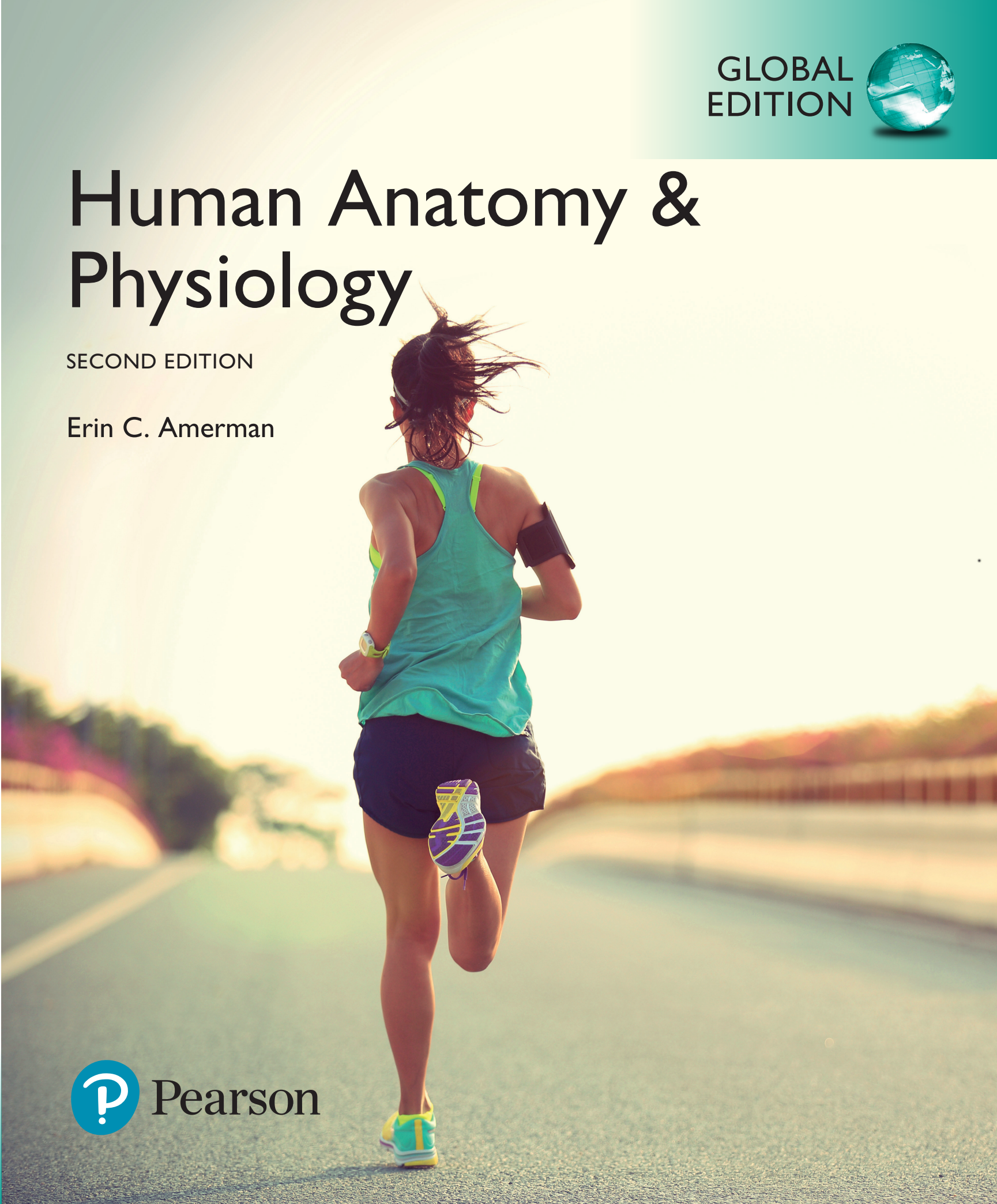
GLOBAL EDITION

Human Anatomy & Physiology

SECOND EDITION

Erin C. Amerman



Pearson

Quick Reference

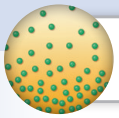
CORE PRINCIPLES in A&P
introduced in chapter one and referenced throughout this book:

CORE PRINCIPLE
Feedback Loops

Feedback loops are homeostatic control mechanisms in which a change in a regulated variable causes effects that *feed back* and in turn affect that same variable.

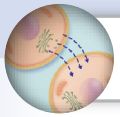
CORE PRINCIPLE
Structure-Function

The form of a structure best suits its function.



CORE PRINCIPLE
Gradients

A gradient is present any time more of something exists in one area than in another and the two areas are connected.

