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Review Article

Pedography in the Diabetic Foot: A Narrative Review of Clinical Applications, Evidence, and Practice Implications

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Abstract

Diabetic foot disease remains one of the most disabling and costly complications of diabetes mellitus, and elevated plantar pressure is a well-established mechanical precursor to ulceration in the insensate foot. Pedography, more widely known as pedobarography, is the clinical technique used to quantify the distribution of pressure between the plantar surface and the ground or shoe during standing and gait. This narrative review synthesises the literature based on the pathophysiological basis of abnormal loading in diabetic peripheral neuropathy, the principles and technology underlying platform-based and in-shoe pedobarographic systems, and the clinical evidence supporting pedography-guided risk stratification, footwear and insole prescription, identification of clinical pedography based on diabetic foot, deformities and foot postural abnormality and exercise-based physiotherapy intervention. Elevated forefoot peak pressure, particularly at the metatarsal heads, is consistently associated with a higher risk of ulceration, and pedobarographic feedback is essential to design offloading footwear and smart insole systems that reduce ulcer recurrence. Foot-ankle therapeutic exercise and intrinsic muscle strengthening also appear to favorably redistribute plantar load. Pedography emerges as a clinically valuable, non-invasive tool that can meaningfully inform physiotherapy assessment and management pathways for the at-risk diabetic foot.

Keywords: Pedography; Pedobarography; Diabetic Foot; Plantar Pressure; Peripheral Neuropathy; Offloading; Physiotherapy

Introduction

Diabetic foot disease is one of the most severe complications linked to diabetes mellitus and poses a considerable global health issue. It includes various pathological conditions, such as peripheral neuropathy, peripheral arterial disease, foot abnormalities, infection, and ulceration. The presence of the above factors can impair protective sensation, disrupt tissue perfusion, change foot biomechanics, and heighten vulnerability to tissue damage and

eventual ulcer formation. Global meta-analytic estimates indicate that the combined prevalence of diabetic foot ulcers in diabetes patients is approximately 6.3%, exhibiting significant regional and type-specific differences. Most diabetes-related lower limb amputations occur after foot ulcers, and healing often leads to recurrence. To avert the risk of amputation due to diabetic foot complications, reliable tools are crucial for detecting feet at biomechanical risk before ulceration occurs [1].

Pedography, or pedobarography, is the technique used to assess the pressure distribution created between the foot's plantar surface and a surface during both static standing and dynamic gait [2,6]. The method started with inked foot prints and evolved into a more advanced technique utilizing sensor-based research that can accurately measure pressure distribution over small areas of the foot in real time.

In the diabetic foot, pedobarography offers objective, consistent information on the locations and amounts of pressure a foot can generate, which is crucial for physiotherapists and podiatrists engaged in screening for high ulceration risk, aiding in footwear prescriptions and rehabilitation.

This review examines three interrelated questions crucial to clinical physiotherapy practice:

- To comprehend how plantar pressure is unevenly distributed in the diabetic foot along with its contributing factors
- How pedobarographic technology is utilized to accurately measure this irregularity.
- How evidence-based strategies can effectively lower foot plantar pressure through offloading, footwear alterations, or therapeutic exercise interventions. It additionally assists in identifying outcomes that are clinically significant.

Pathophysiology: Why plantar pressure rises in the diabetic foot

The diabetic foot is susceptible to abnormal mechanical stress from chronic hyperglycemia that leads to sensory and motor autonomic neuropathy [1,3]. Sensory loss eliminates the protective pain signals that typically prompt a person to feel pressure and relieve an area under high pressure or switch footwear, enabling unnoticed accumulation of repetitive mechanical stress [1]. Motor neuropathy leads to weakness in the intrinsic foot muscles, facilitates clawing of the toes along with progressive forefoot deformity, and this deformity causes abnormal distribution of plantar pressure zones, concentrating load beneath the metatarsal heads. Restricted joint movement, glucose-induced hardness of nearby connective tissues from high blood sugar, and diminished cushioning of the subcutaneous plantar fat pad from atrophy additionally exacerbate the load shift toward smaller, less safeguarded regions of the sole.

The clinical outcome of this is a change in the typical, fairly uniform distribution of plantar pressure toward focused regions of elevated peak pressure, primarily in the forefoot and metatarsal head area, with the hallux and heel also playing a role in certain clinical cases [1,4].

Ulceration occurs when mechanical stress surpasses the limits of insensate areas in poorly perfused tissue; the ability to objectively measure this pressure distribution, rather than depending on visual inspection, is the primary emphasis in contemporary diabetic foot risk evaluation.



Figure 1: Shift of plantar pressure from a normal even distribution to high peak pressure areas at forefoot, metatarsal head region, hallux and heel of diabetic foot.

Pedography in diabetic peripheral neuropathy

Connection between sensory impairment, motor neuropathy, and plantar pressure

The relationship between sensory deficits and motor dysfunction is especially crucial in the emergence of atypical plantar loading, where foot absorbs pressure and ground forces in abnormal pattern. Sensory neuropathy reduces protective feedback, enabling repetitive loading to persist without a suitable behavioural reaction, while motor neuropathy can change muscle activation and stability of the foot.

These alterations may elevate mechanical stress under the forefoot, midfoot, and rearfoot, potentially leading to the formation of calluses and later tissue degradation in individuals at risk [16,29].

Pedobarographic research has shown that people with DPN can display greater plantar pressures compared to those without neuropathy. A systematic review and meta-analysis involving patients with DPN, diabetic controls lacking neuropathy, and healthy controls indicated moderately elevated plantar pressures in the rearfoot, midfoot, and forefoot, along with longer stance times, in individuals with DPN [16].

These results endorse plantar pressure evaluation as an objective approach for detecting biomechanical changes linked to neuropathy.

Changes in gait and plantar pressure distribution

Peripheral neuropathy is linked to changes in various aspects of walking, such as the duration of stance, velocity of gait, joint mobility, and pressure on the soles. A systematic review of type 2 diabetes patients revealed notable distinctions in kinematic and kinetic variables among individuals with neuropathy, individuals with diabetes lacking neuropathy and non-diabetic people [29]. These alterations may influence the progression of the centre of pressure and the distribution of plantar forces during the stance phase.

Dynamic pedobarographic evaluation is especially valuable for detecting these alterations as it captures the reallocation of plantar pressure during walking. Individuals experiencing DPN might exhibit extended stance duration and heightened localized plantar pressure, indicating modified foot-ankle mechanics and diminished capacity to redistribute mechanical loads efficiently [16,30]. Recent studies further suggest that both plantar pressure and shear stress can contribute to mechanical tissue stress in those with diabetic neuropathy, highlighting the significance of evaluating both loading intensity and the length of loading periods [31].

Comparison of diabetic patients with and without neuropathy

Research has shown that pressure patterns vary based on the degree of diabetic neuropathy, existence of peripheral arterial disease, history of ulceration, foot deformities, and additional biomechanical influences [32]. Consequently, pedographic results should not be viewed in isolation but must be combined with neurological, vascular, structural, and functional evaluations.

"The progression of sensory and motor deficits creates an imbalance in weight-bearing mechanics. Research by Caselli., *et al*. demonstrated that while both forefoot and rearfoot pressures rise as neuropathy develops, individuals with severe diabetic neuropathy exhibit a disproportionately high forefoot-to-rearfoot pressure ratio compared to non-neuropathic diabetic controls, reflecting a hazardous anterior shift in mechanical stress that strongly predicts future ulceration [33].

