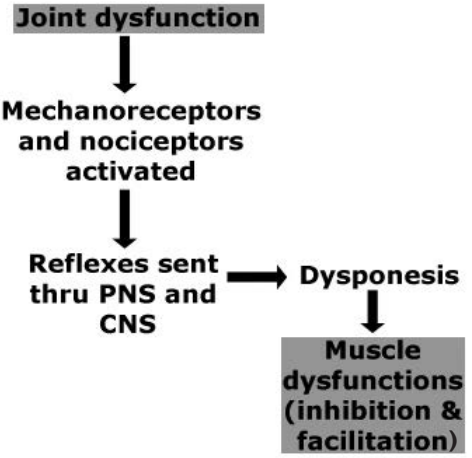


CHAPTER ONE

Manual Muscle Testing for Lower Body Dysfunctions

01

To an experienced applied kinesiologist, manual muscle testing can be of great value in the differential diagnosis of peripheral nerve entrapment. The first and obvious factor is failure of a muscle to perform normally when its efferent supply is disturbed. This is the primary consideration made in most texts dealing with muscle testing, **(Kendall et al., 2005; Daniels & Worthingham, 2002; Walther, 2000, 1981; Janda, 1983)** peripheral nerve entrapment, **(Russell, 2006; Staal et al., 1999; Kopell, 1980)** and general examination of the spine and extremities. **(Liebenson, 2007; Hammer, 2007; Hoppenfeld, 1976)** Their concern is how well the muscle can produce power. In applied kinesiology muscle testing, one is concerned primarily with how effectively the nervous system can control the muscle, as well as its ability to produce power. The applied kinesiologist observes for the muscle's locking capability on the initiation of the test. **(Walther, 2000, 1981)**

Schmitt **(Schmitt, 1986)** has described two types of muscle testing in applied kinesiology. The differentiation is whether the doctor initiates the muscle test by the patient resisting his pressure, or whether the patient applies pressure against the doctor's resistance prior to the doctor applying test pressure. These have been termed gamma I and gamma II muscle tests, respectively, relating to how the neuromuscular spindle cell operates in a test. Conable et al. **(Conable et al., 2005)** evaluated whether examiners trained in applied kinesiology could routinely and accurately assess whether patient-initiated or doctor-initiated MMT had been performed. Using surface EMG, Conable et al. found that the majority of testers in their study did near-simultaneous testing regardless of whether they tried to perform doctor-initiated vs. patient-initiated MMT. The examiner first tested the middle deltoid muscle of the subject in the normal fashion three times and identified the MMT style

as "examiner-started" or "patient-started." The examiner was then asked to perform the other method of MMT. If the examiner said he did not know or did not differentiate which form of testing was initially done, he then performed one series each of examiner- and patient-started MMT. The results of this study showed that nine (approximately 43%) of testers identified their "normally done" muscle test as examiner-started, 4 (19%) as patient-started, and 8 (38%) as simultaneous or undifferentiated. In 64.5% of the MMT described as examiner-started, sEMG showed that the examiner's contraction started before the patient's. In tests identified as patient-started, 54% were indeed patient started. Undifferentiated tests were 45% patient-started, 45% examiner-started, and 10% exactly simultaneous. Near simultaneous contractions were observed in 55% of all tracings evaluated and 70% of undifferentiated tests. The examiner vs. subject initiated tests alone (as described by the examiners), as measured by sEMG, did not clearly differentiate between Schmitt's theorized forms of manual muscle testing.

The doctor–initiated or gamma I muscle test is the one most often used in applied kinesiology. The applied kinesiology methods of muscle testing appear to be much more geared to dynamics rather than simply evaluating whether the muscle is capable of producing power. In applied kinesiology, muscles are not graded as to exact level of strength; rather, consideration is made of whether the muscle is being effectively controlled by the nervous system. The applied kinesiology method of testing is thus very effective in determining subtle peripheral nerve entrapment.

Most other muscle testing methods have a grading system based on motion against gravity and the ability to hold against resistance. A grading system must be used when muscle testing is done to evaluate the nervous system for permanent impairment; it varies among authorities. Listed here is the system in *Guides to the Evaluation of Permanent Impairment, 5th edition* **(American Medical Association, 2001)** by the American Medical Association. In fact, most states have legislatively mandated its use.

(American Medical Association, 2001) Grading Scheme

1. Complete range of motion against gravity and full resistance, 0%.
2. Complete range of motion against gravity and some resistance, or reduced fine movements and motor control, 5–20%.
3. Complete range of motion against gravity and only without resistance, 25–50%.
4. Complete range of motion with gravity eliminated, 55–75%.
5. Slight contractility, but no joint motion, 80–90%.
6. No contractility, 100%.

In addition to the "weak" and "strong" muscles of applied kinesiology and the strength grading scheme of manual muscle testing for impairment ratings is the effort to quantitate strength with dynamometers. There is considerable difference between these methods of muscle testing. **(Kendall et al., 2005; Walther, 2000; Harms-Ringdahl, 1993)** First, applied kinesiology's doctor–initiated manual muscle testing overpowers the maximum isometric contraction and takes the muscle into an eccentric contraction. This appears to evaluate the nervous system's ability to adapt the muscle to combat the changing force of the examiner's test; thus the muscle must be controlled by the nervous system to react properly to information being received from the neuromuscular spindle cell. When force is applied slowly, as in impairment rating or against a fixed strain gauge, there is more time for the nervous system to adapt. This appears to be more a function of whether the alpha motor neuron impulse can be transmitted to the muscle. Simply producing force also appears to be the main factor in testing against isokinetic dynamometers. **(Blaich & Mendenhall, 1984; Blaich, 1981)** Testing a muscle's ability to produce pure strength, as against a strain gauge, often does not reveal the same findings that manual muscle testing does.

Dynamic MMT Assessment

Simons et al **(Simons et al., 1998)** suggest that weakness needs to be evaluated both statically and dynamically, confirming the methods developed by Goodheart. In static testing, a single muscle is being evaluated as the patient attempts a voluntary contraction and the process is under cortical control. In dynamic testing, which involves muscular effort relative to a normal functional movement and where a degree of coordinated muscular effort is required, there is a greater degree of "vulnerability to reflex inhibition", **(Simons et al., 1998)** for example, involving trigger points. Dynamic activity is under less direct cortical control and often involves coordinated patterns of integrated neural and muscular function which are semi-automatic, largely under cerebellar control.

Because of manual muscle testing's versatility it is possible to test patients in many different positions and states (including walking, sitting, supine, prone and moving any number of parts of the nervous systems while the body is being tested). In the AK approach during the manual muscle test, the focus is on the mutual interactions between the patient, their muscular system, and their environment. A large portion of this approach deals with the capabilities of the muscle system to produce movements that are influenced ("challenged") by the patient's sensory or environmental information that coexists with their pain and dysfunction.

One of the most important real world factors that need to be kept in mind when assessing function is that muscle testing and movement assessments should reproduce those actually performed in daily life, particularly those movements that produce pain for the patient. It is appropriate to evaluate a single direction of motion (for example, abduction of the arm) in order to gain information about specific muscles. In daily life, however, abduction of the arm is a movement seldom performed on its own; this movement is usually accompanied by flexion or extension

and some degree of internal or external rotation, depending on the reason for the movement. This highlights the fact that most body movements are compound, and a great many have a spiral nature (to bring a cup to the mouth requires adduction, flexion and internal rotation of the arm). These observations reinforce the need when performing manual muscle tests, to take account of movement patterns which approximate real life activities, most of which are multi-directional.

Specificity of the AK MMT

Manual muscle testing, when expertly done, is better able to maximally isolate the muscle, with the examiner able to observe recruitment of synergistic muscles. An extensive checklist for effective MMT against which all publications which purport to describe AK has been presented by Schmitt and Cuthbert. **(Schmitt & Cuthbert, 2008)** A general evaluation of hand strength with a dynamometer has even less ability to reveal the same information that manual muscle testing does if the entrapment is of a single nerve.

For example, a general evaluation of neck strength with a dynamometer may not reveal the same information that manual muscle testing does if, for instance, the injury is to a single nerve, an individual muscle, or even a portion of a muscle. Several human muscles, including the upper trapezius and anterior scalenes, have broad fan-like attachments dividing the muscle into serial segments, and each section of a dysfunctional muscle may be assessed for strength using the manual muscle test with precise patient positioning (and a dynamometer cannot do this).

Even in a severe neck pain syndrome, only a portion of the fibers may be involved, allowing some muscles to function very well. These may be the muscles primarily tested by instruments evaluating the gross muscle strength in group muscle tests; yet significant changes in individual muscles may be present when manually tested. **(Cuthbert et al., 2011)**

If the involvement is at the thoracic outlet, the chances of the hand–held dynamometer revealing greater strength after correction improve in comparison with an involvement at the hand or wrist, such as a carpal tunnel syndrome. This is because, in some types of thoracic outlet syndrome, the entire neurovascular bundle may be compressed, involving many muscles that may weaken the general hand grip. Only one nerve will be involved in entrapment with more distal syndromes, weakening only some of the muscles affecting the general hand grip.

Even in a severe thoracic outlet syndrome, only a portion of the fibers may be involved, allowing some muscles to function very well. These may be the muscles primarily tested by the hand-held dynamometer. As will be discussed later, challenge, therapy localization, and orthopedic tests are used in conjunction with manual muscle testing to evaluate peripheral nerve entrapment. These may show no change in muscle strength in the extremity when tested with a hand–held dynamometer; yet significant changes in individual muscles may be present when manually tested. Likewise, effective correction at the thoracic outlet may also show no change with a hand–held dynamometer for the same reason.

Familiarity with the course of the muscle's nerve supply and possible locations of entrapment enables the physician to evaluate various muscles supplied by the nerve above and below the possible area of lesion. For example, the flexor pollicis longus muscle receives median nerve supply proximal to the carpal tunnel. The opponens pollicis muscle receives median nerve supply distal to the carpal tunnel. Manual muscle testing revealing the flexor pollicis longus to be strong but the opponens pollicis muscle to be weak gives strong indication that there is a nerve entrapment distal to the innervation of the flexor pollicis longus and proximal to that of the opponens pollicis. Other applied kinesiology procedures, such as challenge and therapy localization, add to this information. If a challenge to the carpal tunnel or the radius and ulna improves the strength of the opponens pollicis muscle, there is added indication of a carpal tunnel syndrome. If therapy localization to structures at the carpal tunnel also strengthens the opponens pollicis muscle, there is even further indication the involvement is a result of entrapment in the carpal tunnel. This information is almost pathognomonic of the condition; added to clinical findings such as paresthesia and history, it provides a firm diagnosis. (Carpal Tunnel Syndrome will be covered in the next volume of this series.)

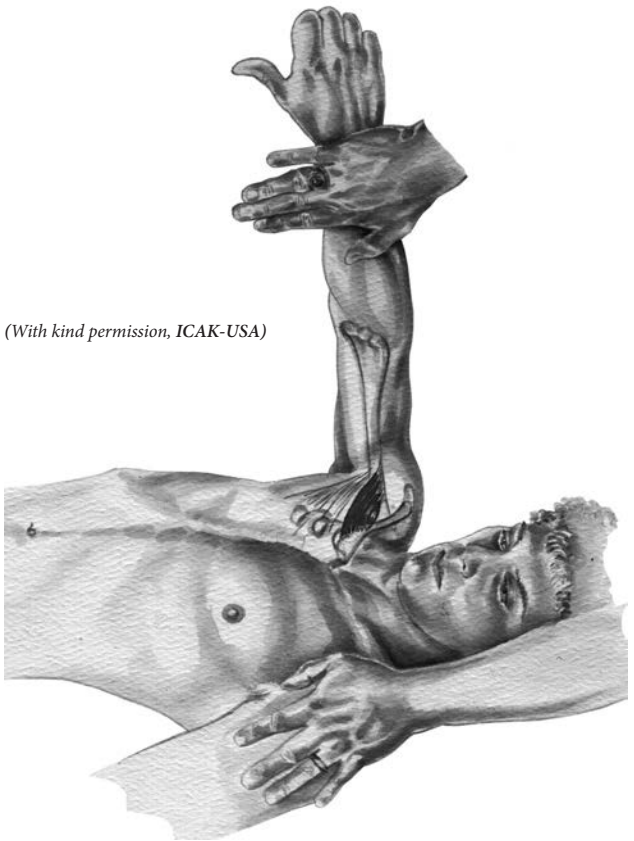
When a nerve entrapment is more proximal, such as in some types of thoracic outlet syndrome, many muscles in the extremity may be weak because the entire neurovascular bundle may be involved. Still, challenge and therapy localization can help locate the area of involvement. When the correct approach is found for this more central entrapment, many muscles in the extremity will strengthen.

As noted throughout the MMT literature, a muscle must function from a stable base to test strong. For instance, stability of the clavicle and/or scapula is essential in shoulder muscle function, and if during examination of the shoulder there is weakness during shoulder MMT, re-evaluate the test by stabilizing the clavicle or scapula. For example, if the pectoralis (clavicular division) tests weak, stabilize the clavicle and re-test the muscle. If it now tests strong, test for subluxations of the sternoclavicular and acromioclavicular articulations. When lack of clavicular or scapular stability is causing a shoulder muscle to test weak, determining the reason for the instability goes a long way toward correcting shoulder dysfunction. This is an example of the AK challenge and therapy localization methods. When the examiner stabilizes the scapula with the AK sensorimotor challenge system of testing, and the dysfunctional muscles of the shoulder strengthen, an important diagnostic clue has just been offered to the examiner. These tools along with the functional evaluation of muscles provide valuable additional information for the physician in the evaluation of the total extremity joint complex.

Ideally, correction is directed toward primary factors. In the example above, if the pectoralis (clavicular division) muscle tests weak and challenge to the clavicle or some other bone causes it to test strong, the subluxation is primary. Although the pectoralis (clavicular division) could probably be strengthened by stimulating the neurolymphatic or neurovascular or acupuncture reflexes or with other types of rehabilitative exercises, it is likely it would immediately lose its correction with gait or some other structural stress

to the clavicle. If so, the primary cause of the pectoralis (clavicular division) weakness appears to be the result of improper stimulation to receptors by the subluxated joint. It might be due to the muscle vainly trying to stabilize the clavicle or some other bone in subluxation, and weakening because of its inability to do so.

(With kind permission, ICAK-USA)



MMT pectoralis major(clavicular division) muscle

There will not always be muscle weakness with peripheral nerve entrapment. The neuropathy may be of a purely sensory nerve with pain the primary complaint. Or sometimes muscle weakness is not observed because synergistic muscles are recruited and are primary in the test. This may be due to poor muscle testing ability on the examiner's part, or because the muscle cannot be "isolated" well. If the nerve involved is mixed and sensory fibers are involved, there will nearly always be an involvement of the motor fibers also, probably because the nerves supplying muscles are more susceptible to compression than cutaneous nerves. **(Russell, 2006; Aguayo, 1975; Haldeman & Meyer 1970; Sunderland 1945; Denny—Brown & Brenner, 1944; Gasser & Erlanger, 1929)**

Vertebral fixations and subluxations or radiculopathy are not considered in this discussion of peripheral entrapment. Nerve encroachment at the radix, such as from degenerative joint disease or the intervertebral disc, causes the same type of predictable involvement of the motor and sensory systems. Vertebral subluxations and fixations do not have that same predictability. Some may argue that it is impossible to have degenerative joint disease, disc involvement, and other local problems without a chiropractic subluxation being present. This argument is well–taken and is probably correct. Long–term and well–established clinical evidence indicates a muscle that tests weak does not necessarily relate to a specific spinal level. Associating the level of spinal innervation to a muscle that tests weak is not an adequate method for determining subluxation levels. As an example, lower extremity muscle weaknesses found on manual muscle testing are often strengthened with upper cervical subluxation correction. This lack of specificity probably relates to the subluxation's influence on the central nervous system, as well as its local segmental nerve level. General disorganization within the neuronal pools may develop.

Manual muscle testing to evaluate peripheral nerve involvement relates more specifically to the nerve involved. In most instances, challenge, therapy localization, and clinical findings described in the chapters on the foot, leg and ankle, and peripheral nerve entrapments in the lower extremity will locate the area of entrapment. There are occasions where an apparent motor nerve entrapment cannot be demonstrated by weakness of the muscles it supplies, yet it seems obvious that there is peripheral nerve entrapment at a specific location. Further evaluation may reveal there is a neurologic correlation. It appears that sometimes the afferent supply of a muscle is cross–stimulated by the entrapment, sending a signal of agonist contraction to the muscle's antagonist when, in reality, it is not contracting. In this case the antagonist would be inhibited and test weak on manual muscle testing. The same methods of testing with challenge and therapy localization will identify the antagonist muscle dysfunction. Correction of the entrapment will improve antagonist and agonist muscle function.

