The knee joint

8

Objectives

- To identify on a human skeleton the most important bone features of the knee.
- To explain the cartilaginous and ligamentous structures of the knee joint.
- To draw and label on a skeletal chart muscles and ligaments of the knee joint.
- To palpate the superficial knee joint structures and muscles on a human subject.
- To demonstrate and palpate with a fellow student all the movements of the knee joint and list their respective planes of motion and axes of rotation.
- To name and explain the actions and importance of the quadriceps and hamstrings muscles.
- To list and organize the muscles that produce the movements of the knee joint and list their antagonists.

The knee joint is the largest joint in the body and is very complex. It is primarily a hinge joint. The combined functions of weight bearing and locomotion place considerable stress and strain on the knee joint. Powerful knee joint extensor and flexor muscles, combined with a strong ligamentous structure, provide a strong functioning joint in most instances.

Bones

The enlarged femoral condyles articulate on the enlarged condyles of the tibia, somewhat in a horizontal line. Since the femur projects downward at an oblique angle toward the midline, its medial condyle is slightly larger than the lateral condyle.

The top of the medial and lateral tibial condyles, known as the medial and lateral tibial plateaus, serve as receptacles for the femoral condyles. The tibia is the medial bone in the leg and bears much more of the body's weight than the fibula. The fibula serves as the attachment for some very important knee joint structures, although it does not articulate with the femur or patella and is not part of the knee joint.

The patella is a sesamoid (floating) bone imbedded in the quadriceps muscle group and patellar tendon. Its location allows it to serve the quadriceps in a fashion similar to a pulley by creating an improved angle of pull. This results in a greater mechanical advantage when performing knee extension.

Joints FIG. 8.1

The knee joint proper, or tibiofemoral joint, is classified as a ginglymus joint because it functions like a hinge. It moves between flexion and extension without side-to-side movement into abduction or adduction. However, it is sometimes referred to as a trochoginglymus joint because of the internal and external rotation movements that can occur during flexion. Some authorities argue that it should be classified as a condyloid joint due to its structure. The patellofemoral joint is classified as an arthrodial joint due to the gliding nature of the patella on the femoral condyles.

The ligaments provide static stability to the knee joint, and contractions of the quadriceps and hamstrings produce dynamic stability. The surfaces between the femur and tibia are protected by articular cartilage, as is true of all diarthrodial joints. In addition to the articular cartilage covering the ends of the bones, there are specialized cartilages (Fig. 8.1), known as the menisci, that form cushions between the bones. These menisci are attached to the tibia and deepen the tibial fossa, thereby enhancing stability.

The medial semilunar cartilage, or more technically, the medial meniscus, is located on the medial tibial plateau to form a receptacle for the medial femoral condyle. The lateral semilunar cartilage (lateral meniscus) sits on the lateral tibial plateau to receive the lateral femoral condyle. Both of these menisci are thicker on the outside border and taper down very thin to the inside border. They can slip about slightly and are held in place by various small ligaments. The medial meniscus is the larger of the two and has a much more open C appearance than the rather closed C lateral meniscus configuration. One or both of the menisci may be torn in several different areas from a variety of mechanisms, resulting in varying degrees of severity and problems. These injuries often occur due to the significant compression and shear forces that develop as the knee rotates while flexing or extending during quick directional changes in running.

Two very important ligaments of the knee are the anterior and posterior cruciate, so named because they cross within the knee between the tibia and the femur. These ligaments are vital in respectively maintaining the anterior and posterior stability of the knee joint, as well as the rotatory stability (see Fig. 8.1).

The anterior cruciate ligament (ACL) tear is one of the most common serious injuries to the knee. The mechanism of this injury often involves noncontact rotary forces associated with planting and cutting. Fortunately, the posterior cruciate ligament (PCL) is not often injured. Injuries of the posterior cruciate usually come about through direct contact with an opponent or with the playing surface.

On the medial side of the knee is the tibial (medial) collateral ligament (MCL) (see Fig. 8.1), which maintains medial stability by resisting valgus forces or preventing the knee joint from being abducted. Injuries to the tibial collateral occur quite commonly, particularly in contact or collision sports in which a teammate or opponent may fall against the lateral aspect of the knee or leg, causing medial opening of the knee joint and stress to the medial ligamentous structures.

On the lateral side of the knee, the fibular (lateral) collateral ligament (LCL) joins the fibula and the femur. Injuries to this ligament are infrequent.

In addition to the other intraarticular ligaments detailed in Fig. 8.1, there are numerous other ligaments not shown that are contiguous with the joint capsule. Generally, these ligaments are of lesser importance and will not be discussed further.*

The knee joint is well supplied with synovial fluid from the synovial cavity, which lies under the patella and between the surfaces of the tibia and the femur. Commonly, this synovial cavity is called the "capsule of the knee." More than 10 bursae are located in the knee, some of which are connected to the synovial cavity. Bursae are located where they can absorb shock or prevent friction.

The knee can usually extend to 180 degrees or a straight line, although it is not uncommon for some knees to hyperextend up to 10 degrees or more. When the knee is in full extension or 0 degrees of flexion, it can move from there to about 140 degrees of flexion. With the knee flexed 30 degrees or more, approximately 30 degrees of internal rotation and 45 degrees of external rotation can occur.

*More detailed discussion of the knee is found in anatomy texts and athletic training manuals.

