Prevalence of Equinus in Diabetic versus Nondiabetic Patients

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Background: There are no conclusive data to support the contention that diabetic patients have an increased frequency of ankle equinus compared with their nondiabetic counterparts. Additionally, a presumed contributing cause of foot ulceration is ankle joint equinus. Therefore, we sought to determine whether persons with diabetes have a higher prevalence of ankle joint equinus than do nondiabetic persons.

Methods: A prospective pilot survey of 102 outpatients (43 diabetic and 59 nondiabetic) was conducted. Demographic and historical data were obtained. Each patient underwent a standard lower-extremity examination, including the use of a biplane goniometer to measure ankle joint range of motion.

Results: Equinus, defined as ankle dorsiflexion measured at 0° or less, was found in 24.5% of the overall population. In the diabetes cohort, 16 of 43 patients (37.2%) were affected compared with 9 of 59 nondiabetic participants (15.3%) ($P = .011$). There was a threefold risk of equinus in the diabetic population (odds ratio [OR], 3.3; 95% confidence interval [CI], 1.28–8.44; $P < .013$). The equinus group had a history of ulceration in 52.0% compared with 20.8% of the nonequinus group ($P = .003$). Equinus, therefore, imparted a fourfold risk of ulceration (OR, 4.13; 95% CI, 1.58–10.77; $P < .004$). We also found a 2.8 times risk of equinus in patients with peripheral neuropathy (OR, 2.8; 95% CI, 1.11–7.09; $P < .029$).

Conclusions: Equinus may be more prevalent in diabetic patients than previously reported. Although we cannot prove causality, we found a significant association between equinus and ulceration. (J Am Podiatr Med Assoc 102(2): 84-88, 2012)

Ulcerations, infections, and deformities of the foot have long been problems known to lead to lower-limb amputations in the diabetic population. Peripheral sensory neuropathy coupled with high plantar pressures and foot deformity commonly lead to plantar ulcerations in diabetic patients.[1,2] Another presumed contributing cause to diabetic foot ulcerations is increased plantar pressures during ambulation through a restriction of ankle joint dorsiflexion, more frequently referred to as an equinus deformity.[3-6]

Equinus has been commonly described as a restriction in ankle joint motion that does not allow dorsiflexion of the foot to a minimum of 0° to 10° during the propulsion midstance phase of the gait cycle.[7-9] There has been some debate in the literature concerning the prevalence and development of equinus in the diabetic population versus persons without diabetes.[10-13] The presence of diabetic peripheral neuropathy has been associated with an increase in plantar forefoot pressure and with changes in gait.[14-16] Current theories propose that people with diabetes, and especially those with diabetic peripheral neuropathy or Charcot's arthropathy, develop equinus as a secondary process

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after development of their disease.[5,17-19] Structural changes have also been seen with microscopic evaluation of the Achilles tendon that could lead to the development of contracture.[20] Note that most theories of a relationship between equinus and diabetic peripheral neuropathy or equinus and ensuing forefoot abnormalities have been retrospective reviews or have been based on speculation. As such, a direct link cannot be proved because the restriction of dorsiflexion is commonly measured at the time of or after the onset of other foot abnormalities (including Charcot's arthropathy). Presently, no evidence suggests that diabetic persons have a greater incidence of equinus compared with nondiabetic persons.

Many others consider equinus to be the major causative factor in multiple common foot abnormalities, including plantar fasciitis, Achilles tendinitis, metatarsalgia, Morton's neuroma, and hallux abducto valgus.[7-9] Nonetheless, since cause and effect have never been proved, these can only be considered associated findings. When restricted ankle dorsiflexion in diabetes is combined with neuropathy, often there is an increase in plantar foot pressures that has been associated with foot ulceration and, ostensibly, increased amputation rates.[21,22]

We, therefore, chose to study the prevalence of equinus deformity in a diabetic as well as a nondiabetic population to ascertain whether there is a higher occurrence in persons with diabetes. We also sought to investigate the relationship between ankle equinus and associated forefoot abnormalities (ulcers, infections, Charcot's arthropathy, etc).

