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VARIABILITY IN ASSESSMENT METHODS FOR ANKLE JOINT DORSIFLEXION

One of the more common measurements in a biomechanical examination of the foot and lower extremity is the measurement of ankle joint dorsiflexion. Podiatrists commonly measure ankle joint dorsiflexion to determine whether the patient is suffering from the condition known as "equinus", where there is a lack of normal ankle joint dorsiflexion. Measurement of ankle joint dorsiflexion may be used to determine the etiology of the patient's foot and lower extremity complaints and whether conservative or surgical treatment will be required to treat the patient's foot and lower extremity complaints. Unfortunately, depending on which specific ankle dorsiflexion measurement technique is used, there may be a very large discrepancy in the amount of apparent ankle joint dorsiflexion being measured. A review of the scientific literature on the various ankle dorsiflexion measurement techniques is therefore important to better appreciate how different ankle dorsiflexion measurement techniques may result in quite different values.

In 1924, Nils Silfverskiöld, a Swedish orthopaedic surgeon, was the first to describe a knee-flexed ankle dorsiflexion measurement to isolate the effect of the gastrocnemius muscle on ankle joint dorsiflexion (Silfverskiöld N: Reduction of the uncrossed two-joints muscles of the leg to one-joint muscles in spastic conditions. Acta Chir Scandinavica. 56:315–330, 1924). By taking the gastrocnemius muscle off stretch with knee flexion when performing the ankle dorsiflexion measurement by using the Silfverskiöld Test, the podiatrist can better assess whether any limitations of ankle joint dorsiflexion are due primarily to the gastrocnemius muscle or rather due to either soleus tightness or osseous blocks within the tibio-talar joint.

Then in 1971, Root et al. described their ankle dorsiflexion measurement technique which is still used within the podiatric profession now 55 years later. Root et al. described their ankle dorsiflexion measurement technique as being done with the patient in a prone position on an examination table and with the examiner manually pressing on the plantar aspect of the forefoot, while also positioning the subtalar joint (STJ) in its "neutral" position. The reference markers for the ankle joint dorsiflexion measurement were the bisection of the distal one-third of the lateral leg and the plantar aspect of the lateral foot. Ankle dorsiflexion measurements were taken in both the knee-extended and knee-flexed position ((Root ML et al.: *Biomechanical Examination of the Foot, Volume 1.* Clin Biomechanics Corporation, Los Angeles, 1971, pp. 92-97).

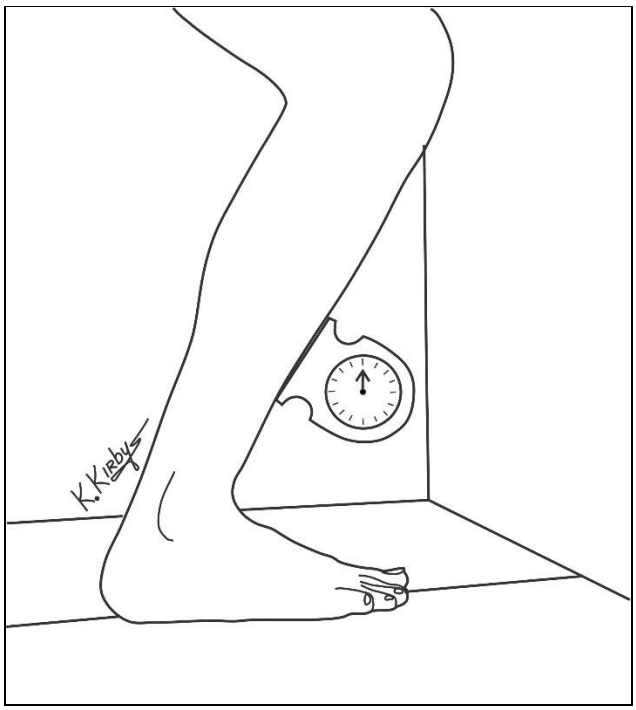

Figure 1. The weightbearing lunge test is a commonly-used ankle dorsiflexion measurement technique where the patient flexes their knee until the knee just touches a vertical wall while still keeping the foot fully plantigrade. A goniometer is placed on the anterior tibia to measure the lunge test value.

Another popular ankle joint dorsiflexion measurement technique, the *lunge test*, is done with the patient fully weightbearing and their knee flexed. In the lunge test, the patient is instructed to put the foot on the ground a certain distance from a vertical wall and then lunge forward until the anterior aspect of the knee just barely touches the wall. Once the foot is as far back away from the wall as possible with their foot still plantigrade and their knee still touching the wall, the angle of the anterior tibial border to the vertical (Fig. 1) is measured as being the value of the lunge test (Ekstrand J, Wiktorsson M, Oberg B, Gillquist J: Lower extremity goniometric measurements: A study to determine their reliability. Arch Phys Med Rehab, 63:171-175, 1982).