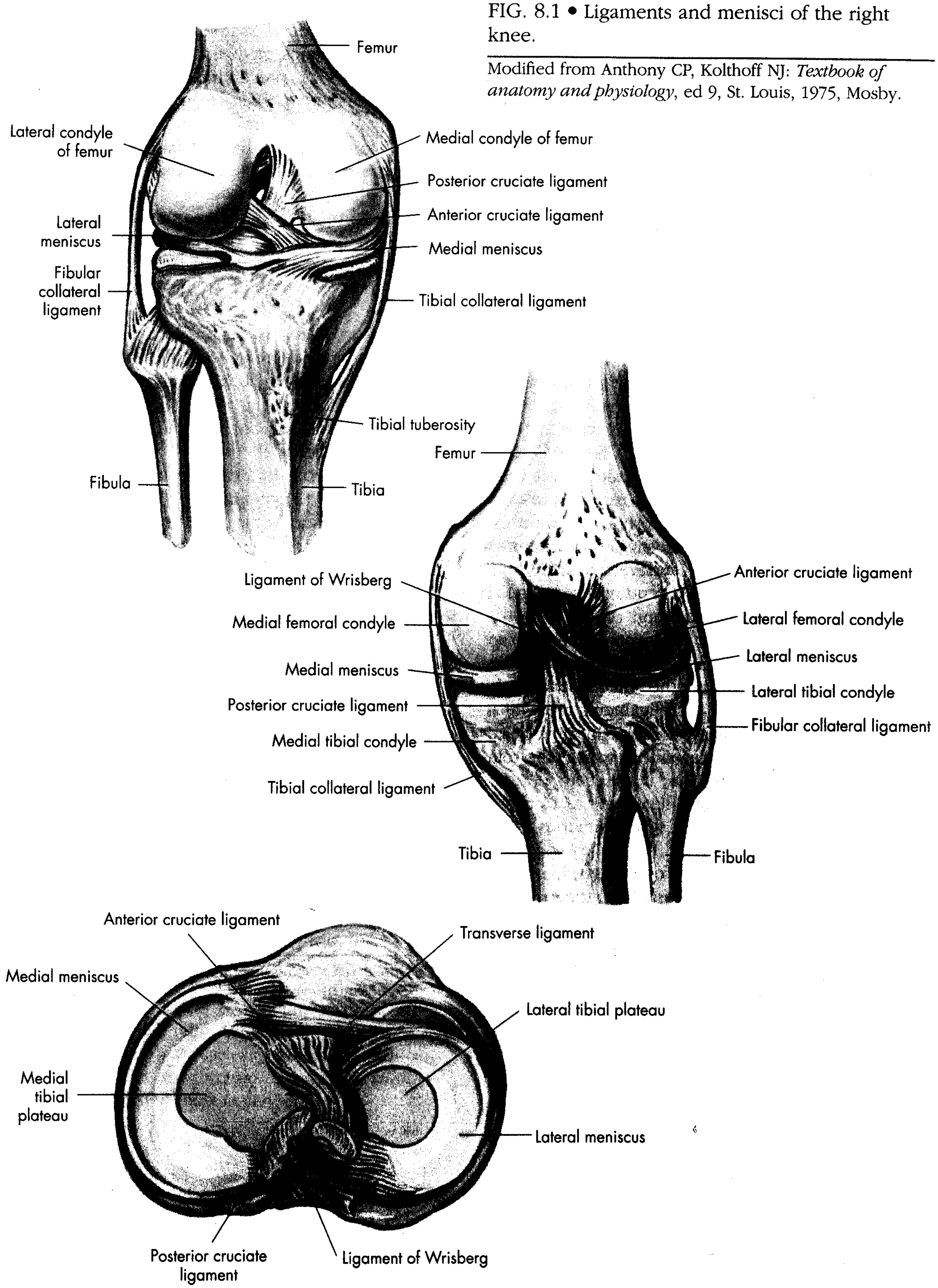


FIG. 8.1 • Ligaments and menisci of the right knee.

Modified from Anthony CP, Kolthoff NJ: *Textbook of anatomy and physiology*, ed 9, St. Louis, 1975, Mosby.

Movements FIG. 8.2

Flexion and extension of the knee occur in the sagittal plane, whereas internal and external rotation occur in the horizontal plane.

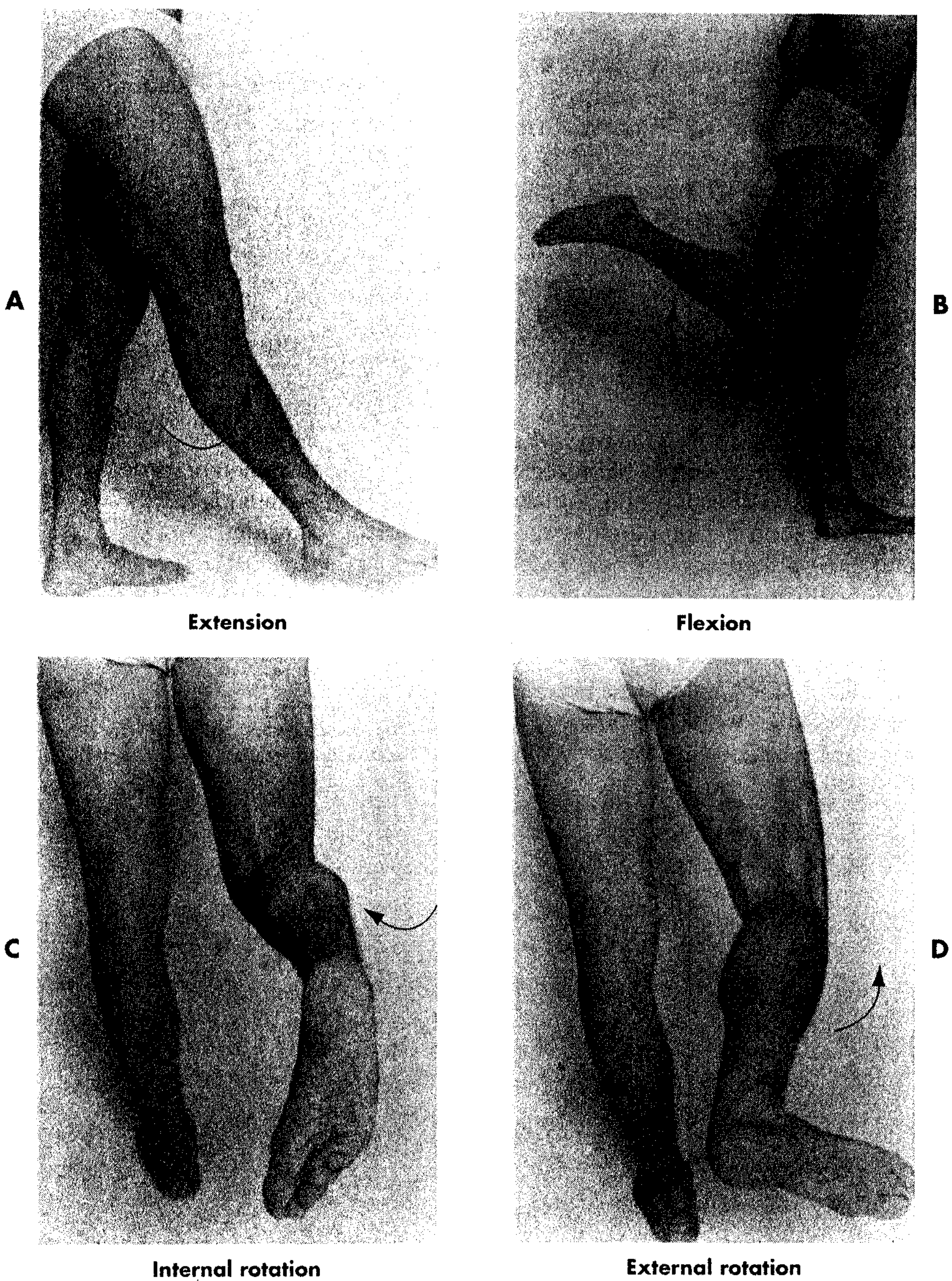
Flexion: bending or decreasing the angle between the femur and lower leg characterized by the heel moving toward the buttocks.

