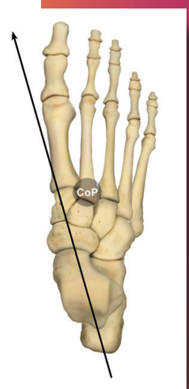
Understanding Equinus: A 2019 Update



This profound causal agent is commonly overlooked and under-treated.

BY PATRICK A. DEHEER, DPM, BRYAN CAMP, DPM, AND MATTHEW LINING, DPM

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.

Welcome to Podiatry Management's CME Instructional program. Podiatry Management Magazine is approved by the Council on Podiatric Medical Education as a provider of continuing education in podiatric medicine. Podiatry Management Magazine has approved this activity for a maximum of 1.5 continuing education contact hours. This CME activity is free from commercial bias and is under the overall management of Podiatry Management Magazine.

You may enroll: 1) on a per issue basis (at $28.00 per topic) or 2) per year, for the special rate of $229 (you save $51). You may submit the answer sheet, along with the other information requested, via mail, fax, or phone. You can also take this and other exams on the Internet at www.podiatrym.com/cme.

If you correctly answer seventy (70%) of the questions correctly, you will receive a certificate attesting to your earned credits. You will also receive a record of any incorrectly answered questions. If you score less than 70%, you can retake the test at no additional cost. A list of states currently honoring CPME approved credits is listed on pg. 150. Other than those entities currently accepting CPME-approved credit, Podiatry Management cannot guarantee that these CME credits will be acceptable by any state licensing agency, hospital, managed care organization or other entity. PM will, however, use its best efforts to ensure the widest acceptance of this program possible.

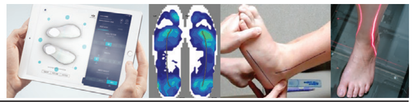
This instructional CME program is designed to supplement, NOT replace, existing CME seminars. *The goal of this program is to advance the knowledge of practicing podiatrists. We will endeavor to publish high quality manuscripts by noted authors and researchers. If you have any questions or comments about this program, you can write or call us at:* ***Program Management Services, P.O. Box 490, East Islip, NY 11730, (631) 563-1604 or e-mail us at bblock@podiatrym.com.***

*Following this article, an answer sheet and full set of instructions are provided (pg. 150).—**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, IT band syndrome, patellofemoral syndrome, ankle sprains/fractures, diabetic foot ulcers, charcot deformity, metatarsalgia, MPJ synovitis, hallux abductovalgus, hammer toes/claw toes, Lisfranc/midfoot arthro-

There are several factors at play that all lead to this under-appreciation and lack of treatment with equinus.

Continued on page 142



Equinus *(from page 141)*

sis, 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, low back pain, arch pain, ankle arthrosis, subtalar arthrosis, sesamoiditis, anterior compartment syndrome, and forefoot nerve entrapment.[1] So, if equinus is so prevalent, how come there is often 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 pathologies. Finally, the lack of treatment is related directly to ineffectual conservative management of the condition. Let's take a journey through equinus to fully understand the condition, and hopefully therefore bring to it the respect it is due.

The triceps surae consists of the gastrocnemius, soleus, and plantaris.

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).

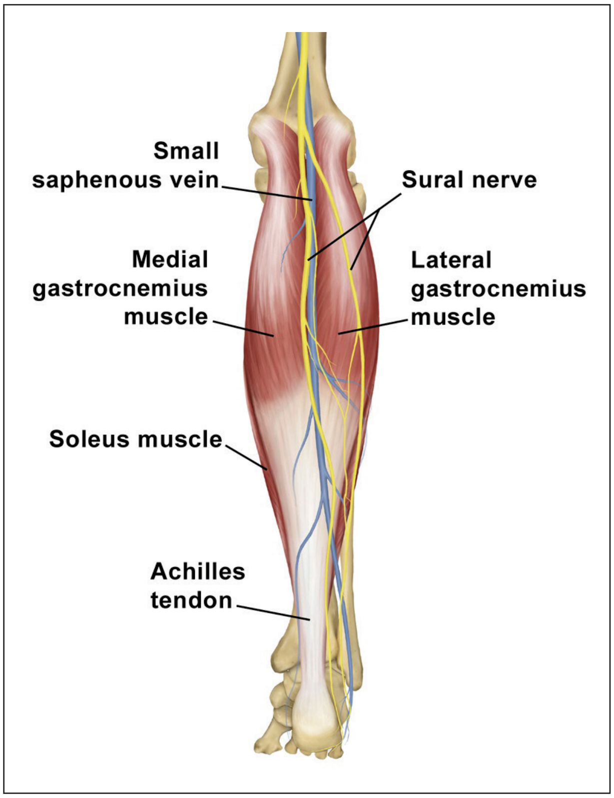


Figure 1: Posterior view of the GSC complex and related anatomical structures.

