limp during stair ascent. A gluteus medius limp is particularly prevalent in inactive older adults and those with hip osteoarthritis or arthroplasties.
- Strengthening the hip abductors in the presence of knee osteoarthritis reduces symptoms.¹³
- Tears or degenerative changes of the attachment of the gluteus medius and minimus may be a source of pain, often attributed to trochanteric bursitis.⁵
- Gluteus medius and minimus atrophy is greater in people with fall-related hip/pelvic fractures (Odds ratio = 2.15).¹⁴
- The weight of the limb alone results in greater external peak torque during side-lying hip abduction than during other hip abductor exercises.¹⁵

Suggested Hip Abduction Exercises (>40% MVIC)^{7,16}

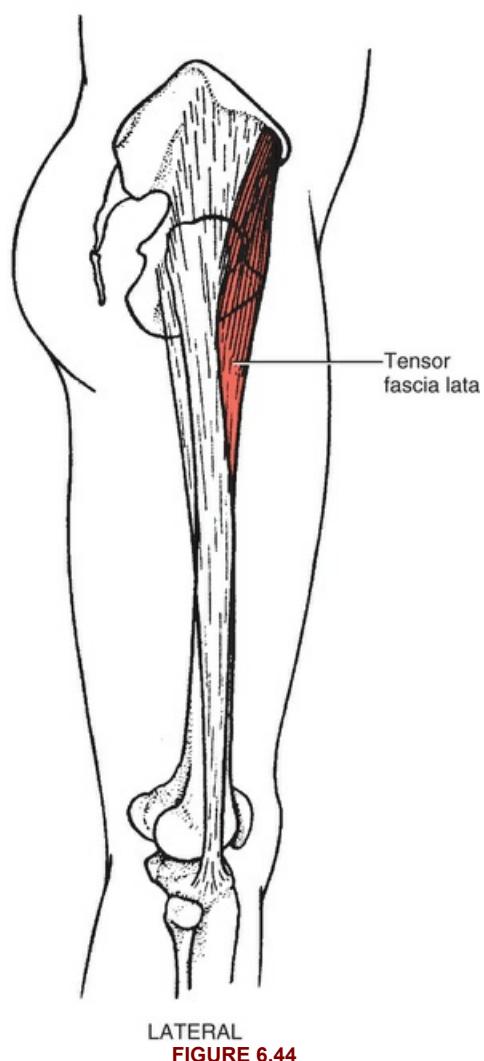
Exercises are listed in order from least to greatest MVIC

- Lateral step up
- Quadruped with contralateral arm and leg lift
- Forward step up
- Unilateral bridge
- Transverse lunge
- Wall squat
- Side-bridge to neutral spine position
- Standing erect pelvic drop
- Single-limb deadlift
- Single-limb squat
- Side-bridge with hip abduction
- Side-lying hip abduction

MVIC, Maximum voluntary isometric contraction.

Hip Abduction From Flexed Position

(*Tensor fasciae latae*)



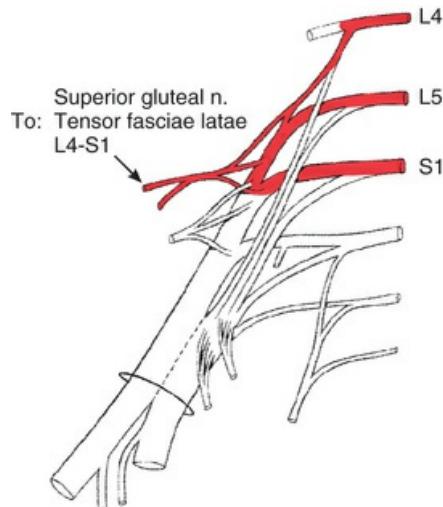


FIGURE 6.45

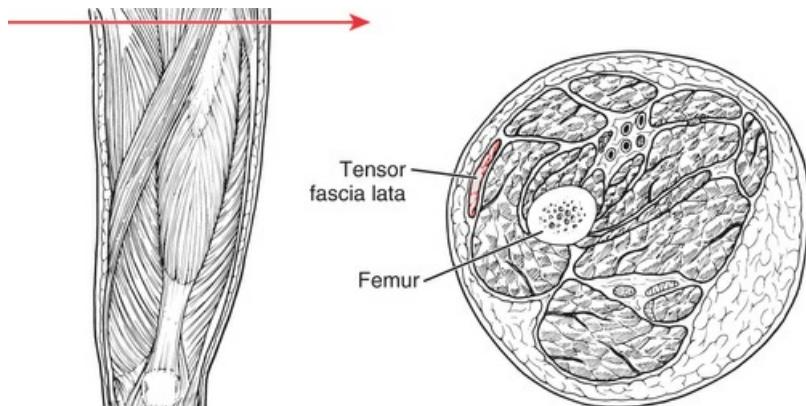


FIGURE 6.46 Arrow indicates level of cross section.

Range of Motion

Two-joint muscle. No specific range of motion can be assigned solely to the tensor.

Table 6.5
HIP ABDUCTION FROM FLEXION

I.D.	Muscle	Origin	Insertion	Function
185	Tensor fasciae latae	Iliac crest (outer lip) Fasciae latae (deep) Anterior superior iliac spine (lateral surface)	Iliotibial tract (between its two layers, ending $\frac{2}{3}$ of the way down)	Hip flexion Hip internal (medial) rotation
<i>Others</i>				
183	Gluteus medius			
184	Gluteus minimus			

The tensor fascia lata (TFL) helps to stabilize and steady the hip and knee joints by putting tension on the iliotibial band of fascia. It helps to maintain one foot in front of the other as in walking. It is tiny muscle, inferior to the iliotibial band.

Grade 5, Grade 4, and Grade 3

Position of Patient:

Side-lying. Uppermost limb (test limb) is flexed to 45° and lies across the lowermost limb with the foot resting on the table (Fig. 6.47).



FIGURE 6.47

Instructions to Therapist:

Stand behind patient at level of pelvis. Ask patient to flex hip and lift leg to 30°. If successful, place hand for resistance on lateral surface of the thigh just above the knee. Hand providing stabilization is placed on the crest of the ilium (Fig. 6.48).

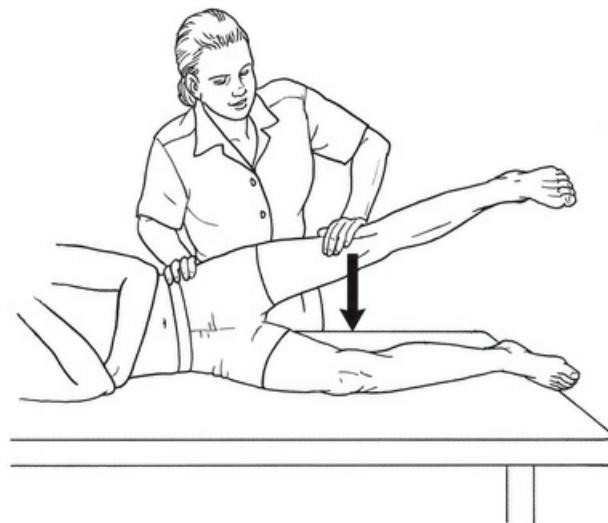


FIGURE 6.48

Test:

Patient abducts hip through approximately 30° of motion. Resistance is given downward (toward floor) from the lateral surface of the distal femur.

Instructions to Patient:

"Lift your leg and hold it. Don't let me push it down."

Grading

Grade 5:

Holds test position against maximum resistance.

Grade 4:

Holds test position against strong to moderate resistance.

Grade 3:

Completes movement; holds test position but without resistance ([Fig. 6.49](#)).

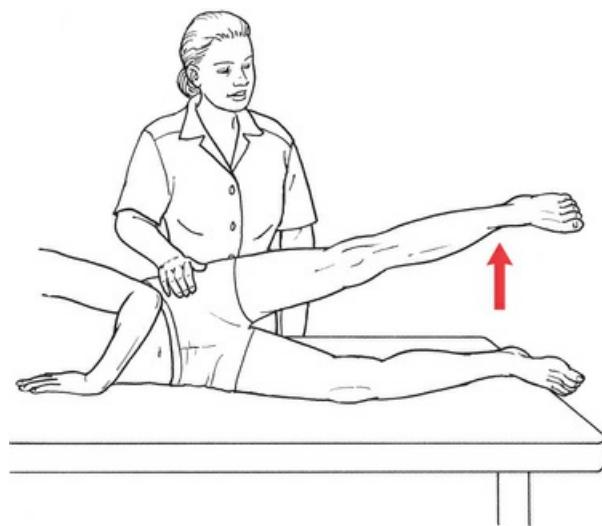


FIGURE 6.49

Grade 2

Position of Patient:

Patient is in long-sitting position, supporting trunk with hands placed behind body on table. Trunk may lean backward up to 45° from vertical ([Fig. 6.50](#)).

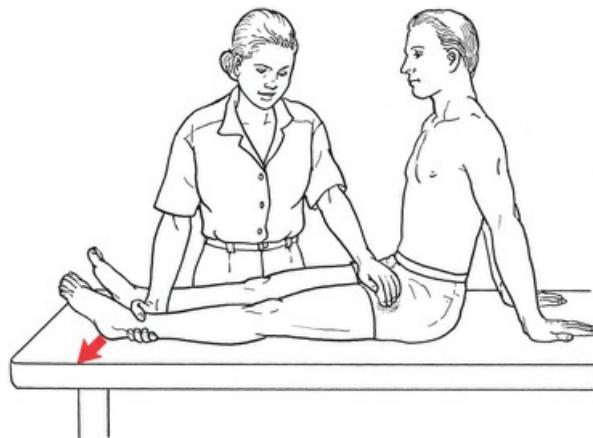


FIGURE 6.50

Instructions to Therapist:

Stand at side of limb to be tested. (Note: [Fig. 6.50](#) deliberately shows therapist on wrong side to avoid obscuring test positions.) One hand supports the limb under the ankle; this hand will be used

to reduce friction with the surface as the patient moves but should neither resist nor assist motion. The other hand palpates the tensor fasciae latae on the proximal anterolateral thigh where it inserts into the iliotibial band.

Test:

Patient abducts hip through 30° of range.

Instructions to Patient:

"Bring your leg out to the side."

Grading

Grade 2

Completes hip abduction motion to 30°.

Grade 1 and Grade 0

Position of Patient:

Long sitting.

Instructions to Therapist:

One hand palpates the insertion of the tensor at the lateral aspect of the knee. The other hand palpates the tensor on the anterolateral thigh ([Fig. 6.51](#)).

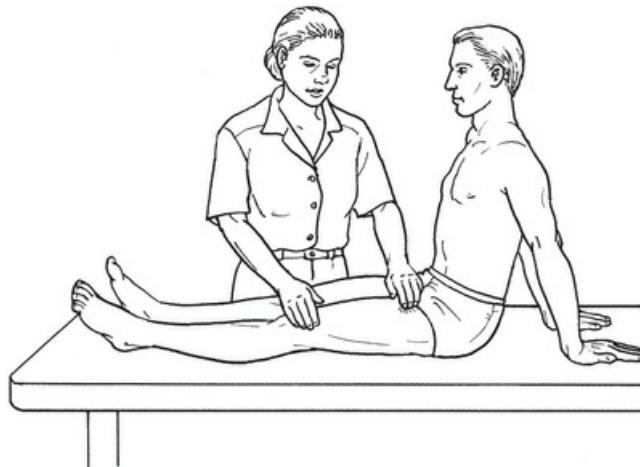


FIGURE 6.51

Test:

Patient attempts to abduct hip.

Instructions to Patient:

"Try to move your leg out to the side."

Grading

Grade 1:

Palpable contraction of tensor fibers but no limb movement.

Grade 0:

No discernable palpable contractile activity.

Hip Adduction

(*Adductors magnus, brevis, and longus; Pectineus and Gracilis*)

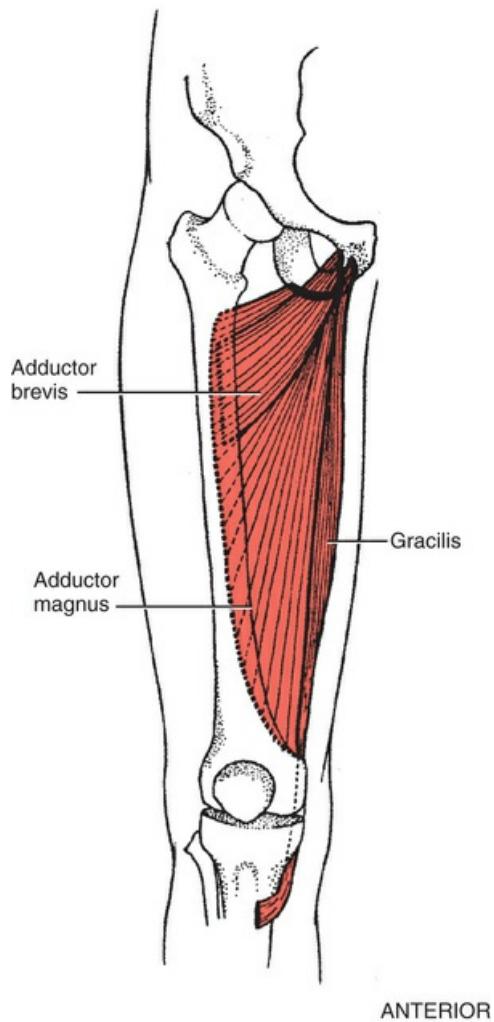


FIGURE 6.52

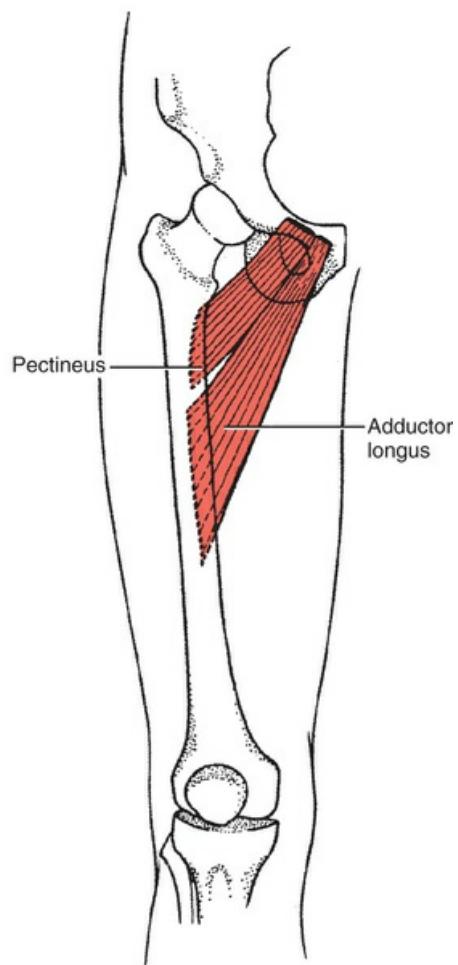


FIGURE 6.53

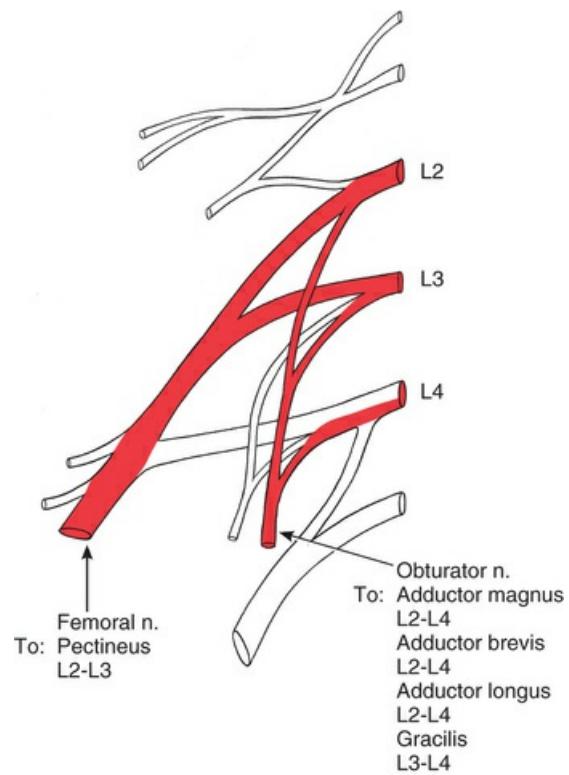


FIGURE 6.54

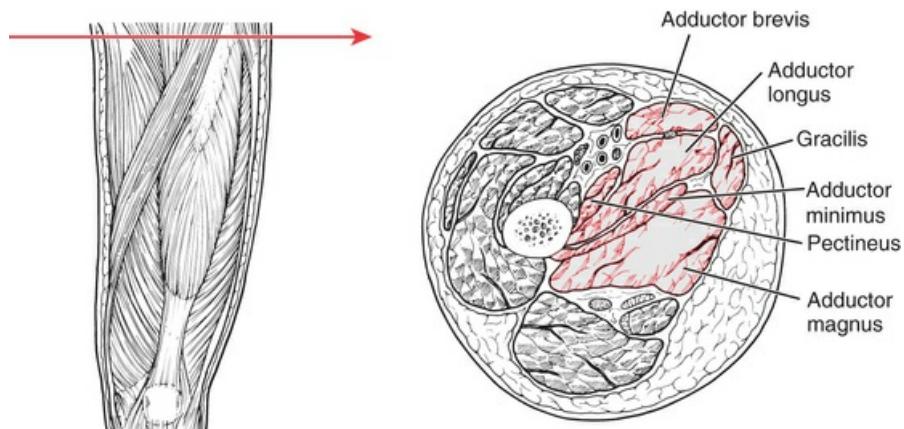


FIGURE 6.55 Arrow indicates level of cross section.

Range of Motion

0°–15°–20°

Table 6.6
HIP ADDUCTION

I.D.	Muscle	Origin	Insertion	Function
181	Adductor magnus	Ischial tuberosity (inferolateral) Ischium (inferior ramus) Pubis (inferior ramus) Fibers from pubic ramus to femur (gluteal)	Femur (linea aspera via aponeurosis, medial supracondylar line, and adductor tubercle on medial condyle)	Hip adduction Hip extension from a position of hip flexion toward extension (inferior fibers) Hip flexion (superior fibers; weak) if the hip is

		tuberosity), often named the <i>Adductor minimus</i>		moving from extension toward flexion ⁵ The role of the adductor magnus in rotation of the hip is dependent on the position of the thigh ¹
180	Adductor brevis	Pubis (body and inferior ramus)	Femur (via aponeurosis to linea aspera)	Hip adduction Hip flexion
179	Adductor longus	Pubis (anterior aspect between crest and symphysis)	Femur (linea aspera via aponeurosis)	Hip adduction Hip flexion (accessory) Hip rotation (depends on position of thigh)
177	Pectenue	Pubic pecten Fascia of pectenue	Femur (on a line from lesser trochanter to linea aspera)	Hip adduction Hip flexion (accessory)
178	Gracilis	Pubis (body and inferior ramus) Ischial ramus	Tibia (medial shaft distal to condyle) Pes anserinus Deep fascia of leg	Hip adduction Knee flexion Internal (medial) rotation of knee (accessory)
<i>Others</i>				
188	Obturator externus			
182	Gluteus maximus (lower)			

The adductor magnus comprises 63% of the mass of adductor volume.¹⁷ The hip adductors are required to work under both closed chain (e.g., in the stance leg, with the axial compression forces from gravity) and open chain (e.g., during kicking). The adductor longus may be more active during open chain activities than the adductor magnus. The adductor magnus is most active in weight-bearing tasks such as sit-to-stand and walking up stairs and during loading and initial contact phases of gait.¹⁸

Grade 5, Grade 4, and Grade 3

Position of Patient:

Side-lying with test limb (lowermost) resting on the table.

