

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

Abstract

Diabetic Mellitus results from failure of the endocrine system to regulate blood glucose level, approximately 15% of the population over the age of 65 in developed countries are diagnosed with diabetes. The number of people with diabetes is expected to reach 228 million by 2025. Foot is the most frequent site of ulceration in individuals hospitalized for diabetes and infection. Neuropathic plantar ulcerations result from repetitive stress over areas of high pressure associated with deformity or joint limitations. 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.

Footwear contributes greatly to the pressure distribution on the plantar surface of the foot. Insoles and appropriate footwear were shown to reduce pressure and prevent plantar ulceration. Studies showed a recurrence rates for chronic wounds in adults to be between 13% and 83%. Studies showed a reduction in the recurrence rate of diabetic ulcer from 83% to 17% by using offloading technique using orthopedic shoe. Insoles were found to have significant impact on the plantar pressure distribution; they reduced the peak pressures, and maximized the contact area compared with shoe-only condition.

Plantar pressure measurements look at the pressure distribution between the foot plantar surface and the supporting surface. 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. This review article will look at the importance of plantar pressure measurements for identifying foot at risk of developing ulcer; it will also look at the role of plantar pressure measurements in assessing the effect of proper footwear and insoles in dispersing the plantar pressure on the plantar surface of the foot. Therefore, reducing the probability of occurrence of ulcer and the recurrence of healed ulcers.

Introduction

Diabetic Mellitus affects approximately 15% of the population over the age of 65 in developed countries [1]. However, the number of people with diabetes is expected to reach 228 million by 2025 [2]. 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 [3]. This will lead to weight bearing abnormality under the foot in the long run resulting in ulcerations.

The complications of foot ulcers in diabetic patients are a major cause of morbidity and mortality. Studies show 1% to 4% annual incidence of foot ulcers in population with 5% to 10% prevalence of diabetes [4]. Diabetic patients who undergo lower limb non traumatic amputation have mortality rate following amputation ranging from 39% to 80% at 5 years [4]. Foot ulceration is the most common cause of amputation in diabetic patients [5]. Eighty five percent (85%) of diabetes related lower extremity amputations are preceded by ulceration [6]. Increased dynamic foot pressures are among the identified risk factors in the formation of diabetic foot ulcer [7-14]. It is estimated that

15% of people with diabetes experience a foot ulcer during their life [15]. Foot care and patients education on footwear are the initial standard treatment protocol for diabetic feet at risk [16].

Plantar Pressure

Foot is the most frequent site of ulceration in individuals hospitalized for diabetes and infection. Neuropathic plantar ulcerations result from repetitive stress over areas of high pressure associated with deformity or joint limitations [17-21]. Studies have also shown that ulcers on the margin of the foot were due to abnormally high plantar pressure [22].

Biomechanical measurements of pressure distribution concentrate on the pressures between the foot plantar surface (sole) and the supporting surface [16] they are useful for assessing the pathomechanics of foot. Plantar callus can cause increase in the plantar pressure by 30% [23]. Various pressure systems are available for the measurements of the pressures inside the shoe (pressure between 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

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problems. Plantar pressure may or may not be influenced by some factors such as body weight, velocity, stride length, and shoe type and construction.

Footwear and Insoles

Diabetic patients with neuropath have higher risk of developing ulcer specially when using ill-fitting shoes because of loss of sensory feedback [24]. This highlights the importance of choosing the appropriate and well-fitting shoes. Shoes must be well fitting, with lace-up or Velcro fasteners in order to hold the foot and prevent it from slipping forward which may risk putting pressure on the toes. They must be wide and deep enough to accommodate the foot comfortably, without subjecting any part of the foot to unnecessary pressure; the bottom of the shoe should be flat with a gentle slope upward under the toes and heel (rocker bottom). It is important that the lining (inside the shoe) be smooth and without seems. A rocker-bottom shoe has been shown to reduce the pressure on the feet; it enhances the normal heel-to-toe rolling motion [24]. A study showed rocker bottom shoes to achieve a 35-65% reduction in the dynamic plantar pressure of the heel and central metatarsal heads of diabetic patients with neuropathy [25]. Examples of different type of shoes are shown in Figures 1-3 Ambulatory biomechanical shoes, urban walker shoes, and off the shelf shoes.



Figure 3: Off the Shelf Footwear.

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 [26-30]. Studies showed that all footwear except the extra depth shoe without an insole had significantly lower peak pressures compared to barefoot walking [31]. A study conducted by James A. Bike and others on comparing the plantar pressure in leprosy patients while walking barefoot with that when walking using 6 types of footwear and patient prescribed footwear, barefoot walking have the highest pressure (1194.4 Kpa), and walking using footwear have lower pressure ranging from 985.5 to 359.5 Kpa, with the patient prescribed footwear having the lowest plantar pressure (359.5 Kpa) [32]. Thick insoles were found to be most significantly associated with lower pressure [31]. There was no significant relationship between sole stiffness and peak pressure [32]. Studies showed extra depth shoes alone do not reduce foot plantar pressures unless they are used with insoles [33]. A study conducted by Saleh S. Altayyar on the impact of custom made insoles on the plantar pressure of diabetic foot showed a significant reduction in the planar pressure when walking using custom made insoles compared to that when walking barefoot, the reduction was 84.7% and 84.5% for female subjects right and left foot respectively, and 77.6% and 76.5% for male subjects right and left foot respectively [34].

Rigid insoles were found to help reduce areas of increased plantar pressures and increase total contact area [16]. More flexible sole shoes were found to have more decreased plantar pressure than the less flexible sole shoes [16]. Proper insoles are very important in restoring foot proper shape and function. Example of low- flat, unsupported arch and ankle, compared to restored foot arch and properly supported ankle using appropriate insoles are shown in Figure 4a & 4b respectively.

Ulcers

It is estimated that 15% of diabetic patients will develop a foot ulcer [35]. The recurrence rates for chronic wounds in adults is estimated between 13% and 83% [36-39], Insoles were found to have significant impact on the plantar pressure distribution, they reduced the local peak pressures, and maximized the contact



Figure 1: Ambulatory Biomechanical Footwear.



Figure 2: Urban Walker Footwear.

area compared with shoe-only condition [40]. A study showed a reduction in the recurrence rate of diabetic ulcer from 83% to 17% by offloading technique using orthopedic shoes [41]. Therefore, it is imperative that the patient be fitted for a pair of custom manufactured insoles and shoes once a wound healing is achieved to prevent recurrence of the ulceration after.



Figure 4a: low - flat unsupported arch and ankle.



Figure 4b: Restored foot arch and properly supported ankle.

Conclusion

The shoes we wear are very important for the health of our feet. However, they are very critical for diabetic patient's health. Proper footwear is very important for diabetic patients. It helps redistribute the pressure and reduce the risk of ulcer development and the recurrence of healed ulcer. Patients prescribed insoles (custom designed) are the most appropriate insoles and were shown to have significant reduction in the plantar pressure. Diabetic patient should be advised to never walk barefoot, or wear sandals which leave the toes exposed, because of the risk of injury. Women are advised to wear a more "foot friendly" shoes for regular everyday wear, and limit the use of fashion shoes to special occasions. It is highly recommended that diabetic patients plantar pressure be assessed in order to provide them with the most appropriate footwear for their condition to reduce the risk ulceration and / or recurrence of healed ulcer.

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