Methods

A prospective cross-sectional study was conducted of patients attending the podiatric medical clinics at the Carl T. Hayden Veterans Affairs Medical Center in Phoenix, Arizona. Regularly scheduled patients were randomly invited to participate in this study by the investigators. This study received approval from the institutional review board of the Carl T. Hayden Veterans Affairs Medical Center, and all of the patients signed an approved informed consent document before undergoing any formal screening or examination. A standard screening instrument was used for each participant to ensure uniformity of data collection. In addition to demographic and medical history variables (age, sex, diabetes status, previous ulcerations, etc), we also collected data on the presence of ulceration, ankle range of motion, deformities, Charcot's arthropathy, and previous amputations. Equinus was defined as ankle joint dorsiflexion of less than 0°. Ankle joint dorsiflexion was measured by one of two physicians (DF, JH) for each enrolled patient using the same biplane goniometer (Lafayette Instrument Co, Lafayette, Indiana) (Fig. 1).[23] Prospective participants were excluded from the study if they had a history of ankle trauma that resulted in limited ankle joint motion, amputation involving the ankle joint or more proximal locations, recent immobilization at the ankle joint for an extended period, and surgery on the lower extremity that may have altered range of motion at the ankle joint.

Statistical analysis was performed with multiple variables and outcomes using Student t tests, χ^2 tests, and univariate and multivariate logistic regression as appropriate. Significance was assumed at $\alpha < .05$.

Results

A total of 102 patients (43 diabetic and 59 nondiabetic) were enrolled in this study. In patients with diabetes, the duration of disease was 2 to 35 years (mean, 14 years). The ages of the participants ranged from 25 to 86 years (mean, 61 years); 13 patients were women and the remaining 89 were men.

Equinus affected 24.5% of the overall population: 16 of 43 diabetic patients (37.2%) compared with 9 of 59 nondiabetic participants (15.3%) ($P = .011$) (Table 1). Of patients with any equinus deformity, 64% had diabetes. On univariate logistic regression, we found a threefold risk of equinus deformity in the diabetic population compared with those

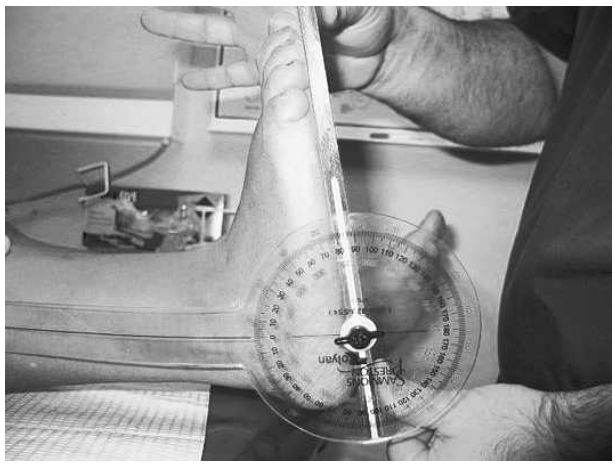

Figure 1. Biplane goniometer.

Table 1. Patient Characteristics and Complications Stratified by Equinus Status

Characteristic	No Equinus (n = 77)	Equinus (n = 25)	Total (N = 102)	*P* Value
Age (mean ± SD [years])	59.7 (12.3)	60.4 (14.01)	59.9 (12.7)	.82
Sex (no. [%])				.89
Male	67 (75.3)	22 (24.7)	89	
Female	10 (76.9)	3 (23.1)	13	
Diabetic (no. [%])				.011
No	50 (84.7)	9 (15.3)	59	
Yes	27 (62.8)	16 (37.2)	43	
Ulceration (no. [%])				.003
No	61 (79.2)	12 (48.0)	73	
Yes	16 (20.8)	13 (52.0)	29	
Neuropathy (no. [%])				.026
No	53 (68.8)	11(44)	64	
Yes	24 (31.2)	14(56)	38	
Charcot's arthropathy				.65
No	72 (75.0)	24 (25.0)	96	
Yes	5 (83.3)	1 (16.7)	6	

without diabetes (odds ratio [OR], 3.3; 95% confidence interval [CI], 1.28–8.44; $P < .013$).

Of the 25 participants found to have equinus, 52.0% had a history of ulceration compared with only 20.8% of the nonequinus group ($P = .003$). Accordingly, this resulted in a fourfold risk of ulceration in patients with restricted ankle joint dorsiflexion (OR, 4.13; 95% CI, 1.58–10.77, $P < .004$). Furthermore, peripheral neuropathy was seen in 14 of 25 patients with equinus (56.0%), imparting a 2.8 times risk of this deformity in neuropathic patients compared with those without neuropathy (OR, 2.8; 95% CI, 1.11–7.09; $P < .029$).