Instructions to Therapist:

Stand behind patient at knee level. Support uppermost limb (non-test limb) in 25° of abduction with forearm, the hand supporting the limb on the medial surface of the knee (Fig. 6.56). Alternatively, the upper limb can be placed on a padded stool straddling the test limb and approximately 9 to 12 inches high (not shown). Ask the patient to lift the bottom leg to the uppermost one. If successful, place hand giving resistance on the medial surface of the distal femur of the lower limb, just proximal to the knee joint. Resistance is directed straight downward toward the table (Fig. 6.57).



FIGURE 6.56

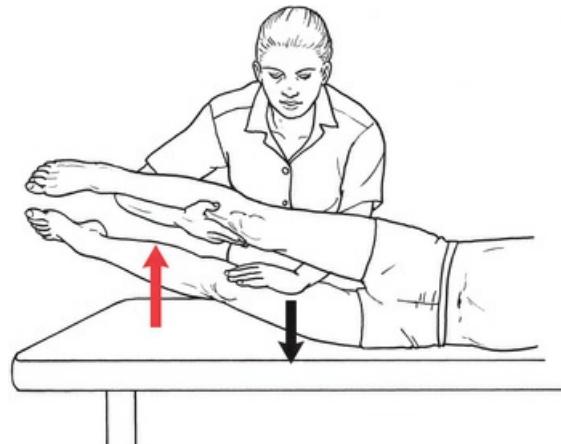


FIGURE 6.57

Test:

Patient adducts hip until the lower limb contacts the upper one.

Instructions to Patient:

"Lift your bottom leg up to your top one. Hold it. Don't let me push it down."
For Grade 3: "Lift your bottom leg up to your top one. Don't let it drop!"

Grading

Grade 5:

Holds test position against maximal resistance.

Grade 4:

Holds test position against strong to moderate resistance.

Grade 3:

Completes full range; holds test position but without resistance ([Fig. 6.58](#)).

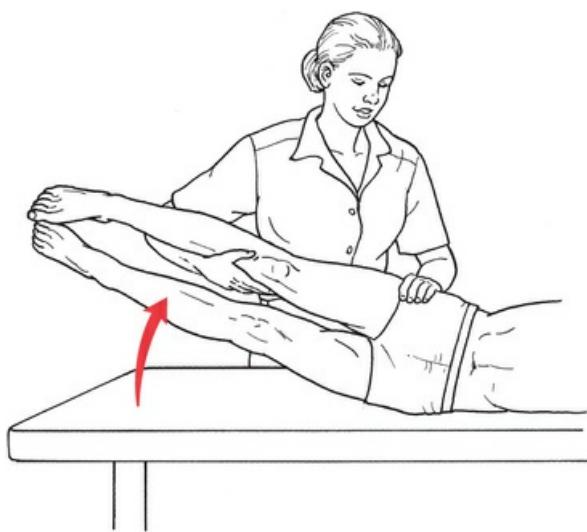


FIGURE 6.58

Grade 2

Position of Patient:

Supine. The non-test limb is positioned in some abduction to prevent interference with motion of the test limb.

Instructions to Therapist:

Stand at side of test limb at knee level. One hand supports the ankle and elevates it slightly from the table surface to decrease friction as the limb moves across the table (Fig. 6.59). The therapist uses this hand neither to assist nor to resist motion. The opposite hand palpates the adductor mass on the inner aspect of the proximal thigh. In the supine test position for Grades 2, 1, and 0, the weight of the opposite limb stabilizes the pelvis, so there is no need for manual stabilization of the non-test hip.

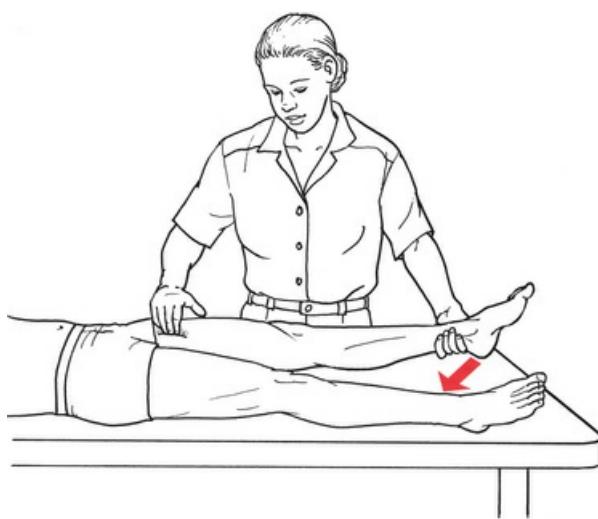


FIGURE 6.59

Test:

Patient adducts hip without rotation. Toes stay pointed toward the ceiling.

Instructions to Patient:

"Bring your leg in toward the other one."

Grading**Grade 2:**

Patient adducts limb through full range with gravity minimized.

Grade 1 and Grade 0**Position of Patient:**

Supine.

Instructions to Therapist:

Stand on side of test limb. One hand supports the limb under the ankle. The other hand palpates the adductor mass on the proximal medial thigh (Fig. 6.60).



FIGURE 6.60

Test:

Patient attempts to adduct hip.

Instructions to Patient:

"Try to bring your leg in."

Grading

Grade 1:

Palpable contraction, no limb movement.

Grade 0:

No discernable palpable contraction.

Substitution

Hip flexor substitution: The patient may attempt to substitute the hip flexors for the adductors by internally rotating the hip (Fig. 6.61). The patient will appear to be trying to turn supine from side-lying. Maintenance of true side-lying is necessary for an accurate test.



FIGURE 6.61

Helpful Hints

- Greater atrophy of the adductor magnus muscle occurs with bed rest, alluding to its function as a hip stabilizer.¹⁸
- The adductor muscles produce an extensor torque when the hip is markedly flexed, assisting the primary hip extensors. When the hip is flexed, the adductors augment the other extensor muscles.⁵ As an example, when runners were permitted to use foot blocks in the Olympics during the 1930s (or dig a trough to permit a crouch position), times for the 100 m race were notably reduced as the adductors contributed explosive force to bring the femur from flexion toward extension.

Suggested Exercises for Hip Adductors

- Ball squeeze with hip in neutral (long lever)¹⁹
- Copenhagen exercise²⁰
- Side-lying hip adduction

Suggested Exercise for Pectineus

- Supine hip flexion²¹

Hip External Rotation

(*Obturators internus and externus, Gemelli superior and inferior, Piriformis, Quadratus femoris, Gluteus maximus [posterior]*)

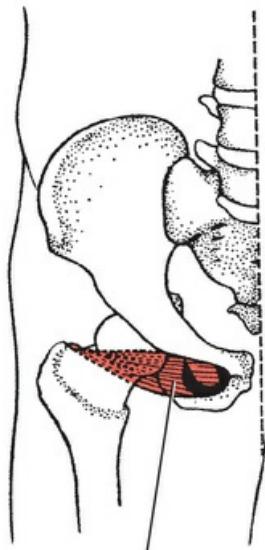


FIGURE 6.62

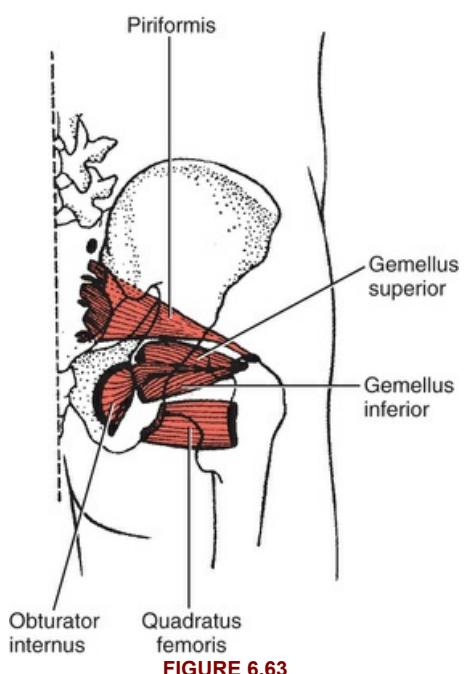


FIGURE 6.63

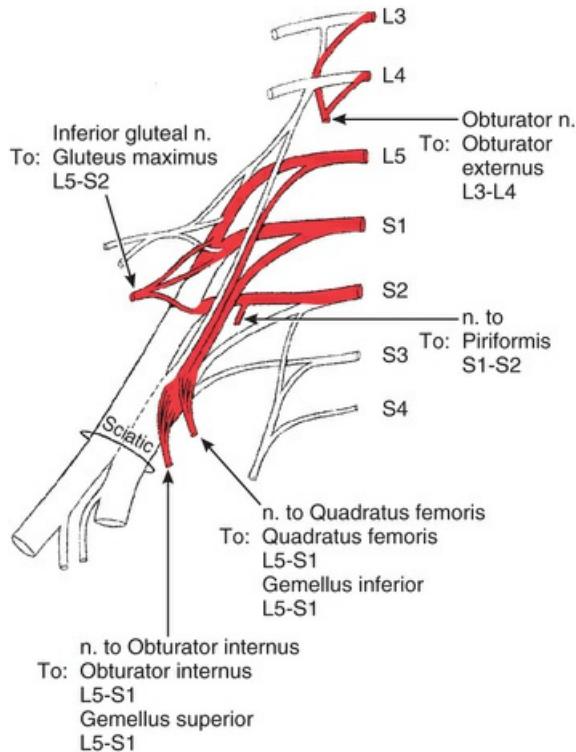


FIGURE 6.64

Range of Motion

0°–35°²²

Table 6.7
HIP EXTERNAL ROTATION

L.D.	Muscle	Origin	Insertion	Function
188	Obturator externus	Obturator membrane (external surface) Ischium (ramus) Pubis (inferior ramus) Pelvis (lesser pelvic cavity, inner surface)	Femur (trochanteric fossa)	Hip external (lateral) rotation Hip adduction (assist)
187	Obturator internus	Pubis (inferior ramus) Ischium (ramus) Obturator fascia Obturator foramen (margin) Obturator membrane Upper brim of greater sciatic foramen	Femur (greater trochanter, medial) Tendon fuses with gemelli	Hip external (lateral) rotation Abduction of flexed hip (assist)
191	Quadratus femoris (may be absent)	Ischial tuberosity (external aspect)	Femur (quadrate tubercle on trochanteric crest)	Hip external (lateral) rotation
186	Piriformis	Sacrum (anterior surface) Ilium (gluteal surface near posterior inferior iliac spine) Sacrotuberous ligament Capsule of sacroiliac joint	Femur (greater trochanter, medial side)	Hip external (lateral) rotation Abducts the flexed hip (assist) (muscle probably too small to do much of this)
189	Gemellus superior (may be absent)	Ischium (spine, dorsal surface)	Femur (greater trochanter, medial surface) Blends with tendon of obturator internus	Hip external (lateral) rotation Hip abduction with hip flexed (accessory)
190	Gemellus inferior	Ischial tuberosity (upper part)	Femur (greater trochanter, medial surface) Blends with tendon of obturator internus	
182	Gluteus maximus Posterior fibers	Ilium (posterior gluteal line and crest) Sacrum (dorsal and lower aspects) Coccyx (side) Sacrotuberous ligament Aponeurosis over gluteus medius	Femur (gluteal tuberosity) Iliotibial tract of fascia lata	Hip external (lateral) rotation Hip abduction with hip flexed (weak assist)
<i>Others</i>				
195	Sartorius			
192	Biceps femoris (long head)			
183	Gluteus medius (posterior)			
174	Psoas major			
181	Adductor magnus (position-dependent)			
179	Adductor longus			
202	Popliteus (tibia fixed)			

The gluteus maximus is potentially the most powerful external rotator of the hip, depending on its line of force.²³

Grade 5, Grade 4, Grade 3, and Grade 2

Position of Patient:

Short sitting with thighs fully supported on table and legs hanging over the edge. (Trunk may be supported by placing hands flat or fisted at sides of chair or table [[Fig. 6.65](#)].)

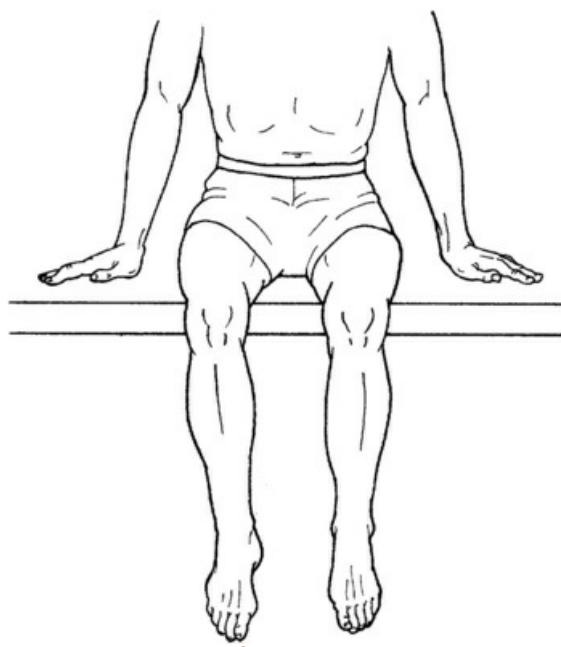


FIGURE 6.65

Instructions to Therapist:

Sit on a low stool or kneel beside limb to be tested. Ask the patient to turn the leg in. If sufficient range is present, position leg in mid position between internal and external rotation. Place the hand providing resistance on the medial aspect of the ankle just above the malleolus ([Fig. 6.66](#)). The other hand, which will offer counter-pressure, is contoured over the lateral aspect of the distal thigh just above the knee. Stabilization is provided in a medially directed force at the knee counteracting the resistance provided at the ankle. The two forces are applied in counter-directions for this rotary motion (see [Fig. 6.66](#)).

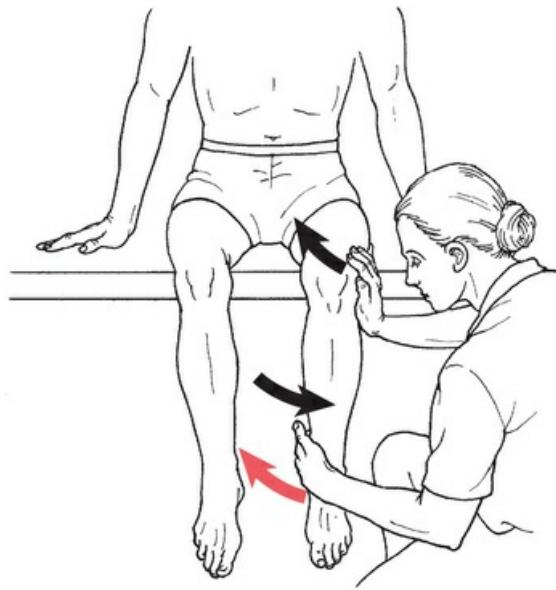


FIGURE 6.66

Test:

Patient externally rotates the hip.

Instructions to Patient:

"Don't let me turn your leg out."

Grading

Grade 5:

Holds test position in midrange against maximal resistance.

Grade 4:

Holds test position in midrange against strong to moderate resistance.

Grade 3:

Able to complete full range of motion with mild to no resistance (this is a gravity-eliminated position, so if the patient is able to exert mild resistance, grade the effort a 3) ([Fig. 6.67](#)).

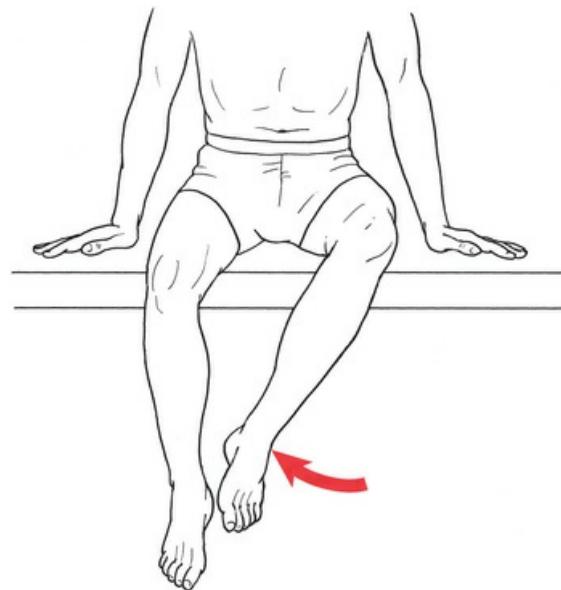


FIGURE 6.67

Grade 2:

Completes full range of motion without resistance (this is a gravity-minimized position). Care needs to be taken to ensure that gravity is not the predominant force.

Grade 2 Alternate Test (if Patient Cannot Sit)

Position of Patient:

Supine. Test limb is in internal rotation.

Instructions to Therapist:

Stand at side of limb to be tested. The therapist may need to support the limb in internal rotation because gravity tends to pull the limb into external rotation.

Test:

Patient externally rotates hip in available range of motion ([Fig. 6.68](#)). One hand may be used to maintain pelvic alignment at lateral hip.

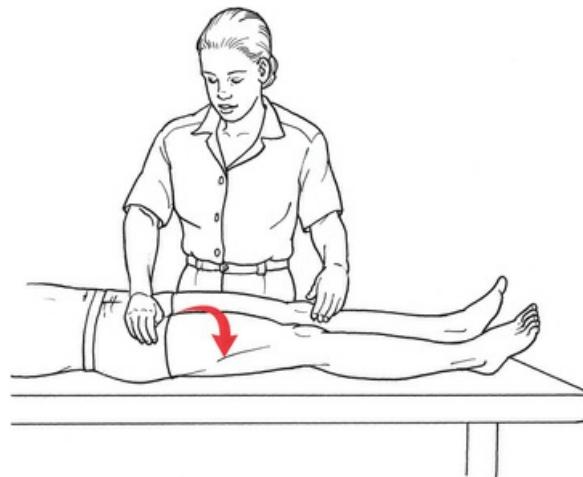


FIGURE 6.68

Instructions to Patient:

"Roll your leg out."

Grading

Grade 2:

Completes external rotation range of motion. As the hip rolls past the midline, minimal resistance can be offered to offset the assistance of gravity.

Grade 1 and Grade 0

Position of Patient:

Supine with test limb placed in internal rotation.

Instructions to Therapist:

Stand at side of limb to be tested.

Test:

Patient attempts to externally rotate hip.

Instructions to Patient:

"Try to roll your leg out."

Grading

Grade 1 and Grade 0:

The external rotator muscles, except for the gluteus maximus, are not palpable. If there is any discernable movement (contractile activity), a grade of 1 should be given; otherwise, a grade of 0 is assigned on the principle that whenever uncertainty exists, the lesser grade should be awarded.

