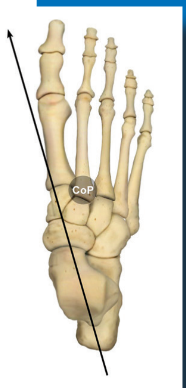
Understanding Equinus: A 2023 Update



This profound causal agent is commonly overlooked and undertreated.

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Goals and Objectives

After completing this CME, the reader should:

1) Understand the definition of equinus.

2) Understand the evaluation of equinus.

3) Understand the treatment of equinus based on evidence-based medicine.

4) Become more aware of the role of equinus in foot and ankle pathology.

5) Include equinus treatment as part of a global treatment plan, when indicated.

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*Following this article, an answer sheet and full set of instructions are provided.—**Editor***

Equinus has been described as "the most profound causal agent in foot pathomechanics and is frequently linked to common foot pathology," and also has been described as "the greatest symptom producer of the human foot;" yet it is commonly overlooked and under-treated. The importance of equinus cannot be overstated, and its management is crucial to treating the underlying pathology of all the following foot and ankle conditions as documented in the literature: plantar heel pain/plantar fasciitis, Achilles tendonitis/tendinosis, posterior tibial tendon dysfunction/adult flatfoot deformity, muscle strains, stress fracture, shin splints, iliotibial band syndrome, patellofemoral syndrome, ankle sprains/fractures, diabetic foot ulcers, charcot deformity, metatarsalgia, metatarsal phalangeal joint synovitis, hallux abductovalgus, hammer toes/ claw toes, Lisfranc/midfoot arthrosis, hallux limitus/hallux rigidus, forefoot calluses, Morton's neuroma, chronic ankle stability, poor balance/increased fall rate in elderly, Sever's disease, pediatric flat foot, lateral foot pain, genu recurvatum, medial tibial stress syndrome, low back pain, arch pain, ankle arthrosis, subtalar arthrosis, sesamoiditis, anterior compartment syndrome, and forefoot nerve entrapment.[1] The prevalence could reach 50% of the general population according to some studies and could be present in 96.5% in the case of foot pathology.[42] With such a high prevalence of equinus, why is there a failure in recognition, association to pathology, and treatment of this condition?

There are several factors at play that all lead to this under-appreciation and lack of treatment with equinus. It all starts with the definition of equinus, as there is no standard definition. The next crucial factor is the lack of appreciation of the relationship between equinus and the above-listed patholo-

gies. Finally, the lack of treatment is related directly to the ineffectual conservative management of the condition. Let's take a journey through equinus to fully understand the condition and, therefore, bring to it the respect it is due.

Anatomy

Most pathologies of the foot and ankle start with anatomy. The anatomy of the triceps surae consists of the gastrocnemius, soleus, and plantaris muscles. The gastrocnemius muscle originates on the posterior aspect of the femoral condyles and posterior knee capsule with the medial head being the larger of the two and descending further distally. The gastrocnemius muscle crosses the knee, ankle, and subtalar joints. This is a very important factor; the multi-joint crossing is directly related to the most common form of equinus, gastrocnemius equinus. The aponeurosis of the gastrocnemius muscle is anterior to the muscle. Its primary blood supply is from the popliteal and sural arteries, and it is innervated by the tibial nerve. The primary act of the gastrocnemius is to supply power for propulsion, knee flexion, and plantarflexion of the ankle joint (Figure 1).

The soleus originates on the posterior aspect of the head of the fibula, the middle one-third of the medial border of the tibia, the soleal line, and the interosseous membrane. The aponeurosis of the soleus is posterior to the muscle. The soleus crosses the ankle and subtalar joints. The soleus is innervated by the tibial nerve and its arterial supply is that of the tibial, peroneal, and sural arteries. The primary function of the soleus muscle is to stabilize the leg onto the foot and plantarflex the ankle joint.

The plantaris tendon originates medial and superior to the lateral head of the gastrocnemius muscle at the lateral head of the femoral condyle, coursing lateral to the gastroc-soleal complex and medial to it. The plantaris tendon inserts medial to the Achilles tendon insertion on the calcaneus. The plantaris tendon can be absent approximately 7% of the time.

The Achilles tendon is the continuation of the aponeurosis of the gastrocnemius and soleus merging together, forming the largest, thickest, strongest tendon in the body, approximately 15 centimeters long. The tendon inserts into the middle one-third of the posterior aspect of the calcaneus. There is a retrocalcaneal bursa between the Achilles tendon and the calcaneus. The fibers of the Achilles tendon rotate laterally at approximately 90° so that the gastrocnemius fibers insert primarily laterally, and the soleus fibers insert primarily medially. The tendon is surrounded by a tendon sheath which allows gliding of the tendon, and below this sheath is the paratenon, which protects and nourishes the tendon. The vascular supply of the Achilles tendon is from the myotendonous junction, the paratenon, and the calcaneal periosteum. There is a well-documented zone of hypovascularity 4-5 cm proximal to the insertion of the tendon.