In summary, pedography offers an unbiased method for recognizing regional plantar-loading irregularities linked to diabetic peripheral neuropathy. Its capability to identify variations under both static and dynamic situations may help clinicians in recognizing high-risk loading patterns, choosing suitable offloading methods, and tracking changes after physiotherapy, foot wear, or orthotic treatments.

Principles and technology of pedobarographic evaluation

There are two primary categories of pedobarographic systems used in clinical settings and research. Platforms such as the EMED or Novel system and Tekscan, MatScan, ohm 3000 embed pressure sensors within a stationary mat that patients either stand or walk on barefoot (during bipedal standing) or while walking, generating a comprehensive static or dynamic pressure map of the plantar surface at a particular moment in the gait cycle. In-shoe systems such as the Novel Pedar or Tekscan F-Scan insoles feature slim, flexible sensors situated within the shoe, allowing for pressure readings during stationary standing and normal walking.

Feature	Platform-based systems	In-shoe (insole-based) systems
Example devices	EMED/ Novel platform, Tek scan Mat Scan /ohm 3000	Novel Pedar, Tekscan F-Scan
Measurement context	Measures plantar pressure during static standing and bare foot walking across a fixed sensor platform	Measures pressure inside foot wear during walking and other functional activities
Typical clinical use	Baseline screening, ulceration-risk stratification	Footwear/insole evaluation and optimisation
Limitation	Does not directly assess the pressure relieving effects of therapeutic foot wear during use. Results may be influenced by walking speed, step placement, measurement protocol.	Sensor drift and calibration demand over prolonged wear

Table 1: Comparison of platform-based and in-shoe pedobarographic (pedography) systems.

Depending on the observed clinical conditions in diabetic patients, either static or dynamic methods are used to evaluate the patients. Static pedobarography captures pressure distribution during still standing, aiding in the assessment of postural load symmetry between both feet as well as balancing the weight distributions across the forefoot, midfoot, and hindfoot, while dynamic pedobarography records the entire pressure transition during the stance phase of walking and is generally regarded as more clinically significant for evaluating ulceration risk. Common outputs report consists of peak plantar pressure, pressure-time integral, contact area, and force, all of which have been investigated as possible predictors of ulceration risk [4,5].

Distribution of plantar pressure across various foot areas

Pedographic evaluation offers regional insights into the distribution of foot pressure across the heel, midfoot, metatarsal heads, big toe, and smaller toes. This regional assessment is clinically significant as excessive mechanical pressure is not evenly spread over the plantar surface and can differ based on neuropathy, foot alignment, deformity, walking pattern, and prior ulceration [16,17,33].

The metatarsal heads and hallux become especially crucial during the terminal stance and push-off stages. In individuals with diabetes, changes in this typical loading sequence can lead to heightened regional peak pressure and pressure-time exposure, especially in the forefoot.

The significance of examining specific plantar areas is additionally showcased by research that categorizes the foot into the heel, midfoot, metatarsal, hallux, and lesser-toe sections. This type of regional segmentation enables healthcare professionals to pinpoint particular zones of mechanical overload instead of depending solely on overall plantar pressure [34]. In individuals with diabetic neuropathy and a previous ulceration history, elevated pressure-time integrals in the midfoot and rearfoot have also been documented, highlighting the need to consider both pressure levels and loading duration [35].

"The distribution of plantar pressure is significantly influenced by the compounding effects of diabetic peripheral neuropathy (DPN) and peripheral arterial disease (PAD). Patients exhibiting these complications demonstrate marked biomechanical shifts—specifically elevated peak pressures in the forefoot, expanded midfoot contact zones, and a forward displacement of the center of pressure (COP)—when compared to diabetic individuals without these conditions [33].

The significance of examining specific plantar areas is additionally showcased by research that categorizes the foot into the heel, midfoot, metatarsal, hallux, and lesser-toe sections. This type of regional segmentation enables healthcare professionals to pinpoint particular zones of mechanical overload instead of depending solely on overall plantar pressure [34]. In individuals with diabetic neuropathy and a previous ulceration history,

elevated pressure-time integrals in the midfoot and rearfoot have also been documented, highlighting the need to consider both pressure levels and loading duration [35].

Foot posture may also affect regional pressure distribution. Planus or pronated feet usually show increased loading in the medial arch, central forefoot, and hallux, while cavus or supinated feet typically exhibit higher pressure in the heel and lateral forefoot. These results are especially important in diabetic foot evaluation since abnormal foot alignment can lead to localized mechanical stress and must be taken into account when analysing pedographic pressure maps.

Pedography and biomechanics of gait

Pedography offers real-time data on foot pressure during the walking cycle and thus enhances traditional clinical evaluations of diabetic foot mechanics. In typical walking, plantar pressure moves from heel contact at the start, through the midfoot, and shifts towards the forefoot and hallux during the push-off phase. Variations in this process can be recognized via regional pressure readings and centre-of-pressure evaluations [16,36].

The stance phase can be functionally categorized into loading response, mid-stance, and terminal stance. While loading response, the heel takes on body weight and absorbs shock. During the mid-stance phase, the foot creates a stable base as the center of pressure moves forward. In people with diabetic peripheral neuropathy, this typical loading sequence is often severely disrupted; biomechanical analyses reveal that compromised lower-limb muscle performance, restricted ankle joint mobility, and profound sensory deficits collectively alter gait kinematics, resulting in abnormal force distribution and an altered center-of-pressure trajectory during the stance phase [36].

Data from systematic reviews and meta-analyses show that people with diabetic peripheral neuropathy exhibit longer stance times and moderately elevated plantar pressure at the rearfoot, midfoot, and forefoot compared to control groups [16]. These results imply that changes in gait timing and plantar loading could enhance mechanical stress on susceptible plantar tissues.

Gait speed is another significant element when analyzing pedographic readings Variations in walking speed can affect plantar pressure, contact duration, and force distribution; thus, it is crucial to have a standardized or recorded walking velocity when comparing measurements between individuals or over repeated evaluations. Variations in measurement systems and the traits of participants can impact regional plantar-pressure readings, highlighting the importance of having standardized evaluation procedures [37].

Dynamic pedograph is helpful for assessing not only the level of plantar pressure but also the timing and spatial features of loading during walking. This data can help clinicians detect unusual loading patterns and assess if interventions like therapeutic shoes, orthotics, gait retraining, or physiotherapy in effectively redistributing the plantar pressures.

Analysis of Centre of Pressure (COP) in the diabetic foot

The center of pressure (COP) indicates the point location of the resultant plantar ground-reaction force and offers insights into the management and progression of body weight while standing and walking.

During dynamic pedobarographic evaluation, the center-of-pressure trajectory is continuously mapped from initial posterior-lateral heel strike, through midfoot flat loading, and across the metatarsal heads to terminal hallux push-off. Quantitative analysis indicates that these dynamic center-of-pressure progression lines are highly sensitive to underlying foot posture alignments and neuromuscular control variations. According to investigations by Ribeiro., *et al*. individuals presenting with flexible flat-foot or pronated posture displays a significant medial displacement of the dynamic weight-transfer vector, forcing abnormal force loading directly toward the first metatarsal ray. Conversely, patients with high-arched or rigid supinated structures exhibit a pronounced lateral trajectory shift that maintains load concentration over the outer forefoot column throughout the stance phase. In the presence of diabetic peripheral neuropathy, this structural deviation is frequently worsened by diminished sensory feedback and altered motor unit recruitment, compromising dynamic postural stability and changing step progression paths during functional walking [24].