Extension: straightening or increasing the angle between the femur and the lower leg.

External rotation: rotary movement of the lower leg laterally away from the midline.

Internal rotation: rotary movement of the lower leg medially toward the midline.

FIG. 8.2 • Movements of the knee with prime movers illustrated.



Muscles

Some of the muscles involved in knee joint movements were discussed in Chapter 7 because of their biarticular arrangement with both the hip and knee joints. As a result, they will not be covered again fully in this chapter. The knee joint muscles that have already been addressed are:

Knee extensor: rectus femoris.

Knee flexors: sartorius, biceps femoris, semitendinosus, semimembranosus, and gracilis.

The gastrocnemius muscle, discussed in Chapter 9, also assists minimally with knee flexion.

The muscle group that extends the knee is located in the anterior compartment of the thigh and is known as the quadriceps. It consists of four muscles: the rectus femoris, the vastus lateralis, the vastus intermedius, and the vastus medialis. The hamstring muscle group is located in the posterior compartment of the thigh and is responsible for knee flexion. The hamstrings consists of three muscles: the semitendinosus, the semimembranosus, and the biceps femoris. The semimembranosus and semitendinosus (medial hamstrings) muscles are assisted by the popliteus in internally rotating the knee, whereas the biceps femoris (lateral hamstring) is responsible for knee external rotation.

Two-joint muscles are most effective when either the origin or the insertion is stabilized to prevent movement in the direction of the muscle when it contacts. Additionally, to a degree, muscles are able to exert greater force when lengthened than when shortened. All of the hamstring muscles, as well as the rectus femoris, are biarticular (two-joint) muscles.

As an example, the sartorius muscle becomes a better flexor at the knee when the pelvis is rotated posteriorly and stabilized by the abdominal muscles, thus increasing its total length by moving its origin further from its insertion. This is exemplified by trying to flex the knee and cross the legs in the sitting position. One usually leans backward to flex the legs at the knees. Again, this is illustrated by kicking a football. The kicker invariably leans well backward to raise and fix the origin of the rectus femoris muscle to make it more effective as an extensor of the leg at the knee. Also, when youngsters hang by the knees, they flex the hips to fix or raise the origin of the hamstrings to make the latter more effective flexors of the knees.

Knee joint muscles—location

Muscle location closely relates to muscle function with the knee.

Anterior

- Primarily knee extension
  - Rectus femoris*
  - Vastus medialis
  - Vastus intermedius
  - Vastus lateralis

Posterior

- Primarily knee flexion
  - Biceps femoris*
  - Semimembranosus*
  - Semitendinosus*
  - Sartorius*
  - Gracilis*
  - Popliteus
  - Gastrocnemius*

*Two-joint muscles; hip actions are discussed in Chapter 7 and ankle actions are discussed in Chapter 9.

Quadriceps muscles FIG. 8.3

(kwod′ri-seps)

The ability to jump is essential in nearly all sports. Individuals who have good jumping ability always have strong quadriceps muscles that extend the leg at the knee. The quadriceps functions as a decelerator when it is necessary to decrease speed to change direction. This deceleration function is also evident in stopping the body when coming down from a jump. The contraction that occurs in the quadriceps during braking or decelerating actions is eccentric. This eccentric action of the quadriceps controls the slowing of movements initiated in previous phases of the sports skill.

The muscles are the rectus femoris (the only two-joint muscle of the group), vastus lateralis (the largest muscle of the group), vastus intermedius, and vastus medialis. All attach to the patella and by the patellar tendon to the tuberosity of the tibia. All are superficial and palpable except the vastus intermedius, which is under the rectus femoris. The vertical jump is a simple test that may be used to indicate the strength or power of the quadriceps. This muscle group is generally desired to be 25% to 33% stronger than the hamstring muscle group (knee flexors).

Rectus femoris muscle FIG. 7.9

(rek′tus fem′o-ris)

Origin

Anterior inferior iliac spine of the ilium and superior margin of the acetabulum.

Insertion

Superior aspect of the patella and patellar tendon to the tibial tuberosity.

Action

Flexion of the hip.
Extension of the knee.

Palpation

Any place on the anterior surface of the femur.