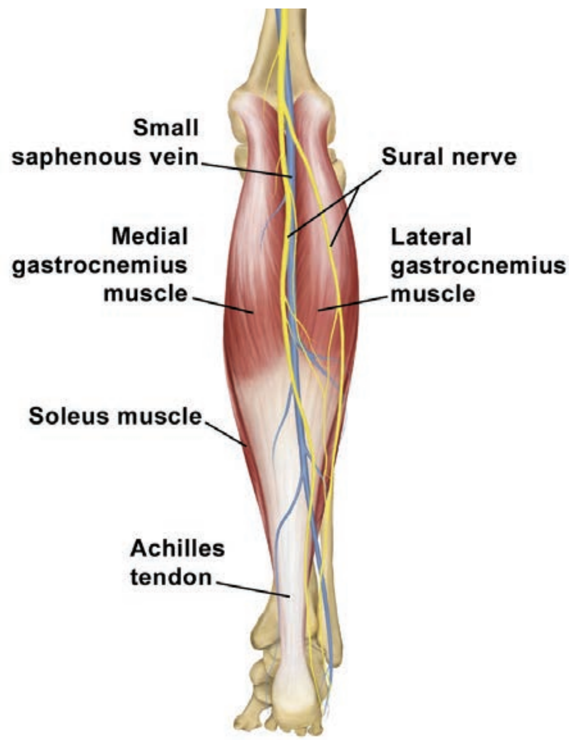


Figure 1: Posterior view of the GSC complex and related anatomical structures.

The gastrocnemius crosses the knee, ankle, and subtalar joint.

Types of Equinus

There are two primary types of equinus—muscular and osseous, with subgroups of each kind. In the muscular group, there can be either spastic or non-spastic equinus. Either of these subgroups of spastic or non-spastic equinus can further be broken down into gastrocnemius or gastro-soleus equinus. The osseous forms include anterior spurring of the ankle joint best seen on a charger view (stress dorsiflexion lateral x-ray), distal tibial-fibular osseous bridging, pseudo-equinus, or combined equinus. Pseudoequinus occurs in the cavus foot structure where ankle joint dorsiflexion occurs to dorsiflex the forefoot, which is plantarflexed to the rearfoot. The ankle dorsiflexion used to do this then limits the amount available for normal ambulation; therefore, the term pseudo-equinus. The combined equinus is just a combination of one type of muscular and osseous equinus.

Clinical Evaluation

The Silfverskiold test is what is used to determine the type of equinus. In this examination, the subtalar is placed in a neutral position and the midtarsal joint is locked by supination of the forefoot. The ankle is dorsiflexed maximally with the knee in full extension and then checked with the knee in flexion (Figures 2 and 3). If the ankle joint dorsiflexes greater than 90° with both the knee extended and flexed, there is no equinus. If the ankle joint dorsiflexes greater than 90° with the knee flexed by less than 90° with the knee extended, the result is gastrocnemius equinus. If the ankle dorsiflexion is less than 90° with both the knee flexed and extended, then it can either be gastroc-soleus equinus or osseous equinus. This is determined by the quality of the end range-of-motion and with a charger dorsiflexion stress lateral ankle x-ray.

A soft-end range-of-motion is more likely a gastroc-soleus equinus, especially if no anterior ankle impingement is noted on the x-ray. This brings into question how to reproducibly measure ankle joint dorsiflexion. There are over 23 methods described in the literature on how to evaluate ankle joint dorsiflexion.[2] Ankle joint dorsiflexion can vary significantly, up to 10°, based on supinated or pronated foot position.[2] Supinating the foot and then dorsiflexing limits the midtarsal joint motion to 2.5°, a clinically significant amount resulting in improved consistency.[2]

Dayton, et al. performed a similar study and came to the same conclusion. The authors compared radiographic evaluation of ankle joint dorsiflexion with the foot pronated, supinated, and in the neutral position.[3] They found a significant difference, 14° between a pronated foot position and a supinated foot position, but only a 9° change between supinated and neutral, while radiographically the tibiotalar angle did not change significantly. They concluded, "Motion of the foot between the neutral and supinated position introduced an additional source of potential error from the measurement technique when using the neutral position as the standard, which has been recommended in the past. We recommend a supinated foot position as a more reliable foot position for measuring the clinical ankle joint range of motion and propose it as a standard."[3]

The gastrocnemius flexes the knee, plantarflexes the ankle joint, and supplies power for propulsion.