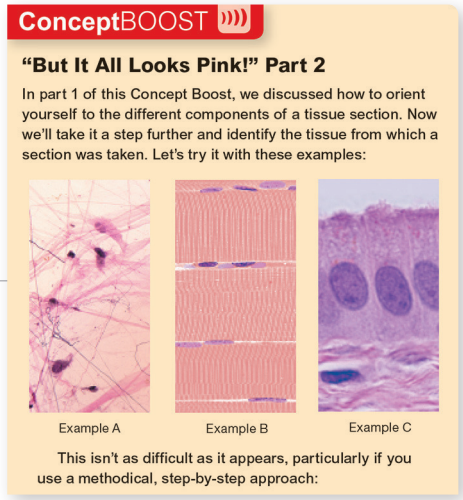


CORE PRINCIPLE
Cell-Cell Communication

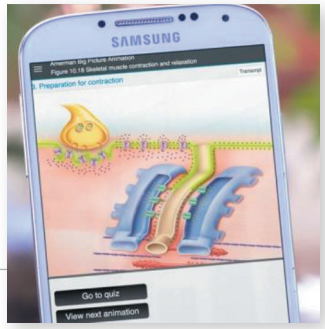
Cells in the body generally communicate via electrical signals or chemical messengers to coordinate functions in the body.

Amerman guides you every step of the way with…

Coaching that clarifies tough concepts



Big Picture Animations that bring Big Picture Figures to life and help reinforce key ideas



One-concept-at-a time art with Big Picture figures help you focus on key concepts

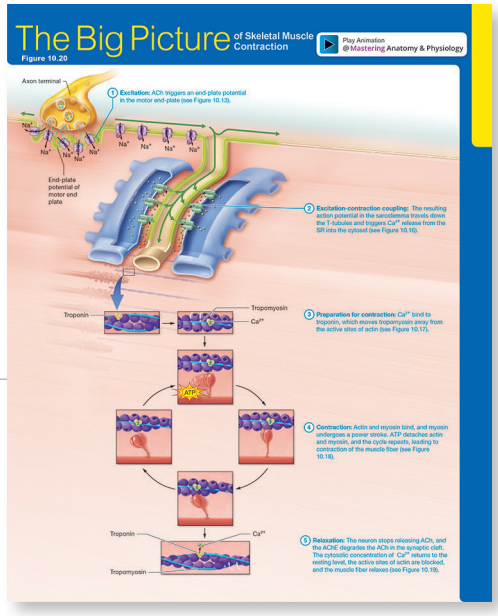
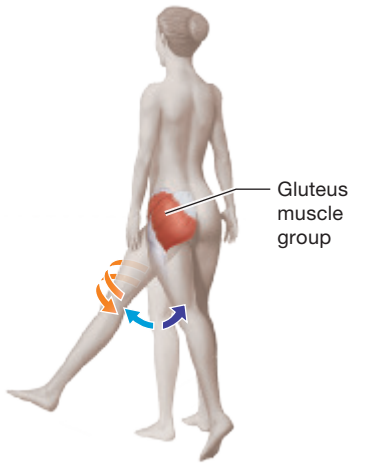
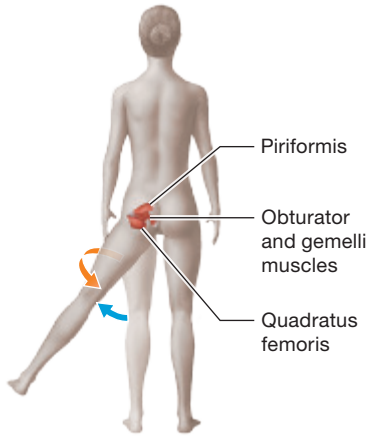
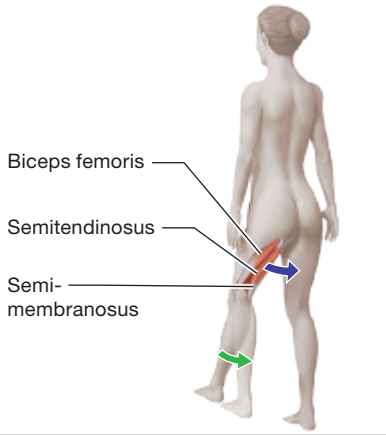


Table 9.18 Muscles That Move the Thigh and Leg: Posterior Muscles

Muscle(s)	Action(s)	Origin/Insertion/Nerve(s)	Concept Figures
Gluteus maximus muscle	**Extends** the thigh (especially when the thigh is in flexed position); laterally **rotates** the thigh; **abducts** the thigh	O: Posterior and lateral portions of the ilium, sacrum, and coccyx I: Gluteal tuberosity of femur N: Inferior gluteal nerve	
Gluteus medius muscle	**Abducts** the thigh; medially **rotates** the thigh; stabilizes pelvis while walking	O: Between posterior and anterior gluteal lines on the outer surface of ilium I: Greater trochanter of femur N: Superior gluteal nerve	
Gluteus minimus muscle	**Abducts** the thigh; medially **rotates** the thigh; stabilizes pelvis while walking	O: Between the anterior and inferior gluteal lines on the outer surface of ilium I: Greater trochanter of femur N: Superior gluteal nerve	
Piriformis muscle	**Abducts** the thigh; laterally **rotates** the thigh	O: Anterior/lateral sacrum I: Greater trochanter of femur N: L5, S1–S2	
Obturator externus muscle	Laterally **rotates** the thigh	O: Edges of and outer surface of obturator foramen and membrane I: Greater trochanter of femur N: Obturator nerve	
Obturator internus muscle	Laterally **rotates** the thigh	O: Edges of and inner surface of obturator foramen and membrane I: Greater trochanter of femur N: L5, S_1	
Gemelli (superior gemellus and inferior gemellus muscles)	Laterally **rotate** the thigh	O: Ischial spine and tuberosity I: Greater trochanter of femur N: L5, S1	
Quadratus femoris muscle	Laterally **rotates** the thigh	O: Ischial tuberosity I: Intertrochanteric crest of femur N: L5, S1	
Hamstring Muscle Group			
Biceps femoris muscle	**Extends** the thigh; **flexes** the leg	O: Ischial tuberosity and distal half of posterior femur I: Head of fibula; lateral condyle of tibia N: Sciatic nerve	
Semitendinosus muscle	**Extends** the thigh; **flexes** the leg	O: Ischial tuberosity I: Proximal medial surface of tibia N: Sciatic nerve	
Semimembranosus muscle	**Extends** the thigh; **flexes** the leg	O: Ischial tuberosity I: Posterior surface of medial condyle of tibia N: Sciatic nerve	