The soleus originates on the posterior aspect of the head of the fibular, 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 only 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 sural artery is to stabilize the leg onto the foot and plantarflex the ankle joint.

The gastrocnemius crosses the knee, ankle, and subtalar 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 can be absent 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 with the plantaris tendon inserting medial to the Achilles tendon. There is a retrocalcaneal bursa between the Achilles tendon and the calcaneus. The fibers of the Achilles tendon rotate laterally 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

Continued on page 143

Equinus *(from page 142)*

hypovascularity 4-5 cm proximal to the insertion of the tendon.

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 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.

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

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 insignificant 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 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 potential standard."[3]

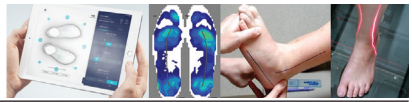
Figure 2: The Silfverskiold test is used to evaluate for equinus. This demonstrates evaluation of the dorsiflexion of the ankle joint with the knee extended.

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, 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 litera-

Continued on page 144



Equinus (*from page 143*)

ture, 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.

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

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.

Incidence of Equinus

In Hill's[5] article, the incidence of equinus with pathological conditions was studied by examining 209 new patient visits over a six-week period of time. Twenty-nine patients were excluded from the study because they did not meet study criteria. Of the remaining 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 GSC equinus. Their definition for equinus was less than 3-degrees dorsiflexion with knee extension. Their findings were 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."

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.

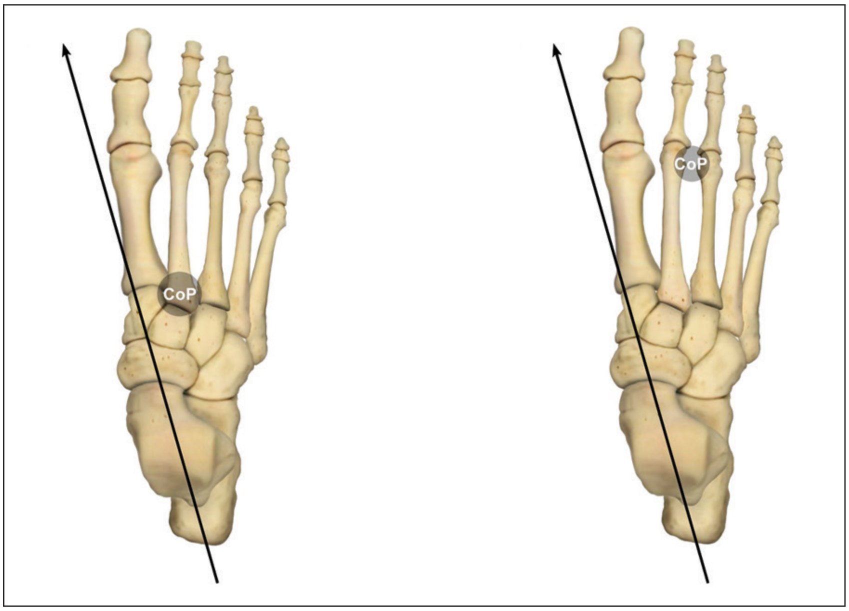
Biomechanics of Equinus

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 plantarflexors. The triceps surae has been documented to be the primary plantarflexor 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.

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

Continued on page 145



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.

Equinus *(from page 144)*

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 GSC 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 naviculacuneiform joint. This occurs due to dampening of the effect of the peroneal longus tendon eversion of the medial cuneiform that leads to 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.

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 says (via personal communication), "accommodative shortening of the GSC will occur with 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 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 naviculocuneiform joint. Amis noted this only lasted about 1/10 of a second but consider how many steps a day a person takes over a lifetime. Amis also noted that the knee goes into full extension at the exact same time, producing twice the abnormal force in half the time.

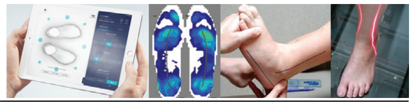
Some authors[41] question if equinus is pathologic, because so many people have equinus without symptomatology. This is a bit of not seeing the forest for the trees. As Amis stated, the abnormal increase in both direct and indirect forces associated with what he termed "The Split-Second Effect" results 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.