Helpful Hints

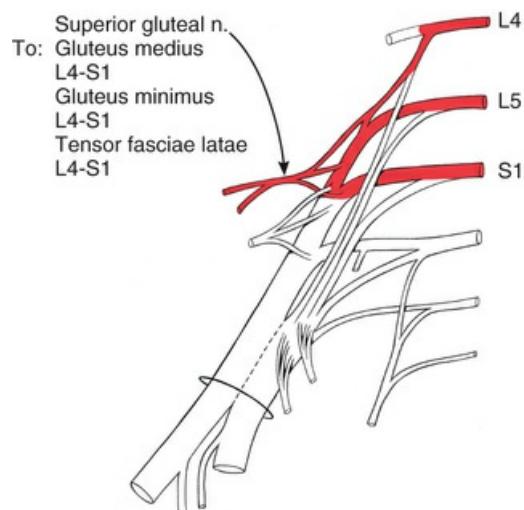
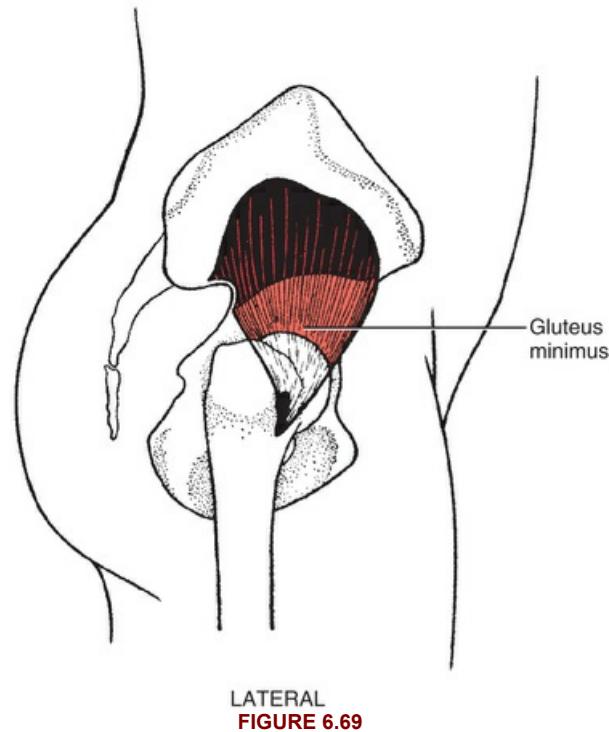
- There is wide variation in the amount of hip external rotation range that can be considered normal. It is imperative therefore that a patient's accurate range (in each test position) be known before manual muscle testing takes place. Muscles that are lengthened often test weak, which is why testing in the mid position between ER and IR is recommended.²⁴
- There is greater range of rotation at the hip when the hip is flexed than when it is extended, probably secondary to laxity of hip joint structures.
- In short-sitting tests, the patient should *not* be allowed to use the following motions, lest they add visual distortion and confound the test results:
 - a. Lift the contralateral buttock off the table or lean in any direction to lift the pelvis;
 - b. Increase flexion of the test knee;
 - c. Abduct the test hip.

Suggested Exercises for Hip External Rotation

- Clamshell exercise against resistance
- Seated external rotation against pulley

Hip Internal Rotation

(Glutei minimus and medius; Tensor fasciae latae)



Range of Motion

0°–40°²²

Table 6.8
HIP INTERNAL ROTATION

I.D.	Muscle	Origin	Insertion	Function
184	Gluteus minimus (anterior fibers)	Ilium (outer surface between anterior and inferior gluteal lines) Greater sciatic notch	Femur (greater trochanter, anterior aspect) Fibrous capsule of hip joint	Hip abduction Hip internal (medial) rotation
185	Tensor fasciae latae	Iliac crest (outer lip) Fascia lata (deep) Anterior superior iliac spine (lateral surface)	Iliotibial tract (between its two layers ending down femur)	X ₃ Hip flexion Hip internal (medial) rotation
183	Gluteus medius (anterior fibers)	Ilium (outer surface between crest and posterior gluteal line) Gluteal fascia	Femur (greater trochanter, lateral surface)	Internal with hip flexion ²³
<i>Others</i>	Gluteus maximus (anterior fibers)			Internal rotator with hip flexed to 90°
193	Semitendinosus			
194	Semimembranosus			
181	Adductor magnus (position-dependent)			
179	Adductor longus (position-dependent)			

Muscular imbalance, such as relative increased internal rotation and weakness of the abductors, external rotators, and hip extensors, often plays a role in biomechanical alignment at the knee.⁵ Therefore it is critical to consider the role of strength at the hip when knee pain or dysfunction is present.

Grade 5, Grade 4, Grade 3, and Grade 2

Position of Patient:

Short sitting with thighs fully supported on table and legs hanging over the edge. (Trunk may be supported by placing hands flat or fisted at sides.)

Instructions to Therapist:

Sit or kneel in front of patient. Ask the patient to move leg out, away from the other leg while maintaining hip stabilization. If sufficient range is present, position leg in mid position between internal and external rotation. Place the hand providing resistance on the lateral surface of the ankle just above the malleolus (Fig. 6.71). The other hand, which offers counter-pressure, is contoured over the medial surface of the distal thigh just above the knee. Stabilization is provided in a medially directed force at the knee counteracting the lateral resistance provided at the ankle. Give resistance in a medially directed force at the ankle.



FIGURE 6.71

Test:

The limb should be placed in mid-range of hip rotation for best results (see Fig. 6.69).²⁴

Grading

Grade 5:

Holds test position against maximal resistance.

Grade 4:

Holds test position against strong to moderate resistance.

Grade 3:

Able to complete full range of motion with mild to no resistance (this is a gravity-eliminated position, so if the patient is able to exert mild resistance, grade the effort a 3) ([Fig. 6.72](#)).

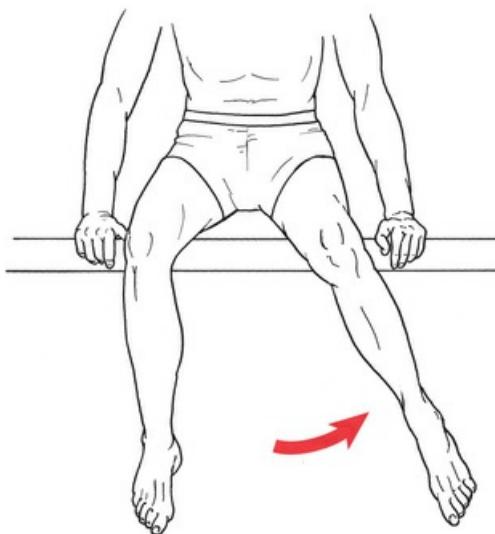


FIGURE 6.72

Grade 2:

Able to complete full range of motion but cannot tolerate resistance (this is a gravity-minimized position). Care needs to be taken to ensure that gravity is not the predominant force.

Alternate Grade 2 for the Patient Who Cannot Sit

Position of Patient:

Supine. Test limb in partial external rotation.

Instructions to Therapist:

Stand next to test leg. Palpate the gluteus medius proximal to the greater trochanter and the tensor fasciae latae ([Fig. 6.73](#)) over the anterolateral hip below the ASIS.

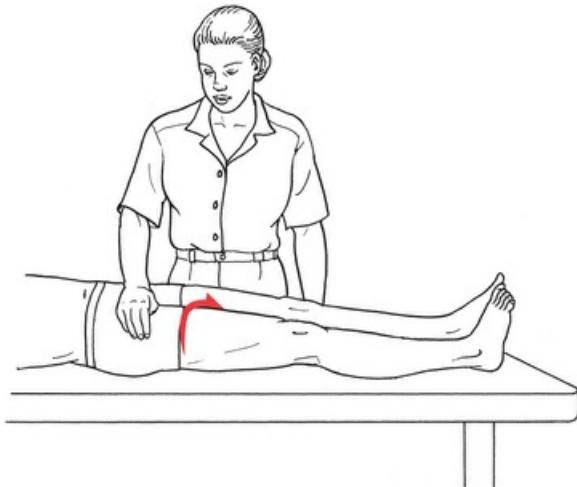


FIGURE 6.73

Test:

Patient internally rotates hip through available range.

Instructions to Patient:

"Roll your leg in toward the other one."

Grading

Grade 2:

Holds test position. As the hip rolls inward past the midline, minimal resistance can be offered to offset the assistance of gravity.

Grade 1 and Grade 0

Position of Patient:

Patient supine with test limb placed in external rotation.

Instructions to Therapist:

Stand next to test leg.

Test:

Patient attempts to internally rotate hip. One hand is used to palpate the gluteus medius (over the posterolateral surface of the hip above the greater trochanter). The other hand is used to palpate the tensor fasciae latae (on the anterolateral surface of the hip below the ASIS).

Instructions to Patient:

"Try to roll your leg in."

Grading

Grade 1:

Palpable contractile activity in either or both muscles.

Grade 0:

No discernable contractile activity.

Helpful Hints

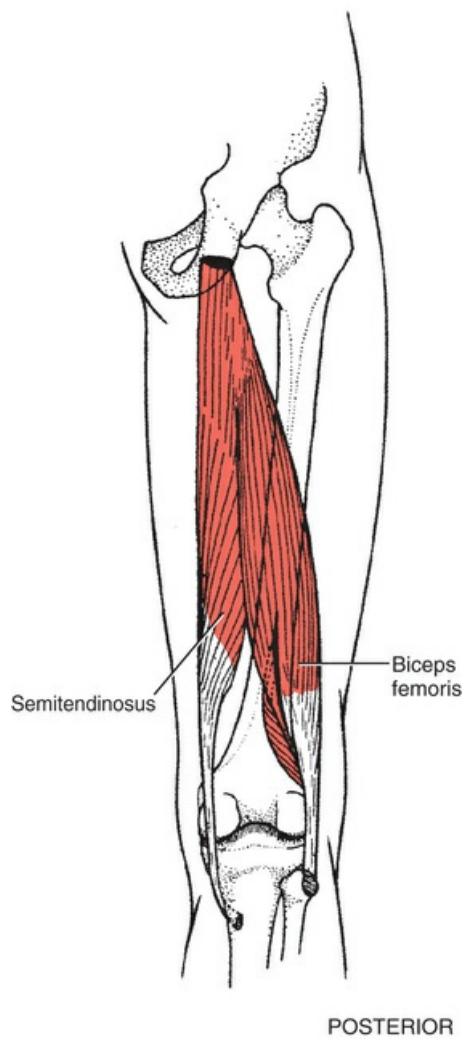
- The patient should neither be allowed to extend the knee nor adduct and extend the hip during performance of the test. These motions contaminate the test by offering visual distortion to the therapist.
- There is greater range of rotation at the hip when the hip is flexed than when it is extended, probably secondary to laxity of hip joint structures.
- In short-sitting tests, the patient should *not* be allowed to use the following motions, lest they add visual distortion and confound the test results:
 - a. Lift the contralateral buttock off the table or lean in any direction to lift the pelvis;
 - b. Increase flexion of the test knee;
 - c. Adduct the test hip.

Suggested Exercises for Hip Internal Rotation²⁵

- Prone isometric with knee in 90° of flexion (can use opposite leg for resistance)
- Reverse clams

Knee Flexion

(All hamstring muscles)



POSTERIOR
FIGURE 6.74

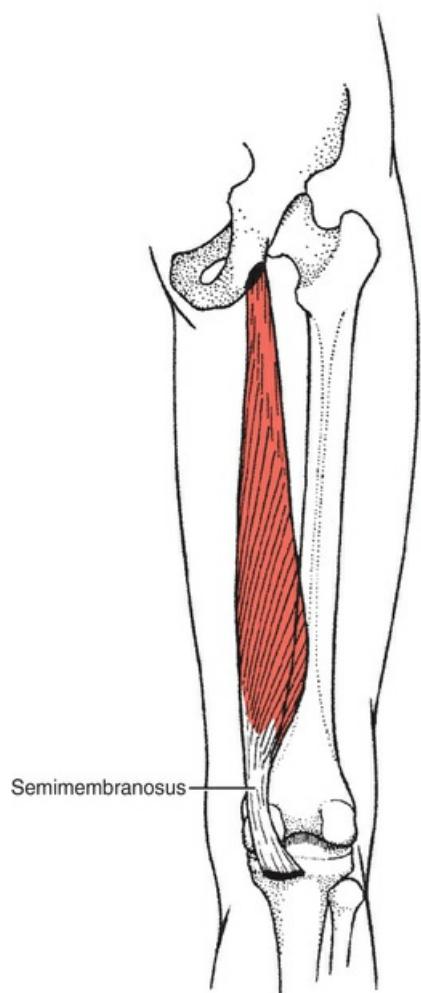


FIGURE 6.75

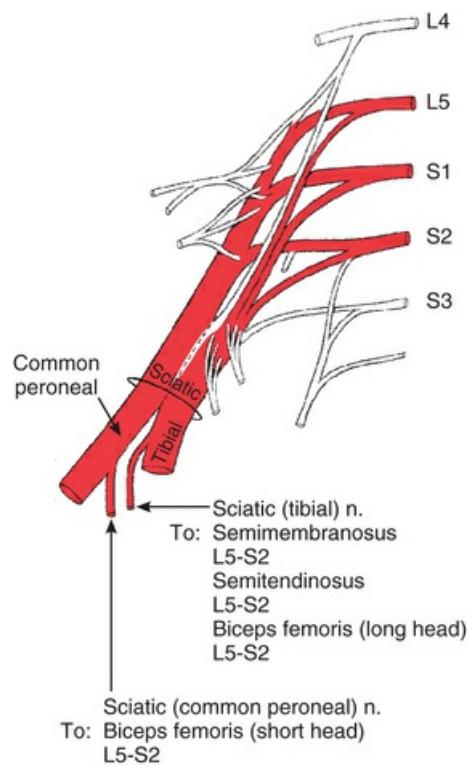


FIGURE 6.76

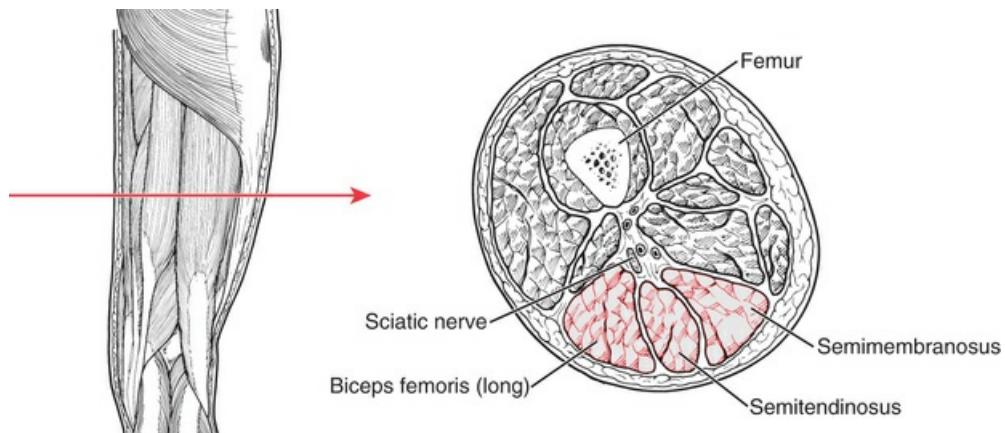


FIGURE 6.77 Arrow indicates level of cross section.

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)	Aponeurosis (posterior)	Hip extension and external rotation (long

		Sacrotuberous ligament	Fibula (head, lateral aspect) Fibular collateral ligament	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

Grade 5, Grade 4, and Grade 3

There are three basic muscle tests for the hamstrings at Grades 5 and 4. The therapist should test first for the aggregate of the three hamstring muscles (with the foot in midline). Only if there is deviation (or asymmetry) in the movement or a question in the therapist's mind is there a need to test the medial and lateral hamstrings separately. The hamstrings are two joint muscles, and should be tested in mid-range.

Hamstring Muscles in Aggregate

Position of Patient:

Prone with legs straight and toes hanging over the edge of the table. A towel roll placed just above the knee may make this position more comfortable (not shown in [Figure 6.78](#)).

Instructions to Therapist:

Stand next to limb to be tested. Ask the patient to flex the knee as far as possible. Observe possible tightness in the rectus femoris that may be indicated by limited knee flexion or the hip flexing. If sufficient range is present, place limb in about 45° of knee flexion (mid-range). Hand provides resistance on posterior surface of the leg just above the ankle ([Fig. 6.78](#)). The other hand provides stabilization over the hamstring tendons on the posterior thigh (optional). Firm pressure with the stabilizing hand may offset any cramping of the hamstring muscles. Resistance is applied in the direction of knee extension for Grades 5 and 4.

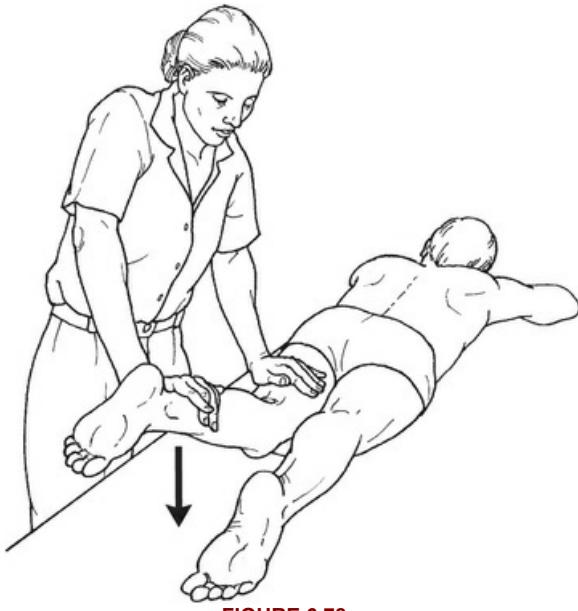


FIGURE 6.78

Test:

Patient holds knee in 45° of knee flexion while maintaining leg in neutral rotation.

Instructions to Patient:

"Hold it! Don't let me straighten it."

Medial Hamstring Test (Semitendinosus and Semimembranosus)

Position of Patient:

Prone with knee flexed to 45°. Leg in internal rotation (toes pointing toward midline).

Instructions to Therapist:

Therapist resists knee flexion at the ankle using a downward and outward force ([Figure 6.79](#)).



FIGURE 6.79

Test:

Patient flexes knee, maintaining the leg in internal rotation (heel toward therapist, toes pointing toward midline).

Lateral Hamstring Test (Biceps Femoris)

Position of Patient:

Prone with knee flexed to 45°. Leg is in external rotation (toes pointing laterally).

Instructions to Therapist:

Therapist resists knee flexion at the ankle using a downward and inward force ([Fig. 6.80](#)).



FIGURE 6.80

Test:

Patient flexes knee, maintaining leg in external rotation (heel away from therapist, toes pointing toward therapist) (see [Fig. 6.78](#)).

Grading the Hamstring Muscles (Grade 5, Grade 4, and Grade 3)

Grade 5 for All Three Tests:

Patient holds test position against maximal resistance.

Grade 4 for All Three Tests:

Holds test position against strong to moderate resistance.

Grade 3 for All Three Tests:

Patient completes full range of motion without external resistance ([Fig. 6.81](#)).

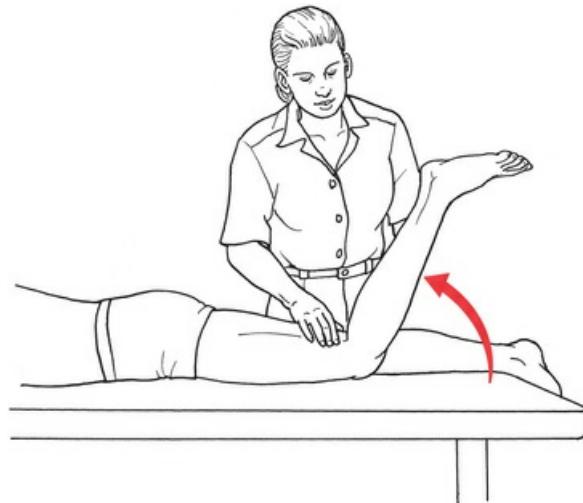


FIGURE 6.81

Grade 2

Position of Patient:

Side-lying with test limb (uppermost limb) supported by therapist or resting on suitable height stool. Lower limb flexed for stability.

Instructions to Therapist:

Stand behind patient at knee level. One arm is used to cradle thigh, providing hand support at medial side of knee. Other hand supports the leg at the ankle just above the malleolus ([Fig. 6.82](#)).