In diabetic peripheral neuropathy, loss of plantar sensation and changes in sensorimotor control may affect postural stability

and walking. Research on diabetic patients has shown shifts in the anterior-posterior position of the center of pressure (COP) alongside modifications in plantar pressure distribution [33]. These alterations may indicate changes in weight-transfer strategies and challenges in preserving the normal movement of the center of pressure while walking. COP speed and deviation may offer further insights into postural stability. COP path length, sway area, and associated metrics have been studied as signs of balance and postural stability, though their reliability can differ based on the assessment method and demography [38]. A systematic review of COP and plantar-pressure metrics indicated that COP sway area and path length were some of the more dependable measures for evaluating postural control, while also highlighting the significance of consistent measurement techniques [38].

The integrated analysis of COP trajectory, COP excursion, COP velocity, and regional plantar pressure may thus offer a more thorough understanding of diabetic foot biomechanics than just peak plantar pressure. This analysis can be especially beneficial when assessing patients who have diabetic neuropathy, unusual foot posture, compromised balance, or gait issues.

In general, COP analysis can enhance regional plantar-pressure assessment by revealing not only the locations of excessive pressure but also to analyze how the loading center shifts across the plantar surface while standing and walking. Combining COP parameters with foot posture, muscle strength, ankle mobility, and balance evaluation could enhance personalized physiotherapy strategies and yield objective results for rehabilitation efforts.

Integral of pressure over time and additional pedographic variables

Peak plantar pressure quantifies the maximum vertical force exerted per unit area within a specific anatomical region during the contact phase of gait, whereas the pressure-time integral captures cumulative mechanical load by calculating the product of pressure magnitude and exposure duration. These parameters offer separate and complementary dimensions when analyzing structural tissue strain across the lower limb. While immediate peak plantar pressure remains a primary biomechanical biomarker for acute localized stress, the pressure-time integral provides critical clinical data in scenarios where moderate force profiles are sustained over a prolonged stance interval. Quantitative data compiled by Giacomozzi., *et al*. demonstrates that the incremental clinical predictive value of utilizing the pressure-time integral alongside peak force metrics varies across mechanical trials, suggesting that both kinetic variables must be interpreted concurrently based on the target patient cohort and the specific lower-limb diagnostic objective [39].

Evaluating mechanical load in the susceptible diabetic foot requires looking beyond isolated peak pressures to include parameters like contact duration, regional force, peak force, force-time characteristics, and plantar contact area. Comprehensive biomechanical profiling is achieved by analyzing spatial data alongside contact area and force-time attributes, as relying solely on peak pressure offers an incomplete assessment [40].

Pedography for timely identification of high-risk feet

Pedography has been suggested as a technique for detecting unusual plantar-loading patterns prior to the onset of clinically visible ulceration. Regions of high pressure may align with areas exposed to continuous mechanical stress, potentially aiding clinicians in recognizing feet that need more careful monitoring or proactive Measures [5].

Assessing diabetic foot risk

The relationship between elevated plantar pressure and diabetic foot ulcers, demonstrating that the region under the most stress usually corresponded with ulceration sites in diabetic individuals. Further studies in Egyptian diabetes patients showed that those with active ulcers had considerably greater forefoot peak plantar pressure and an increased forefoot-to-rearfoot pressure ratio than those with neuropathy only or patients with diabetes without neuropathy. The research indicated a forefoot peak pressure threshold near 355 kPa as an indicator of heightened ulceration risk. A subsequent systematic review and meta-analysis of cohort studies examining baseline plantar pressure and subsequent ulcer formation revealed that pedobarography has clinically significant predictive value for future ulceration, emphasizing its contribution as a risk-stratification element in a thorough foot assessment, rather than being utilized as an independent diagnostic tool.

In clinical practice, pedobarographic risk stratification is most effective when integrated into a standardized assessment process that encompasses screening for loss of protective

sensation, vascular evaluation, and deformity assessment rather than replacing these essential elements. Feasibility studies that incorporate pedobarography into standard diabetic foot clinics indicate that both platform and in-shoe assessments can be incorporated into everyday clinical routines, although difficulties concerning equipment expenses, staff education, and time required for analysis have been recognized.

Biomechanical factors influencing plantar pressure in diabetic feet

Evaluation of diabetic foot deformities through pedograph

Structural abnormalities can significantly alter the distribution of plantar pressure. Claw toes, hammer toes, hallux valgus, prominence of the metatarsal head, pes planus, pes cavus, and Charcot neuroarthropathy can change the contact area and mechanical loading pattern of the plantar surface [25,50].

Claw and hammer-toe deformities can elevate pressure beneath the metatarsal heads and distal toes, while hallux valgus might change the loading on the first metatarsal and hallux. Pes planus can elevate medial midfoot pressure, whereas pes cavus may focus stress under the heel and on the outer forefoot. Charcot neuroarthropathy can lead to significant midfoot pressure linked to the failure of the medial longitudinal arch [20].

Pedography can thus demonstrate the mechanical effects of structural deformity and pinpoint areas needing pressure redistribution. Crucially, deformity, neuropathy, and plantar pressure must be evaluated collectively, as plantar pressure on its own does not offer a thorough evaluation of ulcer risk [5,50].

Pedographs can visualize irregular foot pressure patterns, which aids in the early detection of high-risk deformities and allows for tailored therapeutic approaches [18].

The intrinsic muscles of the foot weaken because of motor neuropathy, resulting in an imbalance between intrinsic and extrinsic muscles. Depending on the specific structural defect, abnormal loading is observed beneath the metatarsal heads, hallux, heel, or midfoot as the deformity progresses. Pedographic assessment is deemed an essential addition to standard diabetic foot evaluation as it aids healthcare professionals in identifying these unusual loading patterns prior to any evident tissue damage [19].

Pedographic traits of typical diabetic foot deformities

Claw toe malformation

Claw toe deformity results from diabetic motor neuropathy and is marked by hyperextension at the metatarsophalangeal joints alongside the flexion of both interphalangeal joints. Intrinsic muscle weakness enables the long flexor and extensor tendons to prevail, resulting in dorsal displacement of the toes and heightened pressure beneath the metatarsal heads. Pedographic analysis typically reveals reduced digital contact in the terminal stance and particular zones of noticeably increased peak plantar pressure beneath the second to fourth metatarsal heads. Individuals facing continuous strain in these regions are at a higher risk of developing plantar calluses and neuropathic sores.

Hammer toe

Hammer toe deformity causes flexion at the proximal interphalangeal joint along with relative hyperextension at the metatarsophalangeal joint. Pressure mapping typically reveals heightened pressure under the impacted metatarsal head and greater loading at the distal toe during propulsion. The ensuing repetitive mechanical strain leads to dorsal corns, apical ulcers, modified propulsion while walking [20].

Hallux valgus

Hallux valgus is marked by the sideways shift of the big toe along with the inward movement of the first metatarsal. Pedographic evaluation typically shows elevated pressure under the first metatarsal head and medial forefoot, along with modified center-of-pressure movement during the terminal stance. With the advancement of deformity, there is often a compensatory shift of load to the lesser metatarsals, raising the likelihood of developing transfer lesions and ulcers [21].

Charcot neuroarthropathy

Charcot neuroarthropathy is a serious complication of diabetic peripheral neuropathy marked by the gradual deterioration of foot bones and joints. The failure of the medial longitudinal arch results in a typical “rocker-bottom” deformity. Pedographic assessment reveals unusually high plantar pressure under the midfoot, a condition seldom seen in healthy people. The concentration of pressure in the midfoot is viewed as a significant indicator of plantar ulceration in individuals with Charcot deformity and aids healthcare providers in choosing suitable offloading options.

Pedography and foot alignment

Pronated or flat feet are typically linked to heightened medial plantar contact and modified pressure distribution across the midfoot and forefoot. In contrast, supinated or cavus feet typically show decreased midfoot contact and increased pressure on the lateral plantar surface. A comprehensive review exploring the connection between foot posture and plantar pressure revealed links between foot posture and specific plantar-pressure traits, though the strength and reliability of these connections differed across studies [24].

