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Can the presence of equinus contracture be established by physical exam alone?

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Abstract—The condition in which ankle dorsiflexion is restricted is known as equinus contracture (EC). Equinus contracture is purported to be associated with a number of clinical conditions. However, there are no data to support or refute a clinician's ability to diagnose EC by clinical exam. We prospectively evaluated the maximum ankle dorsiflexion with the knee fully extended in 68 people (34 patients with isolated fore- or midfoot pain and 34 asymptomatic subjects) both by clinical exam and by a custom-designed ankle goniometer. We compared the likelihood of agreement of the clinical impression (equinus, no equinus) to the maximum ankle dorsiflexion measured with the instrument at two different numerical definitions of EC (5º and 10º of maximum dorsiflexion). When all subjects were included and equinus defined as 5º of ankle dorsiflexion, a clinician's ability to detect the equinus when it is truly present is 77.8%. If equinus is defined as 10º, this ability increases to 97.2%. Alternatively, if equinus is not present, as defined by 5º, then a clinician's ability to correctly diagnose no equinus is 93.8%. If equinus is defined to 10º, this ability decreases to 68.8%.

Key words: *contracture, equinus, gastrocnemius.*

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INTRODUCTION

The gastrocnemius and soleus muscles attach to the calcaneus. Contraction of these muscles moves the foot into plantar flexion. Excessive tightness or spasticity of the muscles prevents full dorsiflexion, a condition known as equinus contracture (EC). Because the gastrocnemius muscle extends across both the knee and ankle joints, it has a different effect than the soleus. Bending the knee can eliminate the effect of a tight gastrocnemius on ankle range of motion. If the soleus muscle is tight, ankle range of motion will not change with knee flexion. These anatomical relationships allow the clinician to distinguish which muscle contributes to EC during the clinical exam (1).

Equinus contracture has long been associated with spasticity in individuals with neurological impairment (2–16). Equinus may also play a role in foot ulceration (17–24) and in the development of other disorders, such as flatfoot (25–29). Since the first description of tendoachilles lengthening in the early 1800s by Delpech, release or attenuation of the superficial posterior compartment of the leg has been performed to relieve EC and improve gait and muscle balance across the foot and ankle (31). However, many details, such as the prevalence, definition, and reliability of diagnosis have not been studied.

Physical examination is the primary tool used to diagnose EC. There are many variables that can influence the interpretation of EC during the clinical examination. Factors include whether the patient is examined prone, supine, or sitting; whether the knee is flexed or extended; the magnitude of the force applied by the examiner; and whether the examiner maintains the hindfoot in a neutral position.

Physical examination should allow discrimination between normal ankle range of motion, EC secondary to gastrocnemius tightness (present only when knee is extended), and equinus secondary to soleus tightness (present independent of knee position) (26). The anatomic cause of the contracture influences the power and function of the limb (32).

There is no uniform agreement of the definition of equinus. Anecdotally, some use inability to dorsiflex beyond 5º while others indicate that 10º may be the limit. Though there are data on the quantitative measurement of spasticity in children (33), we were not able to find any references that quantified the ability of clinicians to measure equinus.

The purpose of this investigation is to determine whether a clinician can diagnose EC by physical examination and to determine if the accuracy of diagnosis differs between a normal population and a patient population with painful foot conditions. With the knee fully extended, we contrasted clinical diagnosis of EC with objective diagnosis of EC utilizing a custom-made ankle goniometer (an "equinometer"). Further, we compared two groups: the first group included patients with foot symptoms where the incidence of EC might be high; the second group included asymptomatic subjects where EC might be expected to be uncommon.

METHODS

Patient Enrollment

Subsequent to obtaining IRB approval, we enrolled 68 subjects. The study population included 34 consecutive patients who presented to the foot and ankle clinic of either Harborview Medical Center at the University of Washington or the Seattle VA Medical Center. These patients complained of isolated fore- or midfoot pain, and were compared to 34 age-matched individuals without foot complaints who were willing to be examined. The exclusion criteria were history of neurological disease, systemic disease potentially affecting the foot or ankle, prior foot or ankle surgery or trauma, bony block to ankle extension, or any patient with an irreducible foot deformity precluding proper testing. All subjects signed an informed consent that was presented by an independent provider. The symptomatic group included 18 males and 16 females with an average age of 46.7 years (range 21 to 76 years). The average weight of individuals in this group was 815 N (range 463 N to 1,535 N). The asymptomatic group included 16 males and 18 females with an average age of 45.1 years (range 28 to 63 years) and average body weight of 760 N (range 534 N to 1,157 N). More left legs were studied than right legs (40 left, 28 right).