Innervation

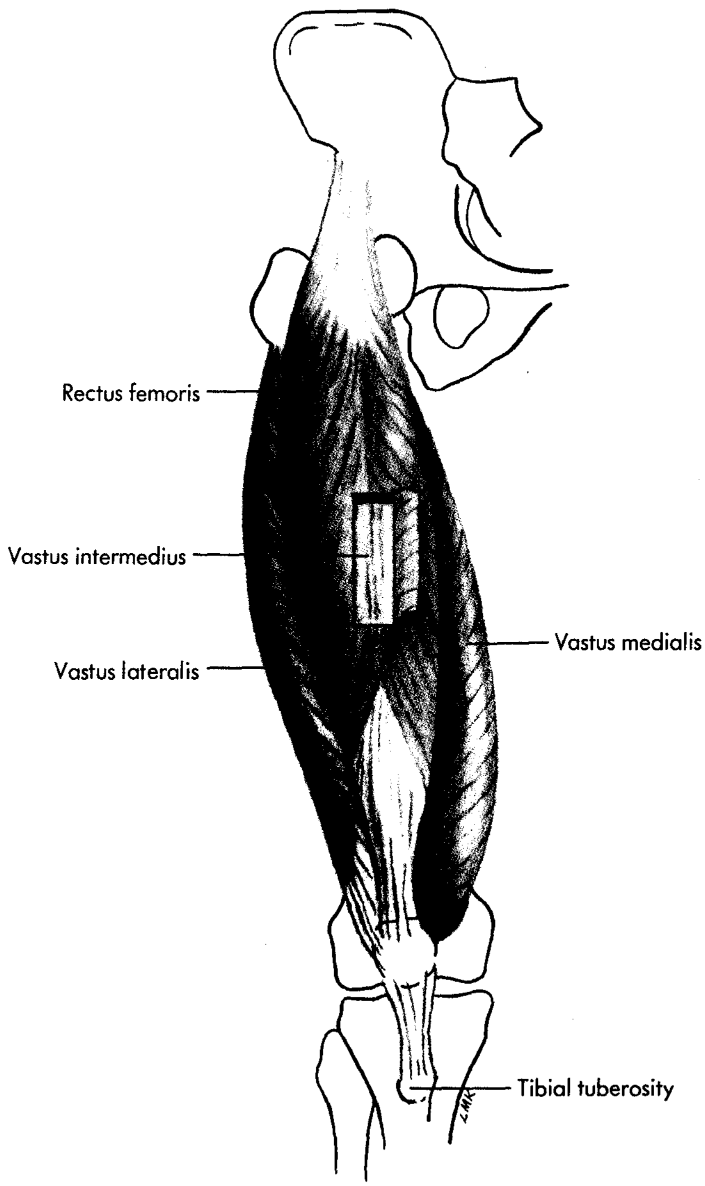
Femoral nerve (L2-4).

Application, strengthening, and flexibility

When the hip is flexed, the rectus femoris becomes shorter, which reduces its effectiveness as an extensor of the knee. The work is then done primarily by the three vasti muscles.

Also see rectus femoris, Chapter 7, p. 113, and above.

FIG. 8.3 • Quadriceps muscle group.



Vastus lateralis (externus) muscle FIG. 8.4

(vas'tus lat-er-a'lis)

Origin

Intertrochanteric line, anterior and inferior borders of the greater trochanter, gluteal tuberosity, upper half of the linea aspera and entire lateral intermuscular septum.

Insertion

Lateral border of the patella and patellar tendon to the tibial tuberosity.

Action

Extension of the knee.

Palpation

Anterior lateral aspect of the thigh.

Innervation

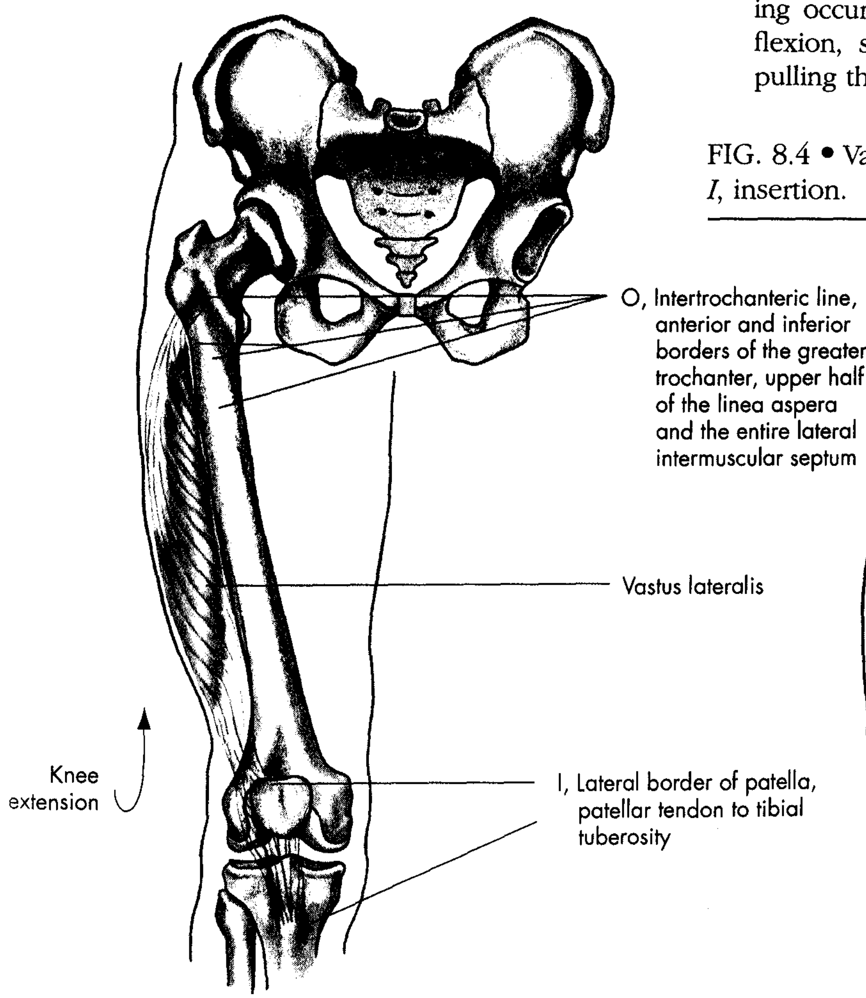
Femoral nerve (L2-4).