complex, the movements get more intricate and involve finer muscle control. Let's take a look at some of the muscles involved in moving the feet and toes.

Muscles That Move the Foot

We'll start with the anterior muscles in the leg, which are shown in **Figure 9.23**. First remember that when we talk about movement of the foot and ankle, we don't use the terms flexion and extension. Instead, we use the terms *dorsiflexion,* in which the toes are brought toward the leg, and *plantarflexion,* in which the toes are pointed away from the leg. The muscles of the anterior leg, including the **tibialis anterior** (tib-ee-AL-iss) and **extensor digitorum longus muscles,** are the main dorsiflexors of the foot. The extensor digitorum longus muscle inserts

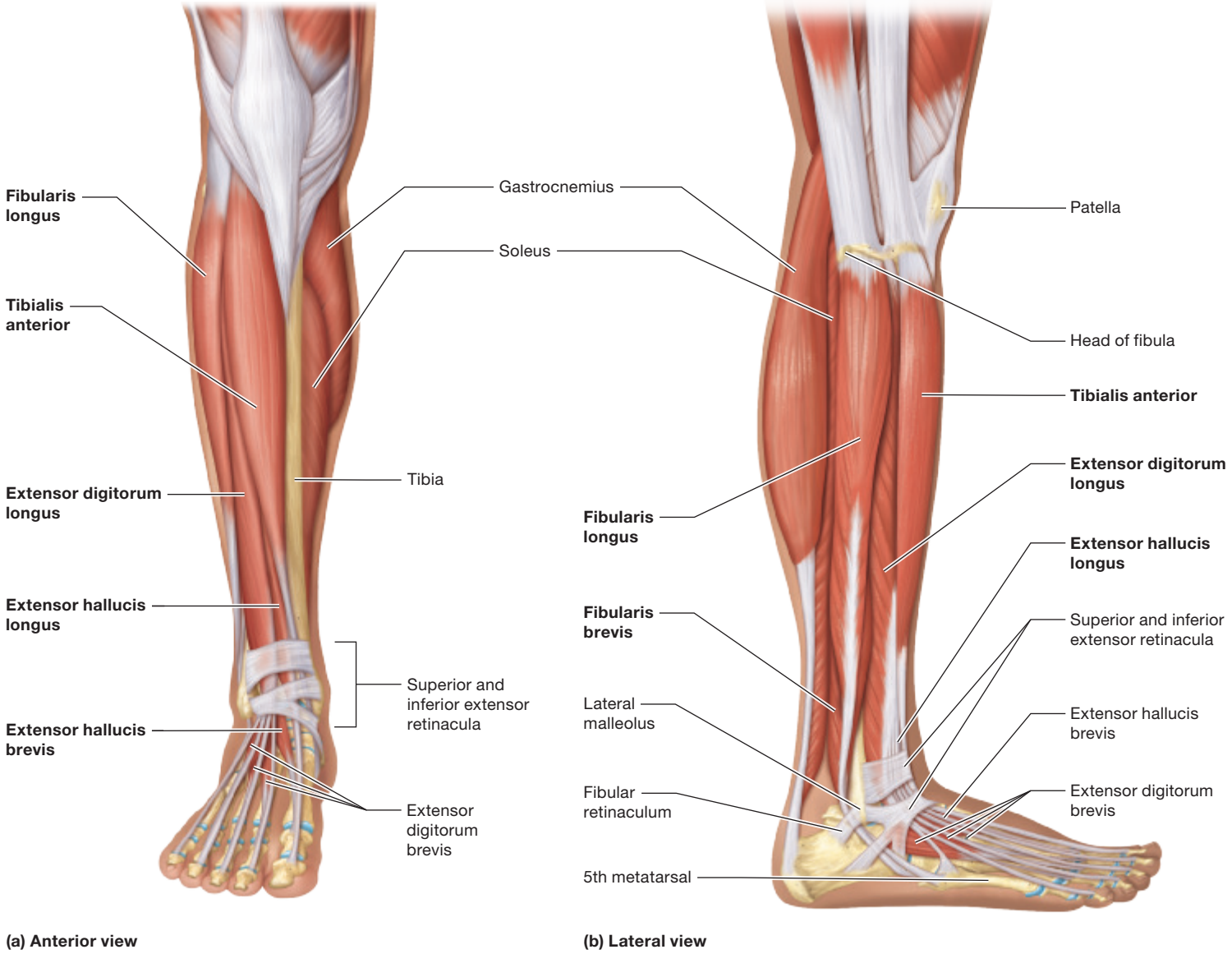


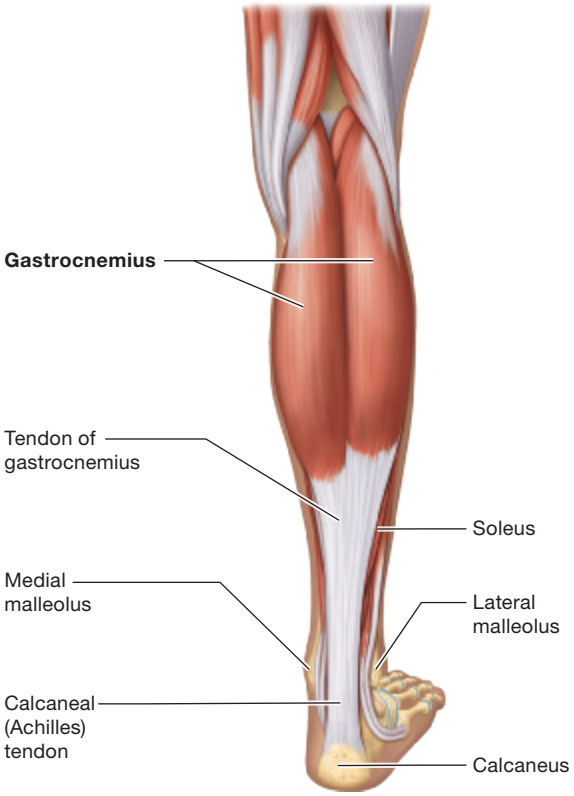
Figure 9.23 Anterior and lateral muscles that move the foot and toes. Labels in **bold** indicate muscles involved in these actions.

into the phalanges of the second through fifth digits, so it also extends these digits, as its name implies. Another anterior muscle, the **extensor hallucis longus muscle** (hal-OO-sis) assists dorsiflexion by extending the hallux (great toe).

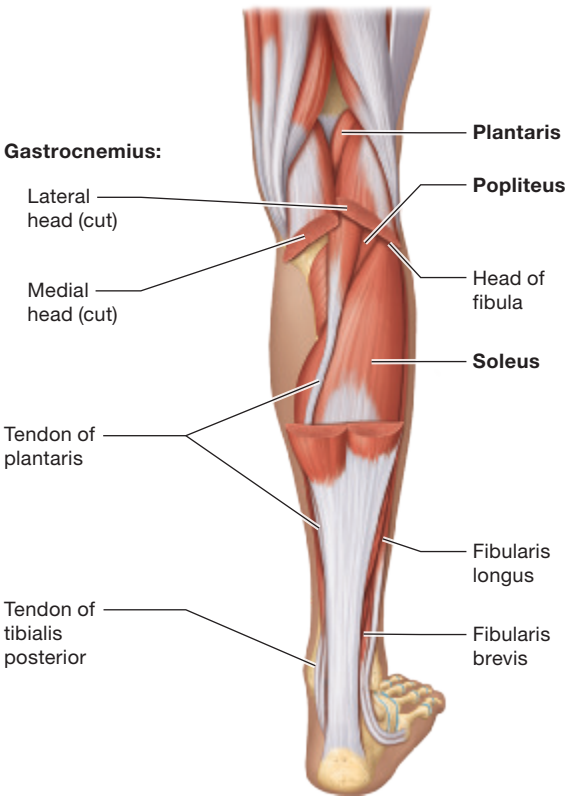