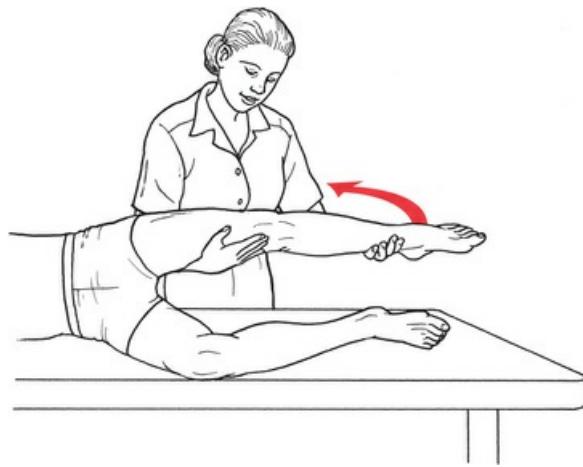


FIGURE 6.82

Test:

Patient flexes knee through available range of motion.

Instructions to Patient:

"Bend your knee."

Grading

Grade 2:

Completes available range of motion in side-lying position, with gravity minimized.

Grade 1 and Grade 0

Position of Patient:

Prone. Limbs are straight with toes extending over end of table. Knee is partially flexed and supported at ankle by therapist.

Instructions to Therapist:

Stand next to test limb at knee level. (Therapist shown on opposite side to avoid obscuring test position.) One hand supports the flexed limb at the ankle ([Fig. 6.83](#)). The opposite hand palpates both the medial and the lateral hamstring tendons just above the posterior knee.



FIGURE 6.83

Test:

Patient attempts to flex knee.

Instructions to Patient:

"Try to bend your knee."

Grading

Grade 1:

Tendons become prominent, but no visible movement occurs.

Grade 0:

No discernable contraction of the muscles; tendons do not stand out.

Substitutions

- Hip flexion substitution: The prone patient may flex the hip to start knee flexion. The buttock on the test side will rise as the hip flexes, and the patient may appear to roll slightly toward supine ([Fig. 6.84](#)).

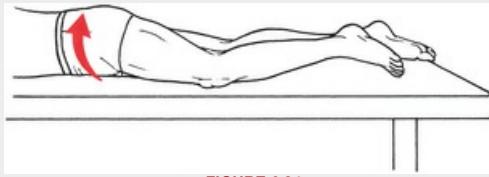


FIGURE 6.84

- Gastrocnemius substitution: Do not permit the patient to strongly dorsiflex in an attempt to use the tenodesis effect of the gastrocnemius.

Helpful Hints

- If the biceps femoris is stronger than the medial hamstrings, the leg will externally rotate during knee flexion. Similarly, if the semitendinosus and semimembranosus are the stronger components, the leg will internally rotate during knee flexion. This is the situation that, when observed, indicates asymmetry and the need to test the medial and lateral hamstrings separately.
- If the hip flexes at the end of the knee flexion range of motion, check for a tight rectus femoris muscle because this tightness will limit the range of knee motion.
- The optimum quadriceps to hamstring strength ratio of 1 : 1 has been proposed as a rehabilitation goal in many types of knee injuries, especially the anterior cruciate ligament deficient and repaired knee.

Suggested Exercises for Hamstrings

- Single-leg deadlifts
- Slide leg curl²⁶
- Good mornings with at least 25% body weight²⁷
- Nordic hamstring exercise
- Eccentric leg curls

Knee Extension

(*Quadriceps femoris*)

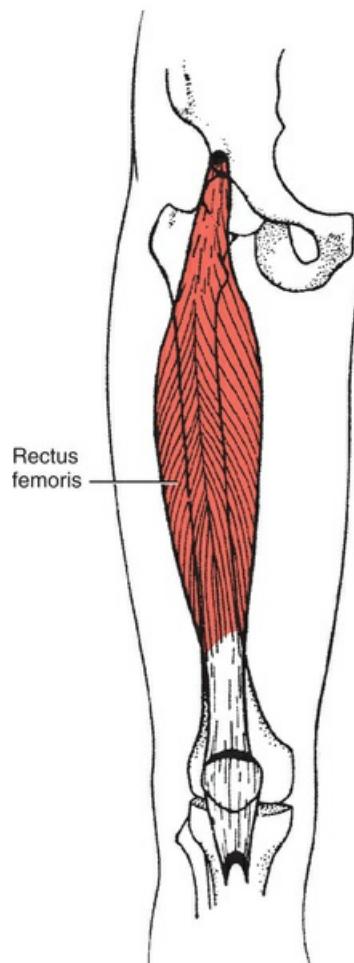
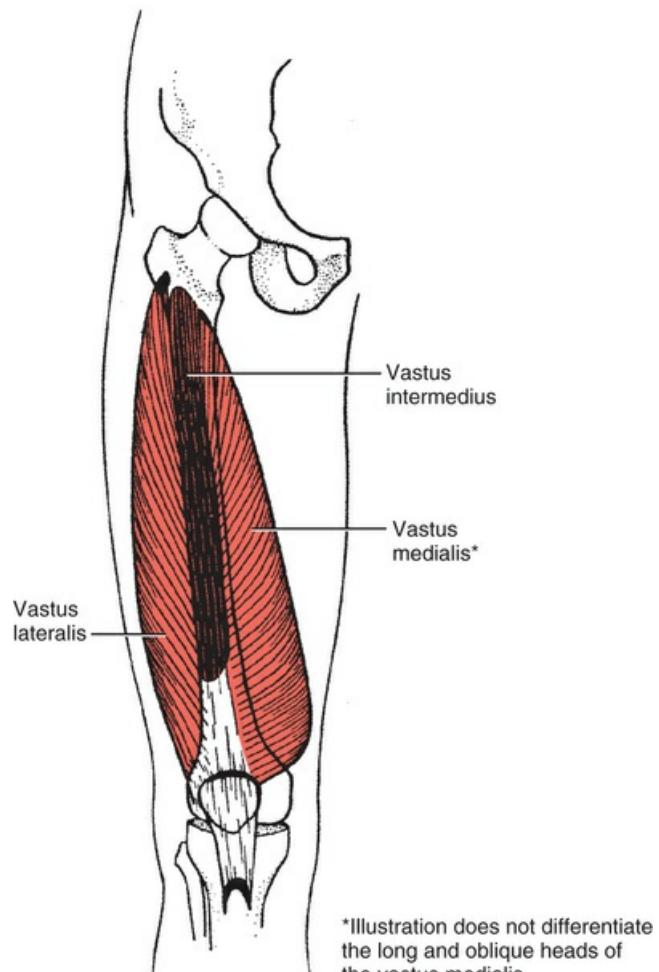


FIGURE 6.85



ANTERIOR

FIGURE 6.86

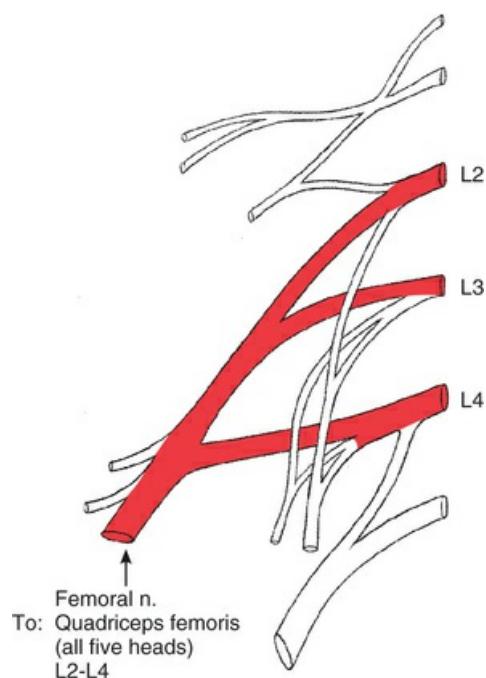


FIGURE 6.87

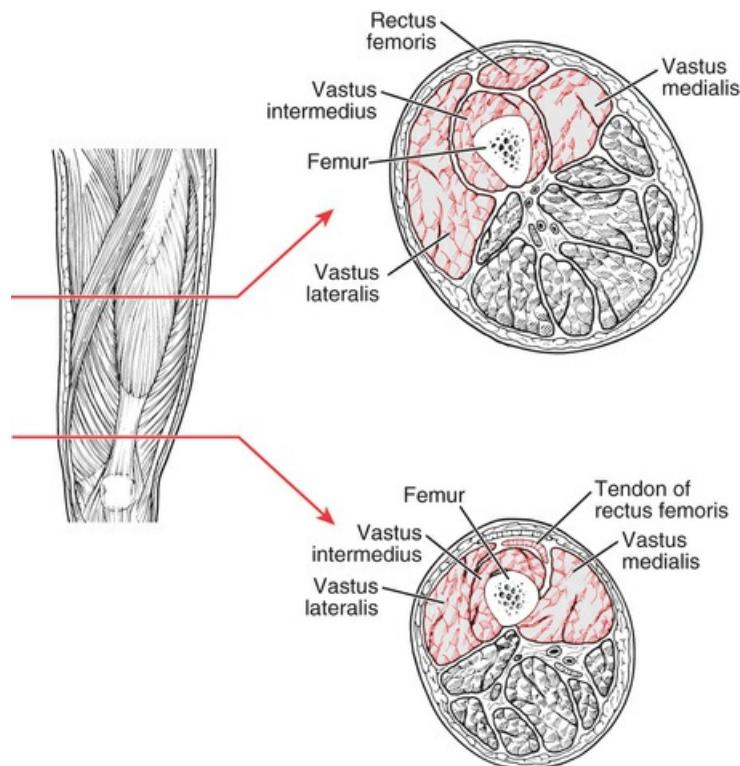


FIGURE 6.88 Arrows indicate level of cross section.

Range of Motion

135° to -2°²²

Table 6.10
KNEE EXTENSION

I.D.	Muscle	Origin	Insertion	Function
196	Rectus femoris	Ilium (anterior inferior iliac spine) Acetabulum (groove above) Capsule of hip joint Aponeurosis (anterior)	Aponeurosis (posterior) Patella (base via quadriceps tendon) Tibial tuberosity via ligamentum patellae	Hip flexion (by rectus femoris, which crosses the hip joint)
198	Vastus intermedius	Femur (shaft, upper $\frac{2}{3}$ lateral and anterior surfaces) Intermuscular septum (lateral)	Aponeurosis (anterior forming deep quadriceps tendon) Patella (base, lateral aspect) Tibia (lateral condyle) Tibial tuberosity via ligamentum patellae	Knee extension (none of the heads functions independently)
197	Vastus lateralis	Femur Linea aspera (lateral lip) Greater trochanter (inferior) Intertrochanteric line (via aponeurosis) Gluteal tuberosity (lateral lip) Lateral intermuscular septum	Aponeurosis (deep surface, distal) Patella (base and lateral border via quadriceps tendon) Lateral expansion to capsule of knee joint and iliotibial tract Tibial tuberosity via ligamentum patellae	Knee extension (none of the heads functions independently)
199	Vastus medialis longus (two parts)	Femur (linea aspera, medial lip; intertrochanteric line) Origin of vastus medialis oblique Tendon of adductor magnus Intermuscular septum (medial)	Aponeurosis (deep) Patella (medial border) Tibial tuberosity via ligamentum patellae	Knee extension (none of the heads functions independently)
200	Vastus medialis oblique (considered part of the vastus medialis) (see Fig. 6.86)	Femur: linea aspera (distal); supracondylar line Tendon of adductor magnus Intermuscular septum	Aponeurosis to capsule of knee joint Patella (medial aspect) Quadriceps tendon (medial) Tibial tuberosity via ligamentum patellae	Knee extension (none of the heads functions independently)

The quadriceps femoris muscles are tested together as a functional group. None of the four muscle heads can be separated from any other by manual muscle testing. The rectus femoris may be

partially isolated from the other quadriceps during a hip flexion test. At one time, the vastus medialis was thought to be activated during the terminal 15° of knee extension; however this has been conclusively disproven.²⁸⁻³⁰

Knowledge of the patient's knee flexion range of motion is useful before conducting tests for knee extension strength, because tight (shortened) hamstrings will limit knee extension. The shorter the hamstrings, the greater the backward trunk lean in short sitting.

A combined force of 1.1 N·m·kg⁻¹ is the minimum strength threshold of the knee extensors required for walking.³ Knee extensor strength contributes to maximum walking speed; however strength greater than a combined knee extensor force of 2.3 N·m·kg⁻¹ is considered reserve and does not further increase maximum walking speed.

Grade 5, Grade 4, and Grade 3

Position of Patient:

Short sitting. Place a towel roll under the patient's distal thigh for comfort. The patient's hands rest on the table on either side of the body for stability or may grasp the table edge. The patient should be allowed to lean backward slightly to relieve hamstring muscle tension. Do not allow the patient to hyperextend the knee because this may lock the knee into position, thus masking weakness.

Instructions to Therapist:

Stand at side of limb to be tested. Ask the patient to straighten the knee. If sufficient range is present, position the knee in approximately 15° of knee flexion. Place the palm of the hand providing resistance over the anterior surface of the distal leg just above the ankle, using a straight arm technique because of the potential strength of these muscles. For Grades 5 and 4, resistance is applied in a downward direction toward the floor (Fig. 6.89).

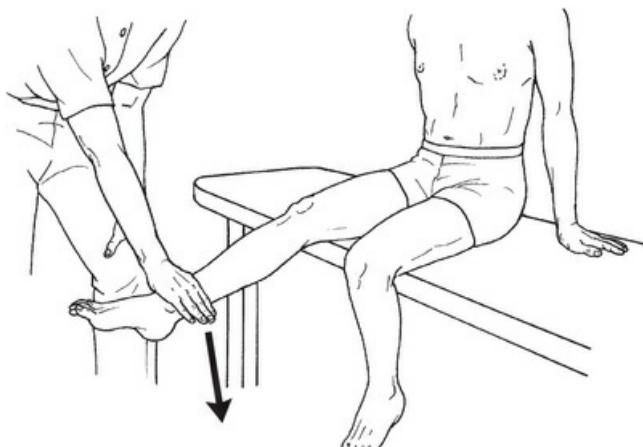


FIGURE 6.89

Test:

Patient extends knee through available range of motion but not beyond 0°.

Instructions to Patient:

"Hold it! Don't let me bend it."

Helpful Hint

To prevent the patient's pelvis from rising (a common occurrence in a Grade 4 or 5 test), the patient may be secured to the testing surface by a belt or strap (not shown).

Grading

Grade 5:

Holds test position against maximal resistance. The therapist should not be able to break the Grade 5 knee extensors.

Grade 4:

Holds test position against strong to moderate resistance.

Grade 3:

Completes available range, including the last 15° ([Fig. 6.90](#)).

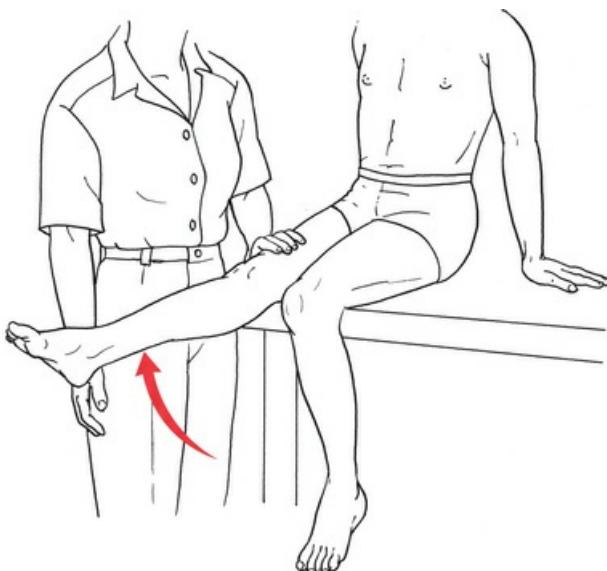


FIGURE 6.90

Grade 2

Position of Patient:

Side-lying with test limb uppermost. Lowermost limb may be flexed for stability. Limb to be tested is held in about 90° of knee flexion. The hip should be in full extension.

Instructions to Therapist:

Stand behind patient at knee level. One arm cradles the test limb around the thigh with the hand supporting the underside of the knee ([Fig. 6.91](#)); alternatively, the test limb may be placed on a powder board. The other hand holds the leg just above the malleolus.

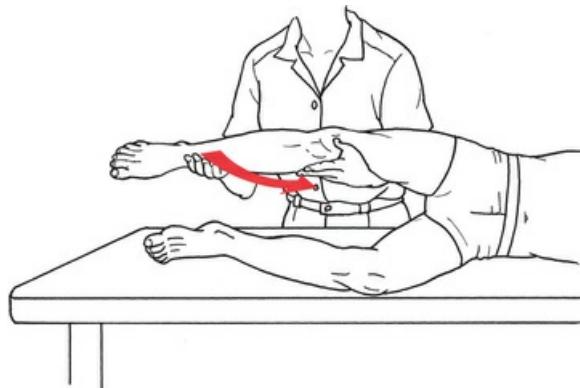


FIGURE 6.91

Test:

Patient extends knee through the available range of motion. The therapist supporting the limb provides neither assistance nor resistance to the patient's voluntary movement.

Instructions to Patient:

"Straighten your knee."

Grading

Grade 2:

Completes available range of motion.

Grade 1 and Grade 0

Position of Patient:

Supine.

Instructions to Therapist:

Stand next to limb to be tested at knee level. Hand used for palpation should be on the quadriceps tendon just above the knee with the tendon "held" gently between the thumb and fingers. The therapist also may want to palpate the patellar tendon just below the knee ([Fig. 6.92](#)).



FIGURE 6.92

Test:

Patient attempts to extend knee.

As an alternate test, the therapist may place one hand under the slightly flexed knee; palpate either the quadriceps or the patellar tendon while the patient tries to extend the knee.

Instructions to Patient:

"Push the back of your knee down into the table." OR "Tighten your kneecap" (quadriceps setting).

For Alternate Test:

"Push the back of your knee down into my hand."

Grading

Grade 1:

Contractile activity can be palpated in muscle through the tendon. No joint movement occurs.

Grade 0:

No discernable contractile activity.

Substitution

When the patient is side-lying (as in the Grade 2 test), he or she may use the hip internal rotators to substitute for the quadriceps, thereby allowing the knee to fall into extension.

Helpful Hints

- To assess functional strength, the quadriceps can be tested by a chair stand test (see description in [Chapter 8, page 334](#)) where strength equal to half the body weight is needed to rise from a chair unassisted (no arm use).³¹
- In stair descent, the forces transmitted through the knee are equal to nearly 3×/body weight,^{32,33} necessitating a greater magnitude of strength than can be detected in a manual muscle test.
- To avoid over-grading the quadriceps, quantitative methods can be used such as hand-held muscle dynamometry ([Chapter 9](#)) or a 1-repetition maximum leg press (see [Chapter 7](#)). These tests have age- and sex-appropriate norms.