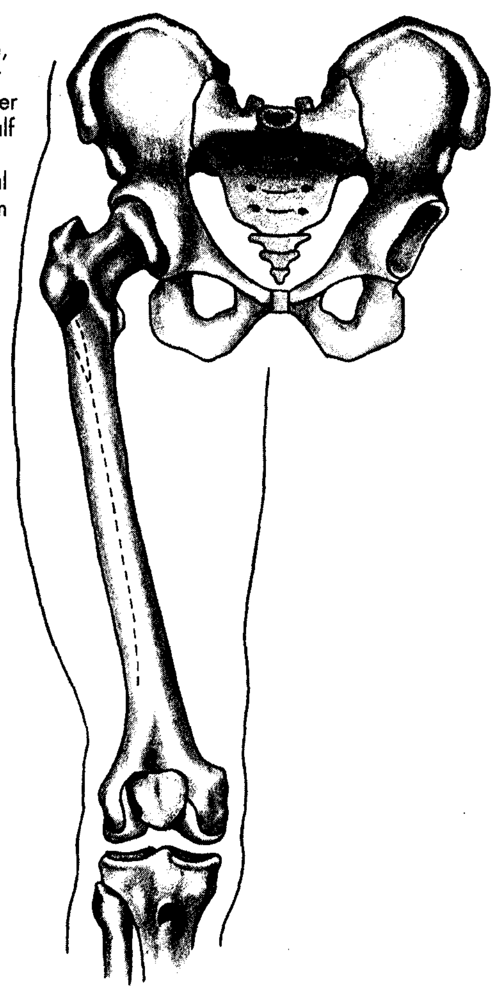
Application, strengthening, and flexibility

All three of the vasti muscles function with the rectus femoris in knee extension. They are typically used in walking and running and must be used to keep the knees straight, as in standing. The vastus lateralis has a slightly superior lateral pull on the patella and, as a result, is occasionally blamed in part for common lateral patellar subluxation and dislocation problems.

The vastus lateralis is strengthened through knee extension activities against resistance. Stretching occurs by pulling the knee into maximum flexion, such as by standing on one leg and pulling the heel of the other leg to the buttocks.

FIG. 8.4 • Vastus lateralis muscle. *O*, Origin; *I*, insertion.





Vastus intermedius muscle FIG. 8.5

(vas'tus in'ter-me'di-us)

Origin

Upper two-thirds of the anterior surface of the femur.

Insertion

Upper border of the patella and patellar tendon to the tibial tuberosity.

Action

Extension of the knee.

Palpation

Cannot be palpated; lies under the rectus femoris muscle.

Innervation

Femoral nerve (L2-4).

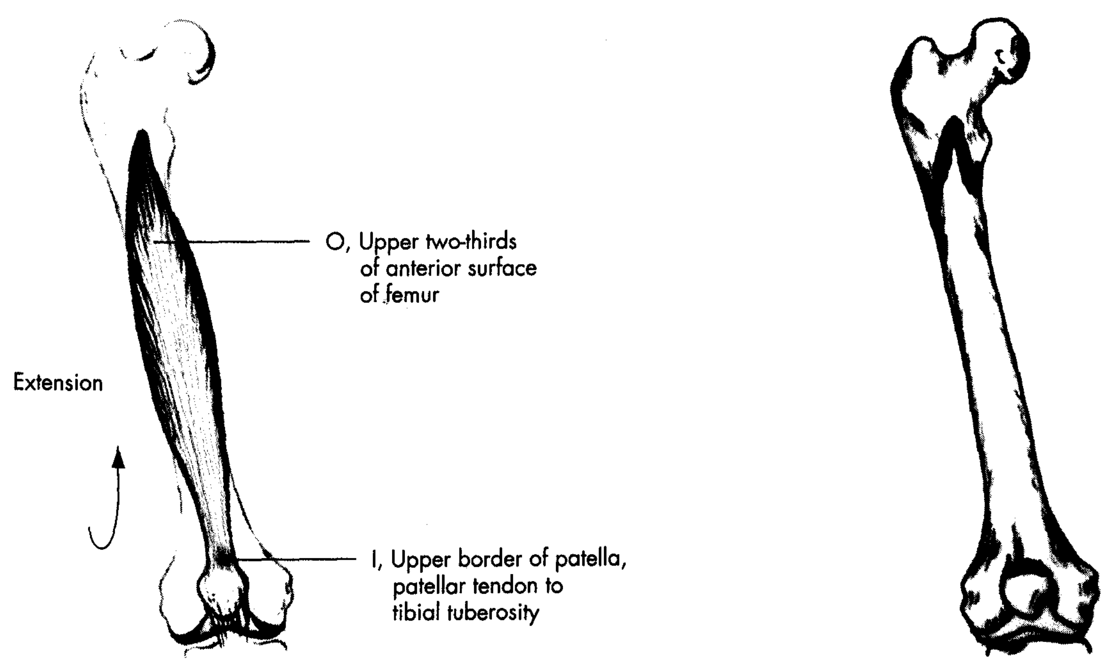
Application, strengthening, and flexibility

The three vasti muscles all contract in knee extension. They are used together with the rectus femoris in running, jumping, hopping, skipping, and walking. The vasti muscles are primarily responsible for extending the knee while the hip is flexed or being flexed. Thus, in doing a knee bend with the trunk bent forward at the hip, the vasti are exercised with little involvement of the rectus femoris. These natural activities mentioned develop the quadriceps.

Squats with a barbell of varying weights on the shoulders, depending on strength, are an excellent exercise for developing the quadriceps if done properly. Caution should be used, along with strict attention to proper technique, to avoid injuries to the knees and lower back. Leg press exercises and knee extensions with weight machines are other good exercises. Full knee flexion stretches all of the quadriceps musculature.