Figure 2: The Silfverskiold test is used to evaluate for equinus. This demonstrates evaluation of the dorsiflexion of the ankle joint with the knee extended.

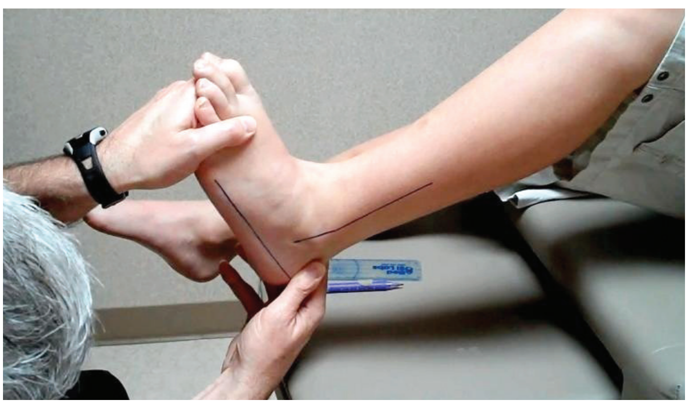


Figure 3: Evaluation of the ankle joint dorsiflexion with the knee bent removes the pull of the gastrocnemius muscle and allows the practitioner to determine whether equinus is gastrocnemius equinus or gastroc-soleal equinus.

Definition

After understanding the anatomy and evaluation method, the definition becomes the next most crucial factor and is surprisingly difficult, especially among different specialties. The definition of equinus ranges from -10° to + 22° in the literature, with +10° as a consensus of thirteen different studies. Sgarlato[4] in *The Journal of American Podiatric Medical Association* in 1975 first described the definition as +10° with the subtalar joint in neutral position and the midtarsal joint locked. Gatt, et al.[2] investigated the relationship between static diagnosis of ankle equinus and dynamic ankle and foot dorsiflexion during stance phase of gait. This is the most applicable study to date on the true definition of equinus since it correlates measurement as it relates to function. It is well established in late midstance prior to heel off, 10° to 15° of ankle joint dorsiflexion is required to move the body from behind the foot over the top of the planted foot. Gatt, et al.'s study consisted of two groups, group A measured < -5° ankle joint dorsiflexion with the foot maximally supinated and group B measured ≤ -5° to 0°. In late midstance, ankle joint dorsiflexion measured 4.4° in group A and 13.9° in group B.

Clearly, 4.4° is inadequate ankle joint dorsiflexion in late midstance and will require proximal and/or distal compensation. The authors concluded, "There is no relationship between a static diagnosis of ankle dorsiflexion at 0° with dorsiflexion during gait. On the other hand, those subjects with less than -5° of dorsiflexion during static examination did exhibit reduced ankle range of motion during gait.[2]" Based on Gatt, et al.'s study, we believe the definition for gastrocnemius equinus should be -5° dorsiflexion of ankle/foot with the foot maximally supinated and the knee straight.

Prevalence of Equinus

In Hill's[5] article, the incidence of equinus with pathological conditions

was studied by examining 174 patients over a six-week period of time. Of the 174 patients, six had normal ankle joint dorsiflexion, leaving 168 of the patients exhibiting equinus. Three of the patients had gastrocnemius equinus and 165 had gastroc-soleus equinus. Their definition for equinus was less than 3 degrees dorsiflexion with knee extension. Concluding that 96.5% of the patients with foot and ankle pathology exhibited equinus.

Jastifer and Martson[6] also examined the frequency of equinus, finding that regardless of the type of measurement technique (ankle range-of-motion device, goniometer, visual), there was a significant difference between the group of patients with pathology of the foot and/or ankle and a control group. The authors concluded, "Patients with foot and ankle pain had less ankle dorsiflexion than the control group. This is the largest study to date using a validated measurement device as well as a control group and supports the findings of previous authors. This study supports the notion that an isolated gastrocnemius contracture may be associated with foot and ankle pain."

Biomechanics of Equinus

Understanding the biomechanics of equinus is crucial to getting an appreciation of the devastation it has on the foot pathomechanics. The center of pressure is about 6 cm anterior to the ankle, roughly over the dorsal 2nd metatarsal-cuneiform joint. This would make us fall forward in normal standing, but that reaction is negated by the pull of the plantar flexors. The triceps surae has been documented to be the primary plantar flexor of the ankle joint and therefore offsets the anteriorly displaced center of pressure. It has further been demonstrated with equinus that the center of pressure moves about 3 cm distally and 3 mm laterally (Figures 4 and 5).