Suggested Exercises for Quadriceps

- Squats (knee angle and hip position will selectively recruit different quad muscles)
- Back squats
- Split squats
- Single-leg press
- Lunges

Ankle Plantar Flexion

(Gastrocnemius and Soleus)

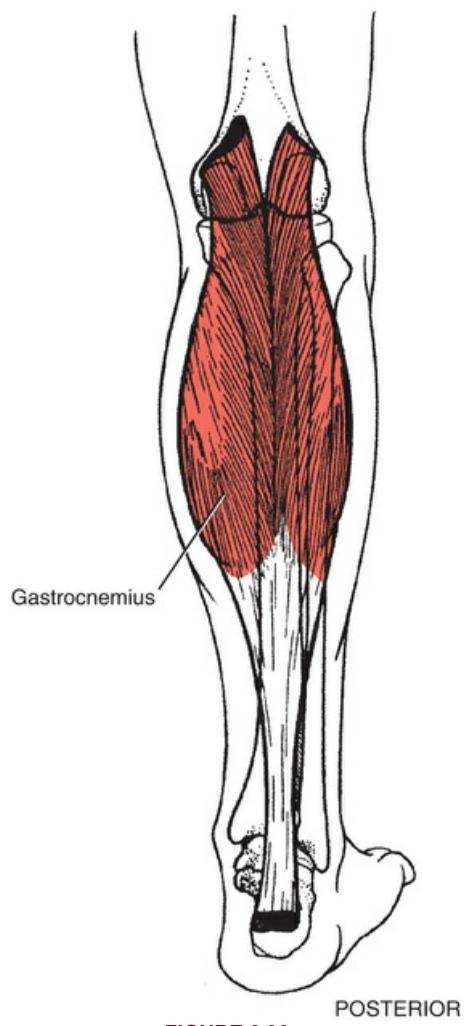


FIGURE 6.93

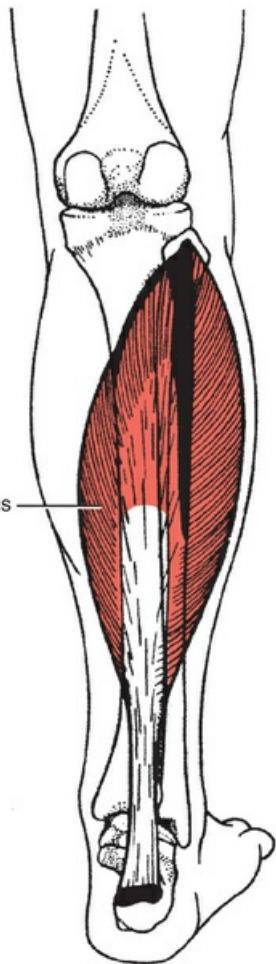


FIGURE 6.94

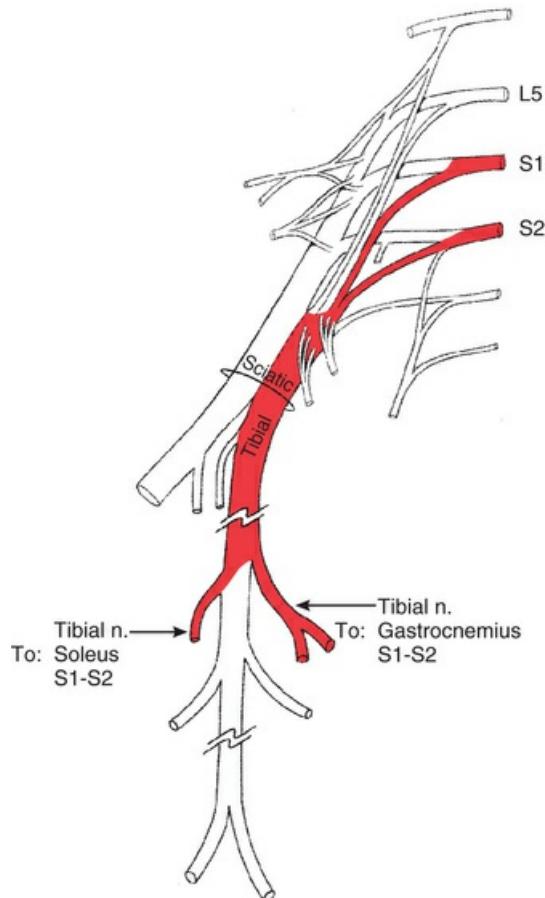


FIGURE 6.95

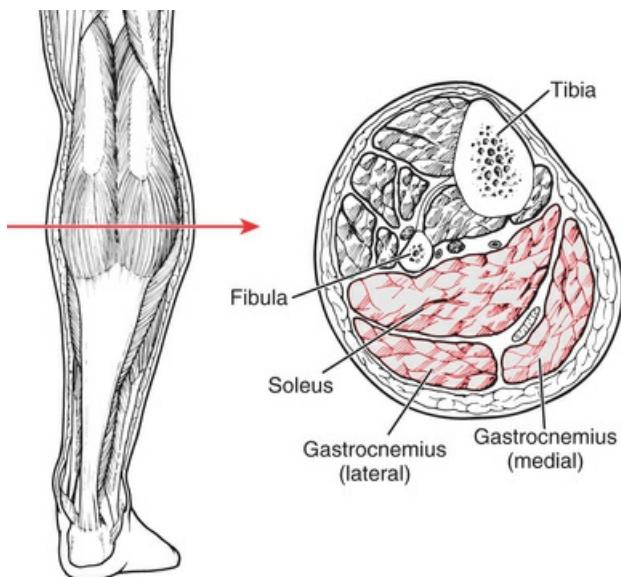


FIGURE 6.96 Arrow indicates level of cross section.

Range of Motion

0°–45°

Table 6.11
PLANTAR FLEXION

L.D.	Muscle	Origin	Insertion	Function
206	Soleus	Fibula (head, posterior aspect, and proximal $\frac{2}{3}$ of shaft) Tibia (soleal line and middle $\frac{1}{3}$ of medial shaft) Aponeurosis between tibia and fibula over popliteal vessels Aponeurosis (anterior)	Aponeurosis (posterior; tendinous raphe in midline of muscle) Tendo calcaneus when tendon of soleus joins tendon of gastrocnemius Calcaneus via tendo calcaneus	Ankle plantar flexion Foot inversion
205	Gastrocnemius			Ankle plantar flexion Knee flexion (accessory) Foot eversion
	Medial head	Femur (medial condyle, popliteal surface) Capsule of knee joint	Anterior aponeurosis Tendo calcaneus (tendon of Achilles) formed when tendon of gastrocnemius joins tendon of soleus	
	Lateral head	Femur (lateral condyle, lateral surface, and supricondylar line) Capsule of knee joint Aponeurosis (posterior)	Calcaneus (posterior)	
<i>Others</i>				
204	Tibialis posterior			
207	Plantaris			
208	Fibularis longus			
209	Fibularis brevis			
213	Flexor digitorum longus			
222	Flexor hallucis longus			

If the gastrocnemius-soleus complex is paralyzed, there is negligible capacity for the accessory muscles to substitute for the action of plantar flexion.

The two ankle plantar flexors make up the triceps surae group. They differ in structure, anatomical position, function, and fiber-type characteristics. The medial gastrocnemius is the larger of the two heads. The gastrocnemius has 49% type 1 fibers compared to 80% in the soleus. This difference in fiber type makes the gastrocnemius more amenable to faster, more explosive movements while the soleus is more active during lower intensity and longer duration activities.³⁴ Because of the architecture and size of the soleus, the soleus generates 2.5 to 3× the force compared with the gastrocnemius. The soleus is isolated by flexing the knee during heel rise (Fig. 6.97).



FIGURE 6.97

Gastrocnemius and Soleus Test

Grade 5, Grade 4, and Grade 3

Position of Patient:

Patient stands on limb to be tested with knee extended, facing a wall. Patient is likely to need external support; thus, fingers can be placed on the wall, above shoulder height. Alternatively, no more than one or two fingers should be used on a table (or other horizontal surface) (Fig. 6.98).

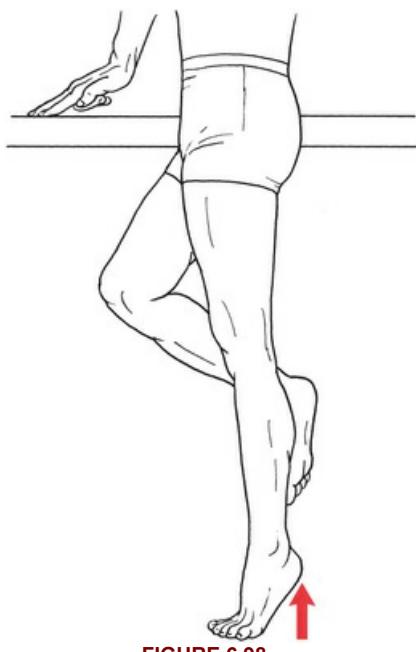


FIGURE 6.98

Instructions to Therapist:

Assess range of motion of the ankle to assure sufficient range is present. Demonstrate heel rise to patient. Then stand or sit with a lateral view of test limb to ascertain height of heel rise. Ask patient to lift heel while keeping knee straight. If patient can clear the floor by 2 inches, ask the patient to continue lifting the heel until the patient can no longer achieve 1 inch of rise. This is when the test is terminated. Patient should not bear weight through arms.

Test:

Patient raises heel from floor consecutively through maximum available range at a rate of one rise every 2 seconds until patient no longer achieves 50% of initial plantar range (Fig. 6.99).

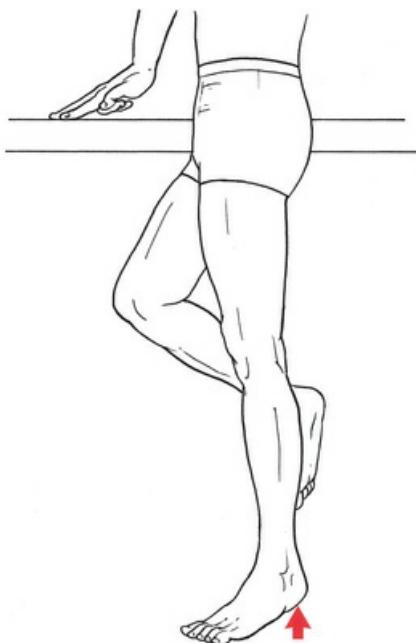


FIGURE 6.99

Instructions to Patient:

"Stand on one leg. Lift your heel. Now down. Repeat this as many times as possible, lifting your heel as high as you can." Repeat test for other limb, if both are tested.

Grading

Grade 5:

Patient successfully completes 25 heel rises through full range of motion without a rest between rises.^{35,36} Twenty-five heel rises elicit approximately 60% of the maximum electromyographic activity of the plantar flexors.¹¹ In the current standardized tests that have been in use for many years, 25 repetitions is the accepted norm. However, a more recent study suggests that the average number of repetitions in the sample studied is less than 25 repetitions (Table 6.12).³⁷ The therapist should be aware that strength deficits in the plantar flexors are common, particularly with advancing age, and strength deficits will affect the heel rise portion of the gait cycle and thus reduce gait speed.

Grade 4:

A grade of 4 is conferred when the patient completes between 2 and 24 heel rises of at least 50% of initial heel raise height at a consistent rate of one rise every 2 seconds using correct form in all repetitions. The criterion for Grade 4 is not well defined.

Grade 3:

Able to hold body weight once in a heel up position, but unable to raise body weight from neutral more than one time.

If the patient cannot complete at least one correct full-range heel rise in the standing position, the grade must be less than 3. Regardless of the force of resistance in a non-standing position for any reason, the patient must be given a grade of less than 3.³⁵

Table 6.12
AVERAGE VALUES OF UNTRAINED SUBJECTS

	MALES (BY AGE)				FEMALES (BY AGE)			
	Lunsford and Perry ³⁶	Jan et al. ³⁷	Jan et al. ³⁷	Jan et al. ³⁷	Lunsford and Perry ³⁶	Jan et al. ³⁷	Jan et al. ³⁷	Jan et al. ³⁷
Age (mean or range)	34.7 (8.5)	21–40	41–60	61–80	29.3 (5.0)	21–40	41–60	61–80
Mean repetitions	27.8 (11.5)	22.1 (9.8)	12.1 (6.6)	4.1 (1.9)	28.4 (9.8)	16.1 (6.7)	9.3 (3.6)	2.7 (1.5)

Range of repetitions	6-70	9-46	4-30	0-7	7-51	6-30	5-19	0-5
80th percentile		17	7	2		10	5	1

Grade 2

Position of Patient:

Prone with feet off end of table.

Instructions to Therapist:

Stand at foot of patient. Ask patient to flex and extend ankle to assure sufficient range is present. Hand giving resistance is placed against the plantar surface at the level of the metatarsal heads with foot in 80° of dorsiflexion. These muscles are capable of tremendous force, which is why a more stable point of resistance is needed ([Fig. 6.100](#)).

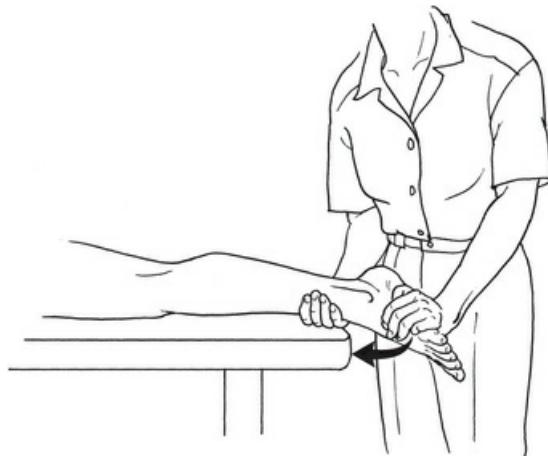


FIGURE 6.100

Test:

Patient plantar flexes ankle against manual resistance.

Grading

Grade 2:

Holds test position against maximal manual resistance.³⁶ Because of the functional strength of these muscles, the therapist should not expect to break the contraction in a Grade 2 (prone) test.

Grade 1 and Grade 0

Position of Patient:

Prone with feet off end of table.

Instructions to Therapist:

Stand at end of table in front of foot to be tested. One hand palpates gastrocnemius-soleus activity by monitoring tension in the Achilles tendon just above the calcaneus ([Fig. 6.101](#)). The muscle bellies of the two muscles also may be palpated (not illustrated).

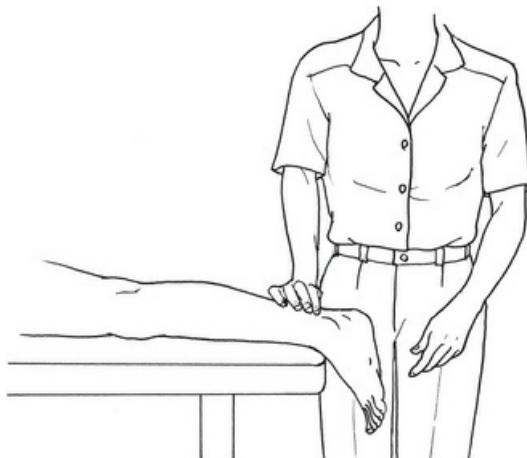


FIGURE 6.101

Test:

Patient attempts to plantar flex the ankle.

Instructions to Patient:

"Point your toes down, like a ballet dancer."

Grading

Grade 1:

Able to move through partial range. Contractile activity may be palpated in muscle bellies. The best location to palpate the gastrocnemius is at midcalf with thumb and fingers on either side of the midline but above the soleus. Palpation of the soleus is best done on the posterolateral surface of the distal calf. In most people with calf strength of Grade 3 or better, the two muscles can be observed and differentiated during plantar flexion testing because their definition is clear.

Grade 0:

No discernable palpable contraction.

Helpful Hints

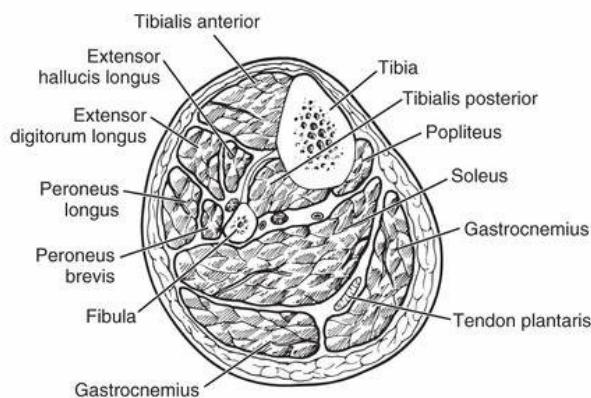
- Patient may try to flex knee and rock forward to ball of foot to raise heel from floor in standing test, which indicates weakness (Grade 2 or less).
- If for any reason the patient cannot lie prone for Grades 2, 1, or 0, an alternative for any of these tests is to use the supine position for non-weight-bearing testing. The highest grade awarded in this case is a Grade 2.
- During standing plantar flexion tests, the tibialis posterior and the fibularis longus and brevis muscles must be Grades 5 or 4 to stabilize the forefoot to attain and hold the tiptoe position.
- Because of the potential strength of the gastrocnemius/soleus muscles, even if the patient is unable to raise the heel in a standing position, it may be advantageous to use a wall to support the therapist's weight while resisting plantar flexion in the prone position. However, even with therapist stabilization, hand-held dynamometry of this muscle group in prone or supine is not reliable.
- Care must be taken to avoid transferring weight through the finger tips used for balance. Therefore it is recommended to place the patient's arms above the head on the wall in front of the patient. However, be sure that the patient maintains a fully erect posture. If the subject leans forward or flexes the knee, such posture can bring the heel off the ground, creating a testing artifact.

- Normative repetitions for children (5–12) are³⁸:
 - Ages 5–6: 12.5 ± 5.4
 - Ages 7–8: $18.1 =/- 3.6$
 - Ages 9–10: $22.3 =/- 8.0$
 - Ages 11–12: $31.6 =/- 12.5$
- Young women who wear shoes with a heel height of at least 5 cm high for 40 hours or more/week for 1 year demonstrated decreased strength and power in the soleus and reduced ankle range.³⁹

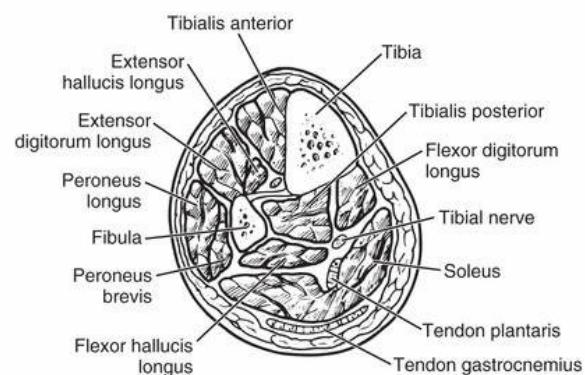
Suggested Exercises for Gastrocnemius and Soleus

- Straight leg heel raises for gastrocnemius³⁴
- Seated calf machine for soleus³⁴
- Agility drills on toes

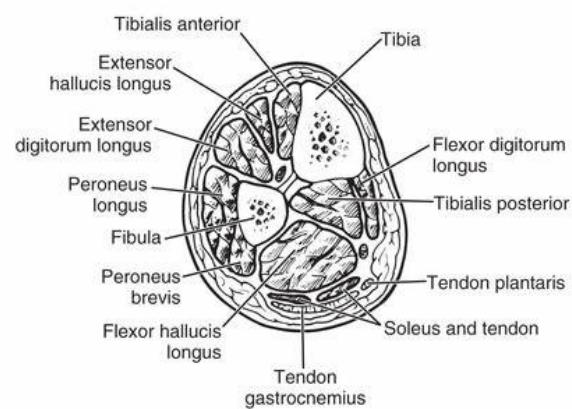
CROSS SECTIONS OF THE LEG



MID LEG
AT UPPER PORTION OF
GASTROCNEMIUS AND
SOLEUS AT LARGEST
CIRCUMFERENCE OF CALF



LOWER LEG
NEAR END OF MUSCULAR
PORTIONS OF TRICEPS
SURAЕ. GASTROCNEMIUS
IS ALL TENDINOUS.