For individuals with diabetes, abnormal posture creates concentrated mechanical stress, making the interaction between neuropathy, foot alignment, and plantar pressure clinically vital. Assessing high-risk biomechanical profiles is greatly improved by pairing dynamic pressure data with clinical alignment tools, as utilizing pedographic mapping alongside foot posture index metrics offers far superior insights than employing either method separately [41].

Pedographic analysis of pronated and supinated feet

Foot alignment has a significant impact on the distribution of plantar pressure and the biomechanics of walking. Pedography objectively measures these changes and offers essential data for physiotherapists working with diabetic foot care.

Flat foot

A pronated foot shows increased eversion of the subtalar joint along with the falling of the medial longitudinal arch. Pedographic analysis typically shows heightened medial heel loading, expanded contact area under the medial midfoot, increased pressure beneath the first metatarsal head, greater hallux loading during propulsion, medial deviation of the center of pressure, and an elevated Arch Index.

Chronic medial overload might lead to plantar fasciopathy, callus development on the first metatarsal, and medial forefoot ulcers in individuals with diabetic neuropathy [24].

Supinated foot

A supinated foot is defined by excessive inversion at the subtalar joint along with a pronounced medial longitudinal arch. Pressure mapping typically shows: elevated lateral heel pressure, diminished midfoot contact area, heightened pressure under the fourth and fifth metatarsal heads, decreased hallux loading, lateral center-of-pressure progression. The inflexible nature of the supinated foot limits shock absorption, leading to increased localized pressure under the lateral forefoot and heel. In patients with diabetes, this loading pattern increases the risk of lateral plantar ulcers and stress-related tissue damage [24].

Pedography and weakness of intrinsic foot muscles

Motor neuropathy and diabetes-associated muscular alterations can lead to weakness and atrophy of the intrinsic muscles of the foot. Diminished intrinsic muscle function can affect the stability of the toes and metatarsophalangeal joints and could lead to modified loading in the forefoot [42].

The connection between intrinsic muscle activity and plantar pressure has recently gained more focus. A 2026 intervention study showed that focused toe-flexor strengthening enhanced plantarflexion strength and intrinsic foot-muscle volume while reducing peak pressure at the second and lateral metatarsal areas in individuals with diabetes [43]. This result offers direct evidence backing the idea that enhancing foot-muscle function can affect plantar-pressure distribution.

Consequently, evaluating the strength of intrinsic foot muscles together with pedography could assist in identifying patients for whom muscle weakness plays a role in abnormal plantar loading. It might also offer a justification for integrating strengthening measures with objective pressure monitoring throughout diabetic-foot rehabilitation [42,43].

Pedography and mobility of the ankle joint

Restricted joint flexibility

The non-enzymatic glycation of collagen leads to increasing stiffness in the ankle, subtalar, and metatarsophalangeal joints among people with diabetes.

"Decreased ankle dorsiflexion restricts typical tibial progression while walking and forces an altered, anteriorly shifted gait. It is explicitly noted, 'limited joint mobility is a major biomechanical factor that restricts normal foot rollover,' resulting in an early heel lift that concentrates destructive shear and vertical forces directly beneath the metatarsal heads [23].

Limitation of ankle dorsiflexion is a significant biomechanical aspect linked to changed plantar loading in individuals with diabetes. Decreased ankle mobility can restrict proper forward movement of the tibia during stance, thereby elevating the mechanical load on the forefoot [44].

A systematic review and meta-analysis identified a minor yet noteworthy correlation between ankle equinus and elevated plantar pressure. The correlation was especially notable in research concerning people who have experienced neuropathic foot ulcers [44].

Consequently, decreased ankle dorsiflexion and tightness in the Achilles tendon should be considered when analyzing increased pressure in the forefoot. Integrating pedographic evaluation with ankle range-of-motion measurement could help clinicians ascertain if limited ankle mobility is a changeable factor in excessive forefoot loading [44].

According to longitudinal trials by Sartor., *et al*. tracking localized ankle flexibility parameters alongside dynamic pedobarographic velocity mapping may help clinicians identify whether limited joint mobility contributes to excessive forefoot pressure concentration [45].

Characteristics of pedograph and plantar soft tissues

Plantar pressure must be understood in connection with the mechanical properties of the tissues subjected to stress. Diabetes and peripheral neuropathy can modify the structure, hardness, and mechanical reactions of plantar soft tissues, possibly diminishing their capacity to endure repeated loading [46].

Alterations in the plantar fat pad are especially significant since the heel and metatarsal areas rely on soft-tissue components for absorbing shock and distributing load. Studies using MRI have shown changes in the composition of sub-calcaneal fat-pad in individuals with diabetic neuropathy, highlighting connections between fat-pad features and heel pressure [47].

Research into tissue mechanics has shown modified stiffness in plantar tissues among individuals with diabetes and neuropathy. Heightened or modified tissue rigidity can influence how mechanical stress is conveyed through the skin and underlying tissues [46,48]. Recent studies have shown links between plantar pressure and tissue firmness, indicating that continuous mechanical exposure might affect local tissue characteristics [49].

Calluses and pre-ulcerative lesions hold clinical significance as they may suggest consistent local mechanical pressure. Thus, plantar-pressure mapping ought to be analyzed in conjunction with evaluating skin integrity, callus development, and additional pre-ulcerative indicators instead of being viewed as a standalone Assessment [50].

Clinical significance of pedographic analysis

The analysis of pedographic results must always be coupled with neurological evaluation, vascular investigation, footwear assessment, and structural deformity examination. Instead of depending only on absolute pressure values, healthcare professionals ought to assess pressure magnitude, contact area, pressure-time integral, and center-of-pressure trajectory to comprehend the fundamental biomechanical issue. This thorough method aids personalized treatment strategies, encompassing tailored orthotics, therapeutic shoes, physical therapy methods, and gait re-education, ultimately minimizing plantar tissue strain and decreasing the occurrence of diabetic foot ulcers [14].

Deformity Site	Typical Pedographic Finding	Common Ulcer	Clinical Significance
Claw toes	High pressure beneath 2nd-4th meta-tarsal heads	Forefoot	Metatarsal callus and ulcer
Hammer toes	Distal toe overload	Toe apex	Digital ulceration
Hallux valgus	Increased first metatarsal pressure	Hallux	Medial forefoot overload
Charcot foot	Markedly increased midfoot pressure	Midfoot	Rocker-bottom ulcer
Limited joint mobility	Increased forefoot loading	Metatarsal heads	Repetitive stress injury
Pesplanus (Pronation)	Increased medial midfoot contact	First metatarsal	Medial plantar ulcer

Table 2: Pedographic Characteristics of Common Diabetic Foot Deformities.

Parameter	Pronated Foot	Supinated Foot
Heel loading	Medial heel	Lateral heel
Midfoot contact	Increased	Reduced
Arch Index	High	Low
Forefoot pressure	First metatarsal	Fourth and fifth metatarsals
Hallux loading	Increased	Reduced
Centre of pressure	Medial progression	Lateral progression
Shock absorption	Increased mobility	Reduced mobility
Ulcer risk	Medial forefoot	Lateral forefoot

Table 3: Pedographic Comparison Between Pronated and Supinated Foot.

Pressure levels linked to ulcer risk: Analysis of pedography

Increased plantar pressure is a significant biomechanical indicator of diabetic foot ulcer development. In people with diabetic peripheral neuropathy, continuous exposure to high mechanical stress leads to gradual tissue injury, often occurring before any noticeable skin damage. Due to reduced or absent protective sensation, patients frequently keep walking even with localized tissue damage, leading to repetitive stress that triggers inflammation, subcutaneous haemorrhage, and ultimately ulcer development [25].