The important concept lies in the relation of the subtalar axis to the center of pressure and the subtalar axis to the insertion of the Achilles tendon. The Achilles tendon inserts medially to the subtalar axis and its distance from the axis is about the same as the laterally placed center of pressure to the subtalar axis in a foot with a normal subtalar axis and no equinus. The medial position of the Achilles creates a supinatory moment, while the lateral center of pressure, due to ground reactive forces (GRF), creates a pronatory moment. These two cancel each other out, providing a rectus foot structure.

The zone of hypovascularity of the Achilles tendon is located 4-5 cm proximal to the insertion of the tendon.

When equinus is present, the distal and lateral positioning of the center of pressure in relation to the subtalar axis creates an increased pronatory effect on the foot due to GRF, which is not offset by the supinatory effect of the Achilles tendon. When the subtalar joint axis is more medially deviated, such as in a pronated foot, this further distances the center of pressure from the subtalar axis, causing even more pronatory deformity due to GRF. The opposite occurs in the supinated foot, where the subtalar joint axis is more laterally deviated to the point where even the center of pressure is on the subtalar axis, medial to the subtalar axis, or just lateral to the subtalar axis. This puts both the Achilles and center of pressure in supinatory moments (or at least is a lesser pronatory moment than the supinatory moment of the Achilles tendon) due to GRF; therefore, making a cavus foot worse over a period of time due to increased rearfoot varus, peroneal pathology, and subtalar instability.

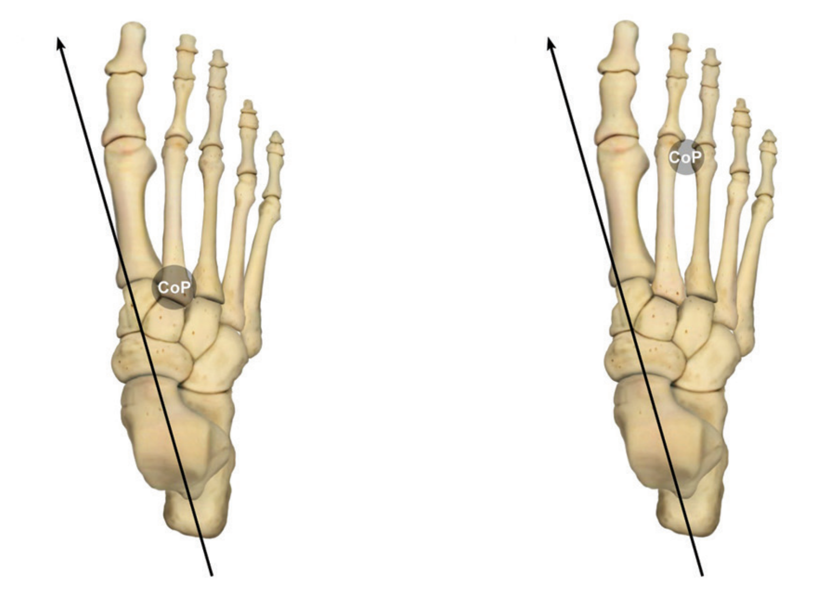
Thordarson, et al.[7] proved that increasing the load of the gastrocsoleus complex is the primary arch deformer in both the sagittal and transverse planes, reinforcing the pronatory effect. The windlass mechanism and posterior tibial tendon were shown to be the primary arch augmenter for sagittal and transverse planes, respectively.

Johnson and Christensen[8] examined the effects of equinus on first ray pathomechanics using cadaver weight-bearing models in their landmark series on first ray pathomechanics. Sensors were applied to each of the individual bones making up the medial column of the foot. Loading of the Achilles tendon was applied, and then three-dimensional data were recorded for each segment of the medial column. The results showed plantarflexion of the talus and navicular, and dorsiflexion of the medial cuneiform and 1st metatarsal occurring through the navicular cuneiform joint. This occurs due to the dampening of the effect of the peroneal longus tendon eversion of the medial cuneiform that leads to the locking of the midtarsal joint. This lack of midtarsal joint locking leads to the above-described medial column instability. This study showed that the effect of equinus is not a stretching of the plantar ligaments over a period of time that leads to first-ray instability but, in fact, is a dampening of the peroneus longus function that leads to first-ray hypermobility.

Evaluation of proximal lower extremity kinetic chain effects from decreased ankle dorsiflexion was evaluated in female athletes by Taylor et al.[44] The authors concluded: "reduced ankle dorsiflexion is associated with corresponding lower levels of knee and hip flexion and hip and knee extensor work absorption and aberrant frontal plane knee motion." This can further place an athlete at higher risk for injury.

An important question that is often overlooked in the biomechanical discussion of equinus is the effect of pronation on the gastrocsoleus complex (GSC). Kevin Kirby, DPM states, "accommodative shortening of the GSC will occur with a prolonged medial deviation of the STJ axis and flattening of the medial arch of the foot."

