Physiology Rocks

Localized Forearm Skin Water Changes Associated with Heat Induced Hyperemia

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Background

Skin water content and distribution are important determinants of skin physiology and are affected by multiple dermatological and cardiovascular conditions. Early water increases may herald later edema and low values may portend reduced skin integrity. Although little is known about acute skin water dynamic changes we speculated that localized heat -induced vasodilation increases capillary filtration causing increased interstitial fluid that is measureable as an increase in skin water. Based on this concept, we hypothesized that there should be a significant changes subsequent to localized hyperemia that is used as a model positive correlation between skin water parameters and the magnitude of hyperemic blood flow. Our goal was to test this hypothesis by assessing skin water of early skin water changes. The process being investigated impacts our basic understanding of skin-related physiology and has potential extensions to skin-related clinical issues.

Methods

Skin water was assessed by stratum corneum (SC) capacitance and by tissue dielectric constant measurements (TDC) at 300 MHz to skin depths of 1.5 mm (TDC15) and 2.5 mm (TDC25) on forearm skin of 32 healthy subjects (24.8 ± 1.7 years, 16 female) before and after localized skin heating from a baseline of 29.5 ± 1.2°C to 39.0 ± 2.7°C for 12 minutes. Skin water loss was determined prior to and after heating by transepidermal water loss (TEWL) measurements. Hyperemia was assessed by laser Doppler blood perfusion (LDP) in perfusion units (pu) before and during heating. Skin temperature (TSK) was assessed via IR. All subjects signed IRB approved consents. Preheat TDC values for males were greater than for females ($p<0.001$) at 1.5 mm (32.5 ± 2.3 vs. 28.7 ± 2.6) and at 2.5 mm (30.5 ± 3.2 vs. 25.5 ± 2.1) with no significant difference in any other parameter.

References

Charkoudian, N., J. H. Eisenach, et al. (2002). "Effects of chronic sympathectomy on locally mediated cutaneous vasodilation in humans." Journal of Applied Physiology 92: 685-690.
Gooding, K. M., M. M. Hannemann, et al. (2006). "Maximum skin hyperaemia induced by local heating: Possible mechanisms." Journal of Vascular Research 43: 270-277.
Pergola, P. E., D. L. J. Kellogg, et al. (1993). "Role of sympathetic nerves in the vascular effects of local temperature in human forearm skin. ." American Journal of Physiology 265(3): H785-792.

Methods

Figure 1: Stratum corneum measurement (SC).

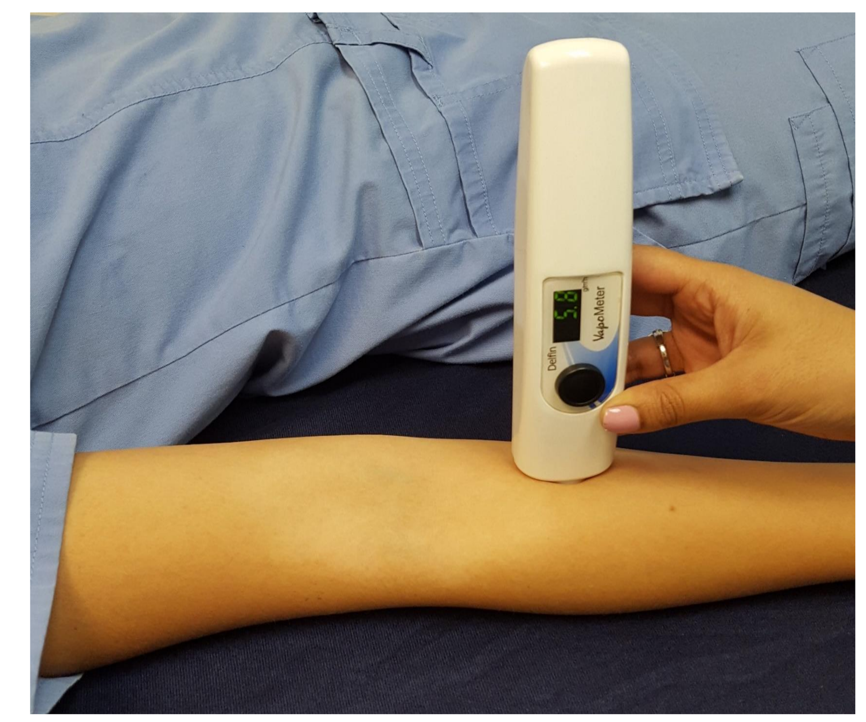

Figure 2: Transepidermal water loss measurement (TEWL).