An important question that is often overlooked in the biomechanical discussion of equinus is the effect of pronation on the gastrocsoleus complex (GSC).

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 lack of ankle joint dorsiflexion and/or MTJ pronation to get the heel

Continued on page 146



Equinus (from page 145)

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.

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

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 some of the 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, and then the 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 rearfoot pressures increased by 34%.

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 re-affirmed 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. 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 of the biomechanical theorists portray, why is the emerging research on this topic so definitive?

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.

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. These totals were not statistically significant, but when one takes into account the minimal amount of stretching done daily, the results are actually encouraging. Macklin, et al.[28] had thirteen runners use a ramp 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."

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

Hill[5] discussed the problems with manual stretching stating,

Continued on page 147

Equinus *(from page 146)*

"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 serious mistakes patients make during their previous attempts at stretching are inadequate stretch time and abducted foot position during the stretch. 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."

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.

Hill states that it is important to adduct the foot 10 degrees when stretching the calf muscles.

Surgical Approaches to Equinus

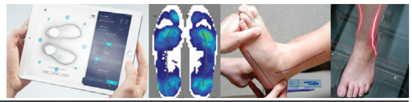
The surgical approach to equinus is well documented in the literature and focuses on mainly two different procedures, the tendo-Achilles lengthening (TAL) or gastrocnemius recession. The TAL approach most commonly utilized is the Hoke triple hemisection. This procedure employs three stab incisions starting one centimeter 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 and 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 problems, three with wound dehiscence, two with superficial infections, seven with scar problems, and two with other complications.

The gastrocnemius recession is one of our favorite procedures and is well documented in the literature. We prefer the Bauman intramuscular approach to 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 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 anal speculum is inserted to spread them 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. 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.

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 (this is 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]

Continued on page 148



Equinus *(from page 147)*

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.

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 treating equinus when present should be a given. **PM**

Equinus must be addressed either conservatively or surgically as part of the overall treatment plan for any condition with an associated equinus deformity.

References

[1] DeHeer, Patrick A. "Equinus and lengthening techniques." Clinics in podiatric medicine and surgery 34.2 (2017): 207-227.

[2] Gatt, Alfred, et al. "A pilot investigation into the relationship between static diagnosis of ankle equinus and dynamic ankle and foot dorsiflexion during stance phase of gait: Time to revisit theory?." The Foot 30 (2017): 47-52.

[3] Dayton, Paul, et al. "Experimental comparison of the clinical measurement of ankle joint dorsiflexion and radiographic Tibiotalar position." The Journal of Foot and Ankle Surgery 56.5 (2017): 1036-1040.

[4] Sgarlato, TE; Morgan, J; Shane, HS; Frenkenberg, A. Tendo Achilles lengthening and its effect on foot disorders. J Am Podiatry Assoc. 65:849-871, 1975.

[5] Hill, RS. Prevalence and linkage to common foot pathology. J Am Podiatr Assoc. 85:295-300, 1995.

[6] Jastifer, James R., and Jessica Marston. "Gastrocnemius contracture in patients with and without foot pathology." Foot & ankle international 37.11 (2016): 1165-1170.

[7] Thordarson, David B., et al. "Dynamic support of the human longitudinal arch. A biomechanical evaluation." Clinical orthopaedics and related research 316 (1995): 165-172.

[8] Johnson, CH; Christensen, JC. Biomechanics of the first ray part V: the effect of equinus deformity. J Foot Ankle Surg. 44:114-120, 2005.

[9] Amis, James. "The split second effect: the mechanism of how equinus can damage the human foot and ankle." Frontiers in surgery 3 (2016): 38.

[10] Aronow, MS; Diaz-Doran, V; Sullivan, RJ; Adams, DJ. The effect of triceps surae contracture force on plantar foot pressure distribution. Foot Ankle Int. 27:43-52, 2006.

[11] Jones, RL. The human foot. An experimental study of its mechanics, and the role of its muscles and ligaments in the support of the arch. Am J Anat. 68:1-38, 1941.

[12] Ward, ED; Phillips, RD; Patterson, PE; Werkhoven, GJ. The effects of extrinsic muscle forces on the forefoot-to-rearfoot loading relationship in vitro. J Am Podiatr Med Assoc. 88:471-482, 1998.