With the complexity of symptoms on display in the typical patient, including pain and dysfunctional tissues, joints, fear about their pain and others, where would it be most appropriate to initiate treatment? The manual muscle test offers a great diagnostic advantage because it identifies the dysfunctional muscle tissues and the process of therapy localization and challenge allows for the identification of the precise anatomical area (articular, muscular, reflex, craniosacral, nutritional, and/or psychological impairment, whether local or remote) that will improve that finding.

Occasionally when efforts are made to clear a peripheral nerve entrapment, the muscles supplied by the nerve do not immediately change from weak to strong on manual muscle testing. It appears there may be actual physiologic change in the muscle from nerve entrapment, as well as a change in the motor control. Physical trauma to muscles and nerves can damage the mechanoreceptors and axons resulting in localized proprioceptive losses. **(Kolosova et al., 2004; Myers & Lephart, 2002; Sharma, 1999)** These proprioceptive deficits may be very small in the muscles but their clinical significance very large. A study done by Christiansen and Meyer **(Christiansen & Meyer, 1987)** observed a change in muscle enzymes after implanting silastic pellets transverse to the sciatic nerve in mice. Further study is needed to understand the physiologic role of peripheral nerve entrapment. The treatment of the tissue in which the receptors are embedded is also important for proprioceptive recovery. **(Leinonen et al., 2003)** In the treatment of musculo-

skeletal disorders, what we are confronted with is not "pathology" in the classic Vercovian sense of that term, where each disease has a verifiable tissue injury or biochemical disorder, but rather a disturbance of the normal rhythms of the musculo-skeletal system – a dynamic dysfunctional state.

Therapy localization can identify an area of possible peripheral nerve entrapment by causing an indicator muscle to weaken when the patient touches the suspected area. Therapy localization can also sometimes cause the muscle that tests weak due to peripheral nerve entrapment to test strong when the patient touches the area of entrapment. In fact, this was Goodheart's original observation of therapy localization. As will be discussed under carpal tunnel syndrome in the subsequent text of this series, when a patient squeezes the distal radius and ulnar bones together in certain types of carpal tunnel syndrome, the opponens pollicis muscle will become strong when it previously tested weak. To demonstrate the effect of the radius and ulnar bones separating, the patient is often asked to squeeze the bones together while the examiner demonstrates the improved strength of the opponens pollicis muscle. On one occasion Goodheart was explaining to the patient that when she held the bones together it released the nerve so the muscle became strong. Surprisingly, the patient said, "I didn't understand you wanted me to squeeze the bones together; I was simply touching the area" — yet the muscle became strong. This unusual experience was the first observation of therapy localization.

Challenge is usually mechanically moving a bone or other structure to a position that temporarily improves the nerve entrapment or irritation. For example, in the tarsal tunnel syndrome the calcaneus is usually subluxated posteriorly. An anterior challenge of the calcaneus will often strengthen the intrinsic muscles innervated by the posterior tibial nerve past the point of entrapment. **(See Foot chapter)** This gives positive indication not only of the entrapment but also of the direction of subluxation correction. As with other extraspinal subluxations, the bone is adjusted in a direction that causes the weak muscle to strengthen.

There are numerous orthopedic provocative tests that are used in evaluating peripheral nerve entrapment in the lower body. Most of these can be used in conjunction with manual muscle testing. An example is Adson's test for scalenus anticus syndrome. In this condition, the ulnar nerve is usually involved. A previously strong triceps muscle may test weak in this position, indicating entrapment by the scalene muscle(s), 1st rib, cervical rib, or anomalous fibrous bands. Conversely, when the triceps muscle tests weak, positions that relax the scalene muscles or otherwise change the position of the thoracic outlet may cause the triceps to become strong, providing evidence of entrapment at the thoracic outlet.

Cross–stimulation of the nerve from entrapment or stimulation to the joint receptors often accompanies peripheral nerve entrapment. The improper afferent signals could go to any muscle associated with the agonist or joint. This neurologic model appears to explain many clinical observations from the evaluation and correction of peripheral nerve entrapment. A common example is neck flexor weakness associated with a tarsal tunnel syndrome. Proprioceptive information from the articulations and intrinsic muscles of the foot, mediated through the central nervous system, provides control for facilitation and inhibition of the neck flexor muscles when walking. This model proposes that the afferent supply from the ligaments, tendons, muscles, fascia, and skin of the foot can be disturbed by entrapment in the tarsal tunnel, creating information to be sent to the central nervous system that is not in keeping with the current actions of the foot. For this reason, the neck flexors — or any other associated muscle in the gait system for that matter — may be inappropriately inhibited; they immediately regain normal function when the tarsal tunnel entrapment is corrected.

Although peripheral nerve entrapment can have widespread influence in the muscular system, the most common — and easiest — use of manual muscle testing to evaluate peripheral nerve entrapment is to test the muscles innervated by the nerve distal to the area of suspected entrapment; this will generally provide the diagnosis. When the structure is corrected and the involvement released, there will often be many additional benefits as remote muscles improve in their function. On the unusual occasion when the suspected peripheral entrapment cannot be evaluated in this manner, the physician must look to synergistic, fixator, and antagonistic muscles that are controlled by the afferent supply of the suspected nerve.

Examination and treatment of all extremity joint disorders must insure that agonist and synergist muscles are contracting at full strength; that there is appropriate timing of the contracting muscles, and that the antagonist muscles are releasing at the appropriate time. The only method of diagnostic evaluation that can measure each of these components of muscle function and their interactions in the clinical setting is the MMT. **(Schmitt & Cuthbert, 2008; Cuthbert & Goodheart, 2007)**

With today's knowledge we see that extremity dysfunction can influence the total body more than just the spine and its nervous system relationship, as described early in the chiropractic profession's history by Janse, **(Janse, 1976)** Goodheart and Walther in applied kinesiology, and many others in the osteopathic, naturopathic, and manual medicine fields, **(Page et al., 2010; Chaitow et al., 2008; Lewit, 1999)** all of whom have written extensively about the closed kinematic chain and structural integration of the body.

A major reason that the MMT for all of the peripheral muscles should be added to the standard diagnostic methods used by the professions and taught in the chiropractic, osteopathic, and manual medicine colleges is that patients with extremity disorders demonstrate joint instability, ligament strain, and muscle inhibition. **(Leaf, 2010; Maffetone, 1999; Logan, 1995, 1994)** Each of these causative factors in extremity joint dysfunction—of obvious interest to the health professions—can be specifically diagnosed and treated with MMT and manipulative treatment. Applied kinesiology assessment adds to lower extremity examination because it detects and specifically treats these muscle impairments that either cause or perpetuate extremity dysfunctions.

From *Applied Kinesiology Volume 1* (1981)
with updates

Abductor Hallucis

Attachments: From the medial process of the calcaneus, flexor retinaculum, plantar aponeurosis, and intermuscular septum with the medial tendon of the flexor hallucis brevis into the medial side of the base of the proximal phalanx of the great toe.

Action: Abducts the great toe (from median line of the foot).

Testing position and stabilization: The patient abducts the toe. This is best accomplished by asking the patient to spread his toes like fan. It is often found that a patient cannot abduct the toe into the testing position. The examiner stabilizes the foot at the heel and lateral aspect, and does not grasp the foot over the abductor hallucis.

Test: Pressure is directed to the medial aspect of the great toe in a direction of adduction. During the test, the examiner continues to observe visually -- and possibly with palpation -- for activity of the muscle belly. Since the muscle is often congenitally inserted so as to be incapable of true abduction, this portion of the test helps delineate whether hallux valgus is due to muscle weakness, or lack of the muscle's ability to abduct the great toe.

Body Language of Weakness:

Testing position: Patient is unable to abduct the great toe into the testing position. This inability has to be evaluated carefully by the examiner because many individuals cannot isolate the muscle activity. Palpation for the presence of the muscle and its ability to contract is often necessary.

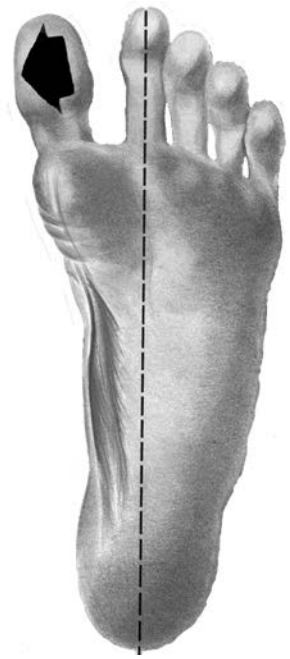
Postural imbalances: Hallux valgus position, and evidence in the general foot of a tarsal tunnel syndrome.

Special Notes: The evaluation of the abductor hallucis is difficult until the examiner has evaluated this muscle in many individuals, both normal and abnormal. The examiner tends not to test this muscle unless there is body language of its weakness or absence. It is necessary to test normal individuals to learn palpation of the muscle belly, and how to motivate individuals to abduct the great toe into the testing position.

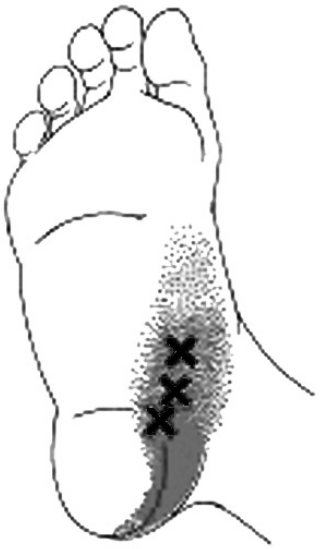
Kerr and Basmajian **(Basmajian, 1978)** studied 22 adult feet by dissection, with emphasis on the insertion of the abductor hallucis to determine its ability in abduction. They concluded that the muscle is so attached as to be capable of true abduction in only 20%. The greatest indication was that the muscle would flex the great toe. When the applied kinesiology examiner is evaluating the abductor hallucis in conditions of hallux valgus, it is necessary to palpate the belly of the muscle to determine if contraction is taking place and to observe the motion of the great toe. Obviously, efforts to balance the abductor and adductor hallucis and flexor hallucis brevis will not improve hallux valgus if the abductor hallucis is inserted in such a way that cannot abduct the great toe. **(Brenner, 1999)**

Abductor hallucis crosses the passageway of the plantar vessels and nerves which serve the sole of the foot and it may entrap these nerves against the medial tarsal bones. **(Travell & Simons, 1992)** Trigger points in the abductor hallucis referred pain to the medial aspect of the heel and foot and the taut bands associated with trigger points in this muscle may be responsible for tarsal tunnel syndrome itself. **(Travell & Simons, 1992)**

Abductor hallucis MMT



Abductor hallucis action



Abductor hallucis MTrPs

Abductor hallucis MTrP

Extensor Digitorum Longus and Brevis

Extensor Digitorum Longus

Attachments: From the lateral tibial condyle, proximal three-fourths of anterior fibula body, interosseous membrane, deep fascia, and intermuscular septa to the lateral four toes, middle and distal phalanges dorsal surface.

Action: Extends toes and with continued action assists in foot and ankle dorsiflexion and eversion; is a strong dorsiflexor and pronator of the foot.

Nerve supply: Peroneal, **L4, 5, S1.**

Extensor Digitorum Brevis

Attachments: From the anterior portion of the superolateral surface of the calcaneus, lateral talocalcaneal ligament, and cruciate crural ligament to the first tendon to the dorsal surface of the base of the great toe proximal phalanx. This muscular slip and tendon are often called the extensor hallucis brevis. The other three tendons insert to the lateral sides of the extensor digitorum longus tendons.

Action: Extends phalanges of the medial four toes.

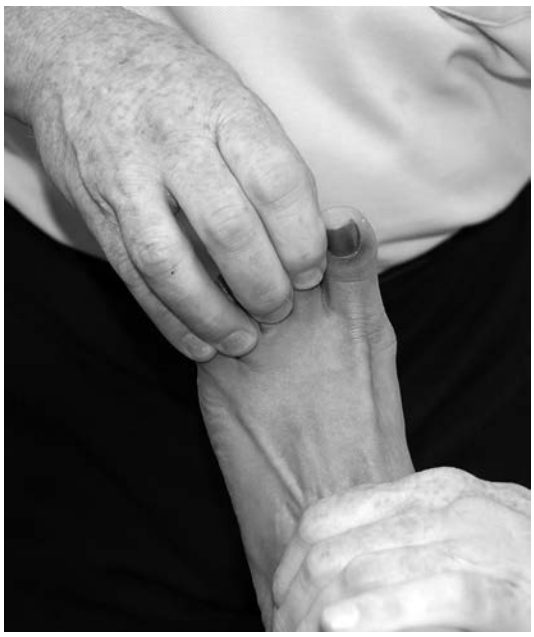
Nerve supply: Deep peroneal, L4, **5, S1.**

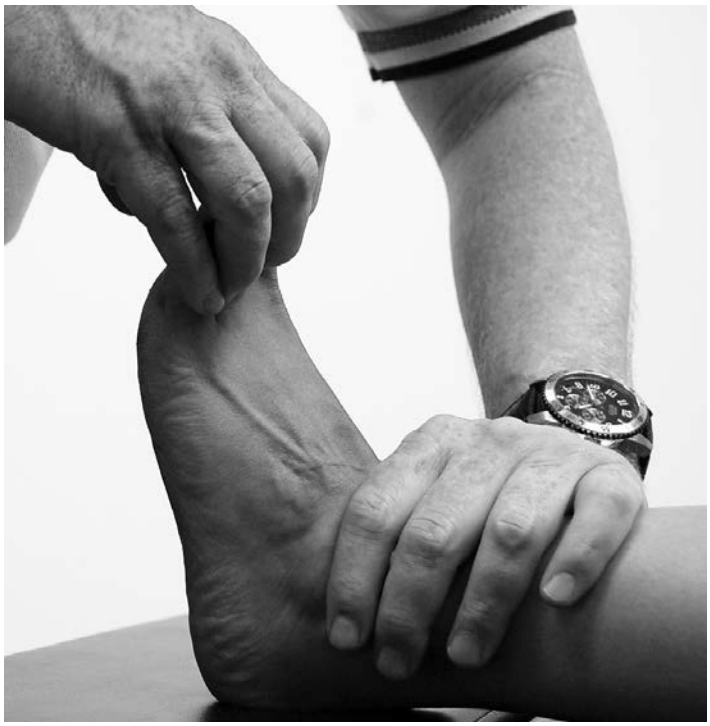
Testing Position: The patient extends his toes to the maximum amount.

Patient Fixation Requirements: The ankle should be stabilized by the patient's and examiner's efforts.

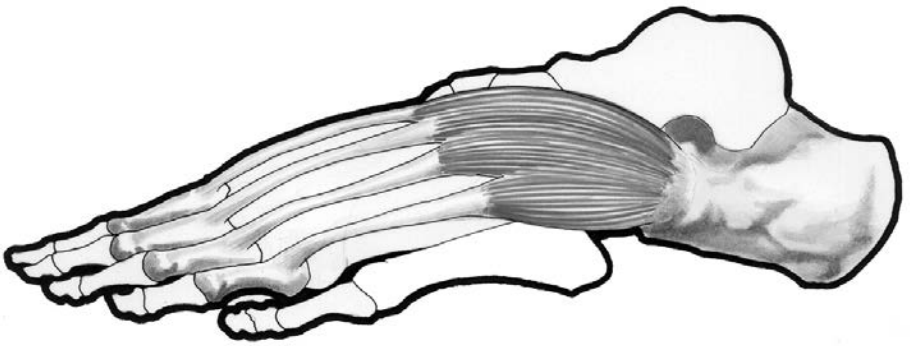
Stabilization: The examiner stabilizes the foot at the calcaneus, with his thumb over the dorsal surface of the foot to prevent the patient from dorsiflexing the ankle.

Test of longus and brevis: The examiner stabilizes the foot in slight plantar flexion, and the patient's toes are extended. The test force is to bring the toes into flexion. Usually the middle three toes are tested; the hallux is tested separately. The most common purpose for examination of these muscles is to determine the relative strength of the toe extensors to the flexors, to evaluate the extension of the metatarsophalangeal articulations in the "hammer toe" position. In the anterior tarsal tunnel syndrome, the most common motor weakness is in the extensor digitorum brevis muscle; the foot should be placed into full plantar flexion in some cases to find this inhibition pattern.