Figure 3: Tissue Dielectric Constant Measurement (TDC using 1.5 and 2.5 mm probes).

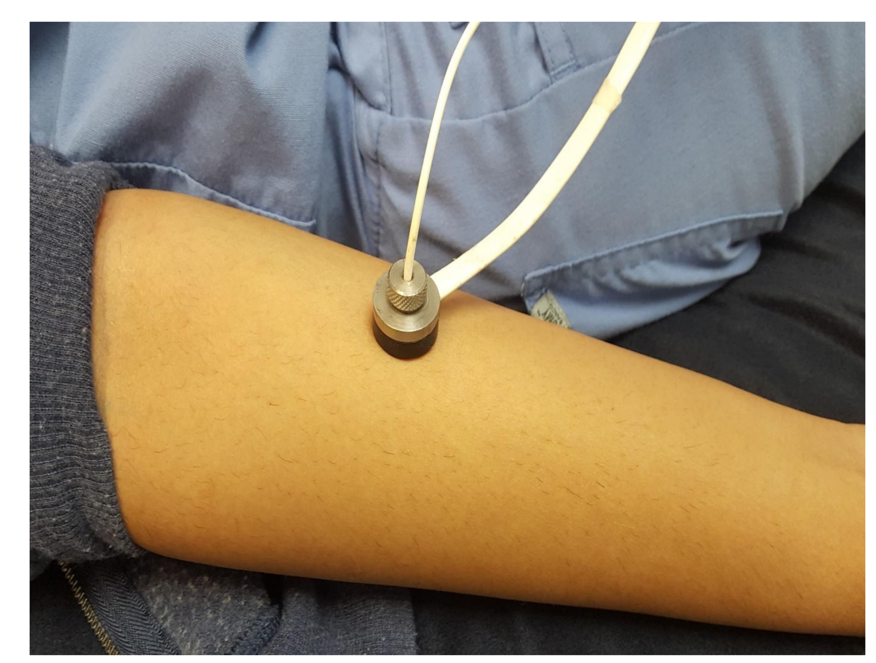

Figure 4: Heating device with laser Doppler probe applied to measurement site.