[13] Mueller, MJ; Sinacore, DR; Hastings, MK; Strube, MJ; Johnson, JE. Effect of Achilles tendon lengthening on neuropathic plantar ulcers. A randomized clinical trial. J Bone Joint Surg. 85-A:1436-1445, 2003.

[14] Patel, A; DiGiovanni, B. Association between plantar fasciitis and isolated contracture of the gastrocnemius. Foot Ankle Int. 32:5-8, 2011.

[15] Cheung, JT; Zhang, M; An, KN. Effect of Achilles tendon loading on plantar fascia tension in the standing foot. Clin Biomech. 21:194-203, 2006.

[16] Nakale, Ngenomeulu T., et al. "Association between plantar fasciitis and isolated gastrocnemius tightness." Foot & ankle international 39.3 (2018): 271-277.

[17] Maskill, John D., Donald R. Bohay, and John G. Anderson. "Gastrocnemius recession to treat isolated foot pain." Foot & ankle international 31.1 (2010): 19-23.

[18] Abbassian, Ali, Julie Kohls-Gatzoulis, and Matthew C. Solan. "Proximal medial gastrocnemius release in the treatment of recalcitrant plantar fasciitis." Foot & ankle international 33.1 (2012): 14-19.

[19] Molund, Marius, et al. "Results after gastrocnemius recession in 73 patients." Foot and Ankle Surgery 20.4 (2014): 272-275.

[20] Monteagudo, Manuel, et al. "Chronic plantar fasciitis: plantar fasciotomy versus gastrocnemius recession." International orthopaedics 37.9 (2013): 1845-1850.

[21] Ficke, Brooks, et al. "Gastrocnemius recession for recalcitrant plantar fasciitis in overweight and obese patients." Foot and Ankle Surgery 24.6 (2018): 471-473.

[22] Hoefnagels, E., et al. "Chronic therapy resistant plantar fasciitis, the effect of lengthening the gastrocnemius muscle." Foot and Ankle Surgery 2.22 (2016): 58.

[23] Ortega-Avila, Ana Belen, et al. "Contribution levels of intrinsic risk factors to the management of patients with plantar heel pain: A pilot study." Journal of the American Podiatric Medical Association 106.2 (2016): 88-92.

[24] Molund, Marius, et al. "Proximal medial gastrocnemius recession and stretching versus stretching as treatment of chronic plantar heel pain." Foot & ankle international 39.12 (2018): 1423-1431.

[25] Cheney, Nicholas, et al. "Isolated Gastrocnemius Recession for Plantar Fasciitis." Foot & Ankle Orthopaedics 3.3 (2018): 2473011418S00186.

[26] Radford, JA; Burns, J; Buchbinder, R; Landorf, KB; Cook, C. Does stretching increase ankle dorsiflexion range of motion? A systematic review. Br J Sports Med. 40:870-875, 2006.

[27] Grady, JF; Saxena, A. Effects of stretching the gastrocnemius muscle. J Foot Surg. 30:465-469, 1991.

[28] Macklin, K., Aoife Healy, and Nachiappan Chockalingam. "The effect of calf muscle stretching exercises on ankle joint dorsiflexion and dynamic foot pressures, force and related temporal parameters." The Foot 22.1 (2012): 10-17.

[29] Evans, A. Podiatric medical applications of posterior night stretch splinting. J Am Podiatr Med Assoc. 91:356-360, 2001.

[30] Holstein, P, et al. "Achilles tendon lengthening, the panacea for plantar forefoot ulceration." Diabetes/metabolism research and reviews 20.S1 (2004): S37-S40.

[31] Nishimoto, Gordon S., Christopher E. Attinger, and Paul S. Cooper. "Lengthening the Achilles tendon for the treatment of diabetic plantar forefoot ulceration." Surgical Clinics 83.3 (2003): 707-726.

Continued on page 149

Equinus (from page 148)

[32] Mueller, Michael J., et al. "Effect of Achilles Tendon Lengthening on Neuropathic Plantar Ulcers*: A Randomized Clinical Trial." JBJS 85.8 (2003): 1436-1445.

[33] Chilvers, Margaret, et al. "Heel overload associated with heel cord insufficiency." Foot & ankle international 28.6 (2007): 687-689.

[34] Rush, SM; Ford, LA; Hamilton, GA. Morbidity associated with high gastrocnemius recession: Retrospective review of 126 cases. J Foot Ankle Surg. 45:156-160, 2006.