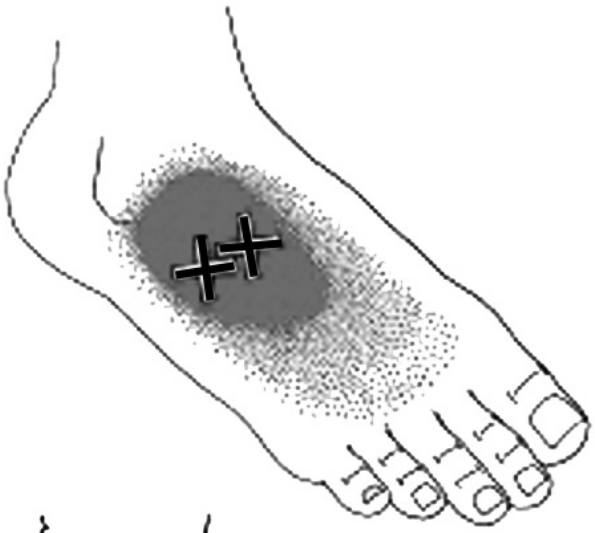


Extensor digitorum longus and brevis tested together

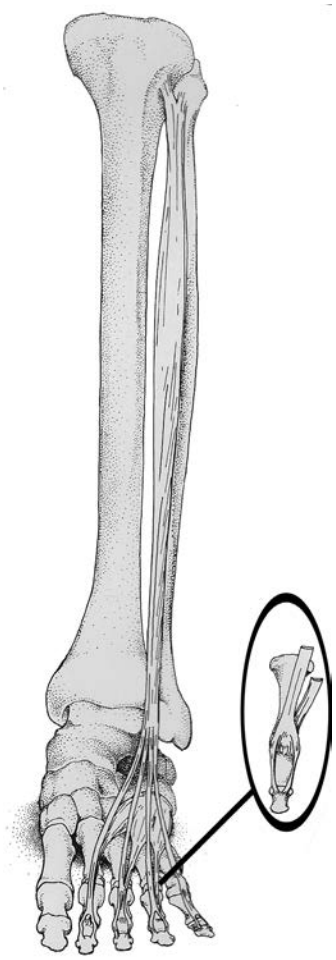


Frequently in this syndrome, an anterior talus subluxation will be pressing the deep peroneal nerve into the extensor retinaculum of the foot. Additionally, inhibition in this muscle is an important clinical parameter for L5-S1 radiculopathy, with associated sensory and motor impairments as well as atrophy in this muscle. **(Sinanovic & Custovic, 2010)**

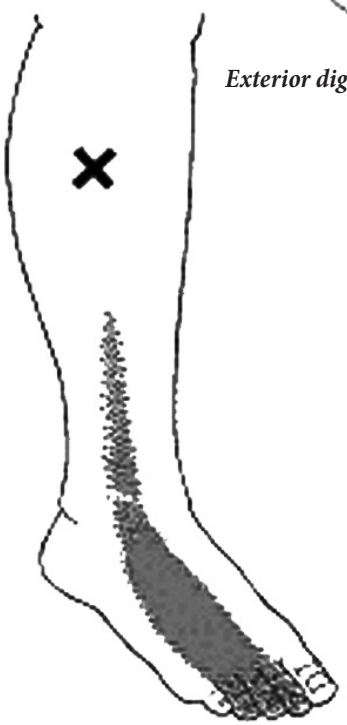
Trigger points in the extensor digitorum longus (most commonly in the upper part of the muscle approximately a hand's width below the head of the fibula) refer pain into the dorsum of the foot or ankle and into the three middle toes. MTrPs in this muscle may also compress the deep peroneal nerve against the head of the fibula with the development of weakness of the toes and a foot drop.



Exterior digitorum brevis MTrps



Attachment to the toes



Exterior digitorum longus MTrP

Extensor Hallucis Longus and Brevis

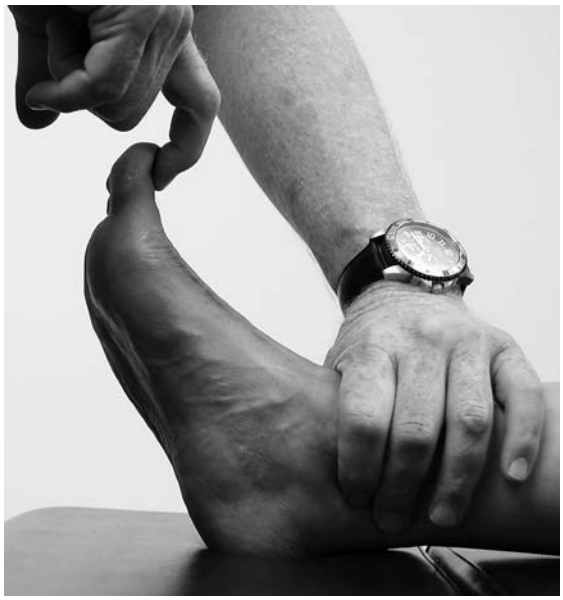
Extensor Hallucis Longus

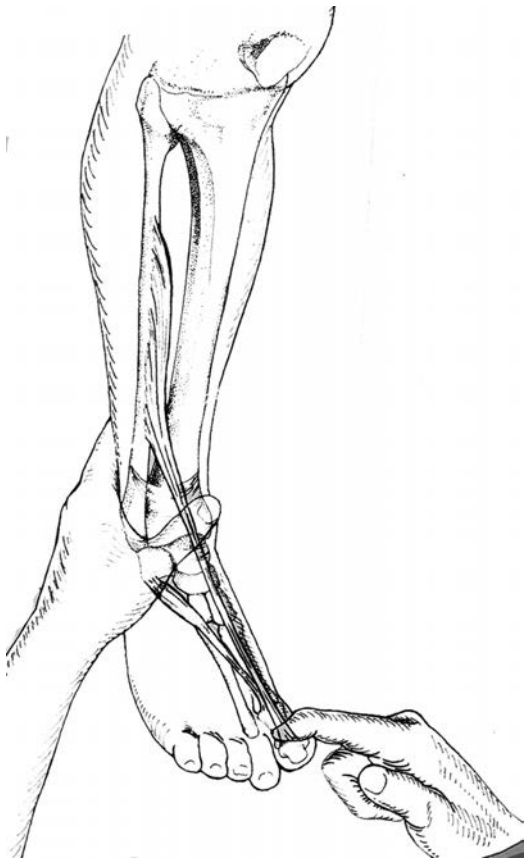
Attachments: From the middle half of anterior fibular surface and adjacent interosseous membrane to the base of distal phalanx of great toe.
Action: Extends the great toe; continued action assists in dorsiflexion and inversion of the foot and ankle.
Nerve supply: Deep peroneal, **L4, 5, S1.**

Extensor Hallucis Brevis

The extensor hallucis brevis is the medial slip of the extensor digitorum brevis.
Attachments: From the anterior portion of the superomedial surface of the calcaneus, lateral talocalcaneal ligament, and cruciate crural ligament to the dorsal surface of the great toe's proximal phalanx.
Action: Extends great toe's proximal phalanx.
Nerve supply: Deep peroneal, L4, **5, S1.**
Testing Position: Patient extends the great toe, with the ankle in a neutral position.
Stabilization: Stabilize the calcaneus with the thumb over the dorsal surface of the foot.
Test for longus and brevis: With the patient sitting or standing, his great toe is placed in extension and the examiner stabilizes the foot and grasps the great toe to flex it while the patient resists.
Body Language of Weakness: Inability to hold the testing position. Significant weakness of this muscle is not nearly as common as other foot muscles. Weakness in the presence of lower lumbar spinal conditions and sciatic neuralgia indicates that evaluation of the fourth lumbar disc is needed.

Special Notes: An important condition affecting the foot and great toe was first described by Dananberg, **(1986)** called functional hallux limitus (FHL). It is the inability of the hallux to fully extended at the metatarsophalangeal articulation at the proper stage of the gait stance phase. The widespread adaptive and dysfunctional patterns which results from FHL demonstrate how foot and ankle imbalances can affect the rest of the body. Dananberg notes that "FHL… because of its asymptomatic nature



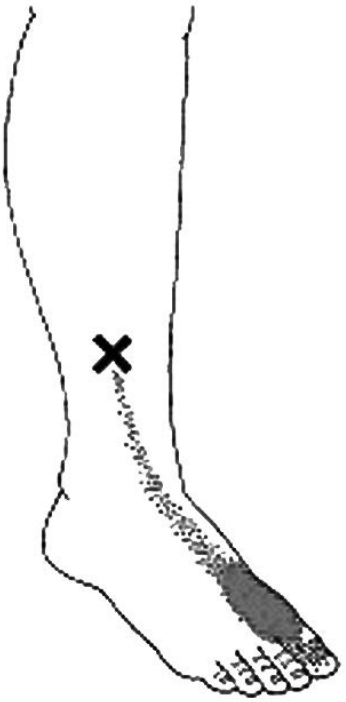


Exterior hallucis longus and brevis are tested together

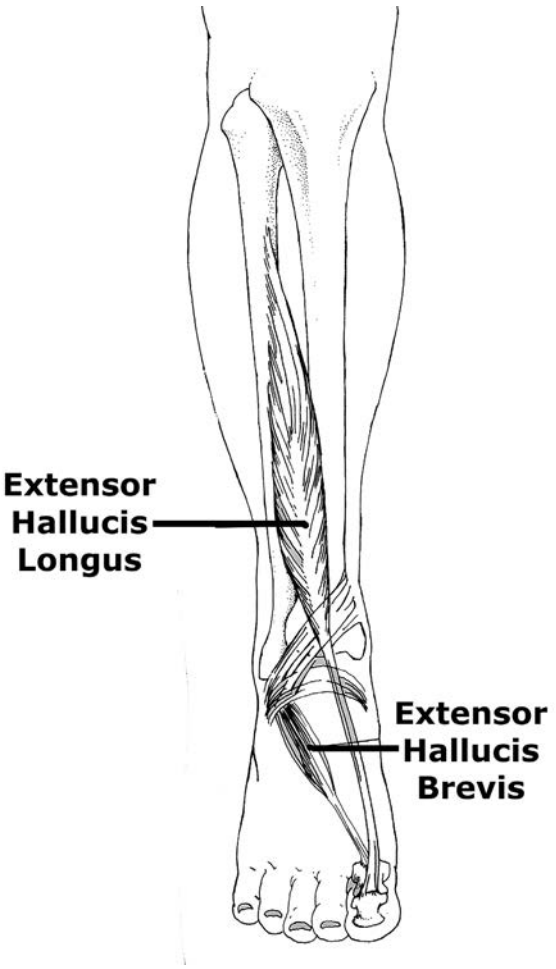
and remote location, has hidden itself as an etiological source of postural degeneration."

The extensor hallucis longus and brevis muscle will usually test weak in the presence of FHL. This weakness causes secondary contraction of the flexor hallucis longus and brevis muscles. The contracted muscle is secondary to the weak antagonist muscle, a familiar finding in applied kinesiology and consistent with contemporary thinking regarding the pain-adaptation model of muscle dysfunction. **(Lund et al., 1991)** Applied kinesiology treatment for FHL is directed to returning the weak extensor hallucis muscles to normal. **(See Foot and Ankle Chapter) (Walther, 2000)**

Trigger points in the extensor hallucis longus refers pain across the dorsum of the foot and strongly into the first metatarsal and great toe areas. Travell and Simons **(1992)** note that an L4-L5 radiculopathy may also lead to MTrPs in the long extensor muscles of the toes.



Exterior hallucis longus MTrP



Flexor Digitorum Brevis

Attachments: From the medial process of the calcaneus, central part of the plantar aponeurosis, and the intermuscular septa between it and the adjacent muscles to attach to the four tendons of the middle phalanges of the 2nd-5th toes. The entire muscle belly is firmly united with the plantar aponeurosis.

Action: Initial action flexes the middle phalanges on the proximal; continued action flexes the proximal phalanges on the metatarsals.

Testing Position: Patient flexes the 2nd-5th toes, with emphasis toward the proximal middle phalanx articulation.

Stabilization: Examiner stabilizes across the top of the metatarsals with the foot and ankle in a neutral position.

Synergist: Flexor digitorum longus.

Test: Examiner contacts all four toes on the plantar surface, and directs pressure toward extension.

Body Language of Weakness:

During Test: Effort to flex toes into testing position pulls distal phalanx into flexion, but does not efficiently flex metatarsophalangeal articulations.

Movement aberrations: As the patient walks or stands, the distal phalanx will point down toward the floor and anterior sway will cause the distal phalanx to dig into the floor. The middle phalanx will rise.

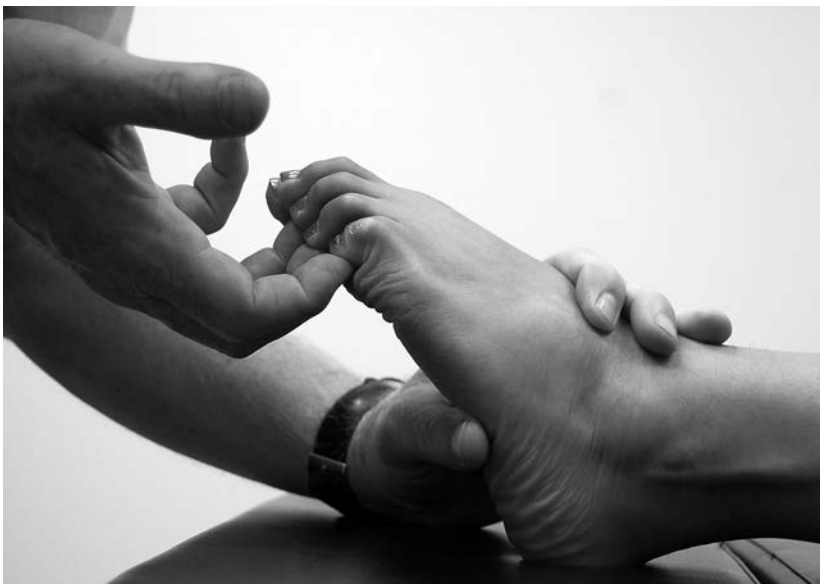
Postural imbalances: The toes will be in a "hammer toe" position in which the metatarsophalangeal articulation will be in extension while the interphalangeal articulations are in flexion. There will be weight bearing evidence on the tips of the toes, and failure of the entire toe to extend into a neutral position.

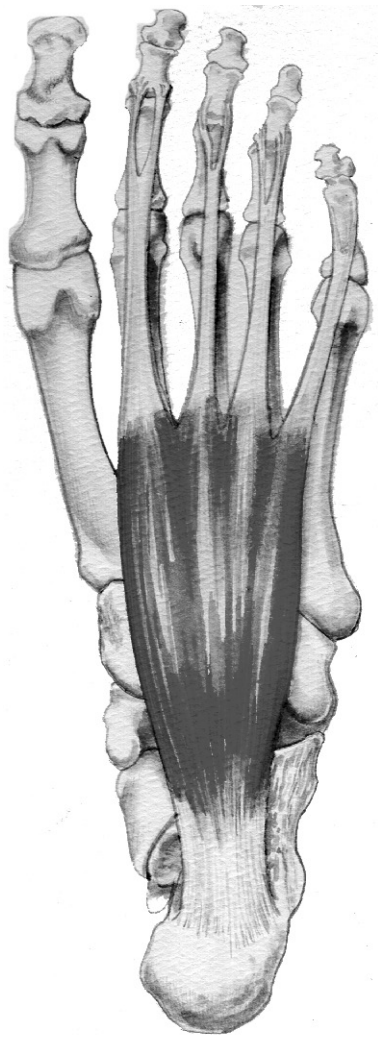
Nerve supply: Medial plantar, L4, **5**, S1

Special Notes: The tendon of the 5th digit is congenitally absent in 23% of cases. **(Gray's Anatomy, 2004)** This muscle frequently requires treatment to the neuromuscular spindle cell, Golgi tendon organ, origin/insertion technique, or percussion. Attempts to exercise this muscle are clinically ineffective if there is a tarsal tunnel syndrome present. Atrophy of the muscle indicates the probability of a tarsal tunnel syndrome.

The way in which the tendons of the flexor digitorum brevis divide and attach to the phalanges is, according to Gray's Anatomy, **(2004)** identical to that of the tendons of the flexor digitorum superficialis in the hand.

Trigger points in the flexor digitorum brevis refer to the plantar surface of the foot, mostly to the area of the heads of the four lesser metatarsals. Travell and Simons **(Travell & Simons, 1992)** associate these trigger points with those found in the flexor digitorum longus muscle.





Flexor Hallucis Longus

Attachments: From lower two-thirds of posterior fibula, interosseous membrane and adjacent intermuscular septa and fascia to the plantar surface of distal phalanx of great toe.

Action: Flexes great toe; continued action aids in plantar flexing the foot; helps give medial ankle stabilization.

Testing position and stabilization: With the patient supine, the examiner stabilizes the metatarsophalangeal articulation in slight extension and holds the foot halfway between dorsal and plantar flexion. The patient flexes the distal phalanx of the great toe.