In this data set, we noted that only a minority of patients with Charcot's arthropathy exhibited an equinus deformity. Of the six enrolled patients with Charcot's arthropathy, only 1 (16.7%) was found to have equinus. Most likely due to the lack of power in this study, we found no association between Charcot's arthropathy and equinus deformity ($P < .65$).

Despite the previously mentioned findings on uncontrolled univariate predictors for equinus, when a multivariate logistic regression was performed, we found no significant relationship with equinus when diabetes was controlled for neuropathy (diabetes: OR, 2.5; 95% CI, 0.76–7.9; $P = .132$; neuropathy: OR, 1.6; 95% CI, 0.15–5.2; $P = .407$). This is likely due to the close relationship between diabetes and neuropathy, which causes them to nullify each other (collinearity).

Discussion

In a large single-cohort study,[4] approximately 10.2% of persons with diabetes were found to have equinus deformity and concomitant increased plantar forefoot pressures. Other studies[22,24] have found that these high plantar pressures are significantly associated with elevated risks of plantar ulceration in the presence of neuropathy. Conversely, there is some indication that restoring motion to the ankle joint will reduce the risk of recurrent ulceration.[18,25] Because of the potential risk that equinus deformity poses to diabetic persons, there has been increased interest in determining an association between this restriction of ankle joint dorsiflexion and subsequent diabetic foot complications.[8]

There is, however, some discrepancy in the literature as to how many degrees of ankle joint dorsiflexion one must lack to have equinus. The literature in this regard proposes ranges from 0° to 25°, with a normal value of approximately 10° of dorsiflexion.[4,8,12,19,26] In reality, there is no set standard that is universally accepted, and there are confounding variables that need to be accounted for. For example, it is reasonable to assume that a patient's measurement will change significantly after multiple attempts to measure equinus due to stretching of the posterior muscle group, that different instruments used will yield conflicting measurements, and that there is some degree of variability between clinicians.

More than half of all nontraumatic lower-extrem-

ity amputations performed in the United States occur in persons with diabetes mellitus. Approximately 85% of these diabetes-related amputations are attributable to nonhealing foot ulcerations.[2] Although common risk factors for ulceration include neuropathy, deformity, trauma, peripheral arterial disease, and high plantar pressures, few prospective studies specifically address the association between equinus deformity and ulceration.[4] It is also commonly assumed that diabetic persons have a greater frequency of equinus and that this restriction in dorsiflexion is implicated in the etiology of high plantar pressures and ulceration and even in the development of neuropathic arthropathy of the midfoot.[8] To our knowledge, there has not been any evidence to suggest that persons with diabetes have a higher frequency of equinus than do those without diabetes. However, in this survey of 102 prospectively enrolled patients, we found a significant threefold association with diabetes. We also found an increased prevalence and fourfold risk of ulceration in patients with limited ankle joint dorsiflexion. Nonetheless, causation of diabetic foot ulcers attributable to equinus cannot be proved because the purported cause (ie, equinus) was measured concurrent with or after the effect (ulcer) had occurred.

The prospective cross-sectional design of this study is unique in the published literature on equinus. Previous studies lacked a comparison of diabetic and nondiabetic patients but concluded that limited ankle joint dorsiflexion is more common in diabetic patients and that this mechanical alteration may predispose this population to high plantar pressures and ulceration. The present study did not include the measurement of plantar pressures. Pedobarographic measurements would have been desirable and should be incorporated into future studies. Such data has the potential to prove or disprove these theories decisively.

Conclusions

An initial review of a comparison between diabetic and nondiabetic patients suggests that equinus may be more prevalent in diabetic patients than previously reported. Restricted ankle joint dorsiflexion during gait has been associated with an increased risk of diabetic foot ulceration. Nonetheless, these data are insufficient to prove causality and lack the required power to prove or disprove these relationships. Future studies, therefore, should enroll more patients and should incorporate a plantar foot pressure mapping system to better determine associations among equinus, high plantar pressures, and foot ulceration. Future treatments, patient education, and preventive measures could subsequently be adopted to potentially reduce the incidence of diabetic foot ulcerations, costly hospitalizations, and life-altering amputations.

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