[35] Herzenberg, JE; Lamm, BM; Corwin, C; Sekel, J. Isolated recession of the gastrocnemius muscle: the Baumann procedure. Foot Ankle Int. 28:1154-1159, 2007.

[36] Rong, Kai, et al. "Comparison of the efficacy of three isolated gastrocnemius recession procedures in a cadaveric model of gastrocnemius tightness." International orthopaedics 40.2 (2016): 417-423.

[37] Nawoczenski, Deborah A., et al. "Ankle power and endurance outcomes following isolated gastrocnemius recession for Achilles tendinopathy." Foot & ankle international 37.7 (2016): 766-775.

[38] Saraph, V., et al. "The Baumann procedure for fixed contracture of the gastrosoleus in cerebral palsy: evaluation of function of the ankle after multilevel surgery." The Journal of bone and joint surgery. British volume 82.4 (2000): 535-540.

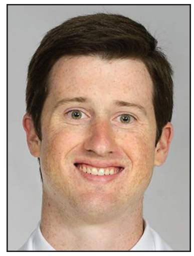
[39] Svehlik, M., et al. "The Baumann procedure to correct equinus gait in children with diplegic cerebral palsy: long-term results." The Journal of bone and joint surgery. British volume 94.8 (2012): 1143-1147.

[40] Morales-Muñoz, Patricia, et al. "Proximal gastrocnemius release in the treatment of mechanical metatarsalgia." Foot & ankle international 37.7 (2016): 782-789.

[41] Jarvis, Hannah L., et al. "Challenging the foundations of the clinical model of foot function: further evidence that the root model assessments fail to appropriately classify foot function." Journal of foot and ankle research 10.1 (2017): 7.

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, President and Founder of Wound Care Haiti, and a medical missionary. Dr. DeHeer is a Trustee of the APMA and is recipient of the 2011 APMA Humanitarian of the Year Award.



Dr. Camp completed his undergraduate degree at Indiana University. Dr. Camp is a graduate of the Scholl College of Podiatric Medicine and is the Chief Resident of the St. Vincent Indianapolis program.

Dr. Lining is a graduate of the Kent State College of Podiatric Medicine and is currently a second year resident at St. Vincent Indianapolis.

CME **EXAMINATION**

SEE ANSWER SHEET ON PAGE 151.

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 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

Continued on page 150

CME EXAMINATION

6) The proximal pathology NOT associated with equinus is:
  A) Hamstring contractures
  B) Quadriceps contractures
  C) Genu recurvatum
  D) Lumbar lordosis

7) What percentage of plantar fasciitis cases was associated with equinus in the study by Patel and DiGiovanni?
  A) 95%
  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
  B) Abduct the foot 10 degrees
  C) Keep the foot at 0 degrees
  D) Stretch for 30 seconds

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 that calf muscle stretching provided:
  A) A decrease in ankle joint dorsiflexion
  B) No change in the amount of ankle dorsiflexion achieved
  C) An increase in ankle joint dorsiflexion
  D) An increase in knee flexion

SEE ANSWER SHEET ON PAGE 151.

The author(s) certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest), or non-financial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript.

PM's CME Program

Welcome to the innovative Continuing Education Program brought to you by *Podiatry Management Magazine*. Our journal has been approved as a sponsor of Continuing Medical Education by the Council on Podiatric Medical Education.

Now it's even easier and more convenient to enroll in PM's CE program!

You can now enroll at any time during the year and submit eligible exams at any time during your enrollment period.

CME articles and examination questions from past issues of *Podiatry Management* can be found on the Internet at http://www.podiatrym.com/cme. Each lesson is approved for 1.5 hours continuing education contact hours. Please read the testing, grading and payment instructions to decide which method of participation is best for you.

Please call (631) 563-1604 if you have any questions. A personal operator will be happy to assist you.

Each of the 10 lessons will count as 1.5 credits; thus a maximum of 15 CME credits may be earned during any 12-month period. You may select any 10 in a 24-month period.

The* Podiatry Management Magazine *CME program is approved by the Council on Podiatric Education in all states where credits in instructional media are accepted. This article is approved for 1.5 Continuing Education Contact Hours (or 0.15 CEU's) for each examination successfully completed.

PM's privacy policy can be found at http://podiatrym.com/privacy.cfm.

This CME is valid for CPME-approved credits for three (3) years from the date of publication.

