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Determinants from Several Systems Linked to Metatarsophalangeal Joint Deformity in People with Type 2 Diabetes

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Abstract

In patients with diabetes mellitus (DM), can affect multiple body systems. The aim of this cross-sectional study was to identify multisystem factors associated with metatarsophalangeal joint deformity in individuals with type 2 diabetes and peripheral neuropathy (n=60). Metatarsophalangeal joint deformity was quantified using computed tomography (CT) scans. Whole-body biomarkers included musculoskeletal "intrinsic muscle deterioration of the foot, tarsal/metatarsal bone density, ankle dorsiflexion, and metatarsophalangeal extension during standing tasks." increase. Vasculature "ankle-humeral index". and the endocrine/immune system (sensitive C-reactive protein, endogenous fluorescence and hemoglobin A1C). Muscle wasting (r=0.27), bone mineral density (r=-0.35), metatarsophalangeal extension (r=0.50), maximal dorsiflexion (r=-0.31), and ankle-humeral index (r=0.33) was related. with metatarsophalangeal joint deformity ($p<0.05$). Regression models related to deformation preserved bone density and metatarsophalangeal extension ($R2 = 0.34$). All musculoskeletal biomarkers and the ankle-humeral index showed a weak to moderate association with metatarsophalangeal joint deformity. Tarsal/metatarsal bone mineral density and toe extension during standing movements were the two strongest factors associated with metatarsophalangeal deformity. Assessment and management of bone mineral density and toe extension movement patterns in the foot may reduce the risk of metatarsophalangeal joint deformity and skin injury and subsequent amputation.

Keywords: Imaging; Computed tomography; Magnetic resonance imaging; Perfusion; Bone mineral density; Intramuscular fat; Advanced glycation end-products; Hammer toe; Claw Toe; C-reactive protein

Introduction

Foot complications associated with diabetes mellitus (DM) represent a significant economic and social burden, adversely affecting the quality of life and medical outcome of affected people. Peripheral neuropathy and metatarsophalangeal (MTP) joint hyperextension are common DM-related complications that increase the risk of ulceration and amputation. Hyperextension deformities of the MTP joint are associated with both 'claw' and 'hammer toe' deformities, depending on the resulting interphalangeal joint flexion or extension. However, regardless of the interphalangeal joint position, the high-pressure area at risk of skin injury due to hyperextension deformity of the MTP joint is at the metatarsal head. Early detection and treatment of foot-related complications have the potential to minimize their progression and adverse effects on patient health and quality of life [**1-3**]. Diabetes is a systemic disease and MTP joint deformity may be a focal symptom of multisystem deterioration. Neurological and motor dysfunction contributes to muscle weakness, fat infiltration of intrinsic leg muscles, and alterations in movement during functional work that are correlated with MTP joint hyperextension. In addition to neurological and motor dysfunction, the vasculature exhibits a variety of disorders associated with DM, including dysregulation of blood flow due to peripheral vascular disease, endothelial dysfunction and autonomic nervous system dysfunction. Both large and small blood vessels in the leg are affected, affecting muscle performance and bone density. Chronic hyperglycemia, which increases neuronal, motor, and vascular dysfunction, contributes to the accumulation of advanced glycation end products (AGEs). Accumulation of AGEs is thought to promote soft tissue dysfunction, is associated with limited ankle mobility, and increases loading on the forefoot and MTP joints during weight-bearing activities. Moreover, binding of AGEs to their receptors upregulates inflammatory pathways, promoting a pro-inflammatory environment and exacerbating cellular and tissue stress [**4,5**]. Functional failures of these systems can occur simultaneously. There is increasing evidence of intra- and inter-system interactions and their role in diabetic neuropathic foot deformity. Loss of intrinsic foot musculature is associated with MTP joint and metatarsal deformity. Foot health and amputation risk were also found to be associated with cardiovascular and inflammatory markers. For healthcare providers, the complex interplay of body systems that affect foot health in individuals with DM and peripheral neuropathy underscores the importance of comprehensive system assessment. However, there is limited literature characterizing diabetic neuropathic paws across multiple body systems. Previous studies have identified an independent relationship between MTP joint deformity and musculoskeletal factors (toe extension and intrinsic leg muscle deterioration during standing). Limitations in the study design prevented us from investigating the contributions of key actions across multiple body systems thought to contribute to the MTP joint. [**6-8**] was to take a multisystem approach to what contributes to MTP joint deformity. A range of clinical measures we hypothesized that musculoskeletal, vascular, and endocrine/immune biomarkers are associated with MTP joint deformity. However, since the outcome of interest is bone placement, we hypothesized that musculoskeletal factors would have the strongest relationship with foot deformity.