FIG. 8.5 • Vastus intermedius muscle. *O*, Origin; *I*, insertion.

Modified from Anthony CP, Kolthoff NJ: *Textbook of anatomy and physiology*, ed 9, St. Louis, 1975, Mosby.



Vastus medialis (internus) muscle FIG. 8.6

(vas'tus me-di-a'lis)

Origin

Whole length of the linea aspera and the medial condyloid ridge.

Insertion

Medial half of the upper border of the patella and patellar tendon to the tibial tuberosity.

Action

Extension of the knee.

Palpation

Anterior medial side of the thigh near the knee joint.

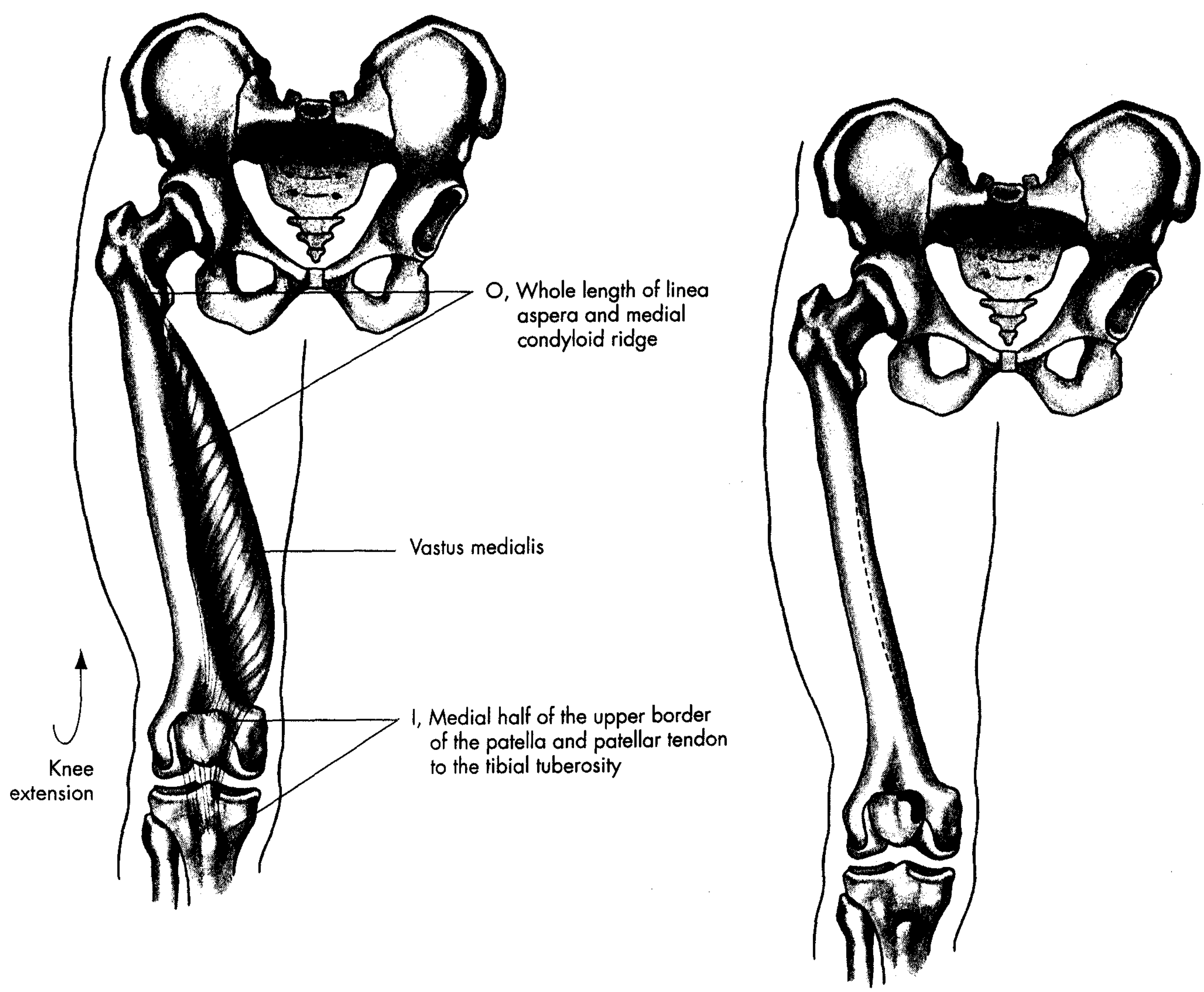
Innervation

Femoral nerve (L2-4).

Application, strengthening, and flexibility

The vastus medialis is thought to be very important in maintaining patellofemoral stability because of the oblique attachment of its distal fibers to the superior medial patella. This portion of the vastus medialis is referred to as the vastus medialis obliquus (VMO). The vastus medialis is strengthened similarly to the other quadriceps muscles by squats, knee extensions, and leg presses; but the VMO is not really emphasized until the last 10 to 20 degrees of knee extension.

FIG. 8.6 • Vastus medialis muscle. *O*, Origin; *I*, insertion.