More recently, Munteanu et al. introduced a weightbearing ankle joint dorsiflexion measurement technique where the knee of the subject is kept fully

extended while the foot is kept plantigrade on the ground. In their study, 30 asymptomatic subjects were asked to lean on the dorsiflexed foot with the knee extended while still keeping the plantar foot fully in contact with the ground. A digital inclinometer was used to measure "ankle joint dorsiflexion" (Munteanu SE, Strawhorn AB, Landorf KB, Bird AR, Murley GS. A weightbearing technique for the measurement of ankle joint dorsiflexion with the knee extended is reliable. J Sci Med Sport, 12(1):54-59, 2009). In addition, research from 2014 by Baumbach et al. on 20 asymptomatic subjects using the weightbearing lunge test both with the knee extended and with varying degrees of knee flexion found that a knee flexion angle of 20^0 was necessary to fully eliminate the restraining effect of the gastrocnemius muscle on apparent ankle joint dorsiflexion (Baumbach S et al.: The influence of knee position on ankle dorsiflexion - a biometric study. BMC Musculoskelet Disord, 15:246, 2014).

In 2014, Dayton et al. performed clinical measurement of ankle joint dorsiflexion in 50 healthy subjects with the STJ positioned in the pronated, neutral and supination positions and compared those measurements to the radiographic position of the tibio-talar joint with the ankle maximally dorsiflexed. Even though the radiographic position of the tibio-talar joint changed less than 0.5^0 on average when the subjects had their ankle joint maximally dorsiflexed in the pronated, neutral and supinated STJ positions, the mean difference between the pronated and supinated STJ position showed a very large difference of about 14^0 in apparent ankle joint dorsiflexion. The difference in apparent ankle joint dorsiflexion from neutral to pronated was 4.8^0 and the difference in apparent ankle joint dorsiflexion from neutral to supinated was 9.2^0. It is interesting to note that the authors recommended measuring ankle joint dorsiflexion with "a moderately supinated position of the foot", thereby significantly increasing the diagnosis of "equinus" in patients using this non-standard ankle dorsiflexion measurement technique (Dayton P et al.: Experimental comparison of the clinical measurement of ankle joint dorsiflexion and radiographic tibiotalar position. JFAS, 56(5):1036-1040, 2017).

Even though Root et al. described that ankle dorsiflexion with the knee extended needed to be at least 10^0 to be "normal" (Root et al., 1971, p. 96), it seems clear that how the ankle dorsiflexion measurement is performed will largely determine how much "ankle joint dorsiflexion" is measured. For example, in a 2015 study by Rabin et al. on 64 asymptomatic male subjects, the mean value for the weightbearing lunge test on the dominant limb was 50.4^0 and on the non-dominant limb was 56.3^0 (Rabin A, Kozol Z, Spitzer E, Finestone AS: Weight-bearing ankle dorsiflexion range of motion-can side-to-side symmetry be assumed? J Athl Training, 50(1):30-35, 2015). This means that there may be at least a $30\text{-}40^0$ difference in "ankle joint dorsiflexion", depending on how "ankle joint dorsiflexion" is measured. Another study on 43 healthy individuals found that knee-flexed ankle joint dorsiflexion was, on average, 23.9^0 in the non-weightbearing setting and 49.5^0 with the weightbearing lunge test. In other words, there was a difference of 25.6^0 between the non-weightbearing and weightbearing measurements of ankle joint dorsiflexion indicating that the magnitude of force being exerted on the plantar forefoot used during ankle dorsiflexion measurement greatly altered "ankle joint dorsiflexion" (Rabin A, Kozol Z: Weightbearing and nonweightbearing ankle dorsiflexion range of motion. Are we measuring the same thing? JAPMA, 102(5):406-422, 2012).

From this brief review of the literature, it seems certain that "ankle joint dorsiflexion" is a widely variable measurement depending on the actual ankle dorsiflexion measurement technique used (i.e., is the knee flexed or extended, is the STJ neutral, supinated or pronated, and/or is the foot is manually loaded or fully weightbearing). Care must therefore be taken when making the diagnosis of "equinus" for patients, especially if surgical lengthening of the gastrocnemius-soleus-Achilles tendon complex is being contemplated as the best treatment for the patient's symptoms and pathology. In other words, the podiatric surgeon should always consider whether their ankle dorsiflexion measurement truly represents an "equinus deformity" or rather, could represent an error in their assessment of the patient's foot and lower extremity biomechanics.

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