Synergists: The muscles that flex the distal phalanges of the toes and fingers are the only ones which can be 100% isolated for muscle testing. The flexor hallucis brevis attaches to the proximal phalanx and is the reason stabilization and slight extension are necessary between the proximal phalanx and the first metatarsal.

Test: From this testing position of flexion between the proximal and distal phalanx, the examiner directs pressure against the distal phalanx of the great toe in the direction of extension.

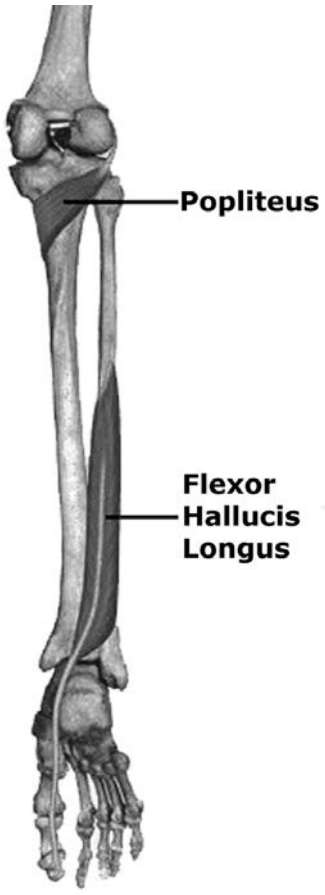
Nerve supply: Tibial, **L5, S1, 2**.

Neurolymphatic:

Anterior: Inferior to the symphysis pubis at the height of the obturator bilaterally (same as peroneus longus and brevis).

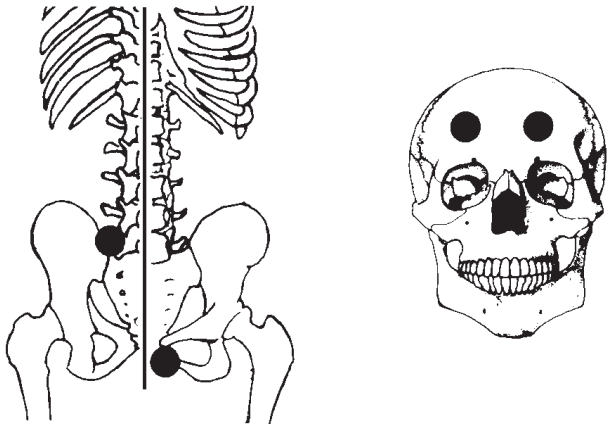
Posterior: Bilaterally between PSIS and L5 spinous.

Neurovascular: Bilateral frontal bone eminences.

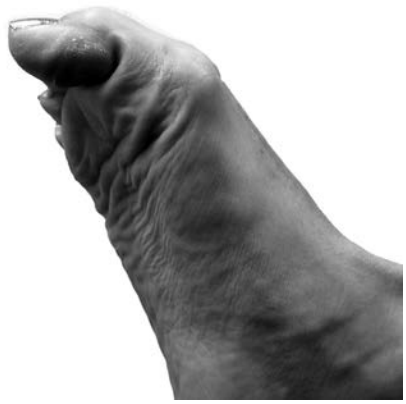


Nutrition: Raw bone concentrate correlating with tarsal tunnel syndrome or other subluxations of the foot.

Meridian association: Circulation sex.



Flexor Hallucis Longus reflexes



Flexor Hallucis Longus MMT

Flexor Hallucis Brevis

Attachments: Medial portion of the plantar surface of the cuboid bone, adjacent portion of the lateral cuneiform bone, and from prolongation of the tendon of the tibialis posterior to the medial and lateral sides of proximal phalanx of the great toe.

Action: Flexes metatarsophalangeal articulation of great toe.

Testing Position and Stabilization: Bringing the patient into the test position for the flexor hallucis brevis is best done in three steps. First, plantar flexes the 2nd, 3rd, and 4th digits to keep them out of the test. Second, fully dorsiflex the 1st and 2nd phalangeal articulations of the great toe to help remove the action of the flexor hallucis longus. Third, keeping the interphalangeal articulation in complete dorsiflexion, plantar flex the metatarsophalangeal articulation into testing position. While holding this position, the examiner stabilizes the foot, maintaining a neutral position between dorsiflexion and plantar flexion of the ankle.

Test: The examiner stabilizes the interphalangeal articulation of the great toe and places the metatarsophalangeal articulation in flexion for the starting test position. While maintaining hyperextension of the interphalangeal articulation, the examiner directs pressure against the plantar surface of the proximal phalanx toward extension.

Body Language of Weakness:

Movement aberrations: When the patient attempts to flex the great toe and there is weakness of the flexor hallucis brevis but strength of the flexor hallucis longus, the proximal phalanx may hyperextend in the distal phalanx will flex. The toe appears to remain straight while walking.

Postural imbalances: When the foot is relaxed, the toe will probably be in a hammer-toe position because of the failure of the flexor hallucis brevis – which inserts on the proximal phalanx -- to hold that phalanx toward flexion.

Nerve supply: Tibial, L4, **5, S1**, 2.

Neurolymphatic:

Anterior: Inferior to the symphysis pubis at the height of the obturator (same as peroneus longus and brevis).

Posterior: Between PSIS and L5 spinous.

Neurovascular: Bilateral frontal bone eminences.

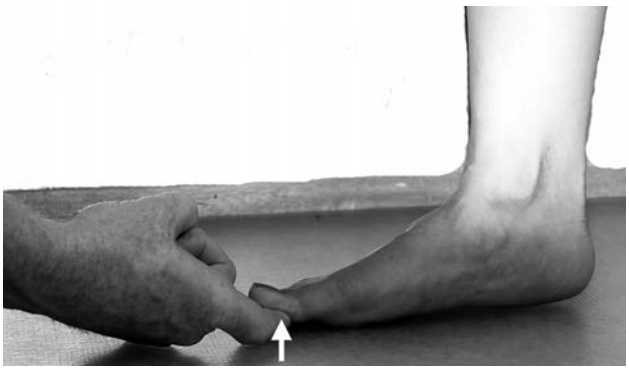
Nutrition: Raw bone concentrate correlating to tarsal tunnel syndrome or other subluxations of the foot.

Meridian association: Circulation sex.

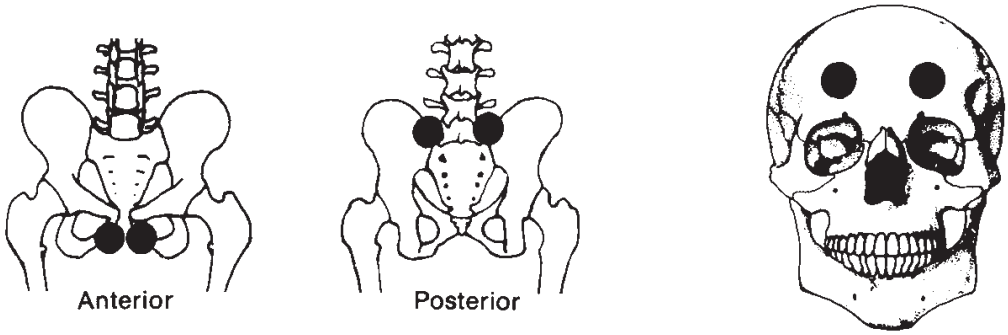
Special Notes: The flexor hallucis longus and brevis are most frequently tested in relation to the tarsal tunnel syndrome. Beardall **(Beardall, 1985)** made an improvement in the methods of testing these two muscles. When testing the flexor hallucis longus, stabilization of the proximal phalanx should be made by the doctor as he tests the plantar flexion ability on the distal phalanx. It was once thought that, in the tarsal tunnel syndrome, both the flexor hallucis longus and brevis were weak; however, with the improved testing methods it became obvious that the flexor hallucis usually remains strong while the brevis shows weakness. The difference in strength of the flexor hallucis longus and brevis in the tarsal tunnel syndrome is realistic, because the longus is in the upper leg and is not innervated by the nerves going through the tarsal tunnel.

Weakness in this muscle can be associated with the weakness of the tibialis posterior due to an inferior displacement of the navicular bone. Ramsak and Gerz **(Ramsak & Gerz, 2002)** recommend shifting the body weight onto the forefoot when testing these muscles in the standing position in order to uncover these problems. This method of testing will increase the stress on the tarsal tunnel during the MMT.

Trigger points in the flexor hallucis longus referred pain and tenderness into the plantar surface of the first metatarsal and great toe. Overactivity of the toe flexor muscles contributes to the development of hammer toes, claw toes and other deforming foot conditions as they attempt to stabilize the foot during weight bearing. **(Travell & Simons, 1992)**



Flexor Hallucis Brevis MMT, standing



Flexor Hallicus Brevis reflexes

Gastrocnemius

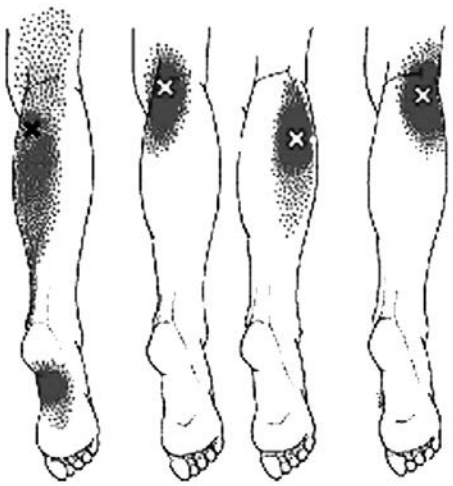
Attachments: Two heads, one from the lateral and the medial condyles, the surface of the femur and capsule of the knee to merge distally with the soleus muscle to form the Achilles tendon which attaches to the posterior surface of the calcaneus.

Action: Plantar flexes foot.

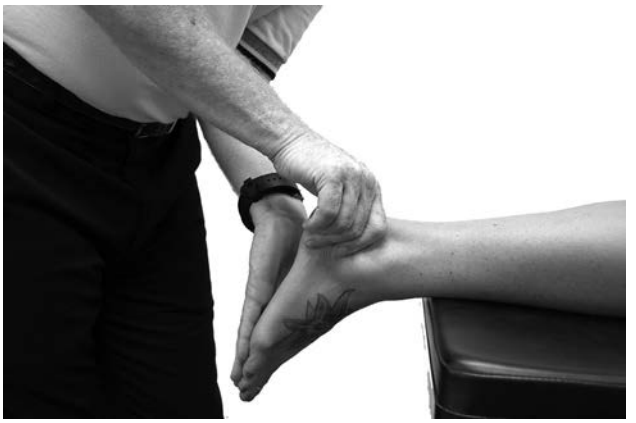
Change of action: Dorsiflexion of the foot increases knee flexion capability. Since the gastrocnemius originates above the knee and the soleus below the knee, the differentiating factor in testing the two muscles is the knee position during the MMT.

Synergists: Soleus, plantaris, tibialis posterior, peroneus longus and brevis, flexor hallucis longus, flexor digitorum longus.

Test: The medial and lateral heads of the gastrocnemius can be tested as described by Beardall. **(Beardall, 1985)** The test must be correlated with hamstring strength because they are significantly synergistic in the test. For both medial and lateral heads of the gastrocnemius, the supine patient flexes the knee to approximately 110° and maximally plantar flexes the foot. For the medial head, the leg is internally rotated; for the lateral test, it is externally rotated. The examiner stabilizes the knee while extending it by pulling on the calcaneus contact.



Gastrocnemius MTrp referral



Testing pressure is dorsiflexion of ankle & traction on the calcaneus.

Alternate Testing Method: All plantar flexors can be tested with the patient standing. The patient stabilizes herself with her hand on a table or wall, but does not use it to aid the test. The patient raises directly up on her toes with one foot, while the examiner observes for capability of elevating to the toes without bending the knee or leaning forward, indicating the recruitment of synergistic muscles due to inhibition of the plantar flexors.

Nerve supply: Tibial, L4, 5, **S1, 2**.

Neurolymphatic:

Anterior: 2" above umbilicus and 1" from midline.

Posterior: Between T11, 12 bilaterally near laminae.

Neurovascular: Lambda.

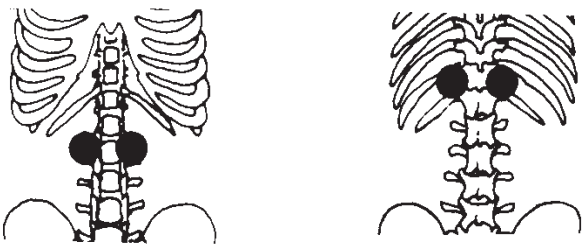
Nutrition: Adrenal concentrate or nucleoprotein extract.

Meridian association: Circulation sex.

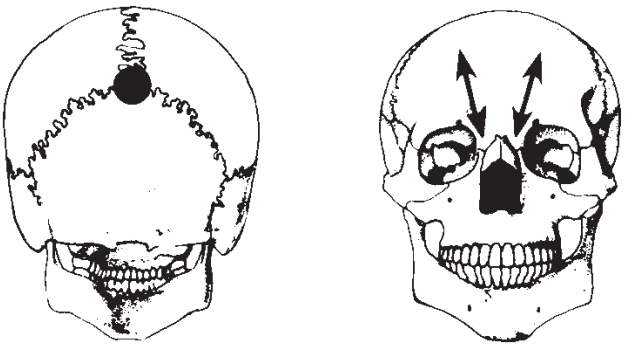
Organ association: adrenal.

Special Notes: The gastrocnemius muscle must be correlated with the soleus muscle for evaluation of its strength. The maximum shortening of the gastrocnemius and soleus varies considerably. The soleus is capable of shortening 44 mm., the gastrocnemius only 39 mm. This is important in the action of these two mucles. Because the gastrocnemius originates proximal to the knee, it is lengthened or shortened with extension or flexion of the knee. When the knee is flexed, the gastrocnemius is shortened, equal to or exceeding its length of contraction. **(Kapandji, 2010)**

The origin of the gastrocnemius above the knee is very important in the muscle's role in the gait mechanism. As the knee is extended by quadriceps action, the gastrocnemius is lengthened to its most advantageous functional

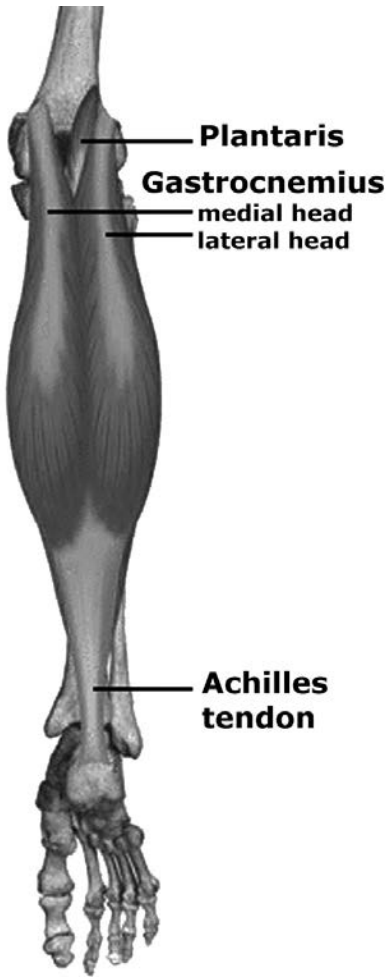


Neurolymphatic



Neurovascular *Stress receptor*

Gastrocnemius reflexes



Standing test for all plantar extensor muscles

position. Thus the action of the quadriceps transfers more power to the ankle by the gastrocnemius. **(Kapandji, 2010)**

The postural position of hyperextension of the knee in the presence of a weak gastrocnemius compensates for failure of its normal action in maintaining the knee in a slight degree of flexion. The medial head of the gastrocnemius is more active than the lateral in maintaining this position. **(Houtz & Walsh, 1959)**

The gastrocnemius and soleus combination is not often tested in applied kinesiology in relation to its glandular correlation with the adrenal glands because of the difficulty in testing these very powerful muscles with the limited leverage available. The gastrocnemius supplies most of its information about glandular correlation from the associated tenderness that usually develops in the muscle when there is adrenal involvement. Frequently, insalivation of a useful adrenal support for the patient will reduce this specific palpation tenderness **(Goodheart, 1998)**

The gastrocnemius is often involved in athletic injuries on a reactive muscle basis. The muscle dysfunction may be primary, causing a weakness in another area, or it may be secondary and develop weakness from another muscle previously contracting. The popliteus and gastrocnemius are often involved with the gastrocnemius on a reactive muscle basis. Usually when these muscles are involved, there is a knee disturbance manifested when running and with consequent cutting action.

Persistent wearing of high or slippery heels may cause a shortness of the gastrocnemius, soleus, and Achilles tendon. The Achilles tendon plays an important part in improving the energy cost and efficiency of locomotion by storing energy elastically and releasing it later in the gait cycle. Goniometer measurement should show 15 degrees of dorsiflexion. When there is limited range of motion, differential diagnosis between shortness of the gastrocnemius and soleus can be obtained by comparing foot dorsiflexion. If the gastrocnemius is short and the foot is dorsiflexed, there will be a restriction of knee extension. If the knee is extended, there will be a restriction of dorsiflexion.