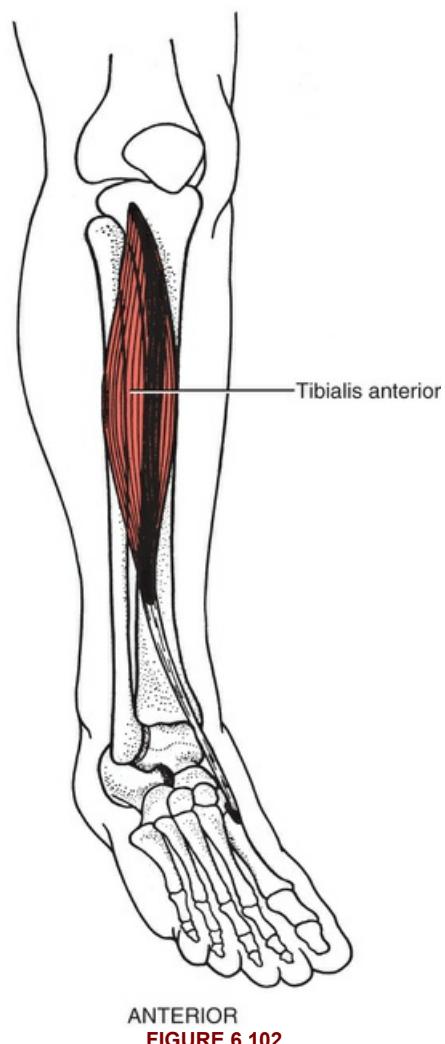


HIGH ANKLE
LOWER LEG WHERE
GASTROCNEMIUS,
SOLEUS, AND PLANTARIS
ARE TENDINOUS

PLATE 7

Foot Dorsiflexion and Inversion

(*Tibialis anterior*)



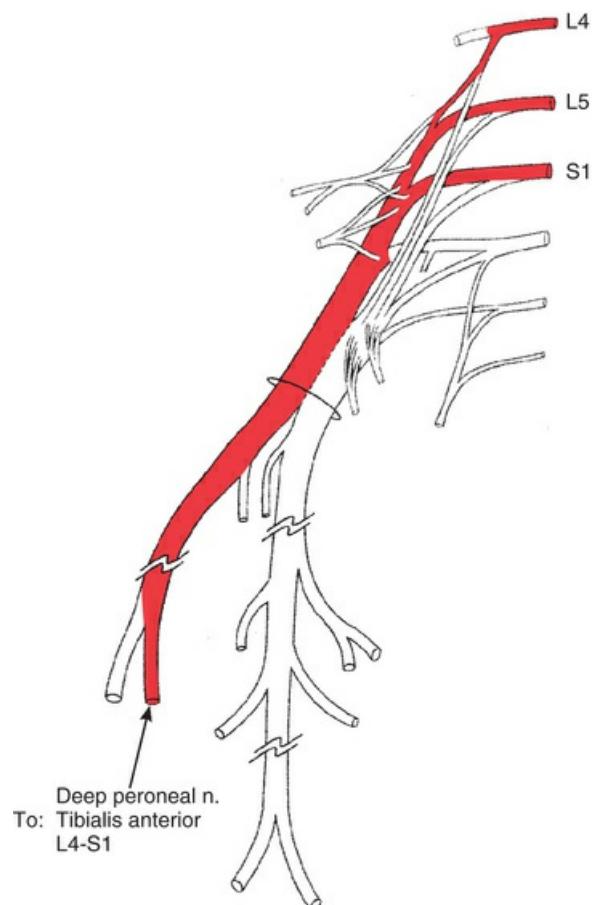


FIGURE 6.103

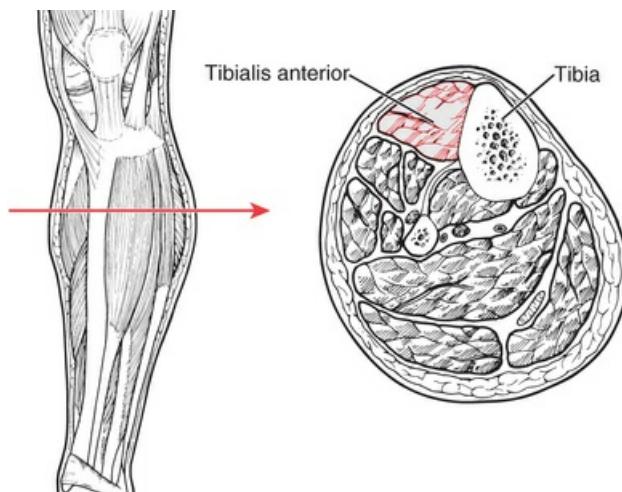


FIGURE 6.104 Arrow indicates level of cross section.

Range of Motion

0° - 25° ²²

Table 6.13
FOOT DORSIFLEXION AND INVERSION

I.D.	Muscle	Origin	Insertion	Function
203	Tibialis anterior	Tibia (lateral condyle and proximal ^{2/3} of lateral shaft) Interosseous membrane Fascia cruris (deep) Intermuscular septum	1st (medial) cuneiform (on medial and plantar surfaces) 1st metatarsal (base)	Ankle dorsiflexion (talocrural joint) Foot inversion and adduction (supination) at subtalar and midtarsal joints Supports medial-longitudinal arch of foot in walking
<i>Others</i>				
210	Fibularis (peroneus) tertius			Ankle dorsiflexion Foot eversion (accessory)
211	Extensor digitorum longus			
221	Extensor hallucis longus			

Ankle dorsiflexion strength and range are critical functions of gait and balance⁴⁰ and therefore of mobility. Reduced ankle dorsiflexion strength is a consequence of many diseases and conditions such as stroke, some types of cancer, idiopathic peripheral neuropathy, diabetes mellitus, and cerebral palsy. Extreme weakness can result in foot drop. Reduced ankle strength, power, and range are factors in falls in people of all ages, especially in older adults. Reduced ankle strength and power are also factors in ankle instability that can increase risk for ankle sprains.

All Grades

Position of Patient:

Supine. (Note: The authors recommend the supine position for this test, rather than an anti-gravity position, because of the mechanical advantage it affords the therapist when providing adequate resistance to this very strong muscle.)

Instructions to Therapist:

Stand at foot of patient with patient's heel resting on table. Ask patient to bring the foot up and in, towards the body (Fig. 6.105). If sufficient range exists, place hand providing resistance on the medial aspect of the foot over the first ray. Resistance is provided down and out (Fig. 6.106). This is a strong muscle, so applying resistance with the hand and flexed forearm can help provide enough resistance for a valid test. Additionally, this position is not against gravity, so this test should be graded stringently.

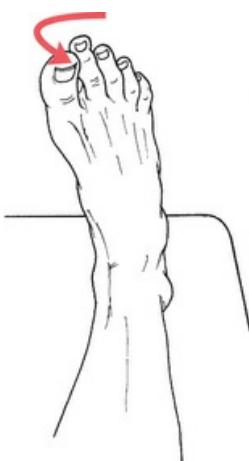


FIGURE 6.105

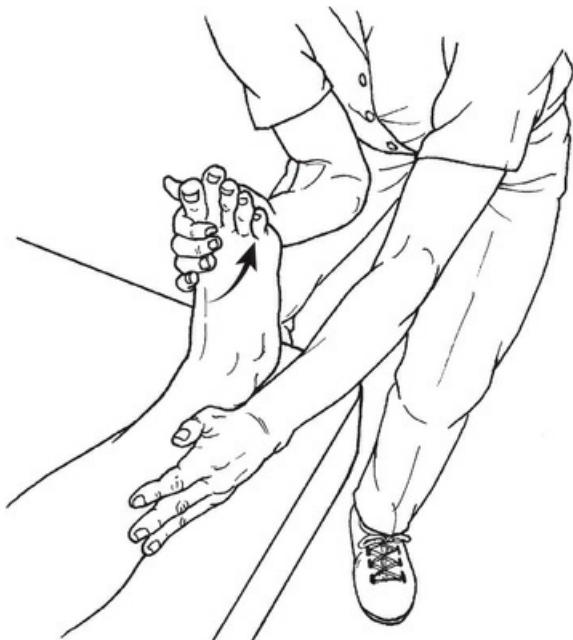


FIGURE 6.106

Test:

Patient dorsiflexes ankle and inverts foot, keeping toes relaxed.

Instructions to Patient:

"Bring your foot up and in. Hold it! Don't let me pull it down."

Grading

Grade 5:

Holds test position against maximal resistance.

Grade 4:

Holds test position against strong to moderate resistance.

Grade 3:

Completes available range of motion without resistance (see Fig. 6.105).

Grade 2:

Completes only a partial range of motion.

Grade 1:

Therapist will be able to detect some contractile activity in the muscle, or the tendon will "stand out." There is no joint movement.

Palpate the tendon of the tibialis anterior on the anteromedial aspect of the ankle at about the level of the malleoli (Fig. 6.107). Alternatively, palpate the muscle for contractile activity over its belly just lateral to the "shin" (not shown).



FIGURE 6.107

Grade 0:

No discernable palpable contraction.

Substitution

Substitution by the extensor digitorum longus and the extensor hallucis longus muscles results in toe extension. Instruct the patient therefore to keep the toes relaxed so that they are not part of the test movement.

Helpful Hints

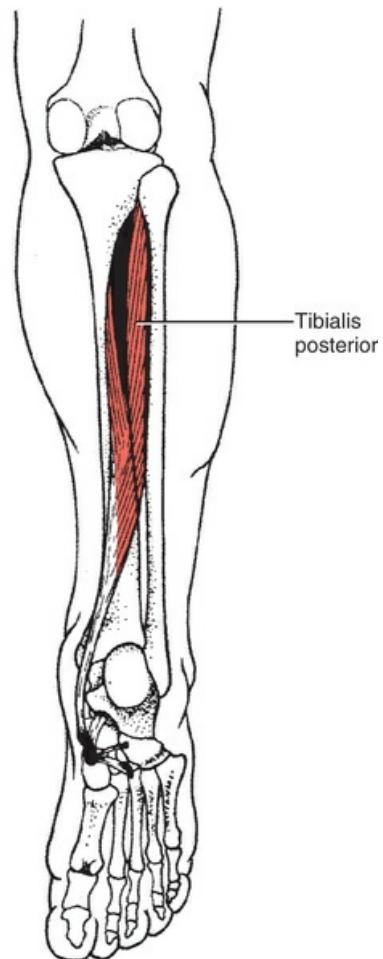
- In the sitting and supine positions, make sure the knee is flexed to put the gastrocnemius on slack. If the knee is extended and there is gastrocnemius tightness, the patient will not be able to achieve full dorsiflexion range.
- Because the supine position is not against gravity, the therapist should expect to give maximum resistance utilizing body weight of the therapist. A pull force will be more protective of the therapist's shoulder than a push force.

Suggested Exercises for Tibialis Anterior

- Resisted dorsiflexion using elastic resistance or pulling against a pedal or other object
- Foot taps
- Heel walking

Foot Inversion

(*Tibialis posterior*)



POSTERIOR VIEW OF LEG
PLANTAR VIEW OF FOOT
FIGURE 6.108

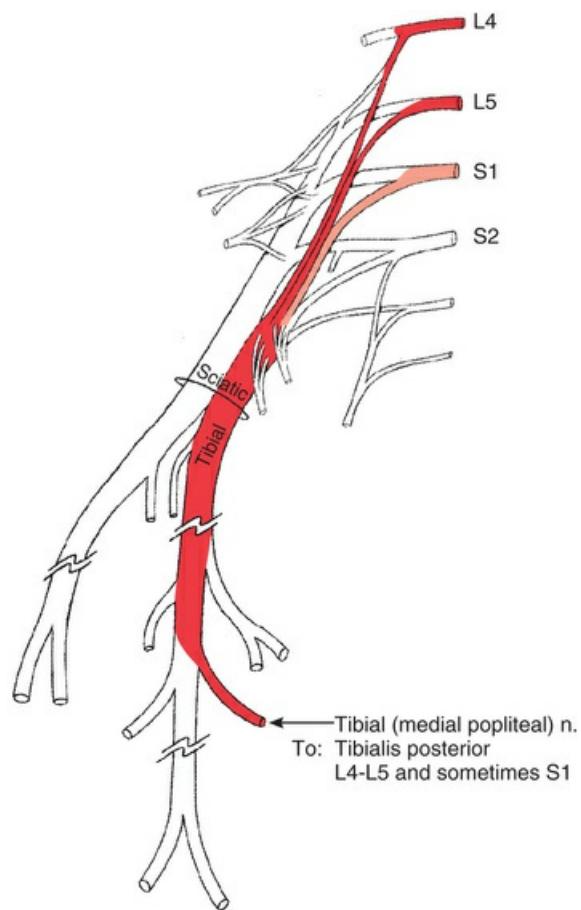


FIGURE 6.109

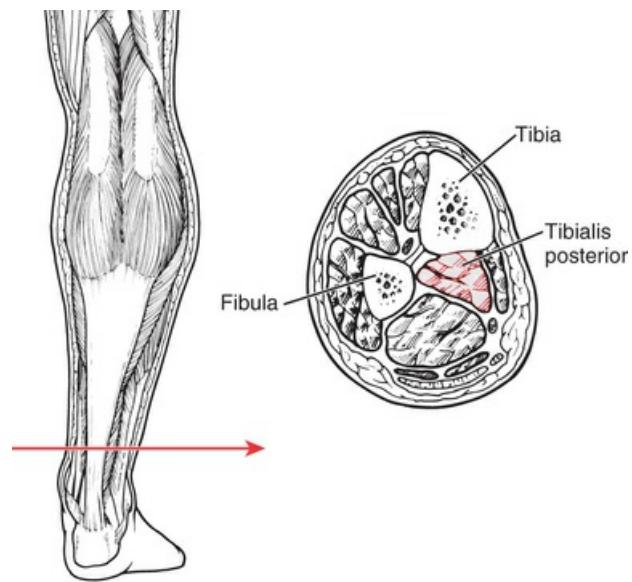


FIGURE 6.110 Arrow indicates level of cross section.

Range of Motion

0°–35°

Table 6.14
FOOT INVERSION

L.D.	Muscle	Origin	Insertion	Function
204	Tibialis posterior	Tibia (proximal $\frac{2}{3}$ of posterior lateral shaft below soleal line) Interosseous membrane (posterior) Fibula (shaft, proximal posterior medial $\frac{2}{3}$) Deep transverse fascia Intermuscular septa	Navicular bone (tuberosity) Cuneiform bones Sustentaculum tali (distal) Metatarsals 2–4 (via tendinous band)	Foot inversion (supination) Ankle plantar flexion (accessory)
<i>Others</i>				
203	Tibialis anterior			
213	Flexor digitorum longus			
222	Flexor hallucis longus			
206	Soleus			
221	Extensor hallucis longus			

The tibialis posterior muscle provides function of the subtalar and midtarsal joints during the stance phase of gait, providing an inversion moment at the subtalar joint and stabilizing the medial longitudinal arch. Dysfunction of the tibialis posterior tendon, a relatively recently recognized degenerative and progressive condition, is a common cause of adult-acquired flat-footedness and tendon rupture.

Grade 5, Grade 4, Grade 3, and Grade 2

Position of Patient:

Sitting with ankle in slight plantar flexion.

Instructions to Therapist:

Sit on low stool in front of patient or on side of test limb (anti-gravity position). With patient's heel resting on therapist's thigh, ask the patient to move the foot down and in. Perform this movement passively if needed. If sufficient active range exists, place stabilizing hand on the posterior calf just above the malleoli (Fig. 6.111). The majority of resistance is toward forefoot abduction (up and out direction). Hand providing resistance is placed on the foot with the hand providing resistance over the medial side of the forefoot.



FIGURE 6.111

Test:

Patient inverts foot through available range of motion.

Instructions to Patient:

"Turn your foot down and in. Hold it. Don't let me move it."

Grading

Grade 5:

The patient holds the test position against maximal resistance.

Grade 4:

The patient holds the test position against strong to moderate resistance.

Grade 3:

The patient will be able to invert the foot through the full available range of motion ([Fig. 6.112](#)).

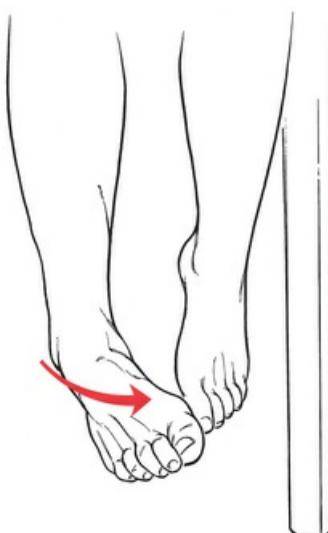


FIGURE 6.112

Grade 2:

The patient will be able to complete only partial range of motion.

Grade 1 and Grade 0

Position of Patient:

Sitting or supine.

Instructions to Therapist:

Sit on low stool or stand in front of patient. Palpate tendon of the tibialis posterior between the medial malleolus and the navicular bone ([Fig. 6.113](#)). Alternatively, palpate tendon above the malleolus.



FIGURE 6.113

Test:

Patient attempts to invert foot.

Instructions to Patient:

"Try to turn your foot down and in."

Grading

Grade 1:

The tibialis posterior tendon will stand out if there is contractile activity in the muscle. If palpable activity occurs in the absence of movement, the grade is 1.

Grade 0:

No discernable palpable contraction.

Substitution

Flexors of the toes should remain relaxed to prevent substitution by the flexor digitorum longus and flexor hallucis longus.

Helpful Hints

The single-leg heel raise is painful or impossible in the presence of tibialis posterior dysfunction.

If heel inversion does not occur or is asymmetrical during the heel rise, this may indicate insufficiency in tibialis posterior.

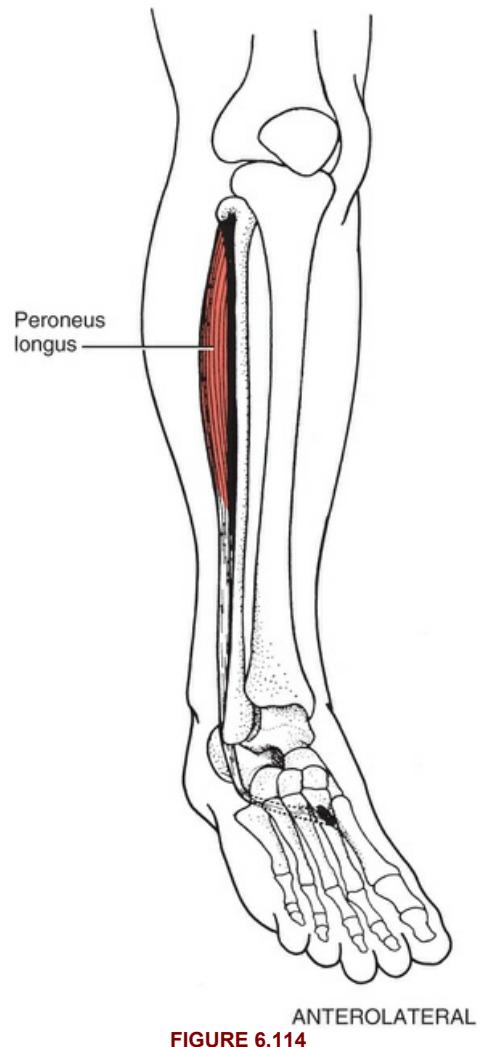
The action of the tibialis posterior is to plantarflex and invert the ankle having the effect of placing the forefoot into adduction. To isolate the tibialis posterior, resisted forefoot adduction should be the primary force with less force toward dorsiflexion (producing the up and out movement).