The development of ulcers is affected by the interplay of pressure intensity, length of time under load, properties of plantar tissue, vascular condition, foot abnormalities, and the activity level of the patient. As a result, pressure measurements must consistently be analyzed alongside neurological assessments, vascular evaluations, and structural deformity examinations instead of being viewed as a standalone diagnostic indicator [26].

The pressure-time integral (PTI) has become a supplementary biomechanical factor that enhances peak pressure readings. Although peak pressure measures the highest force endured by a particular plantar area, PTI captures both the intensity and length of loading. Regions subjected to extended moderate pressure can experience tissue damage similar to areas exposed to short bursts of extremely high pressure [5].

Dynamic pedographic assessment additionally examines the progression of the centre-of-pressure during the stance phase of walking. In healthy individuals, the pressure center moves smoothly from the posterior-lateral heel to the hallux during push-off. Individuals with diabetic neuropathy often exhibit variations in this path due to muscle weakness, restricted joint movement, or anatomical abnormalities. Medial movement of the pressure center is often seen in pronated feet, while lateral shift is more typical of cavus or supinated feet. Acknowledgment of these modified loading pathways helps clinicians pinpoint biomechanical elements accountable for persistent plantar ulceration [27].

From a clinical standpoint, pressure levels determined via pedography offer important insights for tailored intervention strategies. Areas with consistently high plantar pressure might gain from using accommodative insoles, rocker-bottom shoes, metatarsal pads, total contact orthotics, or specific physiotherapeutic methods focused on enhancing ankle mobility, intrinsic foot muscle strength, and walking mechanics. Sequential pedographic assessments additionally allow practitioners to confirm if these treatments have effectively redistributed plantar pressures and diminished biomechanical strain at formerly high-risk areas [28].

Peak Plantar Pressure (kPa)	Pedographic Interpretation	Clinical Significance	Recommended Management
<100kpa	Pressure present initially	Initial ulcer risk	Routine monitoring
200-300	Pressure elevation	Moderate mechanical stress	Footwear advice, exercise
300-350	Increased localized loading	High callus formation risk	Requires Orthoses and pressure redistribution
350-400	High plantar pressure	Increased ulcer risk	Customized offloading footwear
>400	Very high plantar pressure	Very high ulcer recurrence risk	Immediate pressure offloading and close follow-up

Table 4: Pedographic Parameters Used for Ulcer Risk Assessment.

Study	Design/population	Pedography-related finding
Bus., *et al*. [7]	Multicentre RCT, 171 neuropathic patients with healed plantar ulcer	In-shoe pressure-guided footwear optimisation tested against standard prescription
Paton., *et al*. [9]	Participant-blinded RCT, 119 neuropathic participants	F-Scan-measured custom vs prefabricated insoles; custom insoles modestly reduced forefoot pressure-time integral
Abbott., *et al*. [8]	Prospective RCT, proof-of-concept, recently healed ulcer	Real-time in-shoe pressure feedback via smart insole reduced ulcer recurrence
Ahmed., *et al*. [10]	Systematic literature review of footwear/insole design	Synthesizes pedobarography-guided design features that offload the forefoot

Table 6: Selected studies using pedobarography to guide and evaluate offloading interventions in the diabetic foot.

Orthotic management informed by pedography

Pedography can assess the mechanical impact of personalized insoles, metatarsal pads, arch supports, and various orthotic changes. Clinicians can assess if excessive regional loading has been redistributed by analyzing plantar-pressure measurements taken before and after orthotic intervention [18].

Orthotic modifications guided by pressure are especially important for patients who have a history of plantar ulceration or deformity. The latest IWGDF guidelines advocate for well-structured therapeutic shoes and pressure-relief strategies for individuals at moderate to high risk, especially those with considerable deformities or a history of plantar ulcers [51].

A pedographic re-evaluation after orthotic adjustment might thus offer an objective means to verify if an intervention achieves the desired decrease in pressure at areas susceptible to risk [18,51].

Pedography and therapeutic footwear

The 2023 IWGDF prevention guideline suggests using therapeutic footwear that has been proven to relieve plantar pressure for individuals who have healed from a plantar ulcer. Consequently, pedography plays a vital role in enhancing footwear since it allows healthcare professionals to evaluate the mechanical reaction to shoes instead of depending solely on visual assessments or personal comfort [51].

Pedography in rehabilitation focused on physiotherapy

Physiotherapy treatments can target various modifiable factors leading to abnormal plantar loading, such as weak intrinsic foot muscles, limited ankle mobility, poor balance, and modified gait mechanics.

Methods involving exercise might encompass strengthening of intrinsic and extrinsic foot muscles, exercises for ankle mobility, stretching the Achilles tendon, balance improvement, and gait re-education. Objective data from a controlled clinical trial conducted by Iunes., *et al*. confirms that a structured lower-limb physical therapy regimen focused on targeted muscle stretching and joint mobilization yields significant improvements in ankle range of motion and functional foot flexibility. Following the intervention timeline, this specialized exercise protocol successfully changes dynamic plantar contact areas and alters gait propulsion mechanics, providing a validated methodology to safely redistribute mechanical loading profiles and diminish peak forces in neuropathic lower limbs [53].

A clinical trial focusing on individuals with diabetic peripheral neuropathy showed enhancements in ankle dorsiflexion and hallux grip strength after an eight-week regimen that included intrinsic foot-muscle strengthening and ankle mobility workouts [53]. More recent randomized studies have also indicated positive changes in ankle stiffness and muscle strength after structured exercise programs for those with type 2 diabetes and peripheral neuropathy [54].

From a clinical physiotherapy perspective, pedography offers an inherent method for evaluating the results of exercise interventions: theoretically, pre-and post-intervention pedobarographic evaluations can objectively demonstrate if a strength or mobility program has resulted in a quantifiable reduction in regional peak pressure, complementing subjective and impairment-focused outcomes such as range of motion or neuropathy symptom scores. Nonetheless, there are limited studies that have integrated a structured exercise program with formal pedobarographic outcome evaluations, highlighting a distinct opportunity for upcoming physiotherapy research [54].

By consolidating the previous sections, a feasible clinical strategy for incorporating pedography into diabetic foot physiotherapy can be summarized in four stages: (i) an initial risk assessment that encompasses sensory testing, vascular investigation, deformity scrutiny, and, when available, static or dynamic pedobarographic mapping; (ii) identifying specific regions of elevated peak pressure, usually found at the metatarsal heads; (iii) choosing and reviewing offloading devices such as shoes, insoles, or orthotic modifications using pedobarography; and (iv) implementing a focused foot and ankle exercise program aimed at enhancing intrinsic muscle strength, increasing ankle flexibility, and retraining gait, along with periodic re-evaluation via repeat pedobarography to ensure effective pressure redistribution.

This phased method represents the existing evidence while recognizing that the most robust trial data is found in the offloading area, whereas the exercise area is less well measured with pedobarographic results.

Pedography as a measurement result for exercise intervention

Utilizing pedography as a metric could enhance studies exploring exercise-based treatments for diabetic foot issues. Measurements taken before and after the intervention can measure changes in peak plantar pressure, pressure-time integral, contact area, and regional loading.

Serial evaluation can also identify if enhancements in intrinsic foot muscle strength, ankle flexibility, or gait mechanics are associated with a redistribution of plantar pressure. Recent findings directly showed decreases in maximum metatarsal pressure after focused strengthening of the toe-flexors, reinforcing the use of plantar pressure as a precise biomechanical result of foot-muscle rehabilitation [43].

