

Chapter 19

Biomechanical Properties of the Foot Sole in Diabetic Mellitus Patients: A Preliminary Study to Understand Ulcer Formation

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ABSTRACT

This article evaluates and quantifies the biomechanical properties of the foot sole like – loss of protective sensation, hardness of the foot sole and pressure distribution parameter called Power ratio (PR) and its alterations, which have a direct effect on ulcer formation. A new parameter PRS Index is developed to understand the interplay between these parameters and its role in ulcer formation. All diabetic subjects attending the Diabetic foot clinic from Dec2003 to June 2007 undergo a standard foot examination. A total of 652 diabetic patients including 57 ulcer patients are taken for our study. The biomechanical properties include loss of protective sensation (LOPS) which is measured by 10 gm Semmes Weinstein Monofilament (SWMF). Hardness of the foot sole or absence of suppleness is tested using the Durometer (ASTM-D 2240 standards). Plantar pressure measurement is done using the PodoPowerGraph^(p) which measures pressure distribution parameter PR. Foot wear properties like hardness of the insole affecting the formation of plantar ulcers was also measured. The above mentioned important parameters can be measured objectively and calculate PRS index value for diabetic with history of previous ulcer patients. We found a single entity of either the PR or shore independently cannot predict the risk for ulcer formation. In this study we found new PRS index value for diabetic with history of previous ulcer patients show

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significant correlation (i.e. $p < 0.05$ level) between footwear shore and PRS index for history of previous ulcer patients. No significant correlation was shown for diabetic without history of previous ulcer patients and this may be due to diabetic patients are wearing footwear randomly with different degree Shore. From the case studies we found that the PRS index values and other biomechanical parameter of the foot sole can be reversed if the patients wear proper MCR footwear with 20 degree Shore. Use of appropriate footwear has shown that these easily measurable parameters and thus prevent ulcer formation as mentioned in the earlier studies. Several methods are used previously for predicting ulceration in DM patients. But in this study the new index PRS was studied and its role in predicting ulceration. Use of appropriate footwear will reverse the hypertrophic response; this can be quantified by the PRS index. We have found that there is decrease in PRS index by proper off loading the pressure using 20-degree shore MCR footwear.

INTRODUCTION

Diabetes mellitus (DM) is recognised as a major health problem in India. Diabetic foot ulceration is one of the well-recognised long-term sequels among 15% of diabetic patients (Pecoraro, Reiber, & Burgess, 1990). Neuropathy is the precursor of ulceration in all cases and this induces changes in the biomechanical properties of the foot sole (Thomas, Patil, Radhakrishnan, Murthy, & Parivalavan, 2003). Ulceration in the foot in diabetic patients is a constant risk factor in infected foot. A lot of protocols are available for detecting the foot at risk. Plantar pressure, hardness of the foot sole and footwear (Thomas, Patil, Radhakrishnan, Murthy, & Parivalavan, 2003; Charanya, Patil, Narayanamurthy, Parivalavan, & Visvanathan, 2004), which may have a predictive value in detecting foot at risk of ulceration. Loss of protective sensation (LOPS) to 10gm Semmes Weinstein monofilament (SWMF) has been recognised as a very well known parameter to detect the foot at risk (Bell-Krotoski, Weinstein, & Weinstein, 1993; Weinstein, 1993). However this only divides the diabetic population into two groups – those having sensation and those who do not have sensation to 10gm SWMF who have higher risk of development of ulcer formation. It does not detect the subgroup that will develop ulceration. Elevated plantar pressures have been known to be another cause of plantar ulceration. There is no absolute threshold pressure, as ulcers develop (Boulton et al., 1985; Cavanagh, Simoneau, & Ulbrecht, 1993) even below the accepted high level of peak plantar pressures. Only peak pressures have been considered in all the pressure measuring equipments (Wertsch et al., 1992), which measure foot pressure using discrete transducers. These have a 33% margin of error due to the use of discrete transducers having low spatial resolution of the pressure measurement (Lord, Hosein, & Williams, 1992). Therefore in this investigation, foot pressure distribution is recorded using PodoPowerGraph^(P) system based on optical Pedobarograph principle having high spatial resolution of pressure measured using a new parameter PR. The new parameter PR measures the standing plantar pressure distribution in both the feet simultaneously. This is a more accurate method of measuring the foot pressure, because this method involves the measurement of foot pressure using PodoPowerGraph and calculating foot pressure parameter PR using actual foot pressure distribution rather than using only peak pressure. Hardness of the sole of the foot measured by Durometer

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