Musculoskeletal system assessment

Foot-specific muscle degradation rates were measured using an MRI (Siemens Prisma Fit 3T, Siemens Medical Systems, Malvern, PA, USA) similar to that previously described. The participant was placed

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in a supine position and a rim-he coil was wrapped around his legs. The MRI sequence parameters are:

Single shot, Dixon acquisition (Turbo Spin Echo, (TSE 2D), repetition time/echo time (TR/TE) = 1190 ms/13 ms, tilt angle = 123 degrees, field of view (FOV) = 129 × 114 mm. 512 × 576 Slice thickness = 3.5 mm Pixel pitch = 0.2246 × 0.2246 mm Number of instruments = 1 Acquisition time is 10–13 minutes Segmented muscle and fat volumes using the reliable and effective means previously described. as inter/intramuscular adipose tissue mass divided by estimated muscle mass.

Endocrine and immune systems assessment

High-sensitivity C-reactive protein (hsCRP), a marker of inflammation, and hemoglobin A1C (HbA1C), a marker of glycemic control, were measured by blood sampling. Accumulation of AGEs was assessed by skin-specific fluorescence using a SCOUT DS skin fluorescence spectrometer (VeraLight, Albuquerque, NM, USA). From the volar side of his left forearm he obtained two measurements **[9, 10]**. Fluorescence of the skin itself was excited with a light-emitting diode centered at 375 nm, detected in the emission range from 375 to 600 nm, and reported in arbitrary units (AU).

Discussion

In this study, the relationship between MTP joint deformity and multisystem biomarkers in DM patients was characterized. These relationships suggest possible mechanisms underlying MTP joint deformity and future therapeutic targets. Decreased BMD and increased amount of MTP extension during the sitting-to-standing task were the strongest factors associated with MTP joint deformity in this population. However, decreased intrinsic muscle quality of the foot, limited ankle dorsiflexion range of motion, and greater ABI also showed a weak to moderate relationship with greater MTP joint deformity. , has the strongest association with bony MTP joint deformity, but the results of this study also support the contribution of the vasculature to foot health. Contributions from multiple body systems highlight the importance of comprehensive clinical assessments in providing foot care to people with diabetes.

To our knowledge, this study is the first to link decreased BMD to hyperextension deformity of the MTP joint. The importance of BMD has been established in individuals with DM and severe foot deformities, particularly Charcot neuropathic osteoarthritis. Subjects included in this study had, on average for this group, well-maintained muscle quality on MRI, good self-reported foot function according to the FAAM, and previously reported DM use. showed a BMD score of 12 phisit compared to subjects without. The relationship between BMD and MTP joint deformity found in the present study contrasts with previous studies that did not report a relationship between MTP joint deformity and metatarsal head or diaphyseal BMD. Isolated His BMD changes near the joint line may also be affected by arthritic or cortical bone changes that do not represent the overall bone health of the foot and the average BMD of all tarsal and metatarsal bones. There is a nature. Interventions aimed at improving BMD through changes in physical activity and medical measures may help slow the progression of MTP joint deformity and should be investigated in future longitudinal studies.

The association between movement patterns and deformity highlights the importance of assessing the foot in diabetic patients at rest and during exercise. Extension of her MTP joint during functional movements such as walking and switching between sitting and standing has been reported to be associated with a second her MTP joint deformity severity. The results of this study indicate a similar magnitude relationship between her MTP extension movement when transitioning from sitting to standing and the severity of her MTP joint deformity in the second. We also observed the relationship between intrinsic leg muscle quality and her MTP extension movement pattern. This pattern is similar to that observed for intrinsic wasting of the hand. When the intrinsic muscles atrophy and the flexors of the fingers adaptively shorten, there is a tendency to scratch the fingers. The legs appear to follow a similar pattern. That is, the leg muscles are recruited in anticipation of standing, but the intrinsic muscles of the foot are unable to compensate for the pulling of the toe extensors and shortening of the toe flexors. It is reasonable to speculate that over time, alignment abnormalities and abnormal movement patterns may promote deformity and the possibility of metatarsal head or toe ulceration. Future studies examining pattern modification may help determine whether interventions aimed at modifying these movement patterns slow the progression of MTP joint deformity.

Conclusions

Bone density and the tendency to elongate her MTP joint during normal movement were the strongest associations with MTP joint deformity. These results help assess and manage multi-organ factors that contribute to risk factors for skin injury and subsequent amputation.

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