Clinical Examination

A single orthopedic surgeon performed the clinical evaluation of each subject. The surgeon subsequently utilized the equinometer for objective measurement of ankle dorsiflexion range of motion. For the clinical examination, the subject, with foot and lower leg exposed, was seated on an examination table. The exam table supported the thigh, while the leg and foot were free. Individuals were evaluated in a sitting position to mirror the typical methods used in the clinical evaluation of foot and ankle patients in an office setting. With one hand, the examiner held the talonavicular joint in a neutral position, to prevent dorsiflexion through the midfoot (34). The examiner applied an upward torque on the foot with the knee extended until the foot no longer increased its range of dorsiflexion. The examiner then estimated maximum ankle dorsiflexion in degrees and subsequently recorded whether the clinical assessment indicated the presence or absence of contracture.

Equinometer Testing

Maximum ankle dorsiflexion was measured with a custom fabricated device we have called an equinometer (**Figure 1**). This instrument represents an electrogoniometer connected to a lateral leg attachment and an underlying footplate that has a force transducer. The subject is positioned as in the clinical examination. The apparatus is mounted to the subject's lower leg and the clinician applies an upwardly directed force under the foot.

The examiner identified the fibula and second metatarsal head. A measurement from the tip of the fibula to the center of the second metatarsal head (i.e., the moment arm) was then recorded for each person. The device was then carefully positioned alongside the lateral aspect of the leg in line with the fibula. This reference

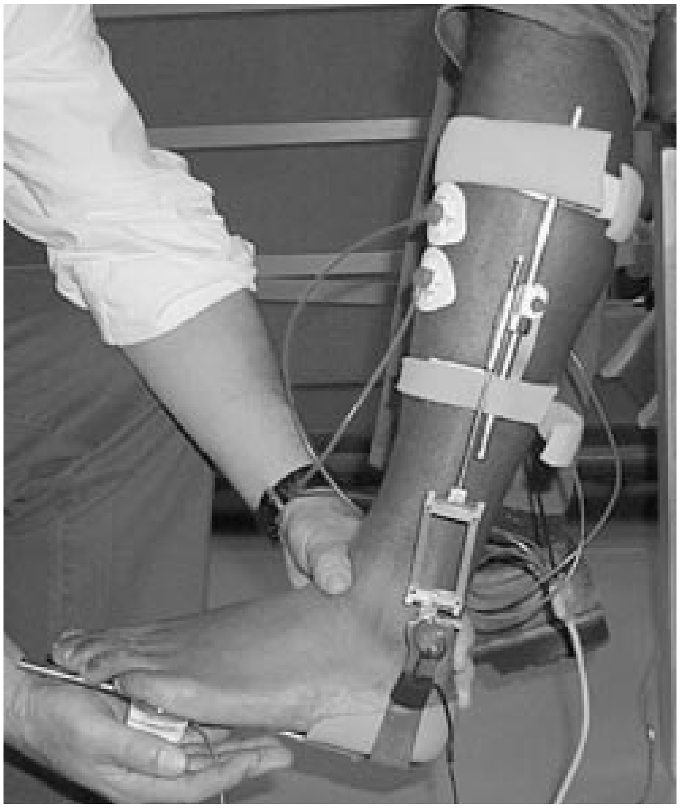

Figure 1.
The equinometer, a customized tool for ankle dorsiflexion measurement. The bar on the leg is aligned to the fibula and attached to a plate under the foot via an electrogoniometer. Thus, the electrogoniometer reads the angle between the foot and the leg. There is a force transducer beneath the metatarsal heads to measure the applied force. The force and angle are recorded on a portable computer. Electromyographic electrodes are seen in this photo, but they were not part of the protocol of this study.

serves as a very reproducible anatomic landmark and has an axis that approximates the center of rotation of the ankle joint. The footplate and accompanying force transducer were attached to the undersurface of the neutrally aligned foot. Data were taken after application of a 10 N-m torque directed dorsally from beneath the second metatarsal head. The ankle angle and applied force were sampled with a Macintosh G3 series computer running a customized LabVIEW™ virtual instrument (National Instruments Corporation; Austin, TX). The software prompts the user for the moment arm and then displays ankle position and torque in the sagittal plane. Both a right- and left-sided model were designed and used, and neutral position (0º of dorsiflexion) of each was recalibrated with a plastic model every few weeks to assure reproducibility. The instrument read 0º attached to a neutral, plantigrade foot, with subsequent positive change indicating relative dorsiflexion and negative change indicating plantarflexion.

