SACRAL SKIN BLOOD PERFUSION IN RELATION TO OTHER POSTERIOR AND REMOTE SITES

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INTRODUCTION

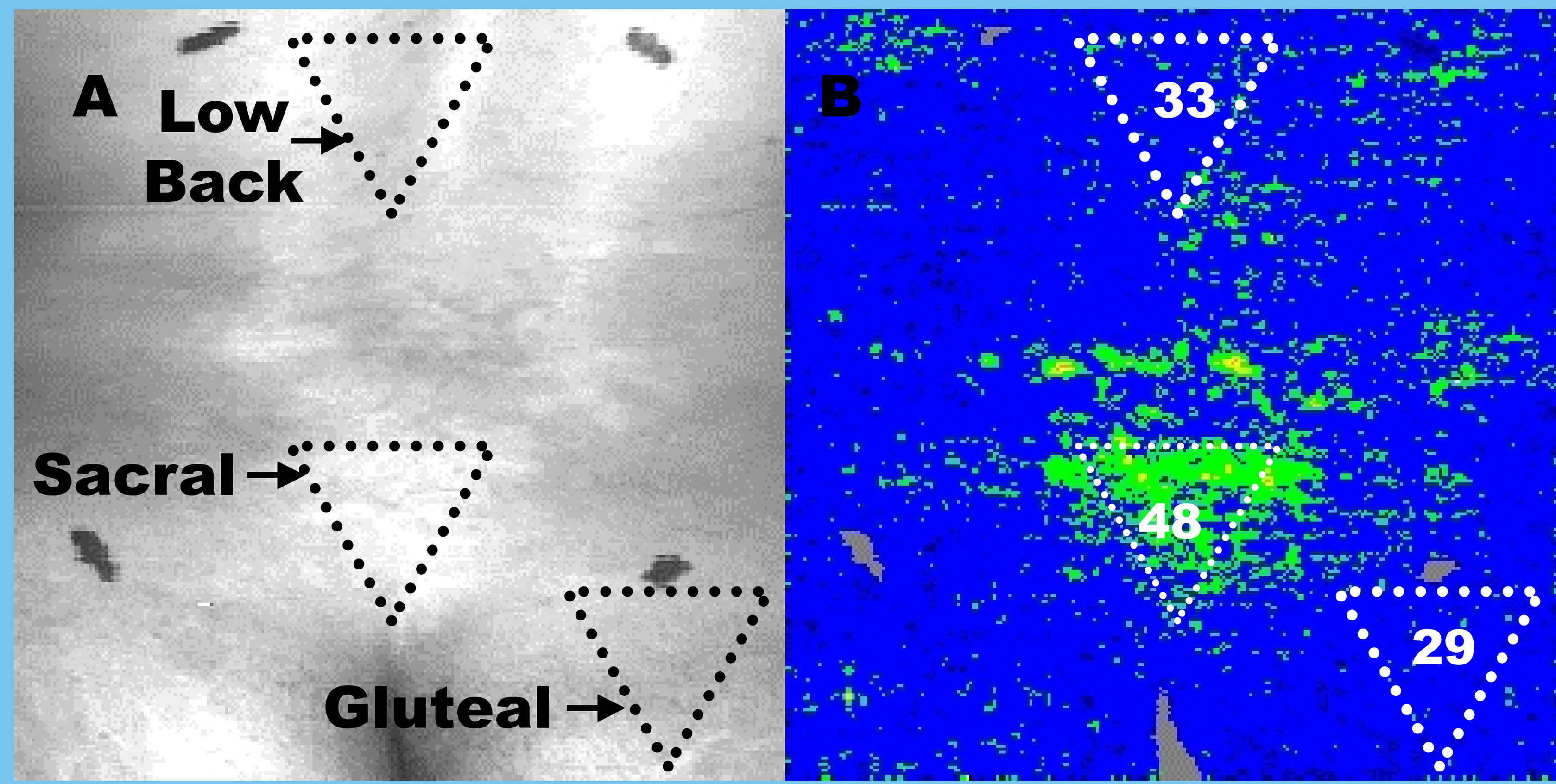
It is well known that certain sites of bony prominence are at particular risk of skin breakdown and pressure ulcer development as compared with soft tissue sites under similar loading conditions. Pressure sores occur over the sacrum but are rare over the gluteus maximus.[1] This predilection is in part explainable by pressure concentration and other mechanical effects on tissue overlying bone. However, differences in response to short term pressure loading of skin, overlying sacrum and gluteus regions, have been reported[2]. A possible contributing factor is that tissue sites with greater resting levels of blood flow might be at greater risk of breakdown when weighted to levels that significantly decrease blood flow. This hypothesis is based on the concept that for equal loading durations, tissue "flow-debt" and therefore injury potential, would be greater in more highly perfused tissue. The validity of this hypothesis depends in part on whether breakdown prone regions do in fact tend to have greater resting perfusion than in nearby surrounding regions. Data describing resting blood flow in the breakdown prone sacral region is scarce and have been based on single point laser-Doppler[3-5]. The combination of the small sample size and small tissue sampling area of single point laser-Doppler (~ 1 mm^2) used in these studies, may have obscured the presence of true differences in SBF between these sites. Thus, as a first step to systematically investigate the relative resting blood perfusion levels in ulcer prone vs. nearby less-at-risk tissue, we have employed laser Doppler imaging[6-13] to measure skin blood perfusion (SBF) within the ulcer prone sacral region, other nearby less-at-risk-tissue and remote sites for comparison.