In normal walking, gastrocnemius restrains the tibia from rotating on the talus as the weight is shifted from the heel to the ball of the foot during the stance phase. **(Travell & Simons, 1992)**

Trigger points in the gastrocnemius refer pain to the posterior-inferior thigh, posterior leg, posterior knee and to the arch of the foot. **(Travell & Simons, 1992)** Some of these trigger points may be associated with nocturnal calf cramps (restless legs), although vitamin (especially riboflavin, niacin, and B6) and mineral imbalances (especially potassium) can be responsible for this disturbing condition. **(Cuthbert & Rosner, 2010; Travell & Simons, 1992)**

Soleus

Attachments: From the posterior surface of the head and upper one-third of the shaft of the fibula; middle one-third of the medial border of the tibia; tendinous arch between tibia and fibula into calcaneus with gastrocnemius by way of the Achilles tendon which attaches to the posterior surface of the calcaneus.

Action: Plantar flexes foot.

Change of action: When the individual is standing, the calcaneus becomes the fixed origin of the muscle. The muscle's action is important in stabilizing the tibia on the calcaneus in the standing position, and limiting forward sway.

Test: The prone patient flexes the knee to 90° and plantar flexes the foot. The examiner directs traction on the calcaneus and pressure on the forefoot in a direction of dorsiflexion. The knee flexion helps take the gastrocnemius out of the test. Because of the great strength of the soleus and its limited leverage, this muscle is difficult to evaluate.

Stabilization: Added differential diagnostic ability between the gastrocnemius and soleus MMT can be obtained by having an assistant stabilize the leg in the 90 degree flexed position. The patient then adds some attempt to extend the knee by quadriceps action, which causes reciprocal inhibition of the gastrocnemius muscle to better isolate the soleus during the MMT.

Synergists: Gastrocnemius, plantaris, tibialis posterior, peroneus longus and brevis, flexor hallucis longus, and flexor digitorum longus.

Body Language of Weakness:

Soleus muscle origin insertion on the leg with the knee bent, stretching affects soleus most

Testing position: As the patient plantar flexes the foot, the gastrocnemius-soleus action on the Achilles tendon gives straight plantar flexion if the entire group of muscles is functioning normally. If the foot moves into inversion with plantar flexion, it indicates either recruitment of the synergist tibialis posterior and toe flexors, or weakness of the peroneus longus and brevis. If the foot moves into plantar flexion with eversion, it indicates recruitment of the synergist peroneus longus and brevis, or weakness of the medial muscles, the tibialis posterior and toe flexors.

During test: An effort to include inversion in the test indicates recruitment of one or all of the tibialis posterior, flexor hallucis longus, or flexor digitorum longus muscles. Attempts to evert the foot, along with plantar flexion, indicate recruitment of the peroneus longus and/or brevis.

Movement aberrations: Difficulty in rising onto the toes or walking on them.

Nerve supply: Tibial, L4, 5, **S1, 2**.

Neurolymphatic:

Anterior: 2" above umbilicus and 1" from midline.

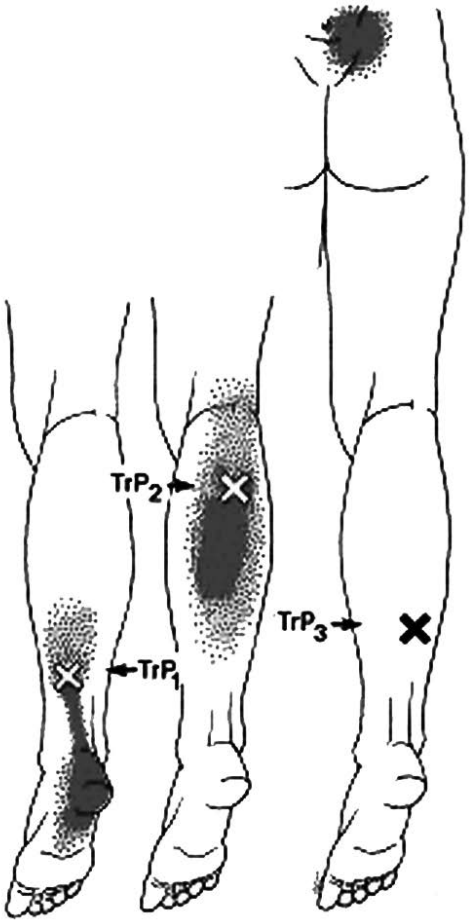
Posterior: Between T11, 12 bilaterally near laminae.

Neurovascular: Lambda.

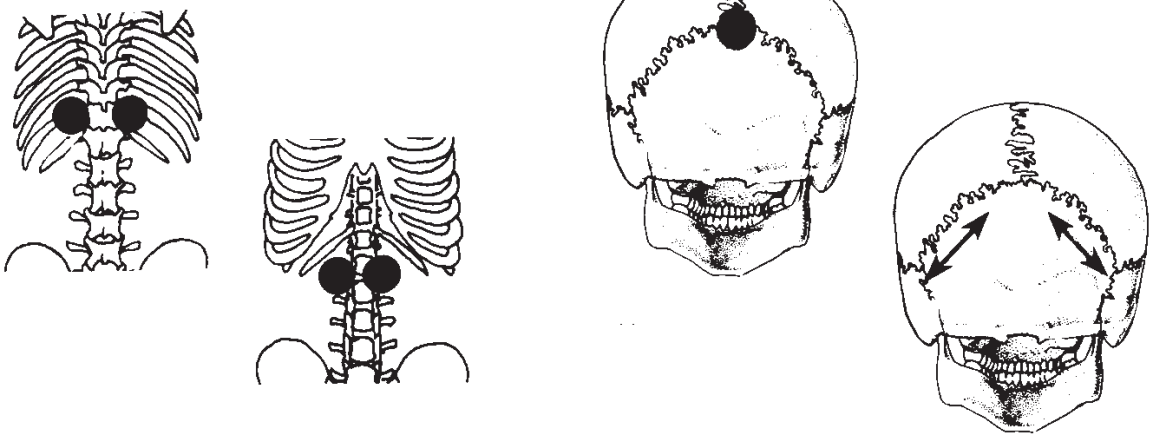
Nutrition: Adrenal concentrate or nucleoprotein extract.

Meridian association: Circulation sex.

Gland association: Adrenal.



Soleus MTrPs

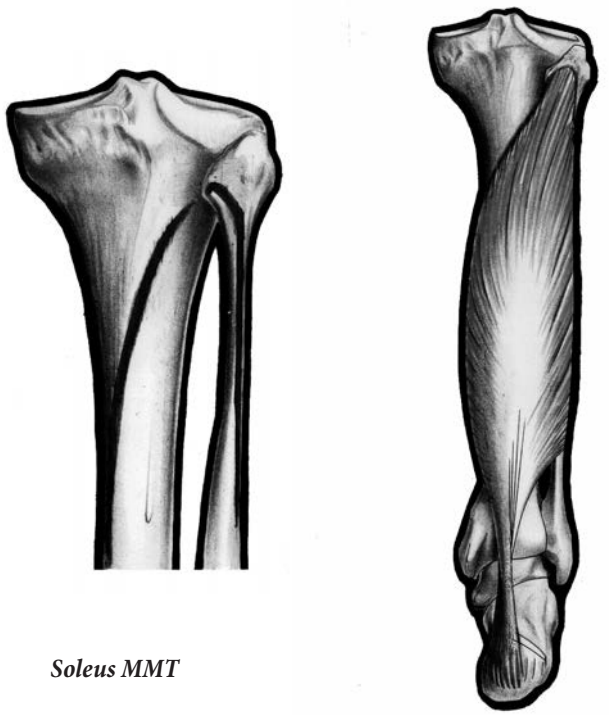


Neurolymphatic *Neurovascular* *Stress receptor*

Soleus reflexes

Special Notes: The soleus is not usually tested in applied kinesiology unless there is the possibility of gross muscular weakness, or an evaluation is being made for reactive muscle patterns.

The gastrocnemius and soleus have typically been known as the triceps surae because the two heads of the gastrocnemius and the soleus insert into a common tendon. It is the strongest plantarflexor of the foot. Campbell et al. **(Campbell, 1973)** have demonstrated electromyographically that these muscles, in reality, act as a quadriceps surae since the medial and lateral aspects of the soleus are capable of acting independently. O'Connell, **(O'Connell, 1958)** using surface and needle electrodes, also found that the medial and lateral aspects of the soleus act independently. This medial and lateral action of the gastrocnemius and soleus correlates with a medial or lateral calcaneus subluxation, which is found in applied kinesiology by using the sensorimotor challenge mechanism. Usually the subluxation correlates with a tarsal tunnel syndrome, where the calcaneus is also posterior. The calcaneus will usually be lateral, and there will be weakness on the medial head of the gastrocnemius and the medial aspect of the soleus. This gives poor medial support to the calcaneus, allowing it to deviate laterally. As with other structural distortions, it is necessary to return the muscles to normal balance to obtain maximum correction. Since the gastrocnemius and soleus are very difficult to evaluate by standard MMT, it is best to evaluate the medial and lateral aspects by therapy localization directly to the muscle. The most common disturbance is dysfunction of the neuromuscular spindle cell or Golgi tendon organ, uncovered with "pincer palpation" followed by MMT. **(Leaf, 2010; Cuthbert, 2002)** There may also be a muscle stretch response on the tight side of the muscles, indicating the presence of myofascial trigger points.



Soleus MMT

When the triceps surae is short, a surgical procedure to lengthen the Achilles tendon is sometimes done. Ryerson **(Ryerson, 1948)** points out, "The tendo-Achilles is not short. The muscle bellies are short." He recommends lengthening the muscle. In applied kinesiology there are many techniques to do this, including fascial release and stretch and spray techniques, and treatment to the muscle proprioceptors. A review of the literature also indicates three studies showing that treatment of MTrPs in the lower limb can improve reduced ankle ROM. **(Grieve et al., 2011; Wu et al., 2006; Grieve, 2006).**

The gastrocnemius has a higher concentration of fast muscle fibers than the soleus. The gastrocnemius is primarily a muscle for fast, quick action, whereas the soleus is a postural muscle for prolonged use. The fatigue characteristics of the gastrocnemius and soleus were studied by Ochs et al. **(Ochs et al., 1977)** with electromyography. The soleus muscle has a mean of about 70% slow muscle fibers, which are the oxidation type, and 30% fast glycolytic fibers. The gastrocnemius is equally divided, with 50% of each. The action potential of the gastrocnemius decreased more rapidly than the soleus, indicating a faster fatigue of the gastrocnemius.

The gastrocnemius and soleus are in their neutral

positions when there is about 30 degrees of plantar flexion; consequently, when in an upright position, the muscles are slightly stretched, taking the slack out of the tendon and keeping the muscles in a position of functional readiness. **(Houtz & Walsh, 1959)** In the standing position, the gastrocnemius and soleus' attachments are reversed, making the foot the base and the origin for muscle action. In the relaxed standing position, the stretch reflex is constantly monitoring the anterior and posterior sway of the body, activating the soleus and anterior tibial for balance. During normal standing, the line of gravity is in front of the ankle joint; the soleus muscle maintains a tonic contraction to prevent the body from falling forward. **(O'Connell, 1958)**

The glandular association of the gastrocnemius and soleus with the adrenal provides body language to indicate when adrenal involvement may be present. The patient may complain of aching in the calves of his legs, especially after being on his feet for a period of time. There will be tenderness in the soleus-gastrocnemius complex when squeezed by the examiner. Of course, this tenderness must be differentiated from vascular conditions and direct metabolic problems with the muscle, such as calcium deficiency causing hypertonicity.

Travell and Simons **(Travell & Simons, 1992)** suggest that the soleus muscle provides the major pumping action for the return of blood from the lower limb to the heart. When the soleus muscle is functioning properly its strong contractions compress the venous sinuses so that its venous blood is forced upward. They call this pumping action of the muscle "the body's second heart" and note that this mechanism depends on competent valves in the popliteal veins.

"Valves in the veins to prevent reflux of the blood are most numerous in the veins of the lower limbs where the vessels must return blood against high hydrostatic pressure. The popliteal vein usually contains four valves. Deeper veins that are subject to the pumping action of muscle contraction are more richly provided with valves."

Additional causes of impairment of the blood supply to these muscles include wearing socks with tight elastic tops; pressure exerted on the calf from sitting with it pressed against the edge of a chair or leg rest, and arterial obstruction such as peripheral arterial disease. **(Baldry, 2001)** The gastrocnemius muscle is the one in which ischemia-induced MTrP activity most often takes place, followed by the gluteus medius, soleus, and tibialis anterior. **(Baldry, 2001)** Trigger points in the soleus muscle refer to the heel, Achilles tendon and ipsilateral sacroiliac joint. Travell and Simons also describe a rare trigger point that is known to refer to the ipsilateral face and jaw, possibly altering occlusion of the teeth.

If injecting a local anesthetic into the MTrP of the gastrocnemius is the method of treatment chosen, it should be explained to the patient that there is a high incidence of post-injection soreness that often lasts for as long as a week **(Travell & Simons, 1992)** In fact, the soreness can be so severe that they warn the procedure should never be carried out in both legs at the same time. Additionally, using this method of treatment in the popliteal region, caution must be exercised to avoid damaging the popliteal artery. These potential complications are avoided by using the techniques employed in AK.

Intrinsic Plantar Foot Muscles

The intrinsic muscles of the foot are usually evaluated in applied kinesiology when there are subluxations or pain present. The muscles appear to stabilize the articulations in the foot and return them to a balanced position when functioning normally, similar to the way the intrinsic muscles of the spinal column are responsible for the articulations in that area. The usual treatment for the intrinsic muscles is origin/insertion technique, neuromuscular spindle cell, Golgi tendon organ, and percussion. **(Fulford, 1996; Cuthbert, 2002)**

There is no listing for neurolymphatic, neurovascular, organ-gland, meridian, or nutritional association for these muscles. Beardall, from his intensive clinical and manual muscle testing experience, has offered these correlations. The intrinsic plantar foot muscles appear to respond clinically to these specific AK manipulative approaches; however, the association is better established for the larger muscles whose association has been established over the past 46 years in applied kinesiology by the thousands of practitioners in the International College of Applied Kinesiology around the world.

In the normal foot, the intrinsic muscles do not appear to have an arch supporting role. **(Basmajian & Stecko, 1971)** "The muscles are spared when the ligaments suffice." **(Basmajian, 1961)** Although the specific intrinsic muscles of the arch were not studied by Gray **(Gray, 1969)** in his comparison of the normal and the flat foot, it seems likely that they are active in the flat foot because of the lack of ligamentous support. In the presence of a chronic tarsal tunnel syndrome, there is clinically observed atrophy of the plantar intrinsic muscles. It is valuable to exercise these muscles after the tarsal tunnel syndrome has been corrected. In many cases, exercise improves function of the foot so that the patient may discontinue wearing orthopedic supports for the arches. **(See Foot and Ankle chapter)**

Travell and Simons **(Travell & Simons, 1992)** note that trigger points in the plantar intrinsic muscles are exacerbated by the wearing tight, poorly fitting or designed shoes, ankle and foot injuries, structural imbalances of the foot, subluxation or loss of structural integrity of the joints of the foot, walking on sandy or sloped surfaces, and conditions where the feet can get chilled as well as systemic conditions (gout, rheumatoid arthritis, diabetes, among others).

It should be remembered that manual treatment to the plantar surface of the foot must be applied through the plantar fascia. The integrity of this fascia is important to the arch system of the foot. The plantar aponeurosis is tensionally loaded and in this way helps maintain the plantar arch. When injured by subluxation or soft tissue dysfunction, this issue may develop inflammation which is commonly termed plantar fasciitis. **(Cailliet, 1997)**

Myers **(Myers, 2001)** offers a simple test that can demonstrate to the clinician and the patient the inter-

relatedness of the plantar muscles of the foot to the rest of the body. Ask the patient to do a forward bend while keeping the knees straight. Measure the resting distance the patient can reach down the legs and the contour of the back. Then ask the patient to roll a golf or tennis ball deeply into the plantar surface of the foot on one side only, working throughout the foot deeply and slowly. Do this for several minutes, making sure the entire foot from the toes to the ball of the foot to the front edge of the heel are treated. Then ask the patient to do the forward bend again and note the bilateral differences in hand position and back contour and ease of movement. In most people this will produce an obvious change in function and show them how working on the intrinsic muscles and fascia of the foot can affect the functioning, comfort, and flexibility of the whole person.