In the lateral view of the leg in Figure 9.23b, we find two muscles that run along the fibula. Accordingly, they are called the **fibularis longus** (fib-yoo-LAH-ris) and **fibularis brevis muscles.** These muscles insert into the lateral side of the foot, which enables them to pull the plantar surface of the foot outward, a movement known as *eversion*. The tibialis anterior muscle acts as an antagonist to these muscles, as it functions in *inversion* of the foot (turning the plantar surface inward).

Turning now to the posterior leg in **Figure 9.24**, you can see that far more muscles are involved in plantarflexion than in dorsiflexion—so many that we divided the figure into three layers in order to show all the muscles. The largest posterior muscle and most powerful plantarflexor of the foot is the *triceps surae muscle group* (SOO-ree), which consists of the superficial two-headed **gastrocnemius muscle** (gas′-trok-NEE-mee-us) and the deeper **soleus muscle.** Notice that the gastrocnemius muscle originates from the femur, and so has a minor action of assisting with leg flexion. The soleus muscle originates from the tibia and fibula and so has no action on the leg (see Figure 9.24b). Both muscles converge to form a common tendon that inserts into the posterior calcaneus called the **calcaneal tendon.** The calcaneal tendon is subject to a great deal of tension, and as such, is prone to injuries. Read more about this topic in *A&P in the Real World: Calcaneal Tendon Injuries*.