METHODS

Thirty subjects (15) male with an age range of 21-56 years participated. No subject reported a history of cardiac or vascular disease and none had a history of diabetes mellitus. In all 30 subjects the lower back, sacrum and gluteus maximus areas were scanned with laser Doppler imaging (LDI), which yields both image and quantitative information on skin blood perfusion (SBF). All laser Doppler images were obtained with subjects in a prone position on an examining table using a 633 nanometer wavelength instrument (Moor Instruments, model LDI-VR), which was positioned at a 50 cm vertical distance above the sacral area. The scan pattern was rectangular (19 cm x 24 cm) with a total scan area of 456 cm^2. The scan was started after the subject had been resting in the prone position for about 15 minutes and each scan took approximately four minutes to complete. Skin temperatures were recorded at the mid-sacrum, gluteus maximus and lower back near on the midline at the level of L2 using a small thermocouple thermometer. In addition to the single baseline back scans, a second scan was done in 13 of the subjects after heating the mid-sacral area with a 1.9 cm diameter contact heater raised to a set temperature of 44°C for five minutes. In eight other subjects, the dorsal surface of the dominant hand was scanned immediately after the back scan. Six of the 30 subjects were re-scanned six weeks after initial back scans.

RESULTS

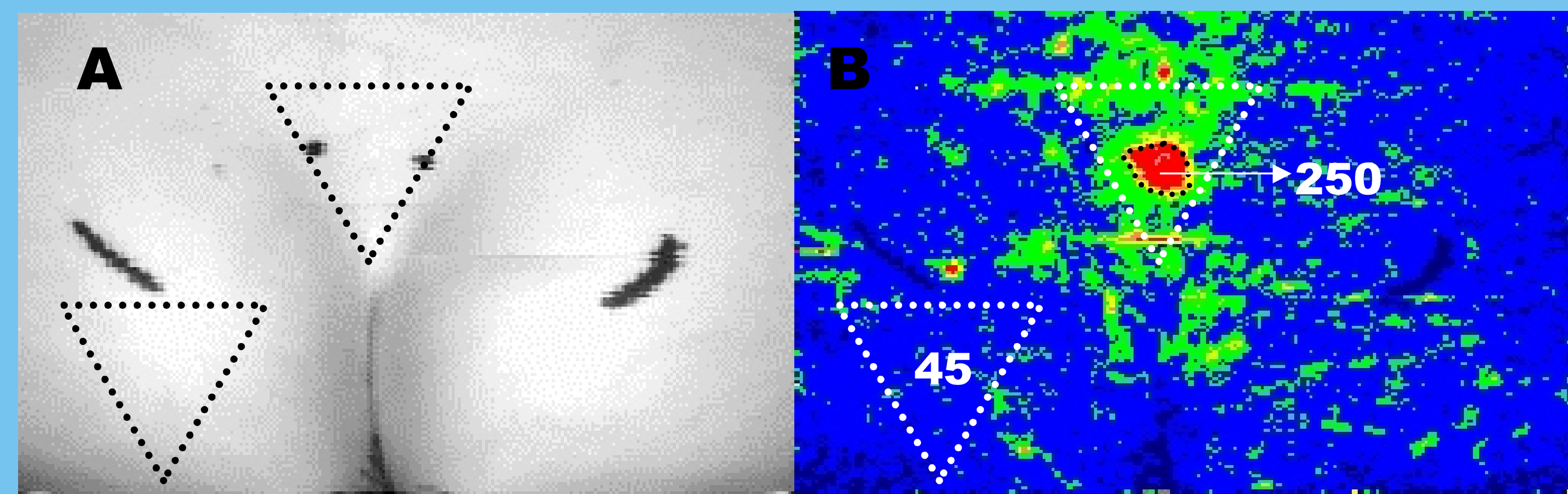
Scan Sites and Sample Perfusion Images



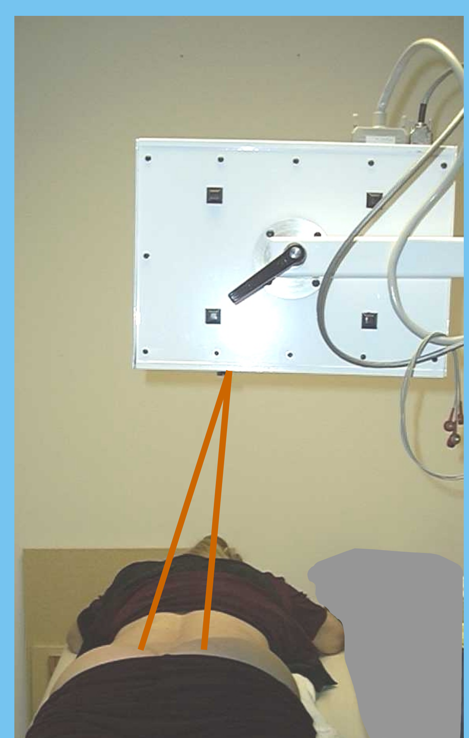
Standardized posterior regions were used