Nevertheless, the evidence foundation is still quite restricted in comparison to studies examining footwear and offloading. More extensive randomized controlled studies utilizing standardized pedographic methods are needed to establish if exercise-related decreases in plantar pressure led to clinically significant reductions in the incidence or recurrence of ulcers [5,43].

Plantar tissue stress is affected by both the intensity of pressure during each step and the frequency and length of loading. As a result, the amount of walking done daily, the intensity of activities, and the total load may affect the mechanical stress faced by susceptible plantar tissues [49].

Ongoing pressure monitoring inside shoes allows for the assessment of plantar loading in everyday activities instead of just during brief laboratory walking tests. Research on intelligent insoles has shown that it is possible to gather pressure data during everyday activities and offer feedback when unusual loading is detected.

Pedobarographic-assisted offloading: Footwear and insoles

Increased plantar pressure is a changeable mechanical risk element; a significant portion of the existing pedobarography research focuses on utilizing pressure information to inform offloading methods. In a multicentre randomized controlled trial, Bus and associates utilized in-shoe plantar pressure evaluation to assess and enhance custom therapeutic footwear for neuropathic patients with a recently healed plantar ulcer, investigating if pressure-guided optimization improved ulcer-free survival relative to standard footwear prescriptions. Paton and collaborators performed a participant-blinded trial with F-Scan in-shoe assessments to contrast custom functional insoles with prefabricated alternatives, finding a slight advantage for custom insoles in reducing forefoot pressure-time integral, although peak pressure overall was comparable between the two groups.

A comprehensive systematic review of footwear and insole design elements found that design decisions guided by pedobarographic such as rocker soles, reinforced uppers, and metatarsal unloading components are consistently linked to lower forefoot pressure in neuropathic diabetic feet.

Abbott and associates evaluated a more sophisticated technique by developing a smart insole system that monitors in-shoe pressure continuously and delivers real-time vibratory feedback to patients when pressure surpasses a threshold associated with ulceration risk, motivating them to redistribute weight from high-risk areas; in a randomized proof-of-concept study with patients who had recently healed ulcers, utilizing the feedback-enabled insole was associated with a reduced ulcer recurrence rate at high-risk plantar sites compared to conventional care.

Study	Design/population	Pedography-related finding
Bus., *et al*. [7]	Multicentre RCT, 171 neuropathic patients with healed plantar ulcer	In-shoe pressure-guided footwear optimisation tested against standard prescription
Paton., *et al*. [9]	Participant-blinded RCT, 119 neuropathic participants	F-Scan-measured custom vs prefabricated insoles; custom insoles modestly reduced forefoot pressure-time integral
Abbott., *et al*. [8]	Prospective RCT, proof-of-concept, recently healed ulcer	Real-time in-shoe pressure feedback via smart insole reduced ulcer recurrence
Ahmed., *et al*. [10]	Systematic literature review of footwear/insole design	Synthesizes pedobarography-guided design features that offload the forefoot

Table 6: Selected studies using pedobarography to guide and evaluate offloading interventions in the diabetic foot.

Biofeedback, intelligent insoles and wearable pedograph

The combination of pedograph and biofeedback technology enables the transmission of plantar-pressure data to patients during their everyday tasks. Instantaneous visual, auditory, or tactile feedback can notify patients when the load surpasses a set limit and may prompt them to adjust their weight distribution or gait.

A smart insole system featuring ongoing monitoring of plantar pressure and audiovisual notifications was assessed in individuals with diabetes, peripheral neuropathy, and a history of plantar ulceration. The intervention led to a decrease in ulcer recurrence in the initial proof-of-concept randomized trial [8].

Later randomized studies have investigated the extended use of smart insoles with customized feedback, showing a decrease in plantar pressure during everyday activities [55]. These innovations could thus help in transition pedography from laboratory evaluations to ongoing surveillance in actual settings.

Artificial intelligence and digital pedography

Artificial intelligence and machine learning methods signify a new trend in pedographic studies. Automated image analysis can detect plantar areas, extract pressure features, and categorize irregular pressure patterns without depending solely on manual assessment [56].

A study conducted in 2025 showed that it is possible to utilize machine-learning algorithms on plantar-pressure data to forecast diabetic peripheral neuropathy. Various algorithms successfully classified neuropathy by utilizing both static and dynamic plantar-pressure data, highlighting the capability of computational techniques for automated risk evaluation [56].

Upcoming digital systems could integrate plantar pressure, gait patterns, foot alignment, sensory results, and patient activity information to create personalized risk profiles. Nonetheless, these technologies need external validation, standardized datasets, and prospective clinical studies before they can be routinely implemented in clinical practice.

Consistency, accuracy, and standardization of pedographic evaluation

The understanding of plantar-pressure readings is heavily influenced by the attributes of the measurement system, calibration

methods, sensor arrangement, walking protocols, and participant traits. Variations among commercially available systems can result in different pressure readings, hindering direct comparisons between research utilizing different technologies [37].

A systematic review of barefoot plantar-pressure measurements showed that the measurement equipment, disease status, age, BMI, and sex notably influenced the regional pressure values. The authors stressed that pressure readings acquired from various systems should not be assumed to be directly comparable [37].

Thus, standardization must encompass suitable sensor calibration, uniform walking speed, adequate familiarization, multiple trials, consistent segmentation of foot regions, and uniform data-processing methods. Such factors are especially vital when pedography is employed to track changes over time or to compare intervention groups [37,57].

Static compared to dynamic pedography and platform against in-shoe systems

Static pedography assesses foot pressure while standing, while dynamic pedography monitors pressure variations during walking. Static measurements can offer valuable insights into weight-bearing symmetry and the distribution of regional loads, whereas dynamic assessment gives extra information about pressure transfer during gait and propulsion.

Platform-based systems offer barefoot pressure measurements in controlled settings, while in-shoe systems allow evaluation during footwear usage and more realistic daily walking. A recent systematic review on in-shoe plantar-pressure technologies revealed significant variability among systems and highlighted the necessity of using consistent measurement tools when analyzing results [57].

The choice between static or dynamic, platform-based or in-shoe evaluation should thus be guided by the clinical or research inquiry. For instance, in-shoe measurement can be especially beneficial when assessing therapeutic footwear, while platform-based assessment might be advantageous for initial biomechanical characterization [57].

Pedography in rehabilitation after ulcer and amputation

People who have had a previous diabetic foot ulcer are at increased risk for recurrence due to ongoing neuropathic, structural, and biomechanical issues that may linger after the wound has healed.

Therapeutic footwear guided by pressure can assist in recognizing and alleviating mechanical stress at former ulcer locations [51].

After a partial foot or trans metatarsal amputation, there may be a change in plantar load distribution due to modified anatomy and a decreased weight-bearing area. Pedographic evaluation can thus aid in recognizing overloading of the remaining foot and the opposite limb and may support adjustments in orthotic or prosthetic devices [18].

Thus, serial pressure evaluation could be beneficial in rehabilitation following ulcer recovery or amputation, especially when alterations in footwear, orthotic devices, or gait are implemented.

Pedography, stability and fall hazard

Diabetic peripheral neuropathy may affect plantar perception and sensorimotor coordination, leading to postural instability and changes in balance. COP displacement, sway patterns, and asymmetry in plantar loading might offer insights into the mechanisms that lead to compromised postural stability.

Even though plantar-pressure and COP measurements can be relevant for balance evaluation, they must not be viewed as standalone indicators of fall risk. Integrating COP analysis with clinical balance assessments, sensory evaluations, and gait analysis could offer a more thorough assessment of functional risk.