More recently, Amis[9], using slow motion photography, illustrated a fourth rocker occurring in feet with equinus starting the last half of midstance when the swing phase foot



Figures 4 & 5: The center of pressure is located as shown on the left drawing approximately 6 cm distal to the ankle joint. With equinus deformity the center of pressure moves distal and lateral further away from the subtalar joint axis as shown on the right drawing.

starts to pass the stance foot and ends at stance as the heel lifts just prior to third rocker beginning. This fourth rocker occurred in the exact location Johnson and Christensen described the navicular cuneiform joint. Amis noted this only lasted about 1/10 of a second but taking into account how many steps a day a person takes over a lifetime this is a considerable amount. Amis also noted that the knee goes into full extension at the exact same time, producing twice the abnormal force in half of the time.

Some authors[41] question if equinus is pathologic because so many people have equinus without symptomatology. Liyanarachi et al., found that approximately 55% had a tight gastrocnemius when the ankle dorsiflexion threshold was set at < 5 degrees with knee extension when measuring children between 5 to 15 years of age.[43] One could argue that if 55% of children fell in this range, then this represents a normal finding rather than "tightness. However, we believe this is not seeing the forest from the trees. As Amis stated, the abnormal increase in both direct and indirect forces associated with what he termed "The Split-Second Effect" results in "occult, unrecognized, overuse of imbalance", leading eventually to damage to the foot and/or ankle. Likewise, Johnson and Christensen[8] summarized this point well in their study stating, "In clinical practice, the early destructive influence of equinus is often not appreciated. Instead, we are usually faced with the end result of equinus effects…" The notion that because a person has equinus but does not have symptomatology, and thus equinus is not pathological, is naïve at best.

Pathological Process of Equinus

Sgarlato[4] described three types of compensation for equinus. The uncompensated equinus deformity manifests itself as a toe walker due to a lack of ankle joint dorsiflexion and/or MTJ pronation to get the heel down to the ground. This accounts for about only 1% of equinus cases. In the partially compensated equinus deformity, the heel is on the ground, but the tibia does not achieve 10 degrees of flexion to the ground. This results in an early heel-off gait pattern. When the equinus deformity is fully compensated, the result is the severely pronated, hypermobile foot with heel contact to the ground and the tibia achieving more than 10 degrees of flexion to the ground. Heel-off in the fully compensated equinus deformity is normal.

The proximal pathologies associated with equinus are numerous and easily overlooked due to the profound distal pathologies that often overshadow these proximal deformities. Lumbar lordosis, hip flexion, knee flexion, genu recurvatum, and hamstring contractures have all been attributed to equinus. The more obvious distal pathologies that directly result from or have a relationship to equinus will be discussed with well-documented literature.

Aronow's[10] study was one of the first to not only explore the changes on forefoot and rearfoot pressures associated with equinus, but also to examine the midfoot changes. A load was applied to the GSC and then to just the gastrocnemius muscle, these changes in pressures were measured. In the GSC group, the rearfoot pressures decreased (18%) and the midfoot (38%) and forefoot (59%) increased. In the gastrocnemius group, the rearfoot pressures decreased (16%) and the midfoot (32%) and forefoot (50%) increased. These numbers were very consistent with other studies on the effect of equinus and forefoot pressure changes, such as Jones[11] in *The American Journal of Anatomy* in 1941 and Ward[12] in *The Journal of the American Podiatric Medical Association* in 1998. When the loads were removed, the pressures on the forefoot decreased 32% and the rearfoot pressures increased 32%. These additional findings were similar to those of Mueller[13] in *The Journal of Bone and Joint Surgery* 2003, who measured the effect of a tendo-Achilles lengthening on pressure changes in the foot. In Mueller's study, the forefoot pressures decreased 31% and the

Gastrocnemius equinus occurs when the ankle joint dorsiflexes less than 90 degrees with the knee extended or greater than 90 degrees with the knee flexed.

rearfoot pressures increased by 34%. Reduction in pressure is particularly important in the diabetic population with co-morbidities of polyneuropathy and peripheral vascular disease as increased pressure in the forefoot leads to chronic ulceration and possible amputation. Among diabetic patients, contracture of the triceps surae is thought to occur and this contributes to ulcer formation.[45]

Genu recurvatum, hamstring contractures, and lumbar lordosis are all associated with equinus.

Plantar Fasciitis and Equinus.