It is obvious to practitioners experienced in applied kinesiology that the methods of challenge and therapy localization to the foot can make this kind of dramatic, measurable improvements in muscle strength, postural function and ease of use with greater rapidity and specificity.

Lumbricales and Dorsal and Plantar Interossei

Lumbricales

Attachments: Between the tendons of the flexor digitorum longus, except for the first, which arises from the medial side of the first tendon of the flexor digitorum longus to attach on the medial side of the proximal phalanx and into the expansions of the tendons of the extensor digitorum longus of the 2nd-5th toes.

Action: Flex the proximal phalanges on the metatarsals, and extend the two distal phalanges of the four small toes.

Synergists: Flexor digitorum brevis and longus for the metatarsophalangeal articulation, and extensor digitorum longus and brevis for the extensor function; dorsal interossei and plantar interossei.

Testing Position: There are two tests for the lumbricales. Described here is the flexing action of the metatarsophalangeal articulation. The extension of the middle and distal phalangeal articulations is tested with the extensor digitorum longus and brevis.

Testing position for flexion of the metatarsophalangeal articulation is difficult to obtain in most individuals. The optimum testing position is flexion of the metatarsophalangeal articulation, with neutral position of the middle and distal interphalangeal articulations.

Stabilization: The examiner stabilizes across the dorsal surface of the metatarsals.

Test: Examiner contacts plantar surface of the proximal phalanges of the 2nd-5th toes, and directs pressure toward extension of the metatarsophalangeal articulations.

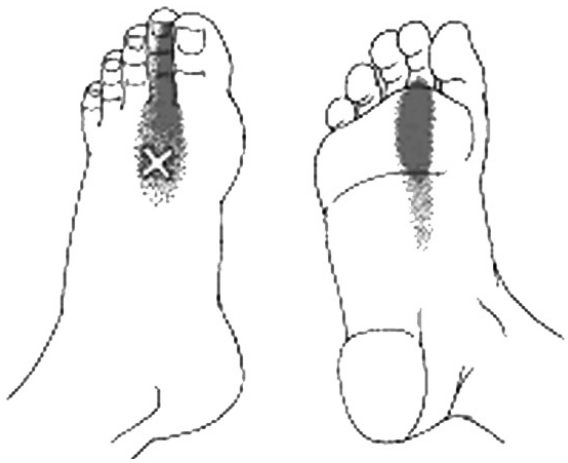
Body Language of Weakness:

Testing Position: The patient has difficulty in actively achieving the testing position. When a patient cannot move into the testing position, the examiner can passively place the toes into the position to determine if the patient can hold it. Care must be taken, because many individuals cannot isolate muscle activity well enough to obtain or maintain the testing position, even though the muscle is not weak; only control is lacking.

Movement aberrations: Similar to those described for the flexor digitorum brevis.

Postural imbalances:

Nerve supply:



Dorsal Interossei MTrPs

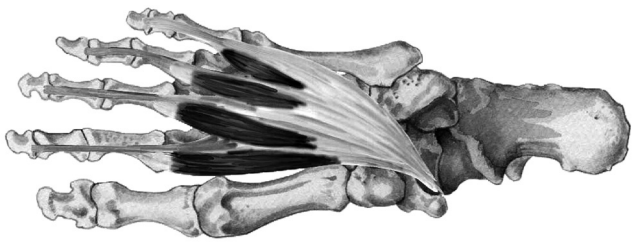
1st Lumbricalis: medial plantar nerve, L4, 5
2nd, 3rd, 4th lumbricales: Lateral plantar nerve, S1, 2

Dorsal Interossei

Attachments: There are 4 dorsal interossei which arise by double pennate fibers from the bases and sides of the bodies of adjacent metatarsal bones and attach to the base of the proximal phalanx and aponeurosis of the tendons of the extensor digitorum longus. The 1st dorsal interosseous (arising from the 1st and 2nd metatarsals) inserts into the 2nd toe. The 2nd-4th dorsal interossei insert into the lateral sides of the 2nd, 3rd, and 4th toes.

Action: Assist in flexing the proximal phalanx and extending the middle and distal phalanges. Abduct the toes from the longitudinal axis of the 2nd toe.

Nerve supply: Lateral plantar



Lumbricales

Plantar Interossei

Attachments: There are 3 plantar interossei arising from the base and medial plantar surface of the 3rd, 4th, and 5th metatarsal bones that attach to the medial side of the base of the 1st phalanx of the same toe, and into the tendons of the extensor digitorum longus.
Action: Flex the proximal and extend the distal phalanges, and adduct toes toward the axis of the 2nd toe.
Nerve supply: Lateral plantar

Special Notes:

The lumbricales and interossei muscles are not often tested in applied kinesiology. Knowledge of the action and location of the muscles is informed for application of direct treatment to them in the case of subluxations and soft tissue dysfunction, as for instance myofascial trigger points, especially if they are recurrent.

The interossei act to stabilize the foot in uneven or rough terrain and stabilize the toes during gait.

The location of the interossei muscles indicates they are important in the gait mechanism. The acupuncture points which are treated with gait dysfunction in AK are in the location of these muscles. It is clinically observed that when there is a gait dysfunction, there is an exquisite tenderness on digital pressure in the area indicated for gait treatment. It seems likely that the muscle in the location of the apparently dysfunctioning acupuncture point is involved in some manner with the problem. Failure to correct any soft tissue involvement or subluxations seems to cause the active acupuncture point to return after it has apparently been effectively treated.

Travell and Simons **(1992)** note that the lumbricales trigger point referral patterns are likely to be similar to the interossei; however the patterns for this muscle have not been confirmed. Travell and Simons add that trigger points in the first dorsal interosseous muscle may produce tingling in the great toe as well as disturbances of sensation that can extend to the dorsum of the foot and the lower shin.

Peroneus Longus and Brevis

The peroneus longus and brevis muscles will be considered together because they are tested simultaneously. The primary requirement for differentiating these two muscles is the origin and insertion for tendon treatment, or attention to the golgi tendon organs or neuromuscular spindle cell for the individual muscle.

Peroneus Brevis

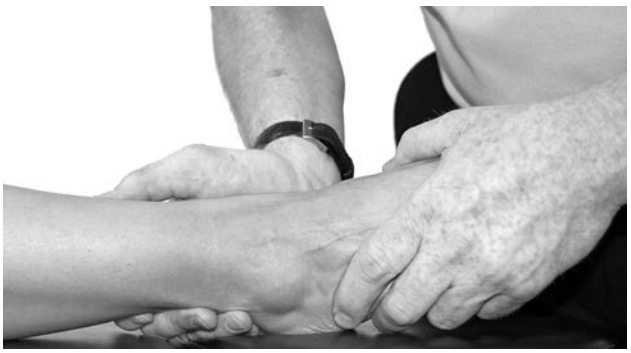
Attachments: From the lower two-thirds of fibula on lateral side and adjacent intermuscular septa to the lateral side of proximal end of 5th metatarsal.
Action: Plantar flexes foot and everts it; gives lateral stability to the ankle.

Peroneus Longus

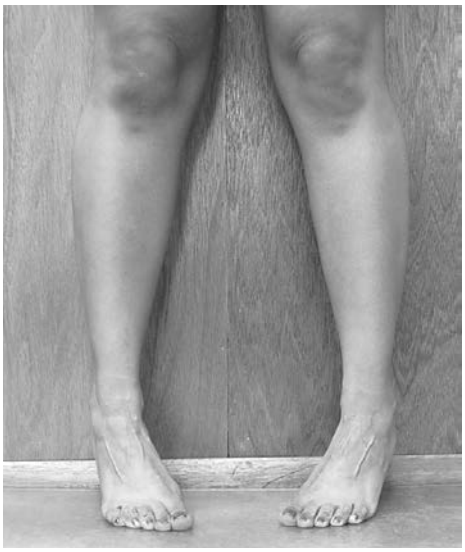
Attachments: From the lateral condyle of tibia, head and upper two-thirds of lateral surface of fibula, intermuscular septa and adjacent fascia to the proximal end of the 1st metatarsal and medial cuneiform on their lateral portions.
Action: Plantar flexes foot and everts it; gives lateral stability to the ankle.

Peroneus Longus and Brevis

Change of Action: When the foot is stabilized, as in standing, the peroneus longus and brevis stabilize the leg on the foot. They are synergistic to the gastrocnemius and soleus muscles in extending the tibia and fibula at the ankle when in the standing position.
Testing Position and Stabilizaton: Supine patient fully plantar flexes the foot and then everts it as much as possible. The toes should be kept neutral or in flexion to limit action of the long muscles of toe flexion and extension. The testing position should be such that the muscle and tendon passing behind the lateral malleolus are in as straight a line as possible. The examiner stabilizes the leg above the ankle.
Test: The supine patient maximally plantar flexes the foot and everts it, with the toes kept in flexion or neutral position. Testing pressure is directed to the side of the foot in the direction of inversion. The test must start from the maximum eversion allowed when the foot is in complete plantar flexion. The range of motion in this test is limited. No dorsiflexion of the foot should be allowed, nor should there be any extension of the toes. The examiner should observe the tendon that courses behind the external malleolus as evidence of maximum isolation of the muscles.
Body language of weakness:
Testing position: It is not unusual to have such great weakness of these muscles that the patient cannot bring the foot into the testing position.
During test: The patient's effort to recruit other muscles into this test is dramatic, and sometimes extremely difficult to stop. The patient will attempt dorsiflexion of the foot and extension of the toes. Even if the examiner prevents the patient from dorsiflexing his foot and extending the toes by holding the position, the patient's effort will change the test significantly. If dorsiflexion of the foot or extension of the toes is allowed, a strong



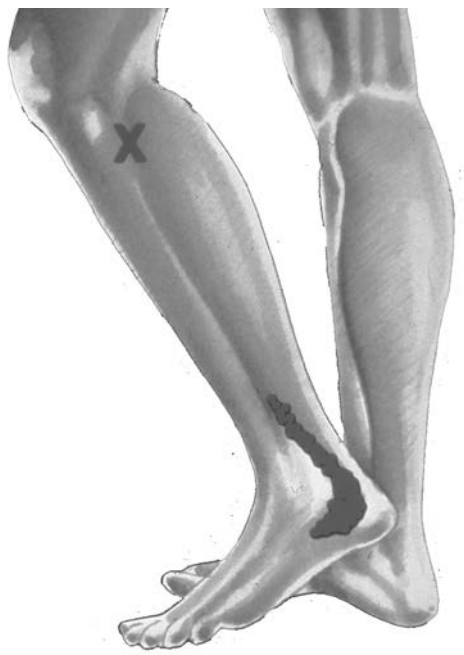
Peroneus Longus & Brevis MMT



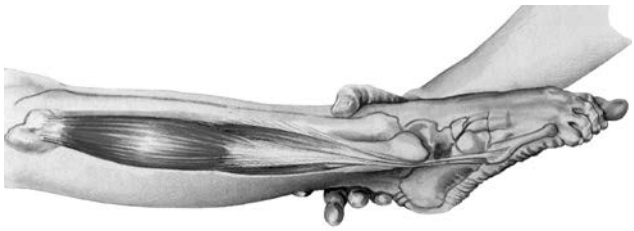
Peroneal Exercises

peroneus longus and brevis may be indicated; in reality, the muscles may be exquisitely weak. In order to eliminate the dorsiflexion and toe extension, it may be necessary to restart the test several times. Once the examiner has felt the dramatic difference between testing a weak peroneus longus and brevis correctly, and the dramatic change the patient can make with dorsiflexion or toe extension, it becomes much easier to perform this test properly.

Postural balance: Balance of the ankle muscles is best observed when the patient is supine. Weakness of the peroneus longus and brevis causes the foot to invert. An imaginary line extending down the tibial ridge should extend over the second toe. Weakness of the peroneus longus and brevis causes this line to be lateral of the second toe or to miss the foot entirely. When evaluating the structural balance of the foot in the supine position, care must be taken that the foot is not resting on the table in such a manner that the table pressure deviates the foot from its relaxed position. It is best to have the foot hang over the edge of the table, or be supported by an ankle rest such as is present on most chiropractic tables.



Peroneus Longus MTrP



Peroneus longus & brevis muscle

Nerve supply: Peroneal, L4, **5, S1**.

Neurolymphatic:

Anterior: Inferior symphysis pubis, bilaterally.

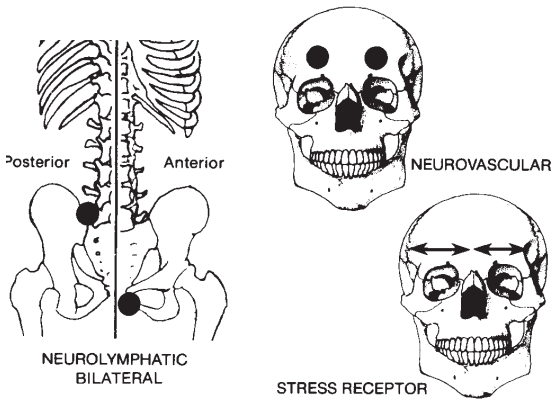
Posterior: Bilaterally between posterior superior iliac spine and L5 spinous process.

Neurovascular: Bilateral frontal bone eminences.

Nutrition: Calcium, vitamin B complex. Avoid oxalic acid foods.

Meridian association: Bladder.

Organ association: Urinary bladder.



Peroneus longus brevis reflexes

Special Notes:

The peroneus longus and brevis are very important in maintaining normal foot and ankle function; this relates to the entire gait mechanism of the body. Weakness of these muscles is often due to foot subluxations. This can be easily determined using applied kinesiology by challenging the foot structures and then re-testing the peroneus longus and brevis for improved function. These muscles are important lateral ankle stabilizers. No other therapeutic method that we know of offers this kind of immediate evaluation tool to determine the measures necessary to improve ankle muscle function so rapidly and accurately. Myofascial trigger points (MTrPs) in the peroneus longus muscle may lead to development of taut bands in it and these will generate the muscle stretch reaction which in AK identifies the presence of MTrPs. These taut bands are able to compress the common peroneal nerve and/or its superficial and deep branches against the fibula. Compression of motor fibers in

these nerves may cause a foot drop to develop, as well as numbness and tingling on the dorsum of the foot between the first and second toes.

The peroneus longus and brevis may be injured from trauma, such as when the ankle is twisted in an inversion sprain. The trauma to the muscle may require origin/insertion technique or treatment to the proprioceptors of the muscles. After the ankle strain or sprain has recovered, evaluation of the muscles should be made for the possible need for treatment. Many recurrent twisted ankles are due to weakness of these muscles and their failure to fully recover. Richie **(Richie, 2001)** has reviewed the syndrome of functional ankle instability and finds that the majority of patients with this condition have a loss of neuromuscular control. The components of neuromuscular control include proprioception, muscle strength and reaction time and postural control during movement. Proprioceptive deficits lead to a delay in peroneal reaction time.

Some consider that the peroneus longus and brevis -- acting together with the peroneus tertius and tibialis posterior and anterior -- function as a sling mechanism to support the arch of the foot.

Peroneus Tertius

Attachments: From lower one-third of the anterior surface of the fibula and adjacent intermuscular septum to the dorsal surface of the base of the 5th metatarsal.

Action: Dorsiflexes and everts the foot.

Testing position and stabilization: The patient is best tested in the supine position. He brings the foot into dorsiflexion and eversion, with the toes kept in neutral position or toward flexion.

Synergists: The extensor digitorum longus assists in the peroneus tertius test. The peroneus tertius is a part of the extensor digitorum longus and might be described as its 5th tendon. The extensor digitorum longus is best kept out of the test by having the toes neutral or slightly flexed.

Test: The supine patient dorsiflexes and everts the foot with the toes kept in neutral position, or toward flexion. Examining pressure is directed against the dorsal lateral surface of the 5th metatarsal in the direction of plantar flexion and inversion. The examiner should evaluate the tendon of the peroneus tertius and the tendons of the extensor digitorum longus for best direction to maximize the effect of the peroneus tertius and minimize that of the toe extensors.

Body Language of Weakness:

Testing position: When the peroneus tertius is weak, it is difficult for the patient to move into the testing position without extension of the toes

During test: The toes attempt to extend from the neutral or slightly flexed position.

Postural imbalances: The peroneus tertius gives some lateral stabilization to the ankle. Lack of lateral stabilization is best seen when the patient is in the supine position. The foot inverts, causing an imaginary line drawn along the tibial ridge to intersect the foot lateral to the second toe. There may also be a lack of support to the lateral longitudinal arch of the foot. In the normal foot, there is no requirement of the peroneus tertius to support the lateral longitudinal arch. In a flat-footed individual, there is greater requirement of all the muscles which support the arch. **(Gray, 1969)**

Nerve supply: Peroneal, **L4, 5, S1**.

Neurolymphatic:

Anterior: Inferior ramus of pubic bones.

