

# **The Importance of Plantar Pressure Measurements and Appropriate Footwear for Diabetic Patients**

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## **Abstract.**

Diabetic Mellitus results from failure of the endocrine system to regulate blood glucose levels. Recent advances enable us to measure the pressures between the shoe or insole and the plantar foot during various activities. This was proven useful in the diagnosis and management of pressure related foot problems. Studies showed a nineteen percent (19%) recurrence rate of healed ulcer in patients using modified shoes and orthoses versus ninety percent (90%) in those using normal footwear.

This paper will look at the importance of plantar pressure measurements on prescription of appropriate footwear, the effect of proper footwear and insoles on dispersing the plantar pressure, and the footwear and insoles benefits in reducing the probability of occurrence of ulcer and the recurrence of healed ulcers.

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## **Introduction.**

Diabetic Mellitus affects approximately 15% of the population over the age of 65 in developed countries.<sup>(1)</sup> Twenty to fifty percent of people with diabetes of more than 10 years will experience symmetrical distal sensory neuropathy resulting in loss of sensation in lower extremity.<sup>(2)</sup> This will lead to weight bearing abnormality under the foot in the long run resulting in ulcerations.

Foot ulceration is the most common cause of amputation in diabetic patients.<sup>(3)</sup> Eighty five percent (85%) of diabetes related lower extremity amputations are preceded by ulceration. Increased dynamic foot pressures is among the identified risk factors in the formation of diabetic foot ulcer.<sup>(4-11)</sup> Foot related hospital admission constitutes twenty percent (20%) of all diabetic patients who enter the hospital. Foot care and patients shoe gear education are the initial standard treatment protocol for diabetic feet at risk.<sup>(12)</sup>

## **Plantar Pressure.**

Foot is the most frequent site of ulceration in individuals hospitalized for diabetes and infection. Table 1. shows the incidence and cost, and ulcers and amputations for diabetes related problems in the united states (USA).<sup>(13)</sup> Neuropathic plantar ulcerations result from repetitive stress over areas of high pressure associated with deformity or joint limitations.<sup>(14-18)</sup> Studies have also show that ulcers on the margin of the foot were do to abnormally high plantar pressure.<sup>(19)</sup>

Biomechanical measurements of pressure distribution concentrate on the pressures between the foot plantar surface (sole) and the supporting surface.<sup>(12)</sup> Various pressure systems are available for the measurements of the pressures inside the shoe or insole and the plantar foot during various activities. Such assessment has proven to be very useful in the diagnosis and management of pressure related foot problems.

Plantar pressure may or may not be influenced by some factors such as body weight, velocity, stride length, and shoe type and construction. However, there is no satisfactory association between body weight and plantar pressure found in literature.

**Table 1. Incidence and cost, and ulcers and amputations for diabetic related problems in the USA.**

Incidence and Cost	
<ul style="list-style-type: none"> <li>• Number of diabetic patients</li> <li>• Number of diabetic patients with foot problems related to the disease.</li> <li>• Number of new cases of diabetes</li> <li>• Diabetic hospital cost for diabetic foot infection.</li> <li>• Average length of stay in hospital.</li> <li>• Cost per hospitalization.</li> <li>• Cost of Amputation.</li> <li>• Admission due to foot problems.</li> </ul>	<p>12,000,000 (5%) 3,000,000</p> <p>600,000/year \$200,000,000/year</p> <p>22 weeks \$6,600 \$8,000-12,000 20% of all diabetic admission.</p>
Ulcers and Amputations.	
<ul style="list-style-type: none"> <li>• 3 years survival rate of diabetic patients with lower extremity amputation.</li> <li>• Reduction in amputation due to podiatric care and patient's education.</li> <li>• Reduction in amputation due to improvement of foot care.</li> <li>• Amputation in diabetic patients as a percentage of all non-traumatic amputations.</li> <li>• Amputations of admitted patients with infected ulcers.</li> </ul>	<p>50%</p> <p>50%</p> <p>50%</p> <p>50% - 70%</p> <p>80%</p>

**Proper Footwear and Insoles.**

Feet come in all sizes; the 26 bones in each foot do not fully set until the age of 18, and the shoe we wear, as children are vital to our future foot health. However, we can still damage our adult feet by wearing the wrong shoes.