Numbers are mean blood perfusion in target areas

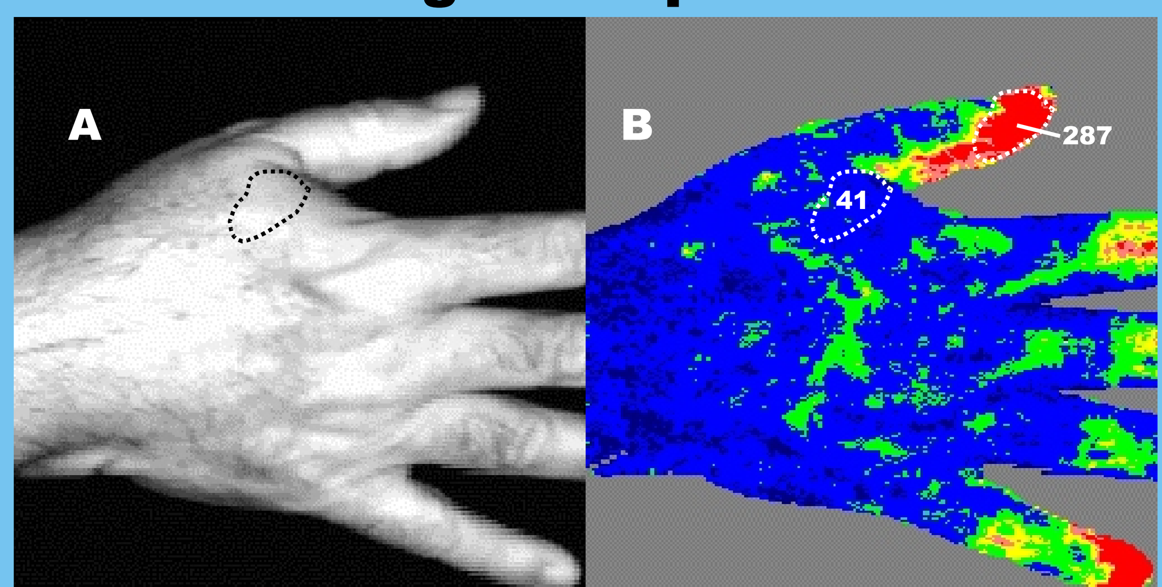
Heat Procedure and Example Scan



Central region of sacrum is heated to 44°C and scanned

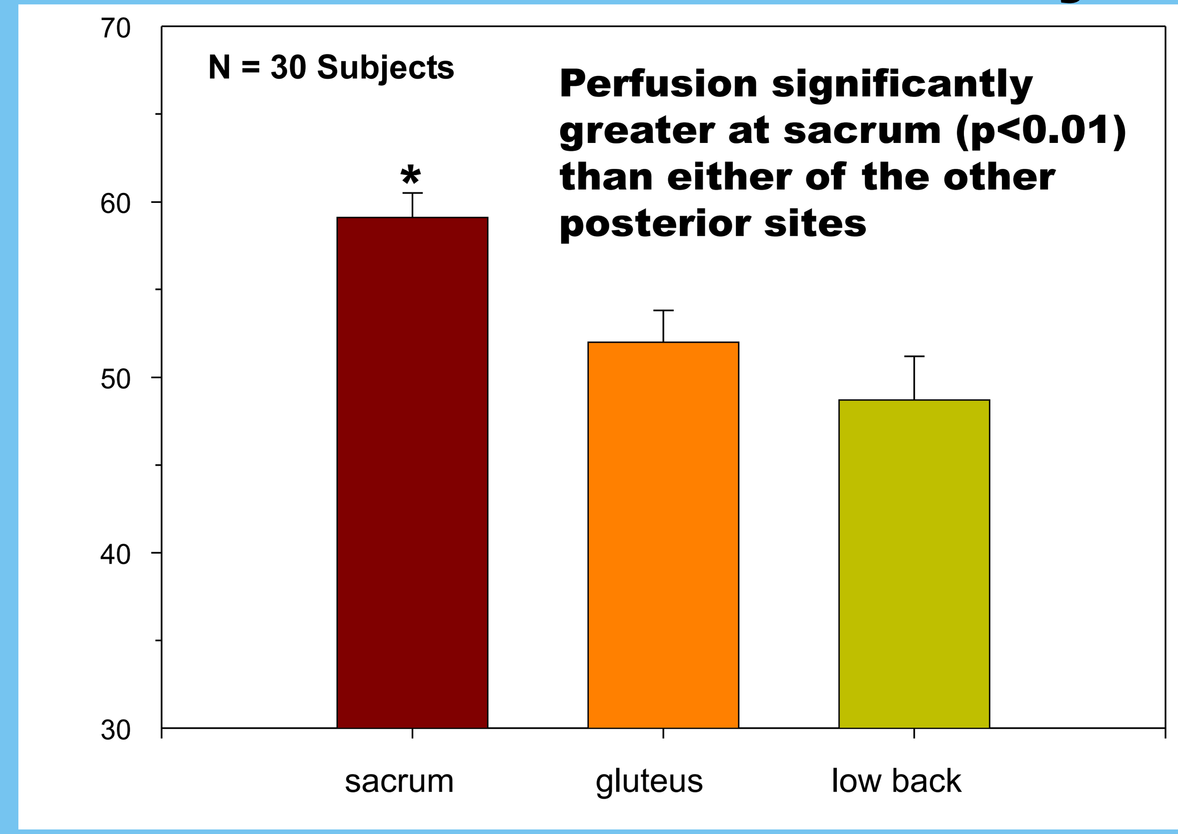


Hand/Digit Comparison Scan



Hands were scanned immediately after posterior scans

Blood Perfusion Summary



Main Findings

The findings demonstrate several features of sacral skin blood perfusion in comparison to other nearby tissue regions and with respect to other skin areas. In contrast to previous data[3-5] obtained with single point laser Doppler methods, the laser Doppler imaging method has revealed that resting sacral SBF is greater than SBF overlying the gluteus maximus and is also greater than nearby lower back skin. Average sacral SBF (59.1 1.4 a.u.) was significantly ($p<0.001$) larger than other posterior sites (48.7 2.5 a.u.) and was greater in females (63.0 1.6 vs. 55.2 1.8, $p<0.01$). On average, sacral SBF was found to be 13.7% greater than gluteal SBF and 21.3% greater than low back SBF. These differences are not explainable on the basis of skin temperature differences, as the low back site had a significantly higher temperature than either of the other two sites. Further, for subjects undergoing the heat response protocol (N=8), the average SBF within the heated area (1.1 0.1 cm^2) increased from a baseline level of 54.5 3.6 a.u. to 186.6 21.8 a.u. This is a heat induced SBF increase by 3.5 0.5. Remote hand measurements show that average perfusion within the sacral region of the present group was close to, but somewhat greater than that in the hand web but was, as expected, significantly less than the high flow normally found in the finger tips. These comparisons help place the resting sacral skin perfusion levels in perspective and combined with the large heat induced responses at the sacrum, show a hyperemia potential at the sacrum near to that of resting digit perfusion.

DISCUSSION & CONCLUSIONS

The higher SBF over the sacrum we found using the laser Doppler imaging method, is at least consistent with the hypothesis that regions of higher resting SBF may be at greater risk of injury when exposed to external forces that cause a substantial reduction in this resting blood flow. Although, the relative importance of this finding, as compared to other factors that predispose the sacrum to pressure ulcers, has not yet been investigated, it is useful to speculate possible implications. The average resting sacral SBF among the persons we studied varied by a factor of about 1.7, and it is likely that in patients, who often have varying superimposed conditions that affect skin blood flow, there would be considerable person-to-person differences in sacral SBF.