Posterior: Between L5 transverse and sacrum.

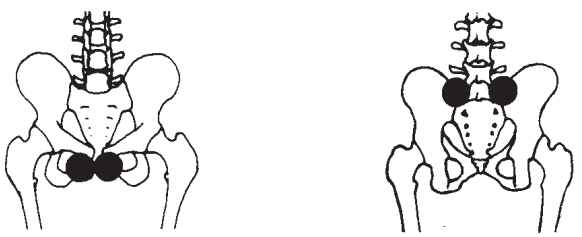
Neurovascular: Bilateral frontal bone eminences.

Nutrition: Calcium, B complex. Avoid oxalic acid foods, e.g., caffeine, cranberries, plums, and others.

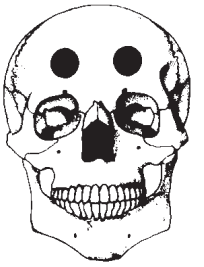
Meridian ssociation: Bladder.

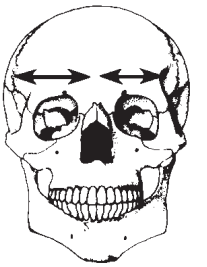
Organ association: Urinary bladder.

Peroneus Tertius MTrP



Peroneus Tertius (reflexes)



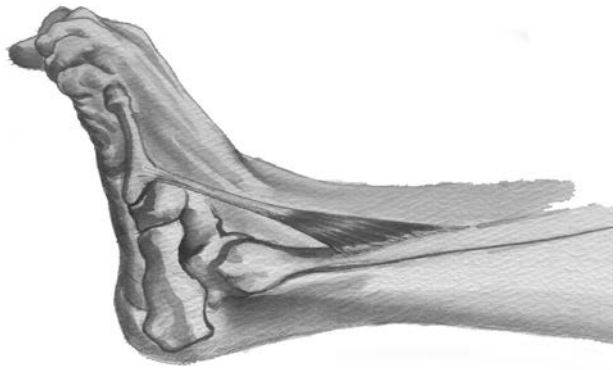


Special Notes:

The peroneus tertius is absent in between or 4.4% to 8.2% of individuals. **(Gray's Anatomy, 2004; Travell & Simons, 1992).** One cause of weakness in the peroneus tertius muscle is a subluxation of the proximal and distal tibiofibular joint, often following an inversion sprain. A compression support, e.g. an approximation challenge over the lateral and medial malleoli or taping over the lateral and medial malleoli, may immediately strengthen the peroneus tertius. Trigger points in the peroneus tertius refer pain into the anterolateral ankle and into the lateral malleolus and the heel. **(Travell & Simons, 1992)**

Ramsak & Gerz **(2002)** recommend the following exercise for the peroneii. The starting position is with both feet in 45 degree internal rotation. Slowly rise up on toes; then lower the heels back to starting position. "If more than 40 repetitions are possible without a problem, the exercise should be done on one leg only, for athletes maybe with additional weights."

Peroneus Tertius MMT

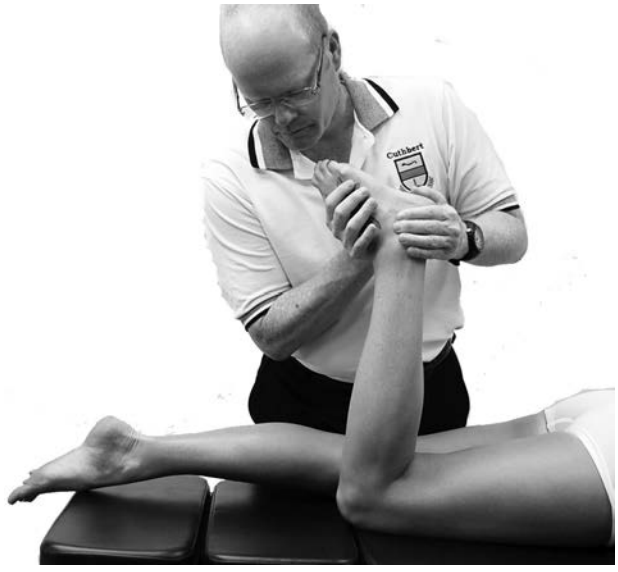


Peroneus Tertius Muscle

Popliteus

Attachments: From the lateral condyle of femur, posterior horn of lateral meniscus and fibular head to the triangular area on posterior surface of tibia above soleal line.

Action: Rotates the tibia internally on the femur or the femur externally on the tibia, depending upon the one fixed; withdraws the meniscus during flexion, and provides rotatory stability to the femur on the tibia; brings the knee out of the "screw-home" position of full extension; helps with posterior stability of the knee.



Popliteus MMT

Testing Position: The prone patient flexes the knee to 90° and medially rotates the tibia on the femur.

Patient Fixation Requirements: The foot is used to impart rotation to the tibia. The ankle must be fixed, and there must be no pathology in the ankle, foot, or knee to cause pain to the patient.

Stabilization: The examiner must make certain that the patient does not rotate the femur, or flex or extend the knee.

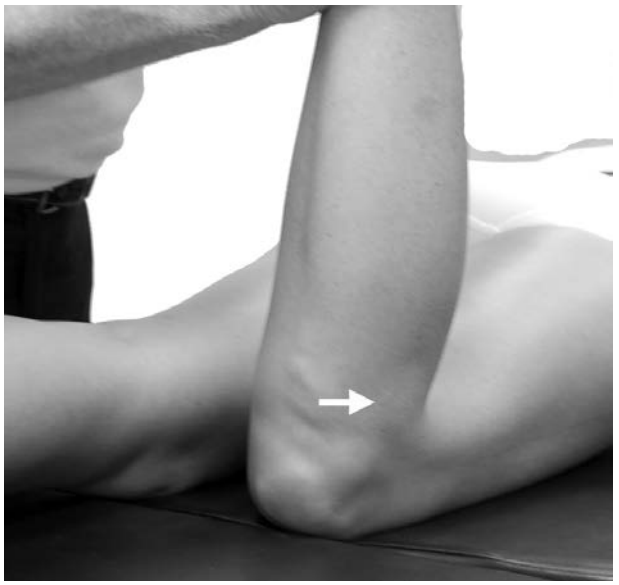
Test: With the patient's knee flexed to 90°, pressure is directed on the distal medial foot, with counter-pressure on the calcaneus to impart lateral rotation of the tibia on the femur. The actual testing motion is slight and can be evaluated only by observing the tibia rotating on the femur and watching for motion of the tibial tubercle. It is quite possible for the examiner to obtain foot rotation, appearing to be a weak popliteus; in fact, it may be a twisting of the tibia and fibula.

Body Language of Weakness:

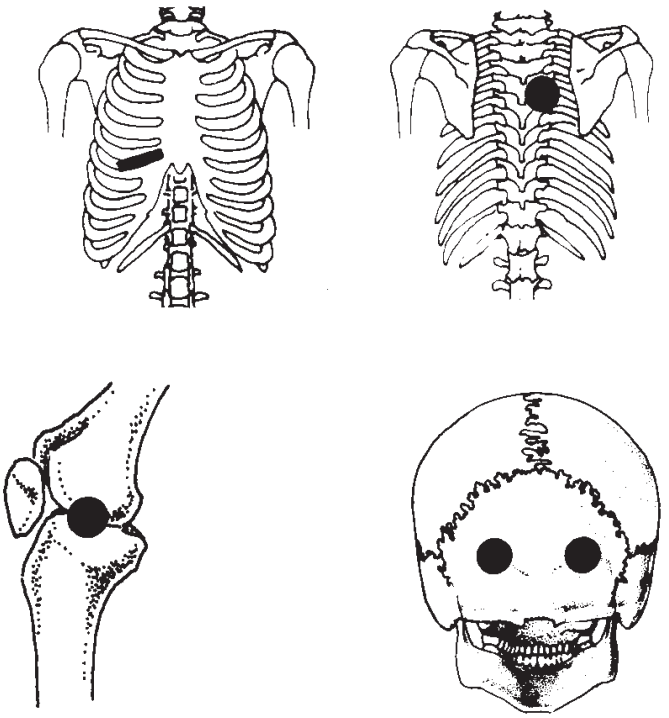
Testing position: In the presence of extreme weakness, the patient will be unable to rotate the tibia medially on the femur.

During test: The patient may attempt to change the parameters of the test by knee flexion, extension, or femur rotation.

Postural imbalances: The patient may stand with a



Movement of tibial tubercle in presence of weak popliteus



Popliteus reflexes

hyperextend knee as compensation for failure of the popliteus to offer good posterior knee stabilization. There will be lateral rotation of the tibia on the femur, giving an appearance of external rotation of the entire leg; actually, it is of the tibia and foot only. Weakness of the popliteus is best observed on a postural basis when the patient is in a relaxed, seated position with his leg hanging freely from the examination table. Weakness will cause the tibial tubercle to be lateral to the leg's midline.

Reactive Muscle Correlation: Gastrocnemius, hamstrings, and upper trapezius.

Nerve supply: Tibial, **L4, 5, S1**.

Neurolymphatic:

Anterior: 5th intercostal space from mid-mamillary line to sternum on the right.

Posterior: Between T5-6 laminae on right.

Neurovascular: Medial aspect of knee at meniscus.

Nutrition: Vitamin A, bile salts, beet leaf extracts.

Meridian Association: Gallbladder.

Organ Association: Gallbladder.

Special Notes:

Bilateral popliteus weakness indicates a probable mid-cervical functional fixation of the vertebrae. Correction of this fixation will immediately restore strength to the muscles.

The popliteus origin at the posterior horn of the lateral meniscus of the knee is a source of considerable involvement when this muscle is weak.

Basmajian and Lovejoy, using bipolar fine-wire electromyography, demonstrated with dynamic studies that the popliteus is more involved with rotation than with flexion. They also concluded that the popliteus is important in drawing the lateral meniscus posterolateral during flexion of the knee and medial rotation of the tibia. This helps prevent forward dislocation of the femur on the tibia during flexion of the knee, and is accomplished by continuous marked activity of the popliteus in the semi-crouched, knee-bent position.

The popliteus muscle is attached to the lateral meniscus as the semimembranosus muscle is to the medial meniscus. The posterior movement of the menisci produced by these muscles during knee flexion helps decrease the chance of meniscus entrapment and the resultant limitation of knee flexion which would result. Travell and Simons **(Travell & Simons, 1992)** note that the popliteus prevents forward displacement of the femur on the tibial plateau. The trigger point referral patterns that they describe, go primarily into the back of the knee.

Baker's cysts are enlargements of bursa in the posterior knee and are continuous with the synovial cavity. The Baker's cyst is a collection of synovial fluid that has escaped from the knee joint to form a 'cyst' in the popliteal space. It is often the result of knee injury or disease, such as a meniscal tear or rheumatoid arthritis. **(Travell & Simons, 1992)** If applied kinesiology's conservative measures fail to reduce the swelling, surgical removal may be required, especially when the cyst encroaches on the neurovascular tissues that course through the popliteal fossa.

Tibialis Anterior

Attachments: Lateral condyle of tibia, proximal two-thirds of lateral surface of tibia, interosseous membrane, deep fascia and lateral intermuscular septum to attach to the medial and plantar surface of medial cuneiform, and base of 1st metatarsal.

Action: Dorsiflexes foot and inverts it.

Change of Action with standing: When in the standing position, the foot is fixed and becomes the origin for the muscle. Action causes forward body lean antagonistic to the plantar flexion of the soleus and gastrocnemius. Active in the balance mechanism of anterior and posterior sway. **(Gray & Basmajian, 1968; O'Connell, 1958)**

Stabilization: The examiner stabilizes the leg above the ankle.

Synergist: Extensor hallucis longus, extensor digitorum longus.

Antagonist: If the gastrocnemius is shortened, the test should be performed with the knee in the flexed position to allow greater ankle dorsiflexion.

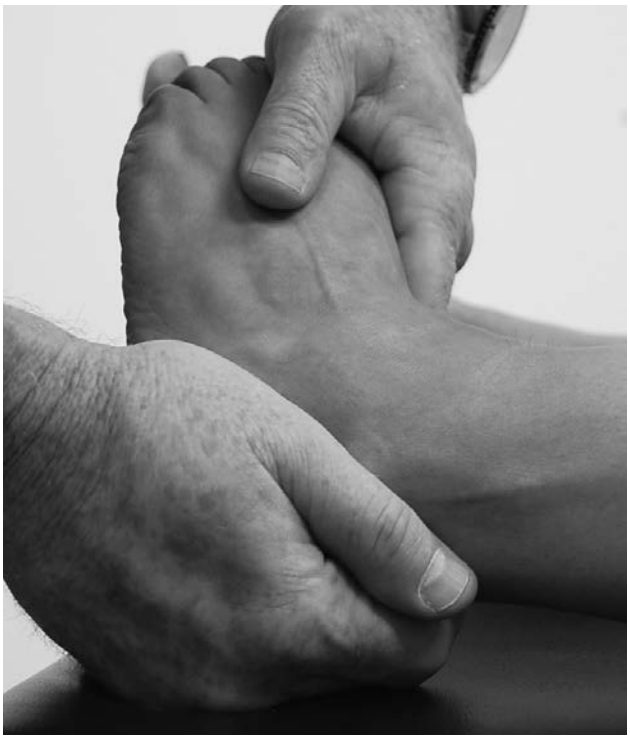
Test: The supine patient inverts and dorsiflexes the foot, with the toes kept in flexion. The examiner applies pressure against the medial dorsal surface of the foot in the direction of plantar flexion and eversion. The examiner should see effective contraction of tibialis anterior as indicated by the tendon elevation during the test.

Alternate Testing Methods: The test can be performed in the sitting position, or in the prone position when the knee is flexed. This may be helpful when testing for reactive muscles. Ramsak & Gerz **(Ramsak & Gerz, 2002)** suggest the muscle will be inhibited more frequently when tested standing or sitting because of lumbar disc problems.

Body Language of Weakness:

During Test: Patient attempts to extend the toes to recruit synergistic action of the extensor digitorum longus and extensor hallucis longus when the tibialis anterior is weak. The ideal test minimizes the contraction of these muscles, as indicated by their tendons not rising or the toes extending. Pain in the muscle is often associated with shin splints.

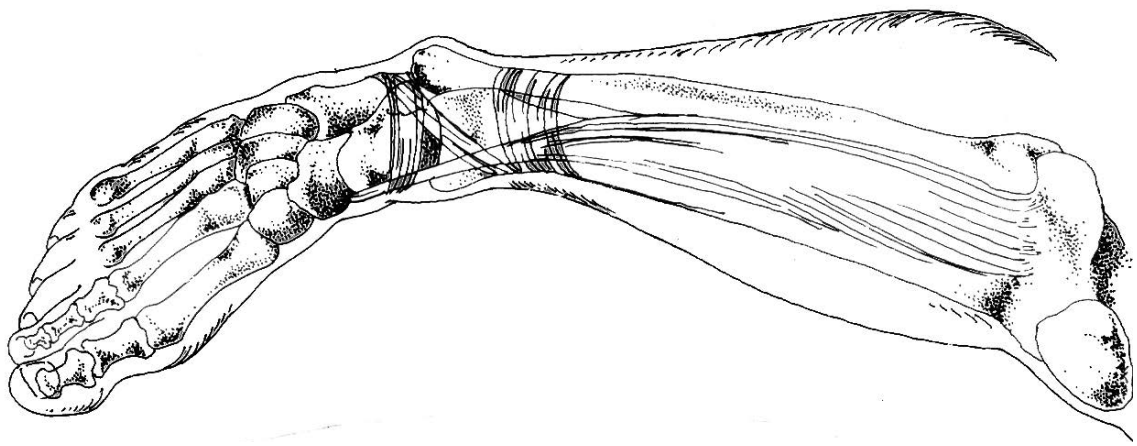
Movement aberrations: Tendency toward foot drop.



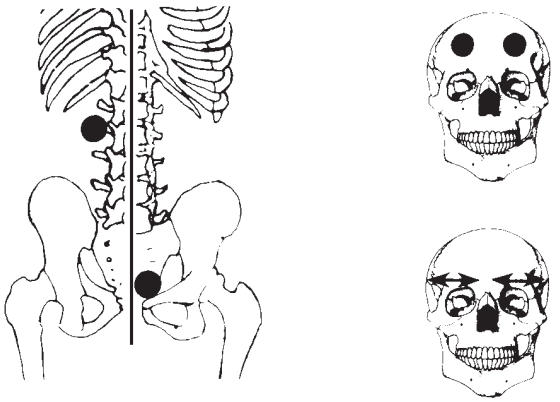
Tibialis anterior MMT

MTrPs in the muscle causes it to become weakened, with impairment of dorsiflexion and, as a consequence, the development of a foot drop. Foot drop must be significant before shoe wear will give an indication of it. A peak of electromyographic activity occurs at toe-off of the stance phase of gait. This is apparently to dorsiflex the ankle, permitting the toes to clear the floor. **(Basmajian, 1978)**

Postural imbalances: The tibialis anterior is a medial ankle stabilizer. In the supine and relaxed position, there will be deviation of the foot laterally. It can be evaluated with an imaginary line drawn down the anterior tibial ridge, which should extend into the second toe. When evaluating the foot for balance in the supine position, care must be taken that the foot is not being deviated from its relaxed position by pressure on the calcaneus by the table. It is best to have the patient in a position where the foot is hanging freely over the end of the table.



