EFFECT OF DIFFERENT TEMPORAL HEEL SUPPORT PATTERNS ON SKIN BLOOD PERFUSION

HN Mayrovitz, L Dribin, N Sims, College of Medical Sciences, NSU, Ft. Lauderdale, Florida

ABSTRACT

OBJECTIVE: It was hypothesized that a balance between pressurization and pressure-relief heel-support durations might minimize impacts of flow deficits during pressurization. Since this possibility depends on if pressure-relief hyperemia adequately compensates for prior intervals of flow deprivation, the main objective was to determine how different temporal patterns of heel pressurization and relief actually affect average skin blood perfusion (SBF).
DESIGN: SBF (laser-Doppler) was measured in heels of 20 healthy subjects laying supine for 80 minutes on a support surface. The cell supporting the heel had three different cyclical patterns of pressurization and pressure-relief levels (full or partial). Each pattern (1,2 or 4-cycles) was in contiguous 20-minute intervals. In two protocols of 10 subjects each, SBF was determined during full pressurization, and during pressure-relief. The main outcome measure was average SBF in relation to baseline SBF.
RESULTS: The main findings show that full pressure-relief yields a significantly greater SBF than partial relief. However, whether full or partial, average SBF of all cycle patterns were greater than baseline.
CONCLUSIONS: A cyclic pressure-relief that results in average heel SBF greater than resting baseline is consistent with the proposed hypothesis. In the healthy subjects studied this occurs because the hyperemia during pressure-relief more than compensates for flow deficits during pressurization. The results are applicable when a normal physiological hyperemic response capability is present. Impacts of diminished hyperemic reserve is the next major investigative challenge.

METHODS

SUBJECTS: Twenty volunteers were tested. None had lower extremity vascular disease nor took medications that would impact on vascular reactivity. They were randomly divided into Groups A and B according to the support pattern protocol they received as described below. For groups A and B respectively there were no significant differences in age (29.8±1.7 vs. 31.3±3.5 years), height (66.7±0.8 vs. 67.0±1.1 inches) or weight (140±30 vs. 140±26 pounds).

PROTOCOL: Subjects lay on a support surface with heels on the end cell (figure 1), which could alternate pressure between upper-lower limits on a cyclic basis under computer control. The dynamic patterns tested had three distinct sequential 20-minute intervals in which either one, two or four full cycles were applied (figure 2). In group A (N=10), the cell's internal pressure cycled from 20 mmHg to 0 mmHg. In group B (N=10), cell pressure cycled from 20 mmHg to 10 mmHg.

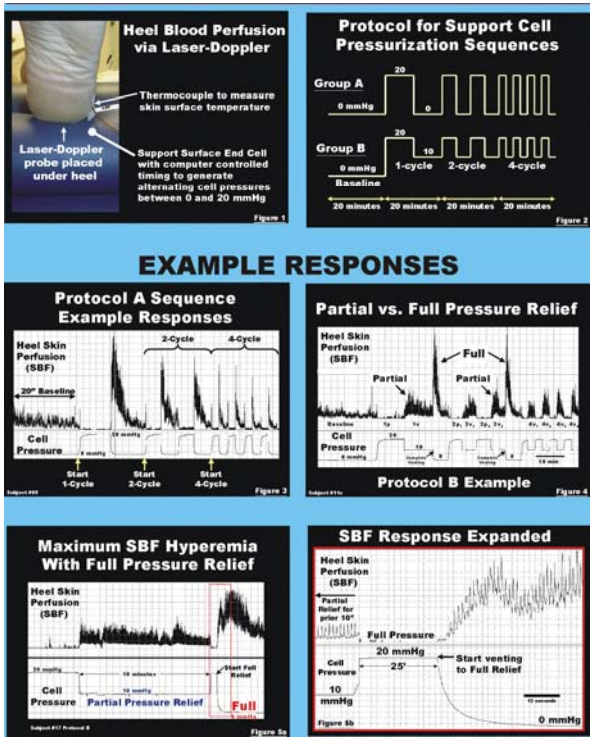
METHODS (CONTINUED)

The half cycle length for 1, 2 & 4 cycles was 10, 5 & 2.5 minutes respectively. The sequence of the cyclic pattern was 4-2-1 cycles in half the subjects and 1-2-4 cycles in the other half in each group. The 1ST pattern was initiated after a baseline interval of 20 minutes in which the heel was unloaded (0 mmHg).

INTERFACE PRESSURE: At the end of the 80-minute sequence, heel interface pressures were measured with a sensor that was placed between the heel and the supporting cell. Cells were pressurized to levels used during the test-sequence. Six measurements of IP were made on each subject at 20 mmHg cell pressure and six measurements were made with the cell at 10 mmHg for group B subjects.

ASSESSMENT PARAMETERS AND DATA ANALYSIS

The main comparison parameter was average SBF during each 20-minute interval in relation to the baseline average SBF. For cyclic support intervals, average SBF was determined for each cycle by summing average SBF during maximum and minimum pressure phases. For two and four cycle patterns, average SBF in each cycle was used to characterize each patterns overall average. SBF in each cycle interval was compared with baseline SBF via the ratio SBFr = (SBFj/SBFbase) in which j =1-3 and corresponds to the 1, 2 and 4 cycle pattern intervals.