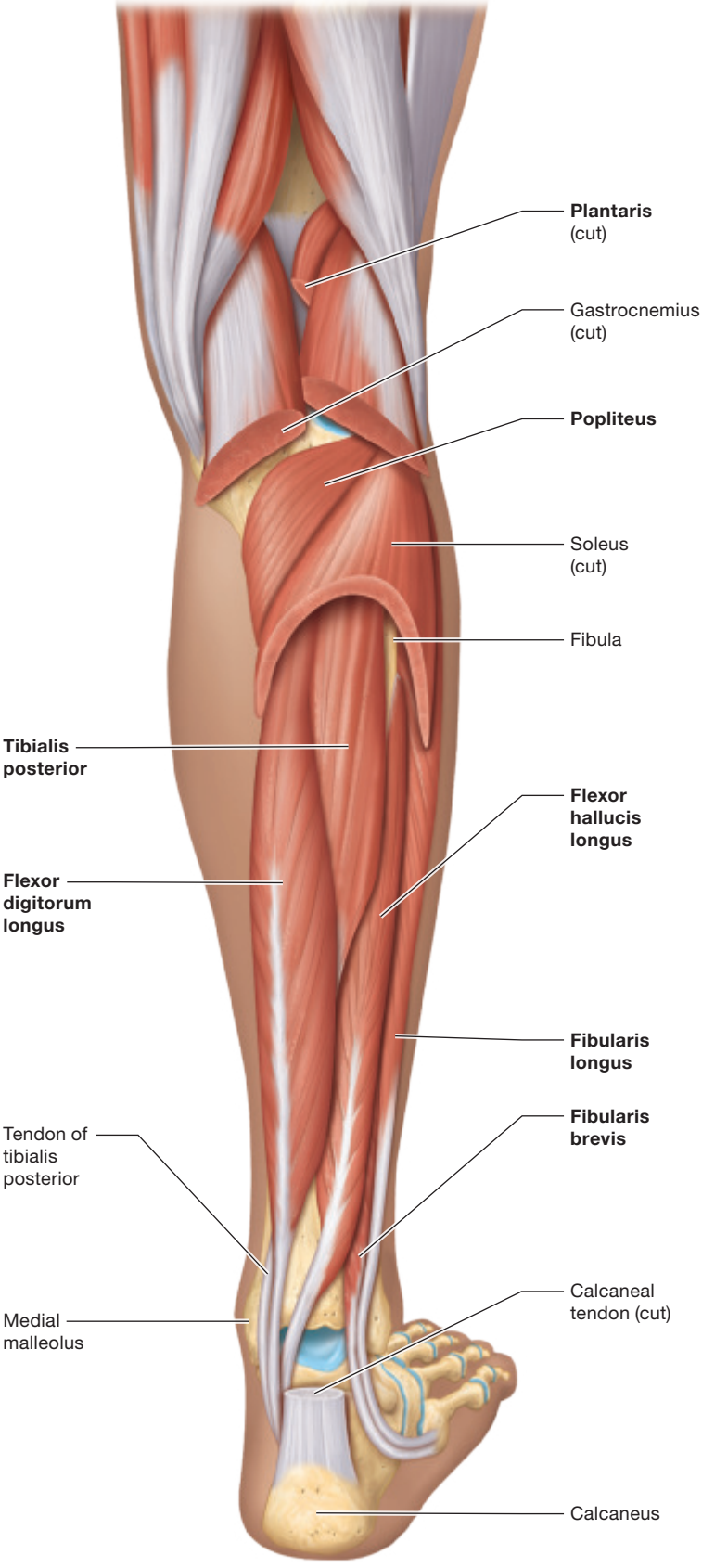
Other muscles that plantarflex the foot include the **plantaris, tibialis posterior,** fibularis longus, and fibularis brevis muscles. Note that the tibialis posterior muscle assists the tibialis anterior muscle with inversion of the foot. See **Table 9.19** for more information on muscles that move the foot.



(a) Superficial muscles



(b) Muscles under the gastrocnemius



(c) Deeper muscles under the gastrocnemius and soleus

Figure 9.24 Right leg: posterior muscles that move the ankle and toes. Labels in **bold** indicate muscles involved in these actions.

A&P in the Real World

Calcaneal Tendon Injuries

Recall from our discussion on levers that the gastrocnemius and soleus muscles form a second-class lever. This type of system generates a lot of force, which makes sense because these two muscles are lifting the entire weight of the body. The high forces generated by the second-class lever put a great deal of strain on the calcaneal tendon. Indeed, injuries to the calcaneal tendon are relatively common, especially in sports such as football, basketball, and gymnastics. The tendon may also be injured by overuse or trauma—stepping in a hole is a common culprit.