A relevant question is whether resting flow variations among patients represents a factor that influences sacral ulcer predilection. For similar sacral loading conditions, it almost seems counter-intuitive to expect that a person with a higher resting blood flow would be more at risk for a sacral ulcer than one who has a lower blood flow. However, it may be argued that if resting flow is reduced to zero or near zero for a sufficient duration, then the relative deficit would actually be greater in the person with the higher resting flow. If blood flow is then restored by offloading the sacral forces, either mechanically, as with pressure relief surfaces, or by turning the patient, the deficit needs to be repaid via the normal hyperemic response. For persons with higher resting flows, this response needs to be more vigorous and sustained. A differentiating factor, as to ulcer risk, may then be whether a suitable amount of hyperemia can occur.

The present findings indicate that a substantial flow reserve is normally present in the sacrum. Based on the localized heat responses, a peak hyperemia that was on average 3.5 times the resting SBF was observed. However, there are at least two broad categories of conditions in which hyperemia in relation to prior flow deprivation might be inadequate. One is the category in which a person's vasodilatory capacity is blunted due to microvascular or other deficits. This would include persons with diabetes, the aged and those with systemic hypotension. The other category includes persons who have experienced an abnormal increase in resting blood flow attributable to prior bed lying, skin heating or other skin related conditions such as localized irritation. These persons may have a vasodilatory blood flow capacity that is adequate to meet their normal resting repayment needs following intervals of flow deprivation, but it may not be adequate to meet the imposed increased blood flow demands. Based on these considerations, it would seem to be prudent to at least consider the possible role of resting SBF as possible added risk component and to consider factoring this concept in to patient care strategies. More investigative work is needed to provide direct evidence for or against this concept.

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