A torque of 10 N-m was chosen in this experiment based upon previous work. This was the average torque applied to the ankle by our orthopedists and rehabilitation medicine specialists while testing for EC in an office setting.

Data suggest that the gastrocnemius muscle is under no tension with knee flexion of 25º or greater (26). Measurements of ankle dorsiflexion in this study were taken with the knee in full extension, which reflects the combined contributions of the gastrocnemius and soleus; and in 90º of flexion, which relaxes the gastrocnemius. Three recordings of maximal ankle dorsiflexion were obtained for each knee position and an average was calculated.

Subjects were randomized (alternated) as to whether testing was started with the knee first in extension or flexion. These latter two steps were taken to isolate independent contributions of both the gastrocnemius and soleus muscles to any existent contracture and to negate any stretching effect on the tissues that repetitive testing might have caused. Note that although data were taken with the knee fully extended as well as flexed to 90º, only the fully extended data were used to compare the clinician's diagnosis to the results from the equinometer.

RESULTS

The agreement between measured and clinician diagnoses of EC varies depending on the definition of EC. Because there are no accepted standards, we used two common definitions of EC, 5º or 10º of maximal ankle dorsiflexion with the knee in full extension.

For symptomatic patients: If EC is defined as 5º of dorsiflexion based upon the equinometer measurement, a clinician's ability to detect the EC was 75.0 percent (**Figure 2**). If equinus is defined as 10º, this ability increased to 96.4 percent. Alternatively, if the clinician made the diagnosis of no EC, as defined by 5º dorsiflexion, they were correct 83.3 percent of the time. If EC is defined as 10º, this ability decreased to 50.0 percent.

For asymptomatic patients: If EC is defined as 5º dorsiflexion, clinicians correctly diagnosed EC in 87.5 percent of cases (**Figure 3**). If equinus is defined as 10º, this ability increased to 100 percent. Alternatively, if EC is

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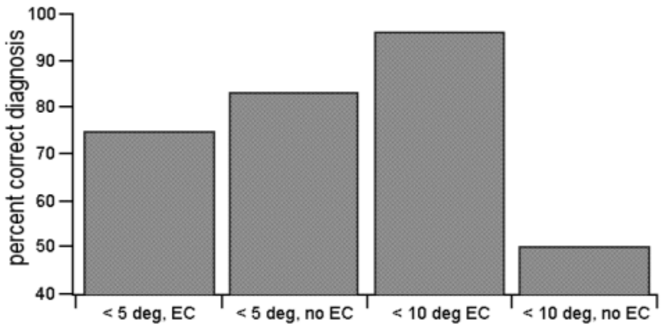

Figure 2.
A summary of the ability of clinicians to correctly diagnose ankle equinus in a symptomatic population.

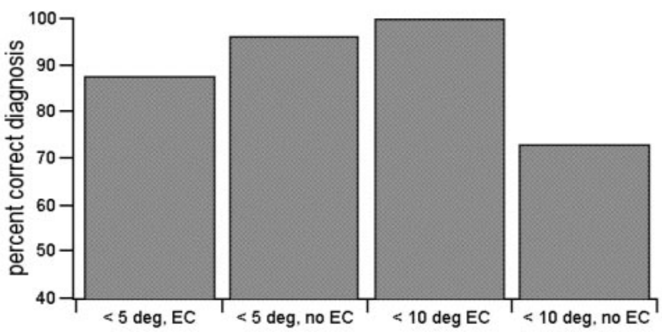

Figure 3.
A summary of the ability of clinicians to correctly diagnose ankle.

not present, as defined by 5º, then clinicians correctly diagnosed the absence of EC in 96.2 percent of cases. If EC is defined as 10º, this ability decreased to 73.1 percent.

For all 68 patients: If EC is defined as 5º of maximal ankle dorsiflexion, a clinician's ability to detect the equinus when it is truly present is 77.8 percent (**Figure 4**). If equinus is defined as 10º, this ability decreased to 97.2 percent. Alternatively, the clinician's ability to correctly diagnose the absence of EC, as defined by 5º, was 93.8 percent. If EC is defined as 10º dorsiflexion, this ability decreased to 68.8 percent.