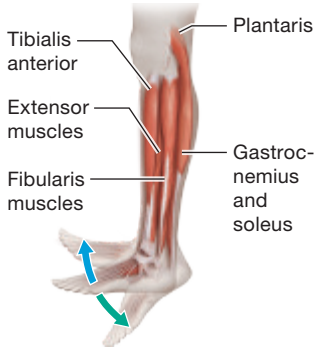
Symptoms of calcaneal tendon injuries depend on their severity. An individual with tendonitis or a partial tear will likely have pain and inflammation over the area that worsens with activity. An individual with a complete tear often reports feeling a "pop" along with severe pain. Such patients will be almost completely unable to plantarflex the affected foot. This is assessed clinically with the *Simmonds test*, during which a patient lies face down and the gastrocnemius muscle is squeezed. If the calcaneal tendon is intact, the foot will plantarflex. If it has ruptured, the foot will not move.

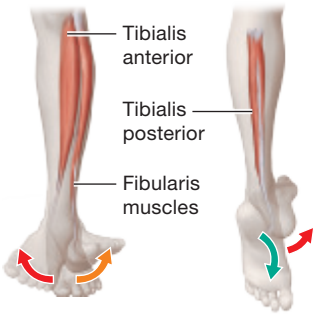
Treatment for a ruptured tendon may involve nonsurgical options, such as wearing a walking boot while the tendon heals, or surgical repair of the torn tendon. Both treatment protocols involve physical therapy to increase the range of motion of the ankle and gently stretch and strengthen the tendon as it heals.

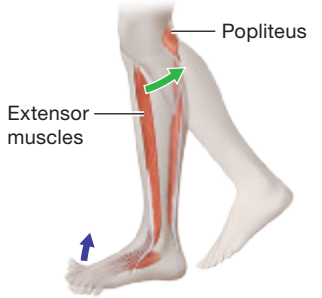
Table 9.19 Muscles That Move the Foot and Toes

Muscle(s)	Action(s)	Origin/Insertion/Nerve(s)
Tibialis anterior muscle	**Dorsiflexes** the foot; **inverts** the foot	O: Lateral condyle and proximal diaphysis of the tibia I: Medial cuneiform bone and first metatarsal N: Deep fibular nerve
Extensor digitorum longus muscle	**Extends** the toes; **dorsiflexes** the foot	O: Lateral condyle of the tibia and proximal portion of the fibula I: Phalanges and connective tissues of toes 2–5 N: Deep fibular nerve
Extensor hallucis longus muscle	**Extends** the hallux (great toe); **dorsiflexes** the foot	O: Diaphysis of the fibula and interosseous membrane I: Distal phalanx of hallux N: Deep fibular nerve
Fibularis longus muscle	**Everts** the foot; **plantarflexes** the foot	O: Proximal lateral fibula I: Medial cuneiform bone and first metatarsal N: Superficial fibular nerve
Fibularis brevis muscle	**Everts** the foot; **plantarflexes** the foot	O: Distal fibula I: Fifth metatarsal N: Superficial fibular nerve
Gastrocnemius muscle*	**Plantarflexes** the foot; flexes leg	O: Medial and lateral condyles of the femur I: Posterior calcaneus N: Tibial nerve
Soleus muscle*	**Plantarflexes** foot	O: Head of the fibula, proximal tibia, and interosseous membrane I: Posterior calcaneus N: Tibial nerve
Plantaris muscle	**Plantarflexes** foot	O: Posterior femur near lateral condyle I: Calcaneus and calcaneal tendon N: Tibial nerve
Tibialis posterior muscle	**Inverts** foot; **plantarflexes** foot; stabilizes foot	O: Proximal tibia, fibula, and interosseous membrane I: Metatarsals 2–4 N: Tibial nerve
Popliteus muscle	**Flexes** leg; rotates leg	O: Lateral condyle of the femur I: Posterior surface of proximal tibia N: Tibial nerve