The relationship between plantar fasciitis and equinus is well documented in the literature, with an estimated 2,000,000 cases of plantar fasciitis per year in the United States. Patel and DiGiovanni[14] found that 83% of plantar fasciitis cases were associated with equinus. Cheung, et al.[15] showed that equinus caused twice the amount of strain on the plantar fascia as body weight. This reaffirmed the close relationship between plantar fasciitis and equinus. Any treatment plan for plantar fasciitis must include equinus management. Likewise, Nakale, et al.[16] demonstrated almost identical results to Patel and DiGiovanni[14] with an 80% rate of equinus deformity demonstrated in their plantar fasciitis subgroup. Pearce et al., quantified the relationship between gastrocnemius tightness and the severity of heel pain in plantar fasciitis. The mean gastrocnemius tightness was 22 degrees at baseline compared with 9 degrees at final follow-up after 6 months of stretching. The mean 100-mm VAS for pain on the first steps in the morning was 6.3 at baseline vs. 1.9 at the final follow-up. The mean 100-mm VAS for the worst pain felt during the previous week was 7.6 at baseline vs. 2.5 at the final follow-up.[46] Gines-Cespedosa et al., found patients reported clinical improvements in pain VAS, AOFAS measurement, and the physical subdomains of the SF-36 scale after undergoing Proximal Medial Gastrocnemius Release for Recalcitrant Plantar Fasciitis.[48] Arshad et al. concluded similar results via a systemic review in 2021. Out of the 118 patients there was a statistically significant postoperative improvement in American Orthopaedic Foot & Ankle Society, visual analog scale, 36-Item Short Form Health Survey, Foot Forum Index, and Foot and Ankle Ability Measure scores were reported for those that underwent gastrocnemius release in the management of chronic plantar fasciitis.[52]

The relationship is so clear now that nine different peer-reviewed journal articles advocate a gastrocnemius recession for chronic refractory plantar fasciitis.[17-25] If equinus is not the pathological component many biomechanical theorists portray, why is the emerging research on this topic so definitive?

Conservative Treatment

Treatment of equinus can be broken down into either conservative care or surgical care. As with most pathologies, conservative care should be attempted initially. The two main forms of conservative care are manual stretching and bracing.

A meta-analysis by Radford, et al. showed that calf muscle stretching provided an increase in ankle joint dorsiflexion.

Radford et al.,[26] in a meta-analysis showed that calf muscle stretching provided a small but statistically significant increase in ankle joint dorsiflexion. Their analysis showed that 15 to 30 minutes per day provided the greatest amount of ankle joint dorsiflexion (3.03 degrees) for each of the three groups. Grady and Saxena[27] in their study had patients stretch once per day over a six-month period of time for 30 seconds, two minutes, or five minutes with the knee extended. The increase in ankle joint dorsiflexion for each group was 2.15, 2.3, and 2.7 degrees, respectively. Macklin, et al.[28] had thirteen runners use a slant board for four minutes each morning and night for stretching. The amount of ankle joint dorsiflexion was measured with a goniometer three times and the average was taken. They found that as the ankle joint flexibility increased, the participants verbally reported improved running times. They discussed that "these results also strongly indicate that this specific non-invasive stretching regime could be considered before resorting to more invasive options." Vialleron et al., found ankle mobility and forward velocity of the center-of-mass at heel-off and motor performance related-parameters (progression velocity, center-of-mass velocity at foot-contact and swing phase duration) were improved after triceps surae stretching in those with Parkinson's disease.[46]

Hill[5] discussed the problems with manual stretching stating, "Active stretching requires detail in teaching the proper technique and must be done at least four times a day at five- to eight-minute sessions. The most common mistakes patients make during their previous attempts at stretching are inadequate stretch time and abducted foot position during the stretch. Both of which lead to inadequate stretching of the gastrosoleous complex. It is critical that the foot be adducted 10 degrees during the stretching to lock the subtalar-midtarsal joints for maximum benefit at the calf." Youdas et al., showed that a 6-week program of once-per-day static stretching for up to 2 minutes was not sufficient to increase active ankle dorsiflexion range of motion in healthy subjects.[47]

Night splints have long been the only mode of bracing for equinus treatment, but there are several flaws with them. First, they are designed to be used at night while sleeping and the most common sleeping position with these braces is on the side with knees bent. This means that the gastrocnemius muscle is not being stretched. Remembering that the gastrocnemius muscle crosses both the knee and ankle, it is most often the contracted structure. This accounts for the ineffective nature of night splints. Based on our personal experience, compliance with night splints is also very poor. These two factors led to the mediocre results attributed to night splints as described in the Evans[29] study, which showed only 6 of 20 patients achieving 10 degrees of dorsiflexion with the use of night splints.

The Equinus Brace® offers numerous advantages over traditional night splints both in terms of functionality and compliance. The Equinus Brace® allows for one hour per day treatment, an above-the-knee extension to lock the knee in full extension while the foot is dorsiflexed, adjustable hinges for controlled treatment to match clinical measurements, and a toe wedge to engage the Windlass mechanism, allowing for stretching in supination and external rotation of the tibia and aiding in locking of the knee into full extension.