Suggested Exercises for Tibialis Posterior

- Foot inversion exercise (pushing soles of feet together)
- Eccentric foot inversion exercise with elastic resistance
- Heel rise with inversion (heels together)

Foot Eversion With Plantar Flexion

(*Fibularis longus and brevis—previously called Peroneus longus and brevis*)



ANTEROLATERAL
FIGURE 6.114

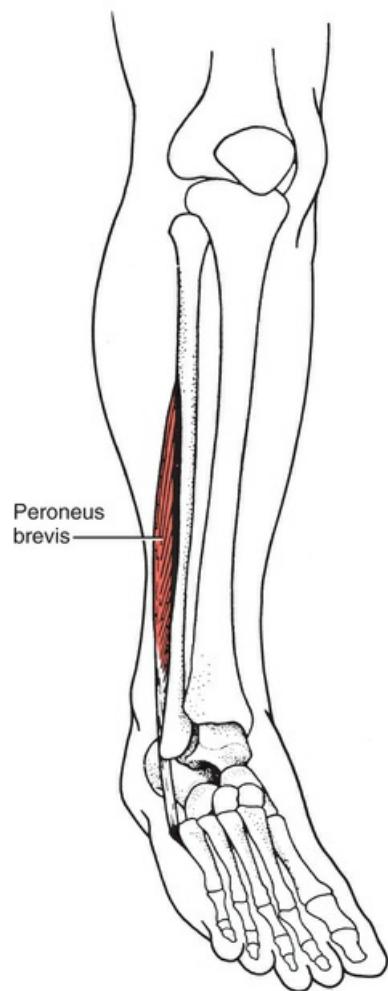


FIGURE 6.115

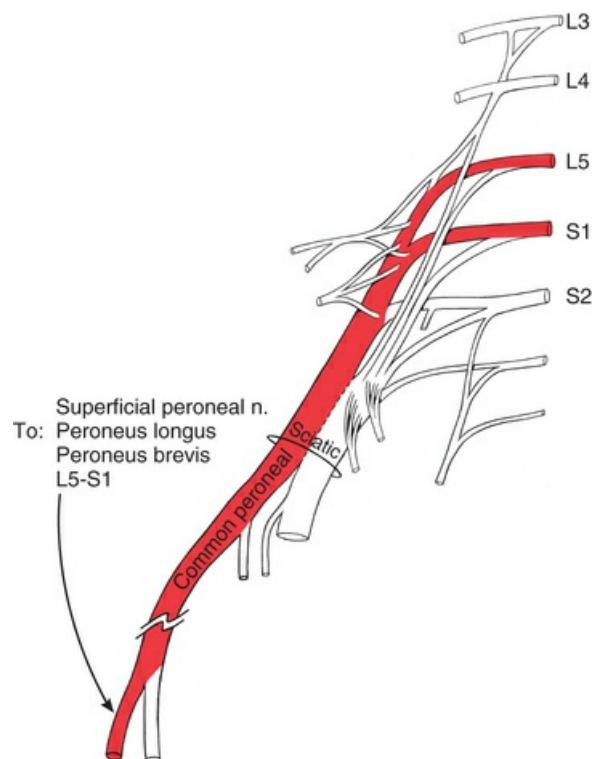


FIGURE 6.116

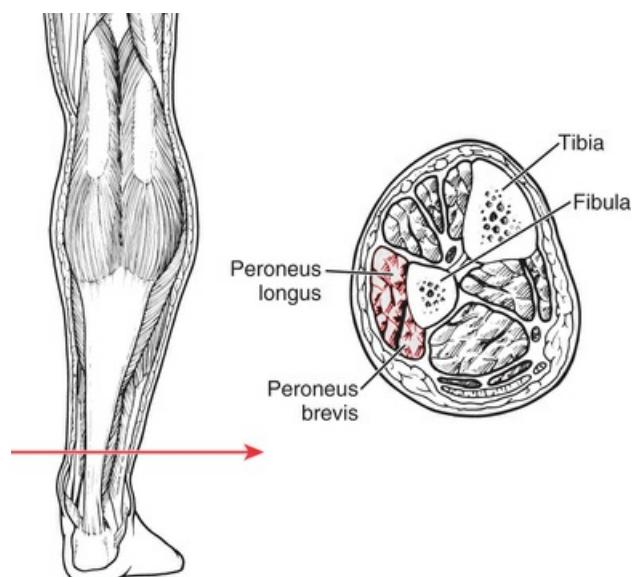


FIGURE 6.117 Arrow indicates level of cross section.

Range of Motion

0°–25°

Table 6.15

FOOT EVERSION

L.D. Muscle	Origin	Insertion	Function	
<i>With Plantar Flexion</i>				
208	Fibularis longus (peroneus longus)	Fibula (head and proximal $\frac{3}{4}$ of shaft, lateral aspect) Tibia (lateral condyle, occasionally) Fascia cruris Intermuscular septa	1st metatarsal (base and lateral aspect) Medial cuneiform (base and lateral aspect) Other metatarsals occasionally	Foot eversion Ankle plantar flexion (assist) Depression of 1st metatarsal Support of longitudinal and transverse arches
209	Fibularis brevis (peroneus brevis)	Fibula (distal and lateral $\frac{3}{4}$ of shaft) Crural intermuscular septum	5th metatarsal (tuberosity at base, lateral aspect)	Foot eversion Ankle plantar flexion (accessory)
<i>With Dorsiflexion</i>				
211	Extensor digitorum longus	Tibia (lateral condyle on lateral side) Fibula (shaft: upper $\frac{3}{4}$ of medial surface) Interosseous membrane (anterior surface) Deep crural fascia and intermuscular septum	Tendon of insertion divides into four tendon slips to dorsum of foot that form an expansion over each toe: Toes 2–5: middle phalanges (PIP joints) of the four lesser toes (intermediate slip to dorsum of base of each) Distal phalanges (two lateral slips to dorsum of base of each)	MP extension of four lesser toes PIP and DIP extension (assist) of four lesser toes Ankle dorsiflexion (accessory) Foot eversion (accessory)
210	Fibularis tertius	Fibula (distal $\frac{1}{3}$ of medial surface) Interosseous membrane (anterior) Intermuscular septum	5th metatarsal (dorsal surface of base; shaft, medial aspect)	Ankle dorsiflexion Foot eversion (accessory)
<i>Other</i>				
205	Gastrocnemius			

DIP, Distal phalanges; MP, metatarsophalangeal; PIP, proximal phalanges.

Grade 5, Grade 4, Grade 3, and Grade 2

Position of Patient:

Sitting with ankle in neutral position (midway between dorsiflexion and plantar flexion). Test also may be performed with patient supine.

Instructions to Therapist:

Sit on low stool in front of patient or stand at end of table if patient is supine. Ask patient to turn foot down and out (eversion). If sufficient range is present, place stabilizing hand at the ankle just above the malleoli. Take care not to squeeze the distal tibia. Hand providing resistance is contoured around the dorsum and lateral border of the forefoot (Fig. 6.118). Resistance is directed toward inversion and slight dorsiflexion (up and in).



FIGURE 6.118

Test:

Patient everts foot with depression of first metatarsal head and some plantar flexion.

Instructions to Patient:

"Turn your foot down and out. Hold it! Don't let me move it in."

Grading

Grade 5:

Patient holds test position against maximal resistance.

Grade 4:

Patient holds test position against strong to moderate resistance.

Grade 3:

Patient completes available range of eversion but without resistance ([Fig. 6.119](#)).

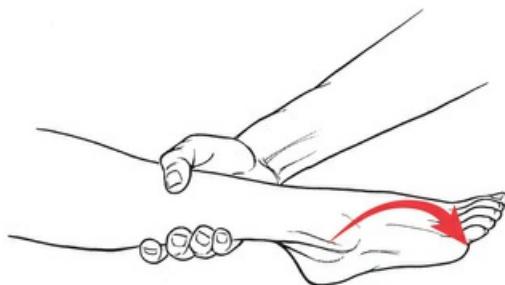


FIGURE 6.119

Grade 2:

Patient will be able to complete only a partial range of eversion motion.

Grade 1 and Grade 0

Position of Patient:

Short sitting or supine.

Instructions to Therapist:

Sit on low stool or stand at end of table. To palpate the fibularis longus, place fingers on the lateral leg over the upper one-third just below the head of the fibula. The tendon of the muscle can be felt posterior to the lateral malleolus but behind the tendon of the fibularis brevis.

To palpate the tendon of the fibularis brevis, place index finger over the tendon as it comes forward from behind the lateral malleolus, proximal to the base of the fifth metatarsal ([Fig. 6.120](#)). The belly of the fibularis brevis can be palpated on the lateral surface of the distal leg over the fibula.

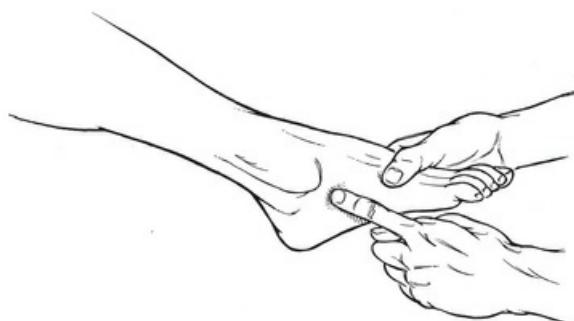


FIGURE 6.120

Grading

Grade 1:

Palpation will reveal contractile activity in either or both muscles, which may cause the tendon to stand out. No motion occurs.

Grade 0:

No discernable palpable contractile activity.

Isolation of Fibularis Longus

Give resistance against the plantar surface of the head of the first metatarsal in a direction toward inversion and dorsiflexion.

Foot Eversion With Dorsiflexion

If the fibularis tertius is present, it can be tested by asking the patient to evert and dorsiflex the foot. In this motion, however, the extensor digitorum longus participates.

The tendon of the fibularis tertius can be palpated on the lateral aspect of the dorsum of the foot, where it lies lateral to the tendon of the extensor digitorum longus slip to the little toe.

Helpful Hints

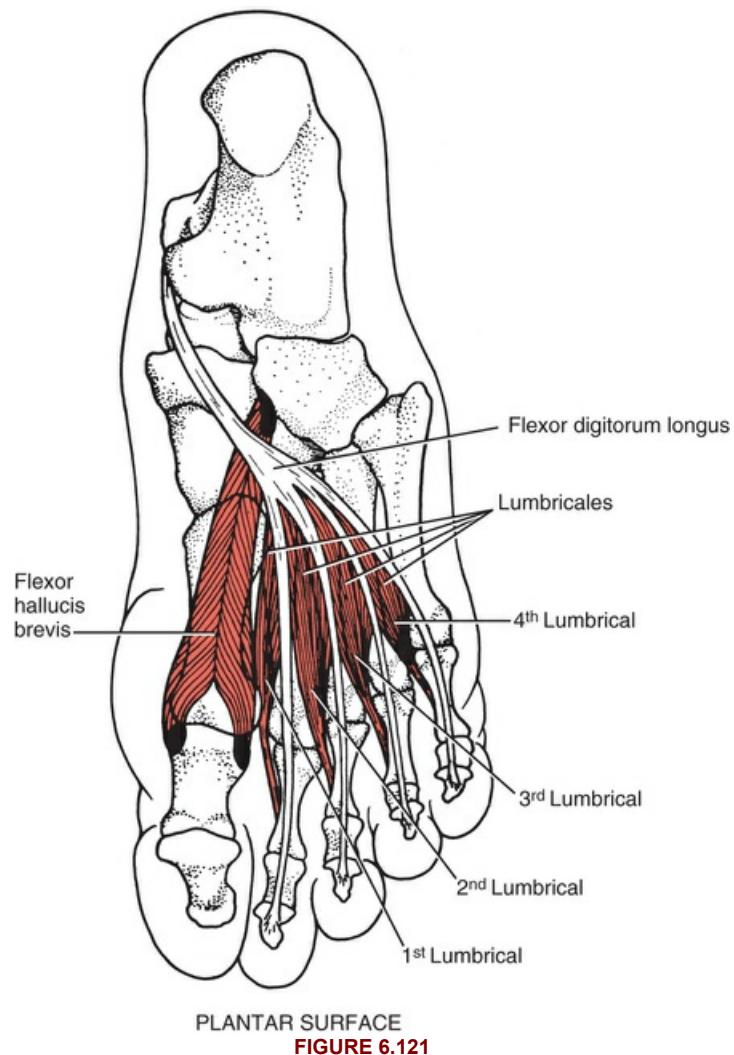
- Foot eversion is accompanied by either dorsiflexion or plantar flexion. The toe extensors are the primary dorsiflexors accompanying eversion because the fibularis tertius is not always present.
- The primary motion of eversion with plantar flexion is accomplished by the fibularis brevis because the fibularis longus is primarily a depressor of the first metatarsal head rather than an evertor.
- The fibularis brevis cannot be isolated if both longus and brevis are innervated and strong.
- If there is a difference in strength between the fibularis longus and the fibularis brevis, the stronger of the two can be ascertained by the relative amount of resistance taken in eversion versus the resistance taken at the first metatarsal head. If greater resistance is taken at the first metatarsal head, the fibularis longus is the stronger muscle.

Suggested Exercise for Foot Eversion

Lateral hop⁴¹

Hallux and Toe MP Flexion

(*Lumbricales and Flexor hallucis brevis*)



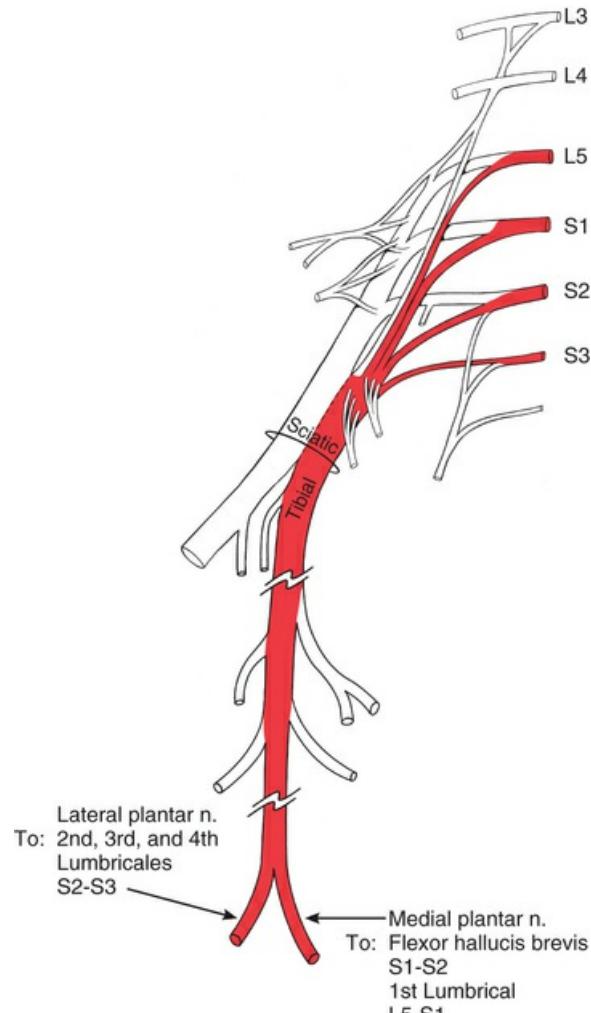


FIGURE 6.122

Range of Motion

Great toe, 0°–45°

Lateral four toes, 0°–40°

Table 6.16
FLEXION OF MP JOINTS OF TOES AND HALLUX

I.D.	Muscle	Origin	Insertion	Function
<i>Toes</i>				
218	Lumbricales	Tendons of flexor digitorum longus near angles of separation 1st lumbrical (by a single head, tendon of flexor digitorum longus bound for toe 2) 2nd–4th lumbricales (arise by dual heads from adjacent sides of tendons of flexor digitorum longus bound for toes 3–5)	All toes 2–5 (proximal phalanges and dorsal expansions of the tendons of extensor digitorum longus) Blends with extensor digitorum longus	Toes 2–5: MP flexion Toes 2–5: PIP and DIP extension (assist)
<i>Hallux</i>				
223	Flexor hallucis brevis (rises by 2 heads)			Hallux abduction (away from toe 2) Hallux MP flexion
	Lateral head	Cuboid bone (plantar surface) Lateral cuneiform bone	Hallux (proximal phalanx on both sides of base) Blends with adductor hallucis	
	Medial head	Medial intermuscular septum Tibialis posterior (tendon)	Hallux (proximal phalanx on both sides of base) Blends with abductor hallucis	
<i>Others</i>				
219 220	Interossei, dorsal and plantar			
216	Flexor digiti minimi brevis			
213	Flexor digitorum longus			

214	Flexor digitorum brevis			
222	Flexor hallucis longus			
224	Abductor hallucis			
225	Adductor hallucis			

DIP, Distal interphalangeal; MP, metatarsophalangeal; PIP, proximal interphalangeal.

Hallux MP Flexion

(*Flexor hallucis brevis*)

Grades 5 to 0

Position of Patient:

Sitting (alternate position: supine) with legs hanging over edge of table. Ankle is in neutral position (midway between dorsiflexion and plantar flexion).

Instructions to Therapist:

Sit on low stool in front of patient. Alternate position: stand at side of table near patient's foot.

Test foot rests on therapist's lap. Ask the patient to bend the big toe over finger. If sufficient range is present, place stabilizing hand over the dorsum of the foot just below the ankle (Fig. 6.123). The index finger of the other hand is placed beneath the proximal phalanx of the great toe.

Alternatively, the tip of the finger (with very short fingernails) is placed up under the proximal phalanx.



FIGURE 6.123

Test:

Patient flexes great toe.

Instructions to Patient:

"Bend your big toe over my finger. Hold it. Don't let me straighten it."

Grading

Grade 5:

Patient holds position against strong resistance.

Grade 4:

Patient holds test position against moderate to mild resistance.

Grade 3:

Patient completes available range of metatarsophalangeal (MP) flexion of the great toe without resistance.

Grade 2:

Patient completes only partial range of motion.

Grade 1:

Therapist may note contractile activity but no toe motion.

Grade 0:

No discernable contractile activity.

Helpful Hints

- The muscle and tendon of the flexor hallucis brevis cannot be palpated.
- When the flexor hallucis longus is not functional, the flexor hallucis brevis will flex the metatarsophalangeal joint but without flexion of the interphalangeal joint. In the opposite condition, when the flexor hallucis brevis is not functional, the IP joint flexes and the metatarsophalangeal joint may hyperextend. (When this condition is chronic, the posture is called hammer toe.)
- Loss of the flexor hallucis longus results in balance instability as it stabilizes the big toe against the ground during each step.

Hallux and Toe MP Flexion

(*Lumbricales, Interossei*)

Toe MP Flexion

Grades 5 to 0

Position of Patient:

Sitting with foot on therapist's lap. Alternate position: supine. Ankle is in neutral (midway between dorsiflexion and plantar flexion).

Instructions to Therapist:

Sit on low stool in front of patient. Alternate position: stand next to table beside test foot. Ask the patient to bend the toes over therapist's fingers. If sufficient range is present, place stabilizing hand over the dorsum of the foot (as in test for flexion of the hallux) (Fig. 6.124). The index finger of the other hand is placed under the MP joints of the four lateral toes to provide resistance to flexion.



FIGURE 6.124

Test:

Patient flexes lateral four toes at the MP joints, keeping the interphalangeal (IP) joints neutral.

Instructions to Patient:

"Bend your toes over my finger. Hold it!"

Grading

Grading is the same as that used for the great toe.

Helpful Hints

In actual practice, the great toe and the lateral toes are rarely tested independently. Many patients cannot separate hallux motion from motion of the lateral toes, nor can they separate metatarsophalangeal and interphalangeal motions.

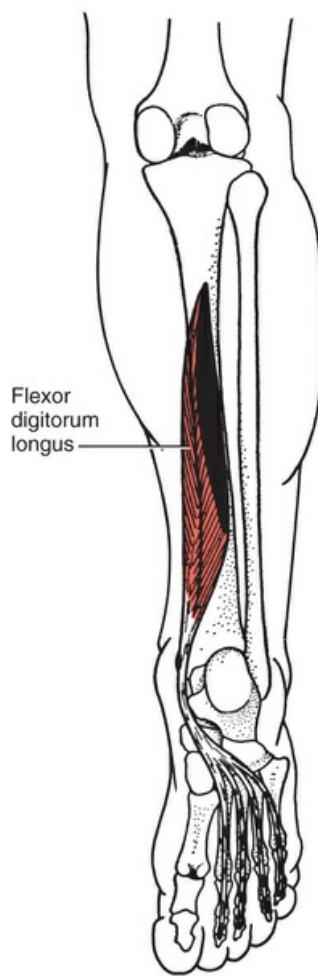
The therapist could test each toe separately because the lumbricales are notoriously uneven in strength. This may not, however, be practicable.