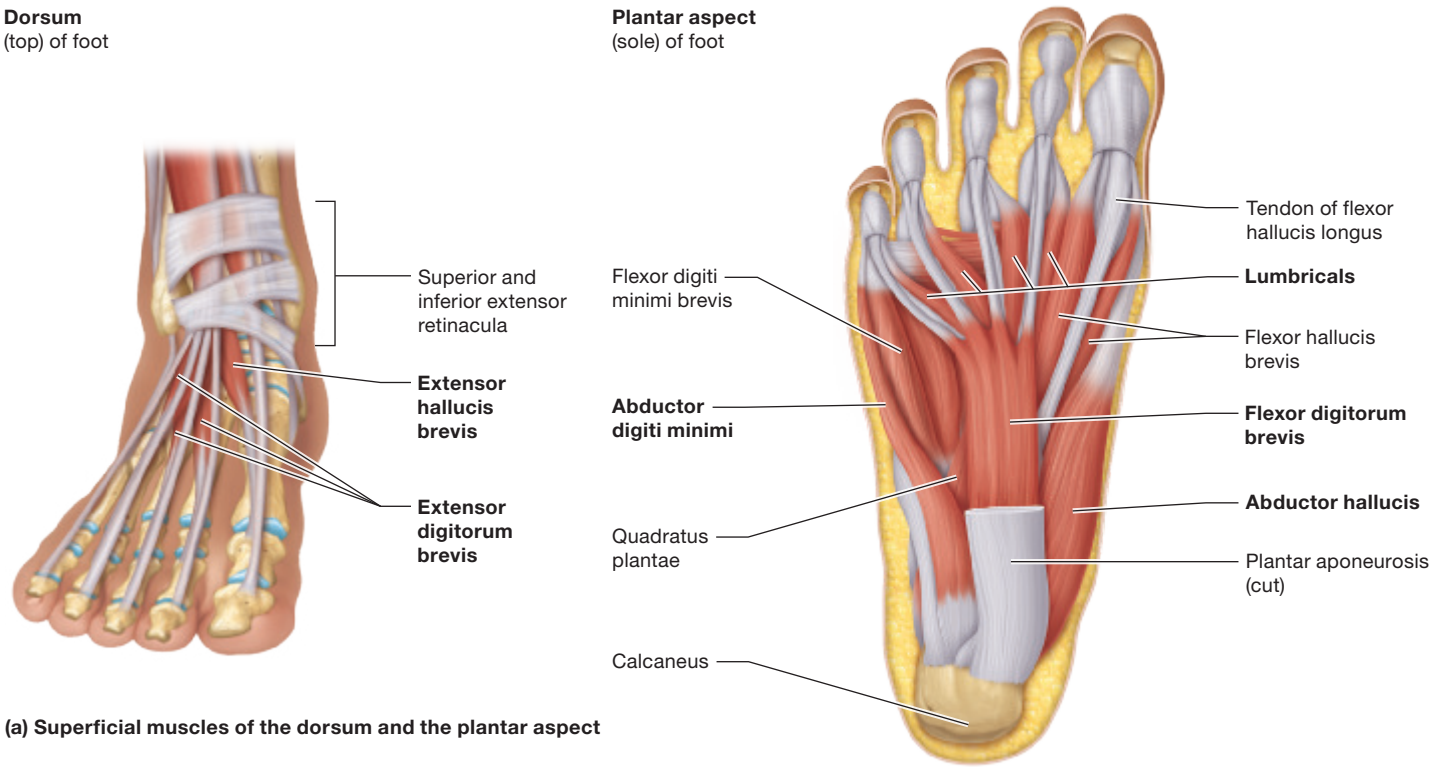
Concept Figures



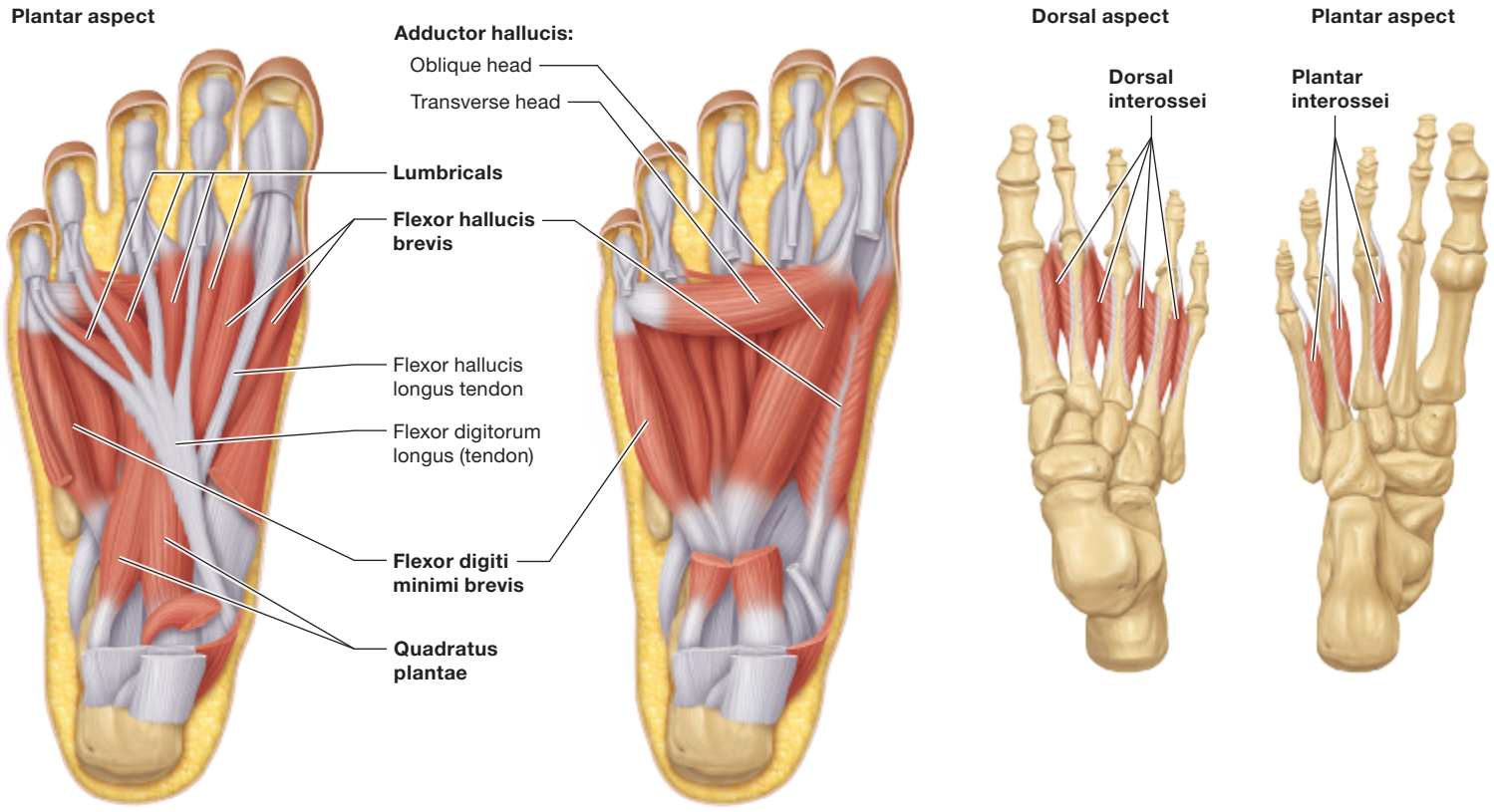




*Part of the triceps surae muscle that shares a common insertion tendon, the calcaneal (Achilles) tendon.



(a) Superficial muscles of the dorsum and the plantar aspect



(b) Deeper muscles of the plantar aspect

(c) Muscles between the toes

Figure 9.25 Muscles that move the toes. Labels in **bold** indicate muscles involved in these actions.

Muscles That Move the Toes

The first muscles we'll examine are actually in the leg (see Figure 9.24c): the **flexor hallucis longus muscle,** which flexes the hallux, and the **flexor digitorum longus muscle,** which flexes the second through the fifth digits. These muscles originate from the posterior fibula and tibia, respectively, and so they also play a role in plantarflexing the foot.

The rest of the muscles that move the toes are *intrinsic foot muscles* and are shown in Figure 9.25. Note that many of the intrinsic foot muscles have similar names to the intrinsic hand muscles you read about earlier; both groups of muscles are named for their actions. For example, the **flexor digitorum brevis muscle** is a small muscle that flexes the second through fourth digits. These muscles support the arches of the foot and allow it to adapt to changing terrain as we walk. They can also be trained to perform quite skilled movements such as drawing, as shown by individuals with upper limb disabilities.

See Table 9.20 for more details about muscles that move the toes.

Table 9.20 Muscles That Move the Toes

Muscle(s)	Action(s)	Origin/Insertion/Nerve(s)
Flexor digitorum longus muscle	Flexes toes; stabilizes foot	O: Posterior tibia I: Distal phalanges of toes 2–5 N: Tibial nerve
Flexor hallucis longus muscle	Flexes hallux	O: Posterior fibula and interosseous membrane I: Distal phalanx of hallux N: Tibial nerve
Extensor digitorum brevis muscle	Extends toes	O: Superior lateral surface of calcaneus I: Dorsal surfaces of toes 2–4 N: Deep fibular nerve