If EC is defined as 5º of maximal ankle dorsiflexion with the knee in full extension, then in the group with symptoms, 21 patients were correctly diagnosed and seven incorrectly diagnosed as tight, while five were correctly diagnosed and one was incorrectly diagnosed as not tight. These data assume the equinometer to be the gold standard against which clinical diagnosis is com-

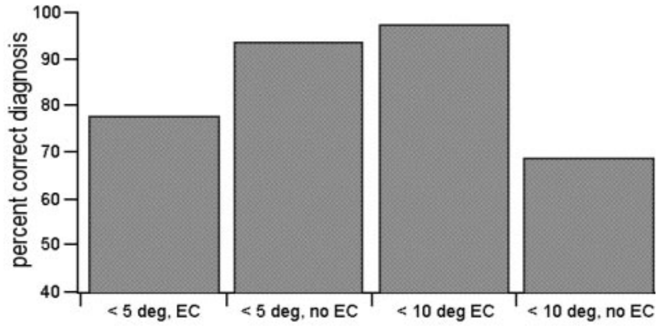

Figure 4.
A summary of the ability of clinicians to correctly diagnose ankle equinus in the combined symptomatic and asymptomatic population.

pared. If EC is defined as 10º, then 27 patients in the study group were correctly diagnosed as tight, with only one incorrect diagnosis, while three were correctly and three also incorrectly diagnosed as not tight. When using 5º for the control population, seven people were correctly diagnosed and one incorrectly diagnosed as tight, and 25 were correctly diagnosed and one incorrectly diagnosed with no contracture. Under the 10º definition, eight were correctly identified as tight and none was incorrectly identified as such, while 19 were correctly diagnosed and seven incorrectly diagnosed as not tight.

DISCUSSION

The ability of a single clinician to correctly diagnose ankle equinus with the knee fully extended was determined. A customized device (equinometer) was used to measure the dorsiflexion range of motion under standardized torque conditions and to determine the presence or absence of contracture based upon limitations of either 5º or 10º of dorsiflexion. The accuracy of the clinical assessment was then compared to the equinometer assessment in two patient populations, one with no symptoms referable to the foot and another with symptoms of forefoot and/or midfoot pain.

There are a number of factors that should be weighed when considering an interpretation of these findings. First, the study group is very heterogeneous, carrying multiple fore- and midfoot diagnoses. Secondly, despite using standardized anatomic landmarks and repetitive examination, our equinometer measurements are associated with some measurement error. There is likely some degree of unaccounted variability in performing measurements in the clinical setting, and it is possible that adjunctive radiographic or electromyographic data would have been helpful in enhancing the accuracy of the measurements. Thirdly, there may be a bias in clinical assessment of EC. The same examiner made the clinical determination of the presence or absence of contracture, and subsequently performed the objective equinometer measurements. Fourthly, the outcome may have been completely different if a different applied torque were chosen.

The measured dorsiflexion range of motion is strongly influenced by the applied torque. If a greater torque were applied, the measured range of motion would be greater and fewer subjects would be defined as having EC at each threshold level. The choice of 10 N-m, however, was the typical average torque applied by three expert examiners, so it likely reflected the clinical torques used in ankle range of motion assessment where the determination of EC would be made. Lastly, there are multiple other variables we found difficult to control, such as the time of day the testing was performed. It is possible that testing in the mornings would offer different results than testing in the evenings after a person theoretically has a chance to stretch out the musculotendinous structures of the superficial posterior compartment. However, this study does provide preliminary data evaluating the accuracy of clinical EC determination. It is important to begin to quantify these measures as significant clinical decisions are made based upon these clinical assessments. It also provides some data of use to individuals designing studies that measure the impact of equinus on clinical conditions.

The relationship between gastrocnemius-soleus complex or Achilles tendon tension and EC has been known for centuries. The majority of the literature supports a relationship between EC and foot problems in patients with neurological impairments. In spite of numerous publications on the causes of foot ulceration in patients with diabetes, and frequent anecdotal discussions of a relationship, only recently has the role of EC in pressure ulceration in diabetes been studied scientifically (35–37).

Possible explanations for the limited study of the role of contracture or stiffness in patients without spasticity include the lack of a definition of equinus, and the lack of a "gold standard" test. The term EC is used by orthopedic surgeons, physiatrists, physical therapists, and podiatrists, but without a uniform definition. Further, it is difficult to establish a statistical relationship if one does not have data on the validity of the measurement tool. In this case, the measurement tool is a clinical exam. The data in this study provides a baseline measure in a small group. It shows that clinicians are good but not perfect at using a clinical examination to determine EC. Further studies of a relationship between EC and disease must factor in the likelihood of correct diagnosis without an objective measurement device.

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