RESULTS

Interface Pressures: At a 20 mmHg cell pressure, IP ranged between 55-147 mmHg, (92±5 mmHg, N=20). Group B IP was significantly less than for group A (81.8±4.6 vs. 101.2±7.4, p=0.016 Mann-Whitney). For a cell pressure of 10 mmHg (group B only), IP ranged from 35-74 mmHg with a mean (48±4 mmHg, N=10). This was about half of that at a cell pressure of 20 mmHg. For group A (but not group B) there was a significant (p<0.01) correlation between IP and subject height (r=0.775) and weight (r=0.765). For group B there was a similar tendency for IP, but it was not significant. In spite of these variations there was no overall correlation between IP and SBF responses for any support cycle or patterns.

Typical SBF Responses: Cell pressurization caused a decrease in SBF and pressure relief resulted in an hyperemic response (figure 3). The amount of increase in SBF depended on whether the release was full (to 0 mmHg) as in protocol A or partial (to 10 mmHg) as in protocol B (figure 4). Release to 0 mmHg was associated with a greater hyperemic response (figures 5a and 5b).

SBF During Full Pressurization

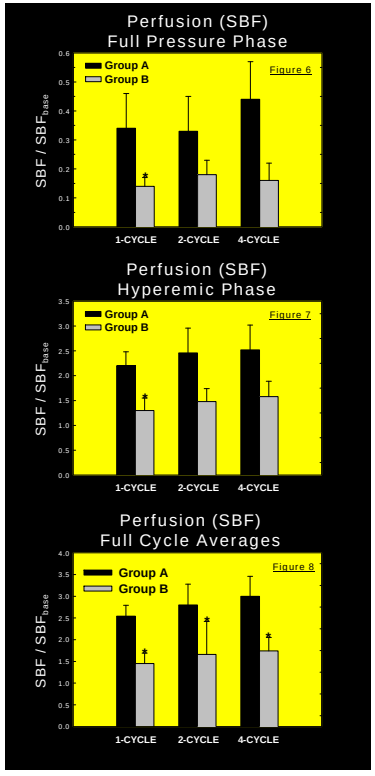
Pressurizing the support cell to 20 mmHg resulted in a decrease in heel SBF to a level that ranged from 0.12 ⍰ 0.05 to 0.44 ⍰ 0.13 of baseline (figure 6). Although group A and B subjects were exposed to equal cell pressures, the mean decrease observed in group B was larger, although only for the 1-cycle pattern was the difference statistically significant (p=0.028, Mann-Whitney test). The greater
SBF reduction can not be explained by differences in interface pressure since SBF of group B was significantly less than for group A.

SBF During Pressure Release

Reduction in cell pressure resulted in a hyperemic response relative to the average SBF during baseline (figure 7). For 1-cycle patterns, the relative hyperemia was significantly less for group B partial-releases (1.3 ⍰ 0.25) than for group A full-releases (2.2⍰0.28, p=0.03). For 2-and 4-cycle patterns, group A vs. B differences were similarly present, but neither difference quite attained statistical significance.

SBF During Full Cycles

Average SBF for each entire cycled test interval (pressurization+relief) was greater than SBF during baseline for all cycle patterns of each protocol (figure 8). However, the values were uniformly lower for group B in comparison to group A. Based on analysis of variance, an overall statistically significant difference between groups was detected. The associated p-values for 1, 2 and 4-cycle patterns were 0.005, 0.049 and 0.042 respectively.
Examination of within group effects using general linear manova analysis for repeated measures indicates no significant differences among cycle patterns detectible for either group A or B. However, nonparametric comparisons between 1-cycle and 4-cycle intervals indicate a near significant difference (p=0.074, Wilcoxon signed ranks) for group B.



CONCLUSIONS

- This investigation of the effects of various cyclical alternating pressure patterns for supporting the heel has demonstrated clear differences between full and partial pressure-relief approaches
- The full relief approach results in an average heel blood perfusion that is actually greater than that during resting baseline. This increase arises because the hyperemic response during the relief phase more than compensates for the flow deficit during heel loading.
- Partial relief blunts this normal response causing less hyperemia, but still results in an average perfusion that exceeds baseline.
- No specific cycle length tested showed a significant advantage with respect to achieving a higher relative perfusion. The slight upward trend in relative perfusion from 1-through 4-cycle patterns suggest a benefit for the 4-cycle approach, but this is not supported by adequate statistical evidence as yet.
- The results are strictly applicable when a normal physiological hyperemic response capability is present. It is unknown what impact depressed vascular responsiveness and/or diminished hyperemic reserve would have on the blood perfusion findings.

This issue represents the next major investigative challenge

Dr. Mayrovitz welcomes comments and queries. He may be contacted at: mayrovit@nova.edu