Extensor hallucis brevis muscle	Extends hallux	O: Superior lateral surface of calcaneus I: Dorsal surface of proximal phalanx of hallux N: Deep fibular nerve
Flexor digitorum brevis muscle	Flexes the toes	O: Calcaneal tuberosity I: Middle phalanx of toes 2–5 N: Medial plantar nerve
Abductor digiti minimi muscle	Flexes and abducts fifth toe	O: Calcaneal tuberosity I: Lateral side of the base of proximal phalanx of toe 5 N: Lateral plantar nerve
Abductor hallucis muscle	Abducts hallux	O: Calcaneal tuberosity I: Medial side of the base of proximal phalanx of hallux N: Medial plantar nerve
Quadratus plantae muscle	Flexes toes	O: Lateral surface of the calcaneus I: Tendon of flexor digitorum longus muscle N: Lateral plantar nerve
Lumbrical muscles	Flex toes close to ball of foot; extend toes at phalanges	O: Tendons of the flexor digitorum longus muscle I: Connective tissues of toes 2–5 N: Lateral and medial plantar nerves
Adductor hallucis muscle	Adducts hallux; stabilizes the metatarsals and arch of the foot	O: Metatarsals and surrounding connective tissues, including the tendon of the fibularis longus muscle I: Base of proximal phalanx of lateral hallux N: Lateral plantar nerve
Flexor hallucis brevis muscle	Flexes hallux	O: Cuboid bone, lateral cuneiform bone, and tendon branches of other muscles (e.g., the tibialis posterior muscle) I: Base of hallux and tendons of other muscles (e.g., the adductor hallucis muscle) N: Medial plantar nerve
Flexor digiti minimi brevis muscle	Flexes fifth toe	O: Fifth metatarsal and tendon of fibularis longus muscle I: Base of proximal phalanx of toe 5 N: Lateral plantar nerve
Plantar interossei muscles	Adduct and flex toes 3–5	O: Metatarsals 3–5 I: Medial base of proximal phalanges of toes 3–5 N: Lateral plantar nerve
Dorsal interossei muscles	Abduct and flex toes 2–4	O: Metatarsals 2–5 I: Base of proximal phalanges of toes 2–4 N: Lateral plantar nerve