Surgical Approaches to Treatment of Equinus

The surgical approach to equinus is well documented in the literature and focuses on mainly two different procedures, the tendo-Achilles lengthening (TAL) or gastrocnemius recession. The TAL approach most commonly utilized is the Hoke triple hemisection. This procedure employs three stab incisions starting 1-1.5 centimeters proximal to the insertion of the GSC, with two medial incisions and one lateral incision between the two medial incisions. The tendon is sectioned through the central portion and incised in the respective direction of the stab incisions. The tendon then slides to a lengthened position. This procedure is not without potential complications, such as under-lengthening, or much worse, over-lengthening leading to a calcaneal gait. Calcaneal gait deformity is an extremely difficult condition to treat and can be devastating in a compromised foot.

The research on recalcitrant diabetic forefoot ulcers treated with TALs provides great insight to the many cautions that should be taken with using a TAL to treat equinus. Although the forefoot ulcers healed in the vast majority of these patients, the heal ulcer transfer rate ranged from 2%-13% leading to often devastating results.[30-33] Rush, et al.[34] looked at the morbidity associated with a high gastrocnemius recession in 126 cases. The complications included four with nerve injury, three with wound dehiscence, two with superficial infections, seven with scar problems, and two with other complications. Though a TAL does have utility for correcting foot and ankle deformities,[50] care should be taken when proceeding with the procedure.

The gastrocnemius recession is one of our favorite procedures and is well documented in the literature. We prefer the Bauman intramuscular approach to the lengthening of the gastrocnemius aponeurosis. This provides controlled, sequential lengthening. The incision is placed at the medial aspect of the calf, midway between the posterior calf and the anterior border of the tibia. The incision is typically 3-4 cm long and is deepened to the level of the deep fascia. The fascia is incised, revealing the gastrocnemius and soleus muscle bellies. Using a finger to identify the natural separation between the aponeurosis of the two muscles, an rectal speculum is inserted to spread the muscles apart. The plantaris tendon is identified when present either on the soleus or gastrocnemius side and then cut, as the tendon acts as a tether. Substantial increase in dorsiflexion is noted upon release of the plantaris tendon. Kindred et al. found a strong positive correlation (rs = 0.842) with a mean dorsiflexion of 9 (interquartile range 6-12)° obtained after plantaris transection.[49] The foot is dorsiflexed with the knee extended, and a long-handled #15 blade is used to cut the proximal portion of the gastrocnemius aponeurosis, including the intramuscular septum. Kindred et al. found an additional (in addition to the plantaris tendon) mean 8 (interquartile range 5-10)° of dorsiflexion was obtained after the recession of the gastrocnemius aponeurosis. Linear regression showed that for every one-degree of dorsiflexion increase with plantaris transection, there was a predicted dorsiflexion increase of 0.69° with gastrocnemius recession.[49]

This is a complete release from lateral to medial with care taken to minimally invade the underlying muscle. If inadequate dorsiflexion is noted, a second more distal (1 cm distal to the initial release) incision is recommended over a soleus recession based on the study by Herzenberg and Lamm[35] in *Foot and Ankle International* 2007. The pre-operative group had 1 degree of ankle joint dorsiflexion with the knee extended, and after gastrocnemius recession, single and double dorsiflexion increased significantly (9 and 15 degrees, respectively). Adding a soleus recession only increased dorsiflexion by one degree--thus it is more effective to perform a double gastrocnemius recession. Rong, et al.[36] compared three gastrocnemius recession procedures for isolated gastrocnemius equinus. The study demonstrated a Baumann gastrocnemius recession with two recessions providing equal range-of-motion compared to a Strayer gastrocnemius recession, while providing superior stability. Other studies found significantly less weakness associated with the Baumann procedure compared to the Strayer procedure.[37-40] Slullitel et al. state that the Baumann procedure offers a chance to lengthen the musculotendinous unit in a predictable manner, through a small incision, avoiding the potential risks of over-lengthening the gastrocnemius-soleus complex.[51]

The treatment of equinus alone has shown to be effective for foot symptomatology without doing anything to the pathology within the foot. Maskill, et al.[17] examined the effect of an isolated gastrocnemius recession on 29 patients (34 feet) that failed six months of conservative therapy. The measure used was the visual analog scale (VAS) and there were three categories of patients (plantar fasciitis, midfoot pain, and arch pain). The VAS scores pre-operatively and post-operatively were as follows for each group: plantar fasciitis 8.1 to 1.9, midfoot pain 7.5 to 2.2, and arch pain 9.3 to 3.3. These drastic pain scale changes were the result of only a gastrocnemius recession without doing

anything to the foot. In a 2019 systemic review by Slullitel et al., there was convincing evidence to support the use of gastrocnemius recession alone as a therapeutic intervention for isolated foot pain associated with an over-load syndrome.[51]

