HEEL INTERFACE PRESSURE: FOOT-LEG GEOMETRIC CONSIDERATIONS

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ABSTRACT

Interface pressure (IP) between heel and support surface is one risk factor for developing pressure ulcers. Most emphasis is on support surface properties whereas geometric aspects of the leg-foot structure have received little attention. We hypothesized that certain geometric factors may predispose to higher IPs. To preliminarily test this concept, heel IP was measured in 30 volunteers (14 male) who were lying supine with one heel on a standardized support with an internally controlled uniform inflation pressure (*Figure 1*). Subjects spanned a wide range of ages, weights, heights, and BMI (*Table 1*).

A dimensionless form factor, FF (*Figure 2*), thought to be related to IP was defined as the product of two ratios; (malleolus-heel distance/ maximum calf circumference) x (lower leg length/subject height). The distribution of IP (*Figure 3*) and its relationship to diastolic pressure (*Figure 4*) were examined and regression analysis (*Figure 5*) was used to test for an association between IP and FF.

Results showed a statistically significant (p=0.03, R^2=0.15) direct relationship, indicating that about 15% of the variability in IP is explainable based on these geometric factors. Although further study, using additional measures is needed, these pilot findings suggest some additional risk associated with the combination of thin long legs with exaggerated heel posterior protuberance dimensions.

METHODS AND RESULTS

Figure 1

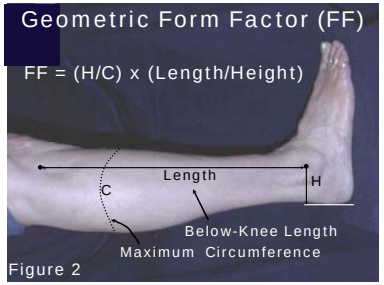
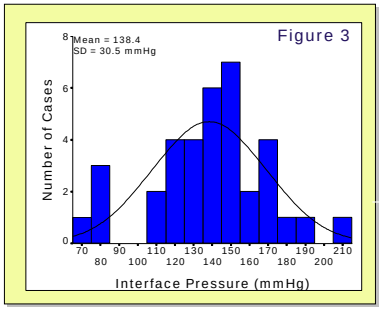
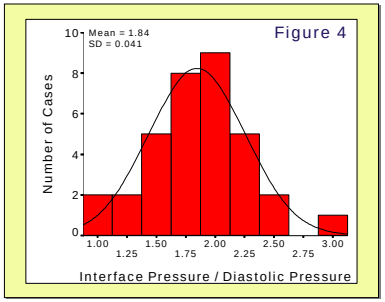


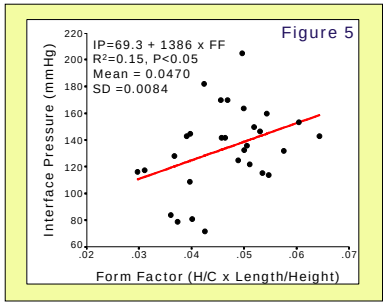
Figure 2

Table 1. Data Summary

PARAMETER	Mean	SD	Min	Max
Age (yrs)	41.1	20.3	21.0	81.0
Height (cm)	170.6	8.3	157.5	190.5
Weight (kg)	78.0	22.2	45.1	139.6
BMI (kg/m^2)	26.6	6.6	17.0	46.8
H (cm)	7.06	1.26	4.5	10.0
C (cm)	37.3	4.14	30.0	47.0
H/C	0.19	0.04	0.12	0.26
L (cm)	41.8	3.1	36.0	47.0
H/L	0.17	0.03	0.10	0.23
L/Height	0.24	.013	0.21	0.27
Pressures (mmHg)				
BP Diastolic	76.3	8.1	58.0	90.0
BP Systolic	124.3	16.9	105.0	168.0
BP Mean	92.5	9.3	75.0	111.7
Interface	138.4	30.5	72.0	205.0







DISCUSSION AND CONCLUSIONS

Pressure ulcers due to sustained unrelieved or inadequately relieved pressure, are an important clinical, humanitarian and economic problem.[1-3] 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 effects[4], in part because of its relatively lower resting blood perfusion level[5], and higher amounts of experienced surface pressure when under load[6-9]. Local blood flow decreases during heel loading[5] and limitations of flow recovery after unloading are involved in the breakdown process[10-12]. 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 pressure that may be experienced at the heel, frequently exceeding the patient's blood pressure, not only at capillary level but also at 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 posterior protuberance, and longer lower leg length in relation to their height. The form factor that was developed takes these factors into account as ratios and appears to account for about 15% of the variability of the interface pressure. Although this may appear to be a small component of the overall interface pressure, it may be a decisive factor in patients with other co-present risk factors[13]. In any case, consideration of foot-leg geometry in patients at risk for heel ulcers is a prudent part of an initial patient evaluation.

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