Hamstring muscles FIG. 8.7

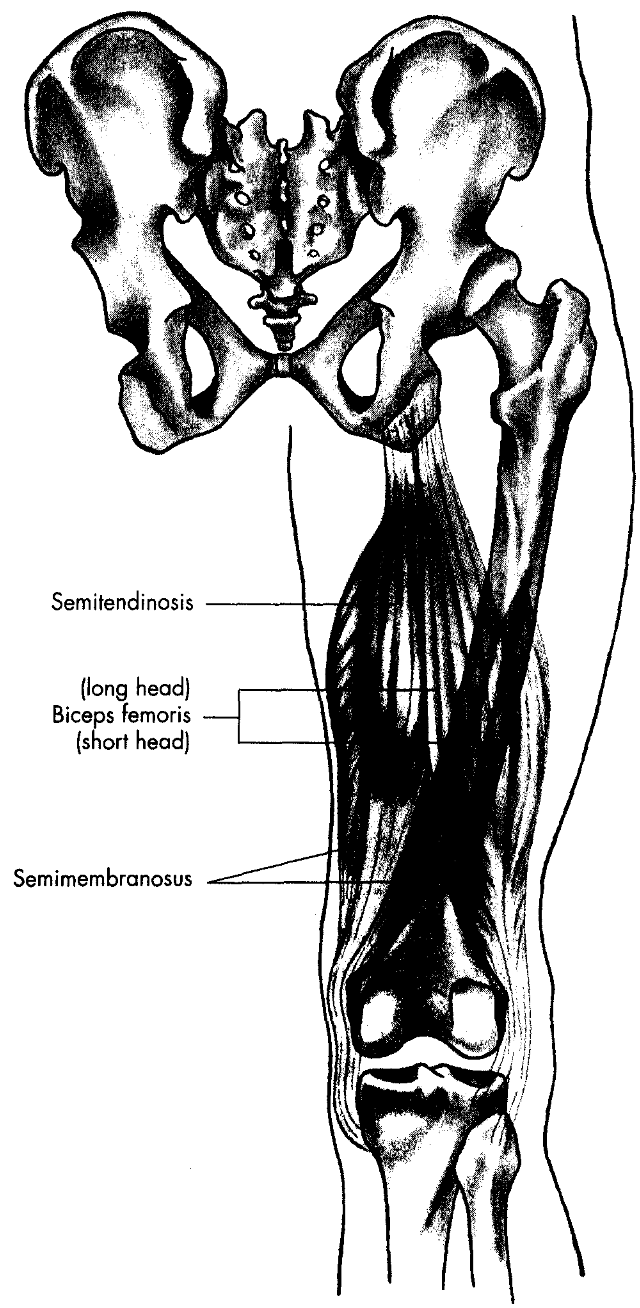
The hamstring muscle group, consisting of the biceps femoris, semimembranosus, and semitendinosus, is covered in complete detail in Chapter 7 but further discussion is included here because of its importance in knee function.

Muscle strains involving the hamstrings are very common in football and other sports that require explosive running. This muscle group is often referred to as the "running muscle" because of its function in acceleration. The hamstring muscles are antagonists to the quadriceps muscles at the knee and are named for their cordlike attachments at the knee. All of the hamstring muscles originate on the ischial tuberosity of the pelvic bone. The semitendinosus and semimembranosus insert on the anteromedial and posteromedial side of the tibia, respectively. The biceps femoris inserts on the lateral tibial condyle and head of the fibula—hence the saying, "Two to the inside and one to the outside." The second head of the biceps femoris is on the linea aspera of the femur.

Special exercises to improve the strength and flexibility of this muscle group are important in decreasing knee injuries. Inability to touch the floor with the fingers when the knees are straight is largely a result of a lack of flexibility of the hamstrings. The hamstrings may be strengthened by performing knee or hamstring curls on a knee table against resistance. The flexibility of these muscles may be improved by performing slow, static stretching exercises, such as flexing the hip slowly while maintaining knee extension in a long sitting position.

The hamstrings are primarily knee flexors and secondarily hip extensors. Rotation of the knee can occur when it is in a flexed position. Knee rotation is brought about by the hamstring muscles. The biceps femoris externally rotates the lower leg at the knee. The semitendinosus and semimembranosus perform internal rotation. Rotation of the knee permits pivoting movements and change in direction of the body. This rotation of the knee is vital in accommodating to forces developing at the hip or ankle during directional changes in order to make the total movement more functional as well as more fluid in appearance.

FIG. 8.7 • The hamstring muscle group.



Popliteus muscle FIG. 8.8

(pop'li-te'us)

Origin

Posterior surface of the lateral condyle of the femur.

Insertion

Upper posterior medial surface of the tibia.

Action

Flexion of the knee.
Internal rotation of the knee.

Palpation

Cannot be palpated.

Innervation

Tibial nerve (L5, S1).

Application, strengthening, and flexibility

The popliteus muscle is the only true flexor of the leg at the knee. All other flexors are two-joint muscles. The popliteus is vital in providing posterolateral stability to the knee. It assists the medial hamstrings in internal rotation of the lower leg at the knee.

Hanging from a bar with the legs flexed at the knee strenuously exercises the popliteus muscle. Also, the less strenuous activities of walking and running exercise this muscle. Specific efforts to strengthen this muscle combine knee internal rotation and flexion exercises against resistance. Stretching of the popliteus is difficult but may be done through passive full knee extension without flexing the hip. Passive maximum external rotation with the knee flexed approximately 20 to 30 degrees also stretches the popliteus.