Equinus is an underlying factor in most of the biomechanically based pathologies associated with the foot and ankle. Equinus must be addressed either conservatively or surgically as part of the overall treatment plan for any condition with an associated equinus deformity. Comprehensive treatment of lower extremity pathologies mandates treating all components of the deformity. The research is clear, undeniable, and robust. Either we practice evidence-based medicine, or we do not. If we do, then equinus must be treated when present. **PM**

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Disclosure: *Patrick A. DeHeer, DPM discloses he is the inventor of The Equinus Brace® and Principal of IQ Medical.*

Dr. DeHeer is in private practice in Central Indiana. He is the team podiatrist for the Indiana Pacers and the Indiana Fever. He is the inventor of the EQ/IQ brace, the President and Founder of Wound Care Haiti, and a medical missionary. Dr. DeHeer is a Trustee of the APMA and is the recipient of the 2011 APMA Humanitarian of the Year Award.

Dr. Patel earned his Bachelor's and Master's degrees at Indiana University and Indiana University School of Medicine, respectively. He then went on to complete his Doctorate of Podiatric Medicine at Scholl College of Podiatric Medicine. Dr. Patel is currently a first-year resident at Ascension St. Vincent Indianapolis.

CME EXAMINATION

1) The triceps surae consists of the following muscles:
- **A) Gastrocnemius**
- **B) Soleus**
- **C) Plantaris**
- **D) All of the above**

2) The gastrocnemius crosses which of the following joints?
- **A) Knee**
- **B) Ankle**
- **C) Subtalar joint**
- **D) All of the above**

3) Which of the following is NOT an action of the gastrocnemius?
- **A) Dorsiflex the ankle joint**
- **B) Supply power for propulsion**
- **C) Flex the knee**
- **D) Plantarflex the ankle joint**

4) The zone of hypovascularity of the Achilles tendon is located:
- **A) 4-5 cm proximal to the insertion of the tendon**
- **B) 7 cm proximal to the insertion of the tendon**
- **C) 1-1.5 cm proximal to the insertion of the tendon**
- **D) At the insertion of the tendon**

5) There is a gastrocnemius equinus when:
- **A) The ankle joint dorsiflexes greater than 90 degrees with the knee extended**
- **B) The ankle joint dorsiflexes less than 90 degrees with the knee extended**
- **C) The ankle joint dorsiflexes greater than 90 degrees with the knee flexed**
- **D) B & C**

Continuing Medical Education

CME EXAMINATION

6) According to Kindered, what is the average dorsiflexion obtained after transection of the plantaris tendon?
- A) 6 degrees
- B) 12 degrees
- C) 9 degrees
- D) 4 degrees

7) What percentage of plantar fasciitis cases was associated with equinus in the study by Patel and DiGiovanni?
- A) 70%
- B) 100%
- C) 83%
- D) 50%

8) Hill states that it is important to do which of the following when stretching the calf muscles:
- A) Adduct the foot 10 degrees to lock the subtalar-midtarsal joints
- B) Abduct the foot 10 degrees to lock the subtalar-midtarsal joints
- C) Keep the foot at 0 degrees to lock the subtalar-midtarsal joints
- D) Stretch for 30 seconds to lock the subtalar-midtarsal joints

9) Based on the study by Herzenberg and Lamm, which of the following is most effective?
- A) A double gastrocnemius recession
- B) A soleus recession
- C) A single gastroc recession
- D) A single gastroc with the addition of a single soleus recession

10) A meta-analysis by Radford, et al. showed the most improvement of ankle dorseflexion with how many minutes of stretching per day?
- A) 2 to 5 minutes
- B) Approximately 10 minutes
- C) 15 to 30 minutes
- D) Approximately 45 minutes

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EXAM #1/23
Understanding Equinus: A 2023 Update
(DeHeer and Patel)

Circle:

1.	**A**	**B**	**C**	**D**	**6.**	**A**	**B**	**C**	**D**
2.	**A**	**B**	**C**	**D**	**7.**	**A**	**B**	**C**	**D**
3.	**A**	**B**	**C**	**D**	**8.**	**A**	**B**	**C**	**D**
4.	**A**	**B**	**C**	**D**	**9.**	**A**	**B**	**C**	**D**
5.	**A**	**B**	**C**	**D**	**10.**	**A**	**B**	**C**	**D**

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Strongly agree [5]	Agree [4]	Neutral [3]	Disagree [2]	Strongly disagree [1]

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6) What overall grade would you assign this lesson?

A B C D

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Yes _____ No _____

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____

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