Clinical judgment utilizing pedography

Pedography ought to be integrated into a complete clinical pathway instead of being utilized as a standalone diagnostic assessment. The initial evaluation must encompass protective sensation, circulatory status, deformities, skin quality, history of previous ulcers, and a functional assessment, then proceed to identify high-pressure areas on the plantar surface if a pedographic assessment is accessible [5].

According to the evidence-based consensus guidelines formulated by Schaper., *et al*. comprehensive risk stratification cannot rely on isolated mechanical parameters; rather, integrating quantitative plantar barograph directly into a structured screening

matrix that evaluates sensory thresholds, arterial patency, and structural osseous alignment provides the only validated methodology to accurately map cumulative tissue stress, anticipate structural breakdown sites, and dictate customized preventative orthotic workflows in at-risk neuropathic patient populations [51].

The recognized pressure pattern can subsequently direct the choice of therapeutic footwear, orthotics, exercise, gait adjustments, or other strategies to reduce pressure. Subsequent pedography can be utilized to assess if the intervention has effectively lessened loading in the intended area.

This method offers a practical sequence for evaluation for identification of pressure in analysis of contributing factors implementing intervention and for reassessment of pressure.

Expense, availability and execution

Even with its clinical promise, the regular application of pedography is affected by the expense of equipment, the necessity for staff training, the need for calibration, data analysis, and the accessibility of specialized services. Recent evaluations have highlighted cost, challenges in clinical implementation, and discrepancies among measurement systems as significant obstacles to widespread use.

These constraints may be especially significant in diabetic-foot services with limited resources. The creation of dependable, cost-effective pressure-sensing technologies and uniform interpretation protocols could enhance accessibility. Nonetheless, more affordable systems need to be properly validated prior to their use in clinical risk stratification.

Limitations

Numerous significant research gaps persist in the clinical use of pedography for diabetes. Initially, significant variability is present in devices, sensor technologies, anatomical obfuscation, walking protocols, outcome measures, and pressure thresholds [5,37,57].

Second, while plantar pressure is evidently linked to the biomechanics of diabetic foot, the predictive capability of pedography by itself for future ulceration is still inadequate to justify its use as an independent screening tool [5].

Third, the foundation of evidence for pedography-guided physiotherapy and exercise is still less established compared to the evidence backing pressure-guided footwear and offloading. Future randomized controlled trials ought to explore if enhancements in intrinsic foot-muscle strength, ankle flexibility, balance, and gait mechanics can help in preventing abnormal foot pressure and ulcer formation. Therefore, there is more necessity to analyse studies based on exercise intervention and its effect on pedography. Ultimately, expenses, training needs, and time limitations can restrict regular pedobarographic availability in numerous clinical environments, especially beyond specialized diabetic foot services.

Conclusion

Pedography, also known as pedobarography, offers an objective and repeatable measurement in the biomechanical loading distribution of the diabetic foot, with extensive research consistently associating high forefoot peak plantar pressure with a higher risk of ulceration [4,5]. Platform-based and in-shoe systems serve complementary functions in screening, footwear assessment, and daily-life surveillance [2,3,9], while pedobarography-assisted offloading strategies, such as custom insoles and smart feedback-enabled insole systems, have shown decreased ulcer recurrence in randomized studies [7-9]. Exercise guided by physiotherapy that focuses on enhancing intrinsic foot muscle strength and ankle mobility presents a biologically reasonable supplementary approach to effectively redistribute plantar load, although additional research quantified through pedobarography would be advantageous in this area [12]. The evidence indicates that pedography ought to be incorporated as a routine, clinically useful component of diabetic foot physiotherapy assessment and management, to enhance but not substitute current sensory, vascular, and structural evaluations.

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Conflict of Interest

The authors declare that there are no known financial, professional, or personal conflicts of interest that could have influenced the work reported in this manuscript. The authors have no competing interests to declare regarding the publication of this manuscript.

Bibliography

1. Zhang P., *et al*. "Global epidemiology of diabetic foot ulceration: a systematic review and meta-analysis". *Annals of Medicine* 49.2 (2017): 106-116.

2. Mesci E. "Pedobarographic evaluations in physical medicine and rehabilitation practice". *Turkish Journal of Physical Medicine and Rehabilitation* 69.4 (2023): 400-409.

3. Gurney JK., *et al*. "Pedobarography as a clinical tool in the management of diabetic feet in New Zealand: a feasibility study". *Journal of Foot and Ankle Research* 10 (2017): 24.

4. Fawzy OA., *et al*. "Plantar pressure as a risk assessment tool for diabetic foot ulceration in Egyptian patients with diabetes". *Clinical Medicine Insights: Endocrinology and Diabetes* 7 (2014): 31-39.

5. De Castro JPW., *et al*. "Accuracy of foot pressure measurement on predicting the development of foot ulcer in patients with diabetes: a systematic review and meta-analysis". *Journal of Diabetes Science and Technology* 17.1 (2023): 70-78.

6. Skopljak A., *et al*. "Pedobarography in diagnosis and clinical application". *Acta Information Medicine* 22.6 (2014): 374-378.

7. Bus SA., *et al*. "The effectiveness of using in-shoe plantar pressure assessment and monitoring in prescription therapeutic footwear to prevent plantar foot ulcer recurrence in diabetic patients: a multicenter randomized controlled trial". *Journal of Foot and Ankle Research* 5 (2012): O11.

8. Abbott CA., *et al*. "Innovative intelligent insole system reduces diabetic foot ulcer recurrence at plantar sites: a prospective, randomised, proof-of-concept study". *Lancet Digital Health* 1.6 (2019): e308-e318.

9. Paton JS., *et al*. "A comparison of customised and prefabricated insoles to reduce risk factors for neuropathic diabetic foot ulceration: a participant-blinded randomised controlled trial". *Journal of Foot and Ankle Research* 5 (2012): 31.

10. Ahmed S., *et al*. "Footwear and insole design features that reduce neuropathic plantar forefoot ulcer risk in people with diabetes: a systematic literature review". *Journal of Foot and Ankle Research* 13 (2020): 1-13.

11. Bus SA., *et al*. "Footwear and offloading interventions to prevent and heal foot ulcers and reduce plantar pressure in patients with diabetes: a systematic review". *Diabetes/Metabolism Research and Reviews* 32.1 (2016): 99-118.

12. Francis D., *et al*. "Effect of exercises for strengthening the intrinsic muscles of the foot and improving ankle mobility on patients of diabetic peripheral neuropathy". *Cureus* 16.3 (2024): e56553.

13. Cavanagh PR and Bus SA. "Off-loading the diabetic foot for ulcer prevention and healing". *Journal of Vascular Surgery* 52.3 (2013): 37S-43S.

14. Bus SA., *et al*. "Guidelines on the prevention of foot ulcers in persons with diabetes (IWGDF Guideline)". *Diabetes/Metabolism Research and Reviews* 36.S1 (2020): e3269.

15. Lazzarini PA., *et al*. "Diabetes-related foot disease: the Cinderella of Australian diabetes management?". *Journal of Foot and Ankle Research* 11 (2018): 24.

16. Fernando M., *et al*. "Biomechanical characteristics of peripheral diabetic neuropathy: a systematic review and meta-analysis of findings from the gait cycle, muscle activity and dynamic barefoot plantar pressure". *Clinical Biomechanics* 28.8 (2013): 831-845.

17. Monteiro-Soares M., *et al*. "Guidelines on the classification of diabetic foot ulcers (IWGDF)". *Diabetes/Metabolism Research and Reviews* 36.S1 (2020): e3273.

