HEEL INTERFACE PRESSURE: FOOT-LEG GEOMETRIC CONSIDERATIONS
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ABSTRACT
Pressure ulcer due to sustained unrelieved or inadequately relieved pressure, are an important clinical, humanitarian and economic problem.1,2 Pressure dependent blood flow changes play a major role in the skin breakdown process with the greatest breakdown frequency at sites of bony prominences. The heel is particularly prone to such effects3, in part because of its relatively lower resting blood perfusion level5, and higher amounts of experienced surface pressure when under load6-9. Local blood flow decreases during heel loading5 and limitations of flow recovery after unloading are involved in the breakdown process10,11. Heel ulcers remain a major clinical problem and methods to lessen their occurrence are continuously being sought. The present findings emphasize the large magnitude of the pressure that may be experienced at the heel, frequently exceeding the patient’s blood pressure, not only at the capillary level but also at the artery level. At these interface pressures there is little doubt that circulation to the loaded parts of the heel is compromised. Since the blood flow decrement is not a linear function of the interface pressure, a reduction of the magnitude of sustained interface pressure is likely to have a positive benefit.

The new finding of this research is that the magnitude of the interface pressure is in part dependent on geometric features of the person’s foot and leg. From a physical point of view, this dependency appears to arise from a concentration of pressure toward the posterior heel in those persons with a thinner calf, longer extension of the below-knee length and combinations of thin long legs with exaggerated heel posterior protuberance dimensions.

REFERENCES

METHODS AND RESULTS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>41.1</td>
<td>20.3</td>
<td>21.0</td>
<td>81.0</td>
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<tr>
<td>Height (cm)</td>
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<td>8.3</td>
<td>157.5</td>
<td>190.5</td>
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<td>Weight (kg)</td>
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<td>14.1</td>
<td>102.0</td>
<td>108.0</td>
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<td>BMI (kg/m²)</td>
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<td>6.6</td>
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<tr>
<td>C (cm)</td>
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<td>4.14</td>
<td>30.0</td>
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<tr>
<td>H/C</td>
<td>0.19</td>
<td>0.04</td>
<td>0.12</td>
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<tr>
<td>L (cm)</td>
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<td>3.1</td>
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<tr>
<td>H/C x Len</td>
<td>1.25</td>
<td>0.25</td>
<td>1.00</td>
<td>1.50</td>
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<tr>
<td>FF = (H/C) x (Length/Height)</td>
<td>0.80</td>
<td>0.08</td>
<td>0.60</td>
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Figure 1
Subject lying on support surface
Pressure sensor under heel
Geometric Form Factor (FF)
Below-Knee Length
Maximum Circumference
Interface Pressure / Diastolic Pressure

Table 1. Data Summary

Figure 2

DISCUSSION AND CONCLUSIONS

Pressure ulcers due to sustained unrelieved or inadequately relieved pressure, are an important clinical, humanitarian and economic problem.1,2 Pressure dependent blood flow changes play a major role in the skin breakdown process with the greatest breakdown frequency at sites of bony prominences. The heel is particularly prone to such effects3, in part because of its relatively lower resting blood perfusion level5, and higher amounts of experienced surface pressure when under load6-9. Local blood flow decreases during heel loading5 and limitations of flow recovery after unloading are involved in the breakdown process10,11. Heel ulcers remain a major clinical problem and methods to lessen their occurrence are continuously being sought. The present findings emphasize the large magnitude of the pressure that may be experienced at the heel, frequently exceeding the patient’s blood pressure, not only at the capillary level but also at the artery level. At these interface pressures there is little doubt that circulation to the loaded parts of the heel is compromised. Since the blood flow decrement is not a linear function of the interface pressure, a reduction of the magnitude of sustained interface pressure is likely to have a positive benefit.

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Figure 3
Mean = 130.4
R² = 0.15
Interface Pressure (mmHg)
Number of Cases
Figure 4
Mean = 120.4
R² = 0.15
Number of Cases
Interface Pressure / Diastolic Pressure

Figure 5
IP=60.3 + 130.4 x FF
R²=0.15, P=0.05
Mean = 0.0470
SD =0.0094

Figure 6
Form Factor (H/C x Length/Height)
Interface Pressure (mmHg)