It is important that diabetes get the right fit for their footwear, shoes that don't fit properly are the source of many foot problem. A proper shoe must be:

- Well fitting made of soft leather, with lace-up or Velcro fasteners which hold the foot firmly in place and prevent it from slipping forward, putting pressure on the toes.
- Wide and deep enough to accommodate the foot comfortably, without putting pressure on any part of it.
- The entire bottom of the shoe should be flat with a gentle slope upward under the toes.
- The main part of the shoe (upper) must be made of natural material, e.g. Leather.
- The lining (inside the shoe) must be smooth and without seams.

Shoe construction and materials are used to reduce the load on the foot during the roll-over process, e.g. special cushioning to decrease the impact during initial heel contact. Studies suggest that individuals with reduced plantar fat pad thickness are at a greater risk of overloading the foot during locomotion.

### **Samples of Proper Shoes.**



Ambulatory Biomechanical footwear limits stress at the foot most susceptible to pain with features such as bio-rocker soles and state of the art removable anti shocks orthotics. The bio rocker sole reduces the stress on the ball of the foot.



Urban walkers are a versatile, “off the shelf) shoe. Designed to ensure proper biomechanical support, they reduce shear force.



“Off the shelf” shoes designed to customize to the feet for comfort and protection. Recommended by foot health professionals for diabetes, arthritis, and forefoot disorders such as bunions and hammertoes. With plastazote foam lining and removable plastazote orthotics.

Insoles are designed with soft elastic materials, molded insoles and/or rigid rocker soles have been recommended to reduce pressure and prevent plantar ulceration in leprosy. <sup>(20-24)</sup> Studies showed that all footwear except the extra depth shoe without an insole had significantly lower peak pressures compared to barefoot walking. <sup>(25)</sup> A study conducted by James A. Bike and others on measuring pressure walking in footwear used in leprosy showed barefoot walking to have the highest pressure, and patients prescribed footwear to have the lowest pressure. <sup>(26)</sup> Table (2).

Thick insole was found to be most significantly associated with lower pressure. <sup>(26)</sup> There was no significant relationship between sole stiffness and peak pressure. <sup>(26)</sup> Studies showed extra depth shoes alone do not reduce foot plantar pressures unless they are used with insoles. <sup>(27)</sup>

Table 2. Comparison of mean peak walking pressure.

Footwear tested	Mean Peak Pressure (Kpa)
Barefoot.	1194.4
USA Extra depth without insole.	985.5
Sandal (handmade Mozambique) with insole.	840.7
USA Extra depth with a poron insoles.	645.2
Bombay (commercial sandal) with rubber insole.	594.3
Chinese (commercial china) tennis shoe with two rubber insoles	549.2
Bombay (commercial sandal) with rubber insole and metal stave for rigidity.	508.5
Patients prescribed.	359.5

Rigid insoles were found to help reduce areas of increased plantar pressures and increase total contact area.<sup>(12)</sup> More flexible sole shoes were found to have more decreased plantar pressure than the less flexible sole shoes.<sup>(12)</sup> Proper insoles are very important in restoring foot proper shape and function. Below is an example of low- flat, unsupported arch and ankle, compared to restored foot arch and properly supported ankle using appropriate insoles.





### **Improper Footwear.**

Badly fitting footwear can be damaging to feet, many adult foot problems are due to poorly fitting shoes. The following type of shoes is examples of shoes that should be avoided.

- Slip-on shoes. They will constrict the foot and cause it to slide forward and cramp the toes.
- Court shoes. They are low-fronted giving no support to the foot, narrow in the toe box.
- Sandals that that leave the toes exposed are high risk of injury.

### **Recurrence of Healed Ulcers.**

Studies showed a nineteen percent (19%) recurrence rate in patients with modified shoes and orthoses versus ninety percent (90%) in patients with normal footwear. Therefore, It is imperative that the patient be fitted for a pair of custom manufactured shoes and insoles once a wound healing is achieved to prevent recurrence of the ulceration after.

### **Conclusion.**

Proper footwear is very important for diabetic patients. It helps redistribute the pressure and reduce the chance of ulcer development. Patients prescribed shoes (custom designed) are the most appropriate one and were shown to reduce pressure tremendously. However, Extra depth

shoes should be prescribed with addition of insoles for pressure dispersment to achieve a plantar pressure reduction.

- Never walk barefoot, or wear sandals which leave the toes exposed, because of the risk of injury.
- Nine out of ten women are wearing shoes that are too small (American study). 70% of women are expected to have osteoarthritis problems in their feet after the age of 60. Since feet tend to spread out as we grow older, it is important that women get their feet measured.
- Fashion shoes are fine for special occasions but it is better you wear a more “foot friendly” shoe for regular everyday wear.



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