Suggested Exercises for Hallux and Toe MP Flexion

- Picking up marbles with the toes (occurs in conjunction with flexor hallucis and flexor digitorum longus)
- Scrunching a towel with the toes

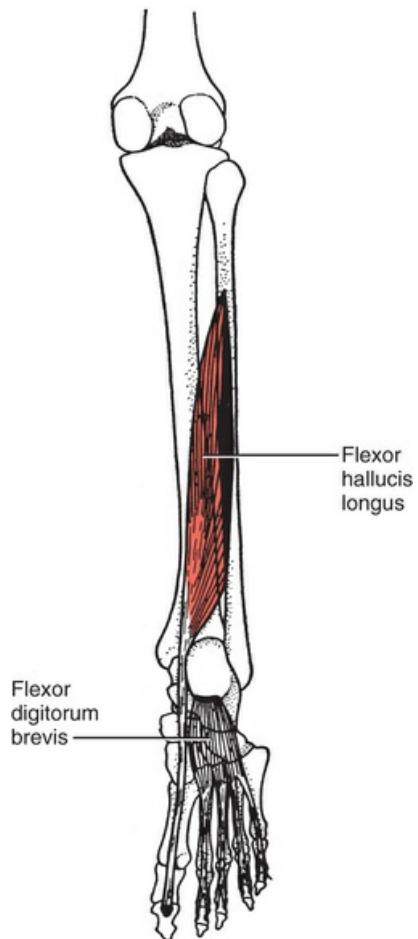
Hallux and Toe DIP and PIP Flexion

(*Flexor digitorum longus, Flexor digitorum brevis, Flexor hallucis longus*)



POSTERIOR VIEW OF LEG

FIGURE 6.125



PLANTAR VIEW OF FOOT
FIGURE 6.126

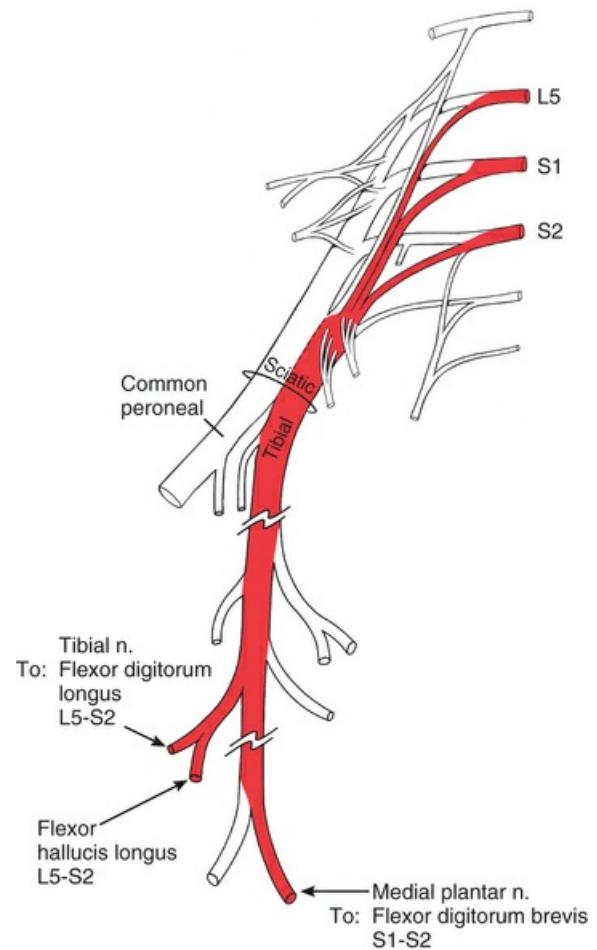


FIGURE 6.127

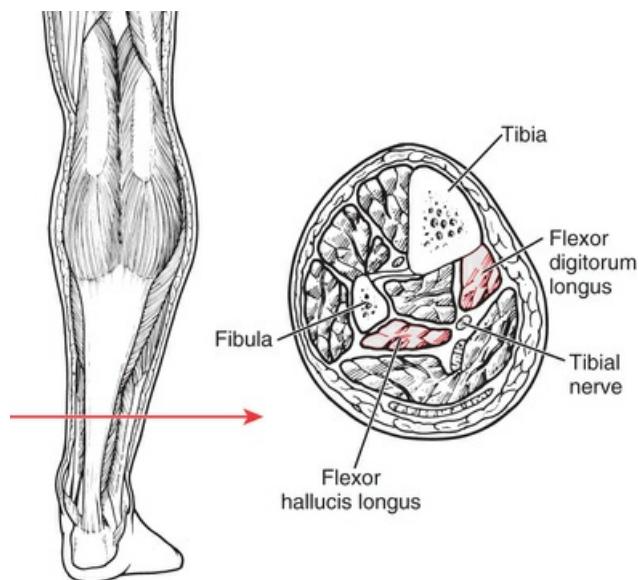


FIGURE 6.128 Arrow indicates level of cross section.

Range of Motion

PIP flexion, four lateral toes: 0°–35°
 DIP flexion, four lateral toes: 0°–60°
 IP flexion of hallux: 0°–90°

Table 6.17
FLEXION OF IP JOINTS OF HALLUX AND TOES

I.D.	Muscle	Origin	Insertion	Function
<i>DIP, Toes</i>				
213	Flexor digitorum longus	Tibia (shaft, posterior aspect of middle 3) Fascia over tibialis posterior	Toes 2–5 (distal phalanges, plantar surfaces, and base)	Toes 2–5: MP, PIP, and DIP flexion Ankle plantar flexion (accessory) Foot inversion (accessory)
<i>PIP, Toes</i>				
214	Flexor digitorum brevis	Calcaneus (tuberosity, medial process) Plantar aponeurosis Intermuscular septum	Toes 2–5 (by 4 tendons to middle phalanges, both sides)	Toes 2–5 MP and PIP flexion
<i>IP, Hallux</i>				
222	Flexor hallucis longus	Fibula (shaft, ⅓ of posterior aspect) Interosseous membrane Intermuscular septum (posterior crural) Fascia over tibialis posterior	Slip of tendon to flexor digitorum longus Hallux (distal phalanx, base, plantar aspect)	Hallux IP flexion Hallux MP flexion (accessory) Ankle plantar flexion and foot inversion (accessory)
<i>Others</i>				
217	Quadratus plantae			
213	Flexor digitorum longus			

DIP, Distal interphalangeal; IP, interphalangeal; MP, metatarsophalangeal; PIP, proximal interphalangeal.

Grades 5 to 0

Position of Patient:

Sitting with foot on therapist's lap, or supine.

Instructions to Therapist:

Sit on a short stool in front of the patient or stand at the side of the table near the patient's foot. Ask the patient to curl toes (or big toe). If sufficient range is present, place stabilizing hand over the anterior foot with the fingers placed across the dorsum of the foot and the thumb under the proximal phalanges (PIP) or distal phalanges (DIP) or under the IP of the hallux (Figs. 6.129, 6.130, and 6.131). The other hand applies resistance using the four fingers or the thumb under the middle phalanges (for the IP test) (see Fig. 6.129), under the distal phalanges for the DIP test (see Fig. 6.130), and with the index finger under the distal phalanx of the hallux (see Fig. 6.131). Resistance will be minimal.

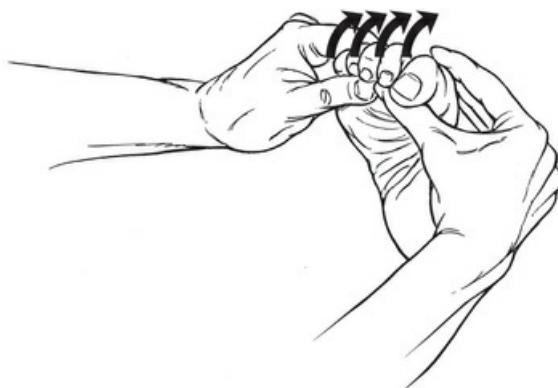


FIGURE 6.129



FIGURE 6.130



FIGURE 6.131

Test:

Patient flexes the toes or hallux.

Instructions to Patient:

"Curl your toes; hold it. Curl your big toe and hold it."

Grading

Grade 5 and Grade 4:

Patient holds test position of toes and then hallux; resistance in both tests may be minimal.

Grade 3 and Grade 2:

Patient holds test position without resistance (Grade 3) or completes only a partial range (Grade 2).

Grade 1 and Grade 0:

Minimal to no palpable contractile activity occurs. Tendon of the flexor hallucis longus may be palpated on the plantar surface of the proximal phalanx of the great toe.

Helpful Hints

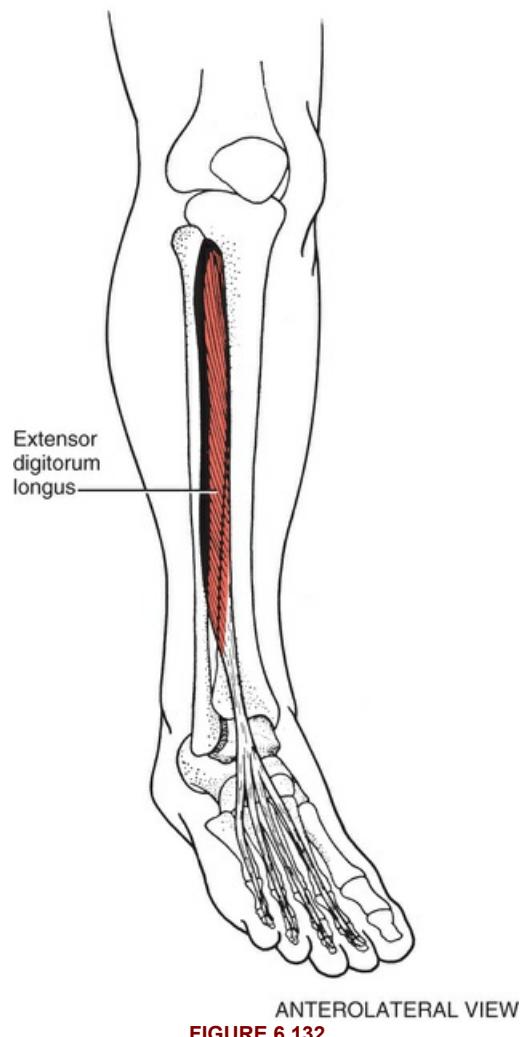
- As with all toe motions, the patient may not be able to move one toe separately from another or separate MP from IP activity among individual toes.
- Some people can separate hallux activity from toe motions, but fewer can separate MP from IP

hallux activity.

- Many people can “pinch” with their great toe (adductor hallucis), but this is not a common clinical test.
- The abductor hallucis is not commonly tested because it is only rarely isolated. Its activity can be observed by resisting adduction of the forefoot, which will bring the great toe into abduction, but the lateral toes commonly extend at the same time.

Hallux and Toe MP and IP Extension

(*Extensor digitorum longus and brevis, Extensor hallucis longus*)



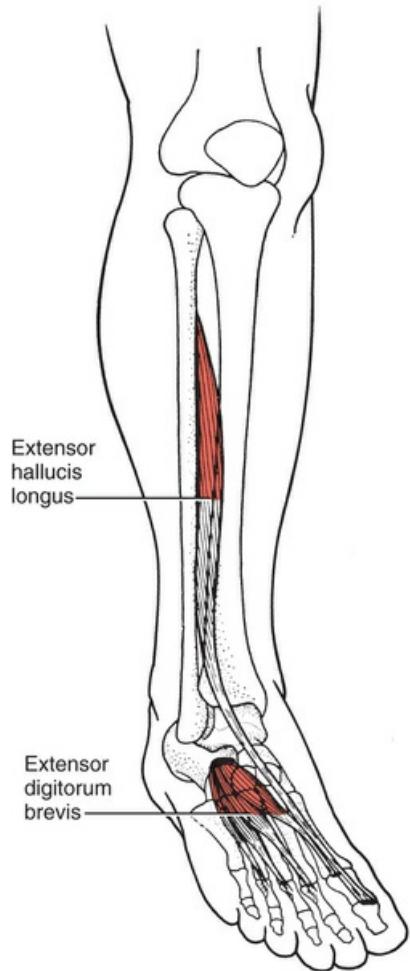


FIGURE 6.133

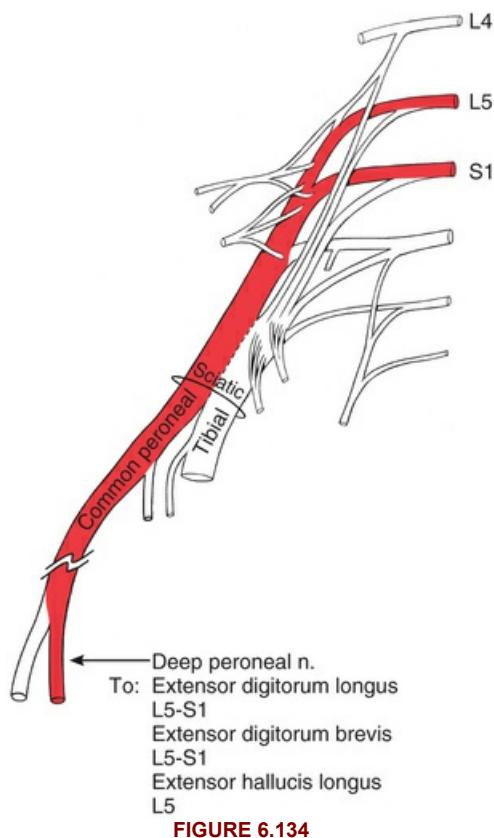


FIGURE 6.134

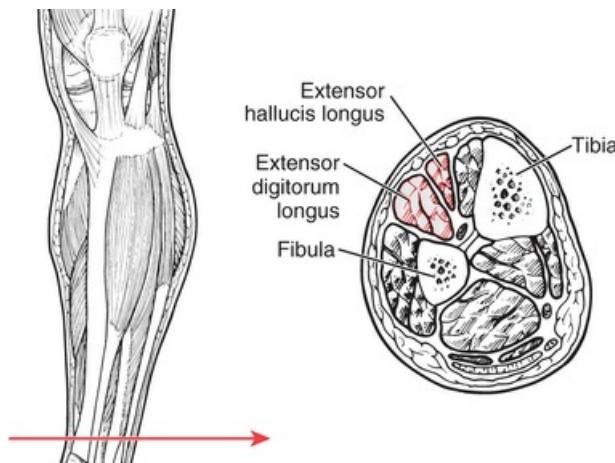


FIGURE 6.135 Arrow indicates level of cross section.

Range of Motion

Hallux: 0°–75°–80°
Digits 2–5: 0°–40°

Table 6.18
EXTENSION OF MP JOINTS OF TOES AND IP JOINT OF HALLUX

I.D.	Muscle	Origin	Insertion	Function
211	Extensor digitorum longus	Tibia (lateral condyle) Fibula (shaft, proximal medial surface) Fascia cruris (deep) Interosseous membrane (anterior) Intermuscular septum	Toes 2–5 (to each middle and each distal phalanx, dorsal surface) <i>3/4 of</i>	MP extension of four lesser toes PIP and DIP extension (assist) of four lesser toes Ankle dorsiflexion (accessory) Foot eversion (accessory)
212	Extensor digitorum brevis	Calcareus (anterior superolateral surface) Lateral talocalcaneal ligament Extensor retinaculum (inferior)	Ends in four tendons: hallux (proximal phalanx, dorsal surface [may be named <i>extensor hallucis brevis</i>]) Toes 2–4: join tendons of extensor digitorum longus (lateral sides)	Hallux (great toe): MP extension Toes 2–4: MP extension Toes 2–4: IP extension (assist)
221	Extensor hallucis longus	Fibula (shaft, middle 1/2 of medial aspect) Interosseous membrane	Hallux (distal phalanx, dorsal aspect of base) Expansion to proximal phalanx	Hallux: MP and IP extension Ankle dorsiflexion (accessory) Foot inversion (accessory)

DIP, Distal interphalangeal; IP, interphalangeal; MP, metatarsophalangeal; PIP, proximal interphalangeal.

Grades 5 to 0

Position of Patient:

Sitting with foot on therapist's lap. Alternate position: supine. Ankle in neutral (midway between plantar flexion and dorsiflexion).

Instructions to Therapist:

Sit on low stool in front of patient, or stand beside table near the patient's foot. Ask patient to straighten big toe or all the toes.

Lateral Toes:

One hand stabilizes the metatarsals with the fingers on the plantar surface and the thumb on the dorsum of the foot (Fig. 6.136). The other hand is used to give resistance with the thumb placed over the dorsal surface of the proximal phalanges of the toes.



FIGURE 6.136

Hallux:

Stabilize the metatarsal area by contouring the hand around the plantar surface of the foot with the thumb curving around to the base of the hallux (Fig. 6.137). The other hand stabilizes the foot at the heel. For resistance, place thumb over the MP joint (see Fig. 6.136) or over the IP joint (Fig. 6.138).

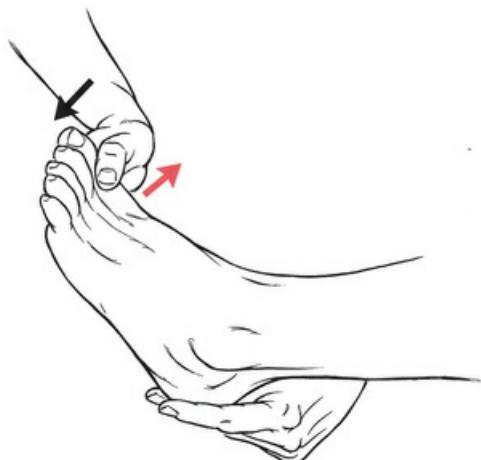


FIGURE 6.137

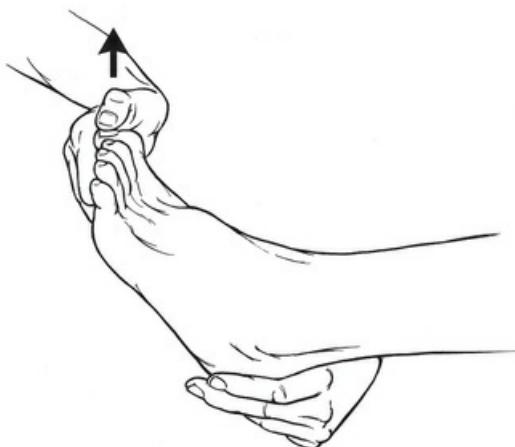


FIGURE 6.138

Test:

Patient extends lateral four toes or extends hallux.

Instructions to Patient:

"Straighten your big toe. Hold it." OR "Straighten your toes and hold it."

Grading

Grade 5 and Grade 4:

Patient can extend the toes fully against variable resistance (which may be small).

Grade 3 and Grade 2:

Patient can complete range of motion with no resistance (Grade 3) or can complete a partial range of motion (Grade 2).

Grade 1 and Grade 0:

Tendons of the extensor digitorum longus can be palpated or observed over dorsum of metatarsals. Tendon of the extensor digitorum brevis often can be palpated on the lateral side of the dorsum of the foot just in front of the malleolus.

Palpable contractile activity is a Grade 1; no discernable palpable contractile activity is a Grade 0.

Helpful Hints

- Many (if not most) patients cannot separate great toe extension from extension of the four lateral toes. Nor can most separate MP from IP activity.
- The test is used not so much to ascertain strength as to determine whether the toe muscles are active.
- Normal strength in the ankle and foot muscles allows us to walk on uneven surfaces and supplies the major muscle forces needed for balance.

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