RELATIONSHIP BETWEEN PRESSURE AND SHEAR UNDER THE FOOT

Z. M. Hasasneh, MS[1, 2], S. C. Sibole[1, 3], B. L. Davis, PhD[1]

1. Department of Biomedical Engineering, The Cleveland Clinic Foundation, Cleveland, OH 44195.
2. Department of Chemical and Biomedical Engineering, Cleveland State University, Cleveland, OH
3. Department of Biomedical Engineering, University of Akron, Akron, OH

INTRODUCTION

Skin ulceration of diabetic feet is a problem that has major repercussions to both the patient and the health care system. It is generally agreed that non-mechanical factors such as peripheral neuropathy, dry skin and/or vascular problems are often major contributing causes. However, current opinion is divided as to the principal *mechanical* factors leading to ulcer formation. Possible contributors to the formation of an ulcer are localized pressures and shear stresses. The purpose of this study was to examine the relationship between pressure and shear stresses under the forefoot of non-diabetic subjects.

METHODS

The method for examination of this relationship consisted of two parts. Part one required collection of pressure and shear data for 10 non-diabetic subjects. A shear and pressure measurement device (Figure 1) employing an array of 80 force transducers (cross-sectional area of 1.61 cm^2) was used to collect data for 5 males and 5 females with a mean age of 24 years old.

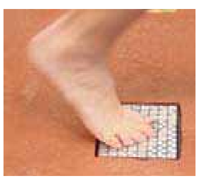

Figure 1: Subject walking on a shear and pressure device.

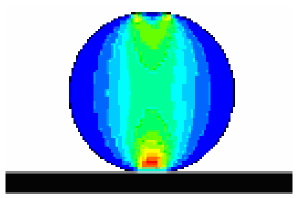

Figure 2: Finite element model of two surfaces in contact.

Data collection consisted of one trial for each subject, in which the subject walked in a straight line and had the right forefoot land on the shear and pressure device. Data were collected at 50Hz for 2 seconds. The data were processed using Matlab programs to convert the voltages into forces [1] followed by low pass filtering (Butterworth filter). Part two consisted of creating a plane-strain finite element model of a hyperelastic ball in contact with a rigid plate (Figure 2) to study the relationship between pressure and shear.

RESULTS AND DISCUSSION

By obtaining the first time derivative of the pressure data, one can not only find the peak pressure in time, but can also gain some insight into the shear behavior (Figure 3). Based on this study's results, the instant of maximum pressure was very close to the instant of maximum shear (Figures 4, 5). Plotting the shear vs. derivative of pressure for all 10 subjects showed the best-fit lines to have similar slopes between -.014 and -0.022 which indicates a good correlation between shear and derivative of pressure (Figure 6). The shear and pressure curves gathered from the finite element model had similar behavior when taking the pressure derivative with respect to position (Figure 7).

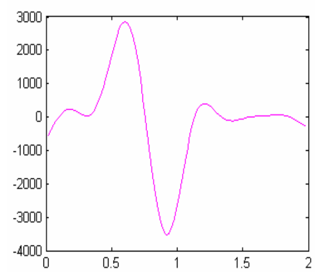

Figure 3: Pressure derivative.

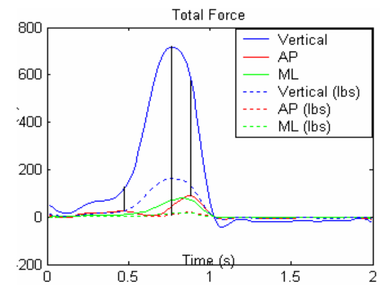

Figure 4: Pressure & shear.

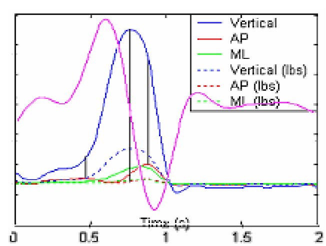

Figure 5: Derivative of pressure overlapping figure 4

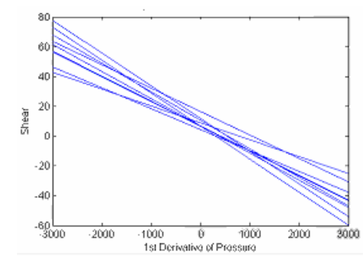

Figure 6: Best fit line of shear vs. derivative of pressure for 10 subjects.

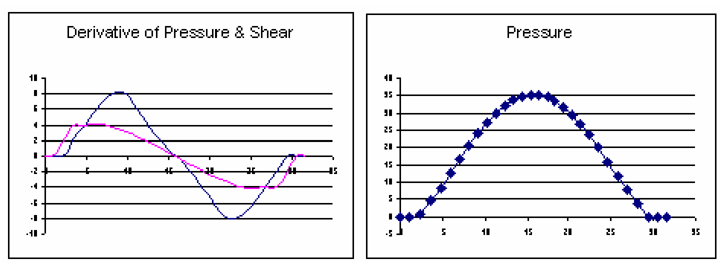

Figure 7: Pressure, derivative of pressure and shear plots of the FEM data.

CONCLUSION

One can hypothesize that maximum shear forces occur at the time and location of peak pressures, however, difficulties in shear measurement impede validation. Based on the results of these trials for control subjects, peak shear position and timing corresponded well with the derivative of pressure. Therefore, through measurement of the pressures, approximate assumptions about the shear behavior can be made.

ACKNOWLEDGMENT

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REFERENCES

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