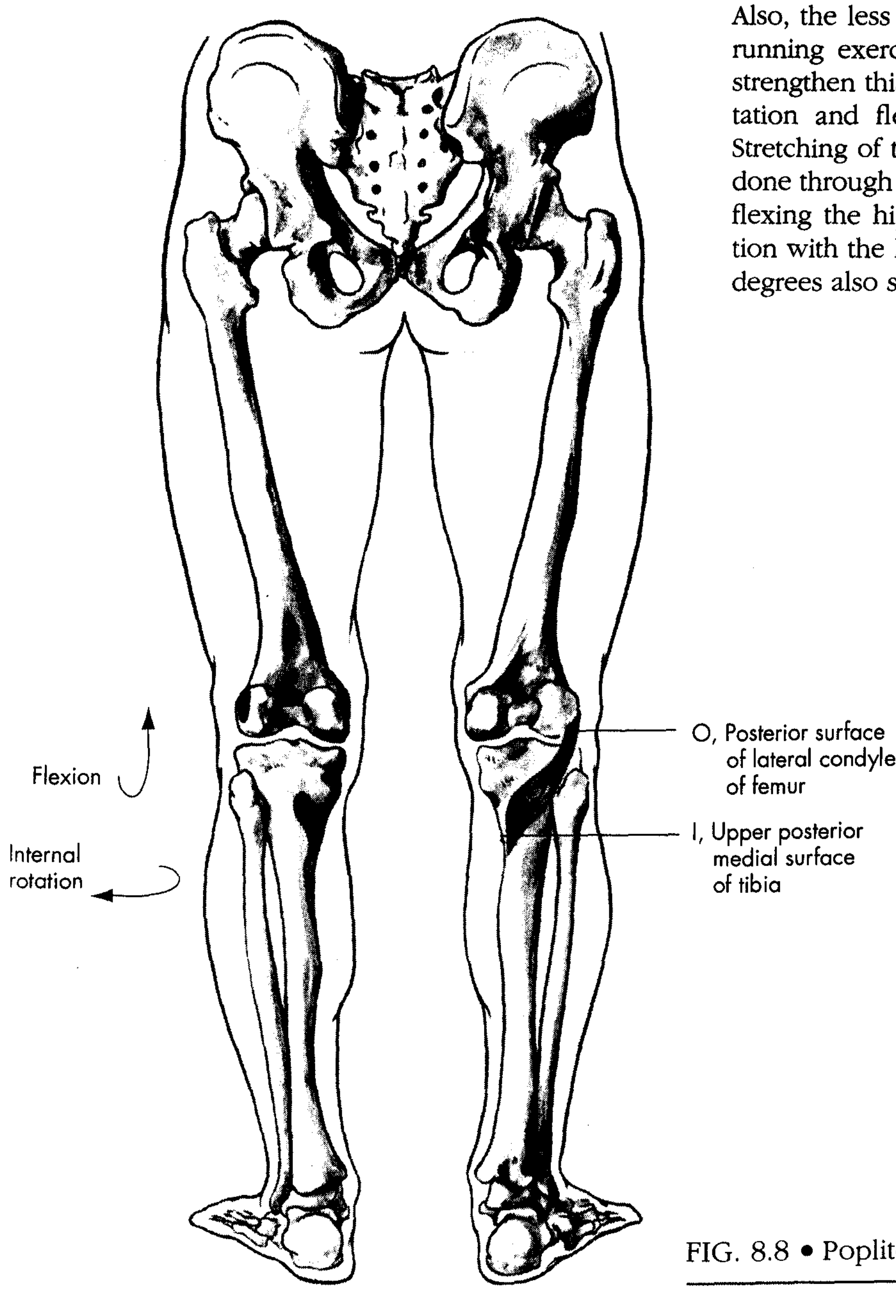


FIG. 8.8 • Popliteus muscle. O, Origin; I, insertion.

Worksheet exercise

As an aid to learning, for in-class or out-of-class assignments, or for testing, a tear-out worksheet is found at the end of the text (p. 256).

Posterior skeletal worksheet (no. 1)

Draw and label on the worksheet the knee joint muscles.

Laboratory and review exercises

1. Locate the following parts of bones on a human skeleton and on a subject:
   a. **Skeleton**
      (1) Head and neck of femur
      (2) Greater trochanter
      (3) Shaft of femur
      (4) Lesser trochanter
      (5) Linea aspera
      (6) Adductor tubercle
      (7) Medial femoral condyle
      (8) Lateral femoral condyle
      (9) Patella
   b. **Subject**
      (1) Greater trochanter
      (2) Adductor tubercle
      (3) Medial femoral condyle
      (4) Lateral femoral condyle
      (5) Patella
2. How and where can the following muscles be palpated on a human subject?
   NOTE: Palpate the previously studied hip joint muscles while they are performing actions at the knee.
   a. Gracilis
   b. Sartorius
   c. Biceps femoris
   d. Semitendinosus
   e. Semimembranosus
   f. Rectus femoris
   g. Vastus lateralis
   h. Vastus intermedius
   i. Vastus medialis
   j. Popliteus
3. Be prepared to indicate on a human skeleton, by using a long rubber band, the origin and insertion of the muscles just listed.
4. Demonstrate the following movements and list the muscles primarily responsible for each.
   a. Extension of the leg at the knee
   b. Flexion of the leg at the knee
   c. Internal rotation of the leg at the knee
   d. External rotation of the leg at the knee
5. List the planes in which each of the following movements occurs. List the respective axis of rotation for each movement in each plane.
   a. Extension of the leg at the knee
   b. Flexion of the leg at the knee
   c. Internal rotation of the leg at the knee
   d. External rotation of the leg at the knee
6. With a laboratory partner, determine how and why maintaining the position of full knee extension limits the ability to maximally flex the hip both actively and passively. Does maintaining excessive hip flexion limit your ability to accomplish full knee extension?
7. With a laboratory partner, determine how and why maintaining the position of full knee flexion limits the ability to maximally extend the hip both actively and passively. Does maintaining excessive hip extension limit your ability to accomplish full knee flexion?
8. Compare and contrast the bony, ligamentous, articular, and cartilaginous aspects of the medial knee joint versus the lateral knee joint.
9. Research the acceptability of deep knee-bends and duck-walk activities in a physical education program and report your findings in class.
10. Prepare a report on the knee, including its ligamentous structure, joint structure, functioning, common injuries, and bracing for injuries.
11. Research preventive and rehabilitative exercises to strengthen the knee joint and report your findings in class.
12. Which muscle group about the knee would be most important to develop for an athlete with a torn anterior cruciate ligament and why? A torn posterior cruciate ligament?
13. In the muscle analysis chart, list the muscles primarily responsible for knee joint movement.
14. Fill in the antagonistic muscle action chart by listing the muscle(s) or parts of muscles that are antagonistic in their actions to the muscles in the left column.

Muscle analysis chart • Knee joint

Flexion	Extension
Internal rotation	External rotation

Antagonistic muscle action chart • Knee joint

Agonist	Antagonist
Biceps femoris	
Semitendinosus	
Semimembranosus	
Rectus femoris	
Vastus lateralis	
Vastus intermedius	
Vastus medialis	
Rectus femoris	
Popliteus	

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