18. Bus SA., *et al*. "Effect of custom-made footwear on foot ulcer recurrence in diabetes: a multicenter randomized controlled trial". *Diabetes Care* 36.12 (2013): 4109-4116.

19. Armstrong DG., *et al*. "Diabetic foot ulcers and their recurrence". *The New England Journal of Medicine* 376.24 (2017): 2367-2375.

20. Cavanagh PR., *et al*. "Biomechanical aspects of diabetic foot disease". *Diabetes/Metabolism Reviews* 12.S1 (1996): S51-S59.

21. Bus SA. "Priorities in offloading the diabetic foot". *Diabetes/Metabolism Research and Reviews* 36.S1 (2020): e3270.

22. Petrova NL and Edmonds ME. "Charcot neuro-osteoarthropathy—current standards". *Diabetes/Metabolism Research and Reviews* 32.S1 (2016): 281-286.

23. Zimny S., *et al*. "The role of limited joint mobility in diabetic patients with an at-risk foot". *Diabetes Care* 27.4 (2014): 942-946.

24. Buldt AK., *et al*. "The relationship between foot posture and plantar pressure during walking in adults: a systematic review". *Gait Posture* 62 (2018): 56-67.

25. Bus SA., *et al*. "IWGDF Guideline on footwear and offloading interventions to prevent and heal foot ulcers in persons with diabetes". *Diabetes/Metabolism Research and Reviews* 36.S1 (2020).

26. van Netten JJ., *et al*. "Definitions and criteria for diabetic foot disease". *Diabetes/Metabolism Research and Reviews* 36 (S1 (2020): e3268.

27. Wearing SC., *et al*. "Plantar pressure measurement in clinical biomechanics: reliability and interpretation". *Gait Posture* 19.3 (2004): 224-232.

28. Bus SA., *et al*. "Guidelines on the prevention of foot ulcers in persons with diabetes (IWGDF Practical Guidelines)". *Diabetes/Metabolism Research and Reviews* 40.S1 (2024).

29. Hazari A., *et al*. "Kinetics and kinematics of diabetic foot in type 2 diabetes mellitus with and without peripheral neuropathy: a systematic review and meta-analysis". *Springerplus* 5.1 (2016): 1819.

30. Abri H., *et al*. "Plantar pressure distribution in diverse stages of diabetic neuropathy". *Journal of Diabetes & Metabolic Disorders* 18.1 (2019): 33-39.

31. Mima S., *et al*. "Plantar pressure and shear stress during gait in people with diabetic neuropathy". *Diabetology International* 16.2 (2025): 285-293.

32. Cao Z., *et al*. "Characteristics of plantar pressure distribution in diabetes with or without diabetic peripheral neuropathy and peripheral arterial disease". *Journal of Diabetes Research* 2022.

33. Caselli A., *et al*. "The forefoot-to-rearfoot plantar pressure ratio is increased in severe diabetic neuropathy and can predict foot ulceration". *Diabetes Care* 25.6 (2002): 1066-1071.

34. Robinson CC., *et al*. "Plantar pressure distribution patterns of individuals with prediabetes in comparison with healthy individuals and individuals with diabetes". *Journal of Diabetes Research* (2013).

35. Bacarin TA., *et al*. "Plantar pressure distribution patterns during gait in diabetic neuropathy patients with a history of foot ulcers". *Clinics* 64.2 (2009): 113-120.

36. Sawacha Z., *et al*. "Diabetic gait and posture abnormalities: a biomechanical investigation through three-dimensional gait analysis". *Clinical Biomechanics* 24.9 (2009): 722-728.

37. Telfer S and Bigham J. "The influence of population characteristics and measurement system on barefoot plantar pressures: a systematic review and meta-regression analysis". *Gait Posture* 67 (2019): 269-276.

38. Hébert-Losier K and Murray L. "Reliability of centre of pressure, plantar pressure, and plantar-flexion isometric strength measures: a systematic review". *Gait Posture* 75 (2020): 46-62.

39. Giacomozzi C., *et al*. "Does the pressure-time integral provide additional information for the assessment of the diabetic foot? A clinical evaluation". *Gait Posture* 21.1 (2001): S88-S94.

40. Melai T., *et al*. "Multidirectional forces on the foot: the distribution of plantar shear stress and vertical pressure during walking". *Gait Posture* 34.1 (2011): 112-117.

41. Ramanathan AK., *et al*. "A comparison of plantar pressure distribution in normal and diabetic feet". *Foot* 20.1 (2010): 10-14.

42. Andersen H., *et al*. "Atrophy of foot muscles: a measure of diabetic neuropathy". *Diabetes Care* 27.10 (2004): 2382-2385.

43. Höhne A., *et al*. "Targeted foot muscle strengthening reverses atrophy and reduces plantar peak pressure in diabetic neuropathic feet". *Foot (Edinb)* 67 (2026): 102253.

44. Searle A., *et al*. "Association between ankle equinus and plantar pressures in people with diabetes: a systematic review and meta-analysis". *Clinical Biomechanics* 43 (2017): 8-14.

45. Sartor CD., *et al*. "Effects of a foot-ankle therapeutic exercise program on condition severity, modifiable risk factors, and gait in diabetic neuropathy: a randomized controlled trial". *BMC Musculoskeletal Disorder* 15 (2014): 1-12.

46. Duffin AC., *et al*. "Ultrasonography of plantar soft tissue thickness in children with diabetes". *Diabetic Medicine* (2002).

47. Cheung JTM., *et al*. "Three-dimensional finite element analysis of the foot during standing—a material sensitivity study". *Journal of Biomechanics* 38.5 (2005): 1045-1054.

48. Lavery LA., *et al*. "Practical criteria for screening patients at high risk for diabetic foot ulceration". *Archives of Internal Medicine* 158.2 (1998): 157-162.

49. Allan D., *et al*. "Increased exposure to loading is associated with decreased plantar soft tissue hardness in people with diabetes and neuropathy". *Diabetes Research and Clinical Practice* 187 (2022): 109865.

50. Frykberg RG., *et al*. "Diabetic foot disorders: a clinical practice guideline". *Journal of Foot and Ankle Surgery* 45.5 (2006): S1-S66.

51. Schaper NC., *et al*. "Practical guidelines on the prevention and management of diabetic foot disease (IWGDF guidelines)". *Diabetes/Metabolism Research and Reviews* 36.S1 (2020): e3266.

52. Edmonds M., *et al*. "Improved survival of the diabetic foot: the role of a specialized foot clinic". *QJM* 60.2 (2026): 763-771.

53. Iunes DH., *et al*. "Effects of a physical therapy program on the footprints and plantar pressure of diabetic neuropathy patients: a controlled clinical trial". *Journal of Physical Therapy Science* 26.8 (2014): 1027-1031.

54. Koltak C., *et al*. "Effects of different exercise programmes on ankle stiffness, muscle strength, and plantar pressure distribution in individuals with type 2 diabetes mellitus and peripheral neuropathy: a single-blind randomised controlled trial". *BMC Sports Science, Medicine and Rehabilitation* 18 (2026): 353.

55. Chatwin KE., *et al*. "An intelligent insole system with personalised digital feedback reduces foot pressures during daily life: an 18-month randomised controlled trial". *Diabetes Research and Clinical Practice* 181 (2021): 109091.

56. Sheikh MM., *et al*. "Predicting diabetic peripheral neuropathy through advanced plantar pressure analysis: a machine learning approach". *Scientific Report* 15 (2025): 20962.

57. Castro-Martins P., *et al*. "In-shoe plantar pressure measurement technologies for the diabetic foot: a systematic review". *Heliyon* 10.9 (2024): e29672.