Enrollment/Testing Information and Answer Sheet

Note: If you are mailing your answer sheet, you must complete all info. on the front and back of this page and mail with your credit card information to: **Program Management Services, P.O. Box 490, East Islip, NY 11730.**

TESTING, GRADING AND PAYMENT INSTRUCTIONS

(1) Each participant achieving a passing grade of 70% or higher on any examination will receive an official computer form stating the number of CE credits earned. This form should be safeguarded and may be used as documentation of credits earned.

(2) Participants receiving a failing grade on any exam will be notified and permitted to take one re-examination at no extra cost.

(3) All answers should be recorded on the answer form below. For each question, decide which choice is the best answer, and circle the letter representing your choice.

(4) Complete all other information on the front and back of this page.

(5) Choose one out of the 3 options for testgrading: mail-in, fax, or phone. To select the type of service that best suits your needs, please read the following section, "Test Grading Options".

TEST GRADING OPTIONS

Mail-In Grading

To receive your CME certificate, complete all information and mail with your credit card information to: **Program Management Services, P.O. Box 490, East Islip, NY 11730. PLEASE DO NOT SEND WITH SIGNATURE REQUIRED, AS THESE WILL NOT BE ACCEPTED.**

There is **no charge** for the mail-in service if you have already enrolled in the annual exam CME program, and we receive this exam during your current enrollment period. If you are not enrolled, please send $28.00 per exam, or $229 to cover all 10 exams (thus saving $51 over the cost of 10 individual exam fees).

Facsimile Grading

To receive your CME certificate, complete all information and fax 24 hours a day to 1631-532-1964. Your CME certificate will be dated and mailed within 48 hours. This service is available for $2.95 per exam if you are currently enrolled in the annual 10-exam CME program (and this exam falls within your enrollment period), and can be charged to your Visa, MasterCard, or American Express.

If you are *not* enrolled in the annual 10-exam CME program, the fee is $28 per exam.

Phone-In Grading

You may also complete your exam by using the toll-free service. Call 1-800-232-4422 from 10 a.m. to 5 p.m. EST, Monday through Friday. Your CME certificate will be dated the same day you call and mailed within 48 hours. There is a $2.95 charge for this service if you are currently enrolled in the annual 10-exam CME program (and this exam falls within your enrollment period), and this fee can be charged to your Visa, Mastercard, American Express, or Discover. If you are not currently enrolled, the fee is $28 per exam. When you call, please have ready:

1. Program number (Month and Year)
2. The answers to the test
3. Credit card information

In the event you require additional CME information, please contact PMS, Inc., at **1-631-563-1604**.

ENROLLMENT FORM & ANSWER SHEET

Please print clearly...Certificate will be issued from information below.

Name ______________________________________ Email Address ____________________
Please Print: FIRST MI LAST

Address ____

City ______________________________ State ______________ Zip ________________

Charge to: _____Visa _____ MasterCard _____ American Express

Card # ____________________________ Exp. Date ______________ Zip for credit card ____________

Note: Credit card is the only method of payment. Checks are no longer accepted.

Signature ____________________ Email Address ________________ Daytime Phone ______________

State License(s) ________________ Is this a new address? Yes _______ No _______

Check one: ______ I am currently enrolled. (If faxing or phoning in your answer form please note that $2.95 will be charged to your credit card.)

______ I am not enrolled. Enclosed is my credit card information. Please charge my credit card $28.00 for each exam submitted. (plus $2.95 for each exam if submitting by fax or phone).

______ I am not enrolled and I wish to enroll for 10 courses at $229.00 (thus saving me $51 over the cost of 10 individual exam fees). I understand there will be an additional fee of $2.95 for any exam I wish to submit via fax or phone.

Over, please

ENROLLMENT FORM & ANSWER SHEET *(continued)*

EXAM #7/19
Understanding Equinus: A 2019 Update
(DeHeer, Camp, and Lining)

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

Medical Education Lesson Evaluation

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

1) This CME lesson was helpful to my practice ____

2) The educational objectives were accomplished ____

3) I will apply the knowledge I learned from this lesson ____

4) I will makes changes in my practice behavior based on this lesson ____

5) This lesson presented quality information with adequate current references ____

6) What overall grade would you assign this lesson?
A B C D

7) This activity was balanced and free of commercial bias.
Yes _____ No _____

8) What overall grade would you assign to the overall management of this activity?
A B C D

How long did it take you to complete this lesson?

______hour ______minutes

What topics would you like to see in future CME lessons ?
Please list :

____

____

____

____

____