Tibialis anterior action



Tibialis Anterior reflexes

Nerve supply: Peroneal, **L4, 5**, S1.
Neurolymphatic:
Anterior: 3/4" above symphysis pubis bilaterally.
Posterior: L2 transverse process.
Neurovascular: Bilateral frontal bone eminences.
Nutrition: Vitamin A.
Meridian association: Bladder.
Organ association: Urinary bladder.
Special Notes:

This muscle is often associated with shin splints. When present, the treatment is frequently origin/insertion, proprioceptive, percussion, or fascial release technique. When shin splints are present, there will usually be pain during the muscle test; this should be dramatically relieved after treatment.

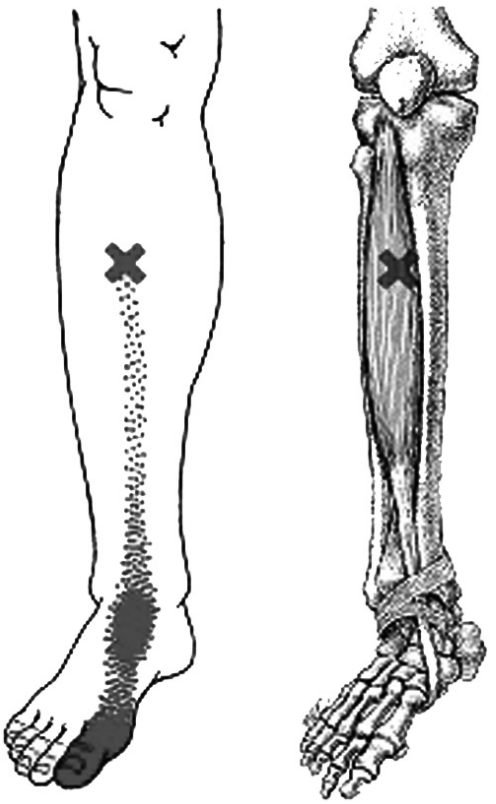
The response of the tibialis anterior muscle to a "proprioceptive technique" used in applied kinesiology was investigated by Perot et al **(Perot et al., 1991)** during manual muscle testing using a graphical registration of both mechanical and electromyographic parameters. Experiments were conducted blind on ten subjects. Each subject was tested with MMT and EMG ten times, five times as a reference, and five times after proprioceptive techniques to inhibit the muscle. Results indicated that after treatment an inhibition was easily registered. The reliability of the proposed procedure is mostly dependent upon satisfactory subject-examiner coordination that is also necessary in standard manual muscle testing.

This study demonstrated that there was a significant difference in electrical activity in the muscle, and that this corresponded with the difference found between "strong" versus "weak" muscle testing outcomes by the examiners. It further demonstrated that these outcomes were not attributable to increased or decreased testing force from the doctor during the tests. In addition, the study showed that manual treatment methods used in AK to reduce the level of muscle tone in the spindle cells of the muscle are in fact capable of creating a reduction in tone of the muscle, as had been observed clinically. **(Perot, 1991)**

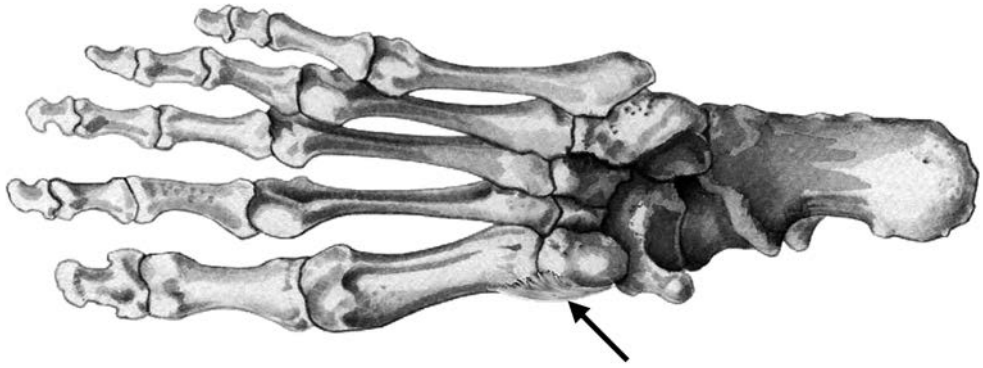
Another study by Costa and de Araujo showed that by needling the accupuncture point ST36, functional changes (decreased strength) in the tibialis anterior muscle was produced as measured by EMG. **(Costa & de Araujo, 2008)** According to AK, the tibialis anterior muscle corresponds to the Bladder meridian. This sedation point stimulation of the Bladder meridian, and its weakening effect upon the tibialis anterior muscle, confirms one of the approaches AK has used for decades in evaluating the meridian system.

In the relaxed standing position, the only activity of the tibialis anterior is in controlling sway. **(Gray & Basmajian, 1968; O'Connell, 1958)** In a normal foot, there is no electrical activity of this muscle to support the arch when in the standing position. Basmajian and Stecko **(Basmajian & Stecko, 1963)** studied the muscles of the normal foot and leg and their influence on arch maintenance using electromyography while weight-loading the foot. The subject was in a seated position, and the load was placed on the knee to transmit weight through the vertical leg and into the foot; thus there was no possible influence of postural sway. Activity of the tibialis anterior was demonstrated with a weight of 400 pounds placed on the knee, but not with all subjects. Gray **(Gray, 1969)** studied both normal and flat feet, and found that in the normal standing position there was marked activity on EMG in 23 out of 27 subjects with flat feet -- a significant contrast to 6 subjects tested with normal feet which revealed only one subject with slight activity; 5 showed none.

In free movement of dorsiflexion, electromyography shows that the tibialis anterior begins the motion, followed by contraction of the extensor digitorum longus. Near the end of the motion, the extensor hallucis longus participates in the action. **(Suzuki, 1956)** This seems to indicate that the primary synergist to the tibialis anterior muscle is the extensor digitorum longus. The extensor hallucis longus probably is more active in the foot inversion position in which the tibialis anterior is tested than it is in straight



Tibialis Anterior MTrP



Tibialis Anterior attachment

dorsiflexion. The examiner can limit these muscles in the test by being certain there is no toe extension during the procedure.

Decreased ankle dorsiflexion is frequently caused by excess tone in the gastrocnemius and soleus muscles, and this may inhibit the tibialis anterior muscle on MMT. **(Maffetone, 2003)**

Ramsak and Gerz **(Ramsak & Gerz, 2002)** observe that pathologic or functional disturbances of the bladder may not cause the tibialis anterior to show weakness on MMT, and suggest instead that a previously strong indicator muscle be tested with therapy localization to the acupuncture point Conception Vessel 3 instead (alarm point for the bladder).

Trigger points in the tibialis anterior muscle referred pain and tenderness of the mid-shin region to the distal end of the great toe, and strongest to the ankle and toe. These trigger points may be activated by ankle injuries of many kinds, or by walking on sloping surfaces or rough terrain. **(Travell & Simons, 1992)**

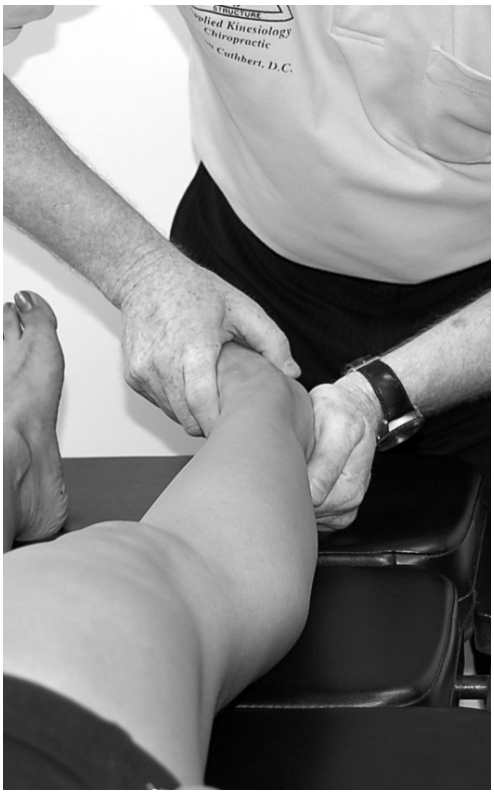
Tibialis Posterior

Attachments: From the lateral part of posterior surface of tibia, medial two-thirds of fibula, interosseous membrane, intermuscular septa, and deep fascia to attach to the tuberosity of navicular bone, plantar surface of all cuneiforms, plantar surface of base of 2nd, 3rd, and 4th metatarsal bones, cuboid bone, and sustentaculum tali.

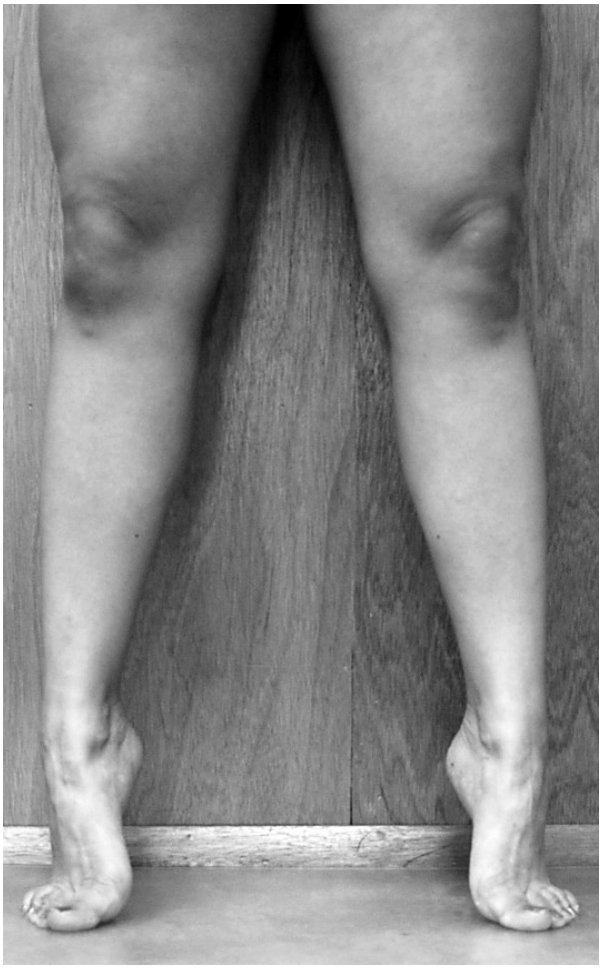
Action: Inverts and plantar flexes foot; medial ankle stabilizer.

Test: The supine patient maximally plantar flexes the foot and then inverts it, keeping the toes in a flexed position. The examiner places his hand on the medial side and over the foot. Pressure is directed against the medial side of the foot in the direction of eversion. The

Foot is first brought into full plantar flexion and inversion, with toes in flexion. Observe for attempts at toe extension dorsiflexion



Tibialis Anterior MMT



Tibialis Posterior exercises

examiner should observe for the rising tendon of the tibialis posterior when the muscle contracts. Care should be taken that the patient does not dorsiflex the foot to change the parameters of the test.

Nerve supply: Tibial nerve (**L4-S1**).

Neurolymphatic:

Anterior: 2" above the umbilicus and 1" from the midline bilaterally.

Posterior: Between T11, 12 bilaterally by laminae.

Neurovascular: Lambda.

Nutrition: Adrenal concentrate or nucleoprotein extract.

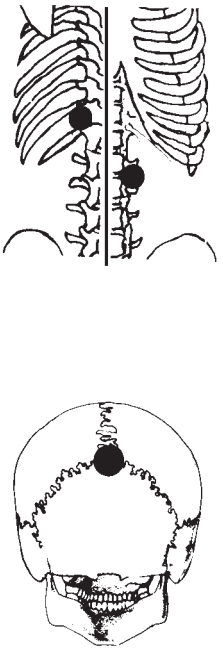
Meridian association: Circulation sex.

Organ/gland association: Adrenal; possibly urinary bladder.

Special Notes:

Tibialis posterior is the deepest muscle of the posterior compartment. **(See compartment syndromes, Chapter 5)** When the body is supported on one leg the supinator action of the tibialis posterior, exerted from below, helps to maintain balance by resisting any tendency to sway laterally.

The tibialis posterior is often found weak during accurate MMT. It contributes much to foot dysfunction and is often involved with foot pronation syndromes. Proper function of this muscle is necessary for sports requiring athletes to rise on their toes. Maffetone **(Maffetone, 2003)** observes that tibialis posterior inhibition may be followed



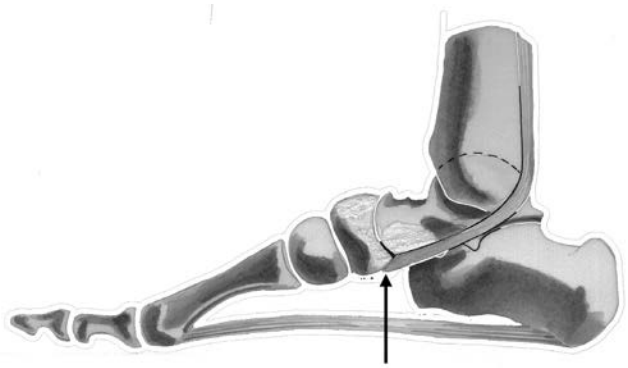
Tibialis Posterior reflexes

Tibialis Posterior MTrPs

by secondary tightness of the gastrocnemius and soleus and may be responsible for posterior shin splints.

As with other muscles associated with the foot, the primary weakness of the tibialis posterior is often due to a foot subluxation. When the muscles of the foot are weak, it is of value to challenge the foot in its many different aspects in an attempt to find a subluxation affecting the muscle. If a positive challenge is found which strengthens the muscle, a subluxation is probably the primary cause of weakness and should be corrected first. Neurolymphatic reflex, neurovascular reflex, acupuncture meridian involvements, and other treatment approaches will probably strengthen the muscle; however, if a foot subluxation is primarily responsible for the weakness, the other corrections will not hold. As soon as the patient walks, the muscle weakness will usually return until the subluxation in the foot is corrected.

This muscle will often test weak the presence of a caudal subluxation of the navicular bone, as well as in pronation of the foot. Examination of the tibialis posterior muscle should



Tibialis Posterior action on the navicular

always include palpation of the muscle belly, where painful sites will frequently be found. **(Ramsak & Gerz, 2002)**

It is frequently found that a more long-term approach to therapy is required if the muscle weakness is associated with adrenal dysfunction.

Activity of the tibialis posterior is important in stabilization of the ankle mortise. Kapandji points out that the distal tibiofibular articulation is a syndesmosis without articular cartilage, and the two bones are not in contact with each other. The change of relationship of the medial and lateral malleolus is necessary to accommodate the trochlear surface of the talus, which is wider at the anterior than the posterior by approximately 5 mm. In plantar flexion, the intermalleolar space must narrow to maintain articular stability on the narrower portion of the trochlear surface of the talus. The movement of the distal tibiofibular articulation is efficiently accomplished in plantar flexion by the pennate arrangement of the muscle fibers. As the posterior tibialis contracts, it pulls through its pennate arrangement on the tibia and fibula, approximating them, which reduces the intermalleolar space and keeps the ankle mortise tight and secure. In dorsiflexion, the tibialis posterior is relaxed, allowing the intermalleolar space to widen to accommodate the wider portion of the trochlear surface of the tibia.

Individuals with active trigger points in the tibialis posterior muscle will complain of pain in the foot when running or walking. The pain is particularly felt in the sole of the foot and Achilles tendon, as well as the midcalf and heel. Differential diagnosis of the causative factor in cases of foot and ankle pain, using referred pain as your only guide, is therefore troublesome.

Tibialis posterior trigger points are difficult to treat with manual techniques, or injections, due to be overlying muscles and adjacent neurovascular structures. The authors have found spray and stretched techniques, ice stripping, described by Travell & Simons **(1999),** and particularly percussion techniques described by Fulford **(Cuthbert, 2002; Fulford, 1996)** to be an effective treatment method. With these approaches, in addition to the correction of associated articular, muscular, and myofascial conditions, in addition to the appropriate home-treatment program, successful reduction in pain and dysfunction from these trigger points are likely.

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