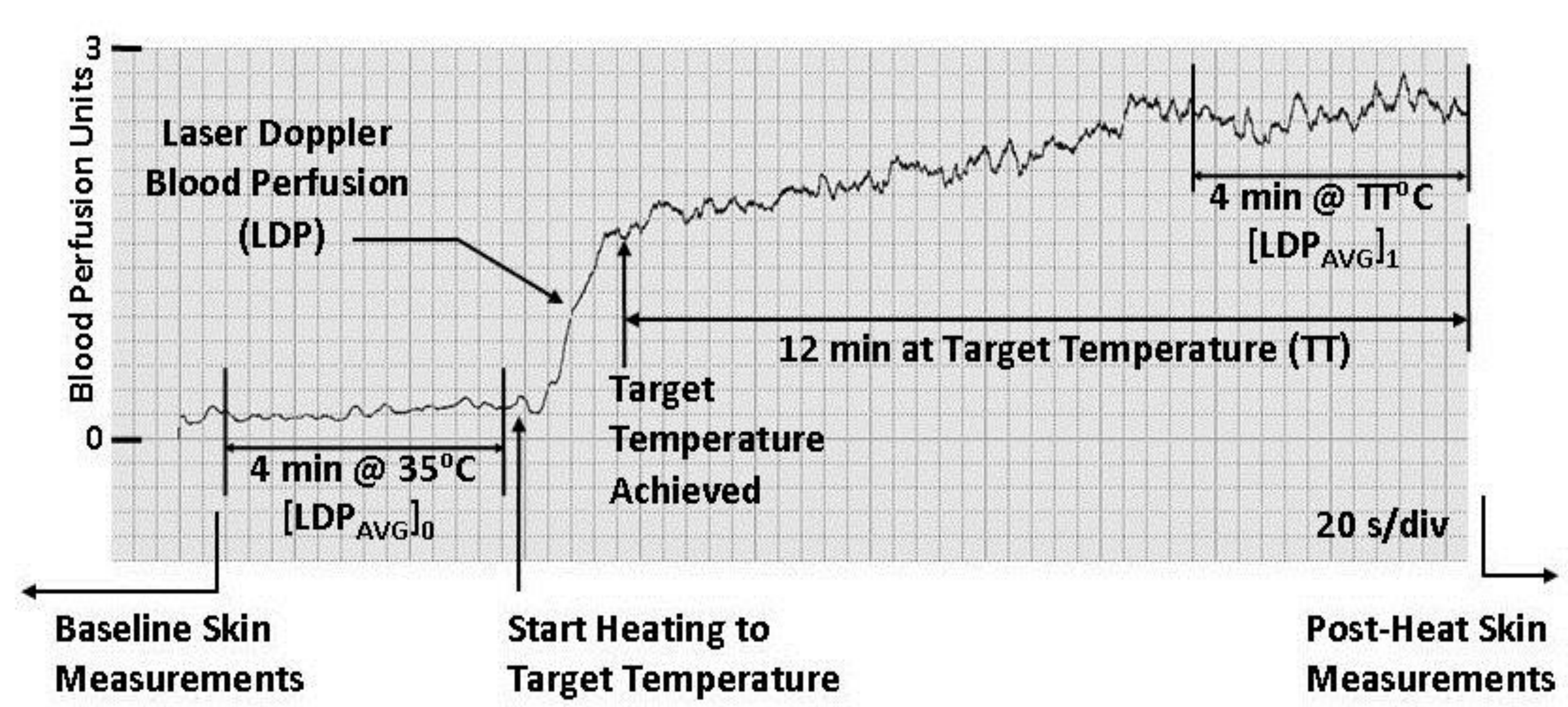

Figure 5: Summary of protocol describing baseline skin measurements to be taken for 4 mins @ 35 degrees C, measurement of blood flow during heating phase for 12 minutes, and post heat measurements taken afterwards.

Results

Immediate post-heat peak perfusion assessed via LDP measurements increased from a baseline (35°C) value of 2.8 ± 1.6 pu to 23.6 ± 9.7 pu. The hyperemia ratio (10.5 ± 6.3) was accompanied by significant ($p<0.001$) increases in all measured skin parameters with the following post-heat/pre-heat ratios; TEWL (4.3 ± 2.4), SC (9.0 ± 11.0) (figure 7) TDC2.5 (1.10 ± 0.11) and TDC1.5 (1.08 ± 0.07) (figure 6).

Male pre-and-post heating TDC values were significantly greater ($p<0.01$) than female values but all other skin parameters and changes were similar between genders. After an initial post-heat peak, skin water parameters declined but remained above baseline ($p<0.001$) for at least 15 minutes after heat removal. Regression analysis of post-heat data showed significant correlations between SC and TEWL ($r = 0.516$, $p =0.002$), LDP and TSK ($r=0.585$, $p<0.001$). A moderate correlation between post-to-pre heat ratios of TDC25 and LDP values was also observed ($r = 0.366$, $p = 0.04$) but there was no other significant relationship between the hyperemic response magnitude and any other measured skin water parameter.

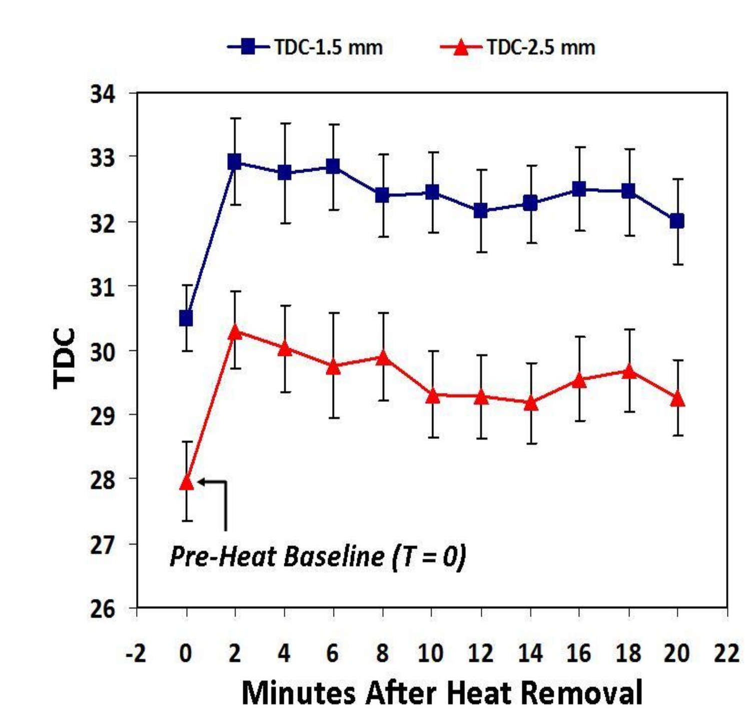

Figure 6: TDC at 1.5 and 2.5 mm after heating skin to 39 degrees C on average.

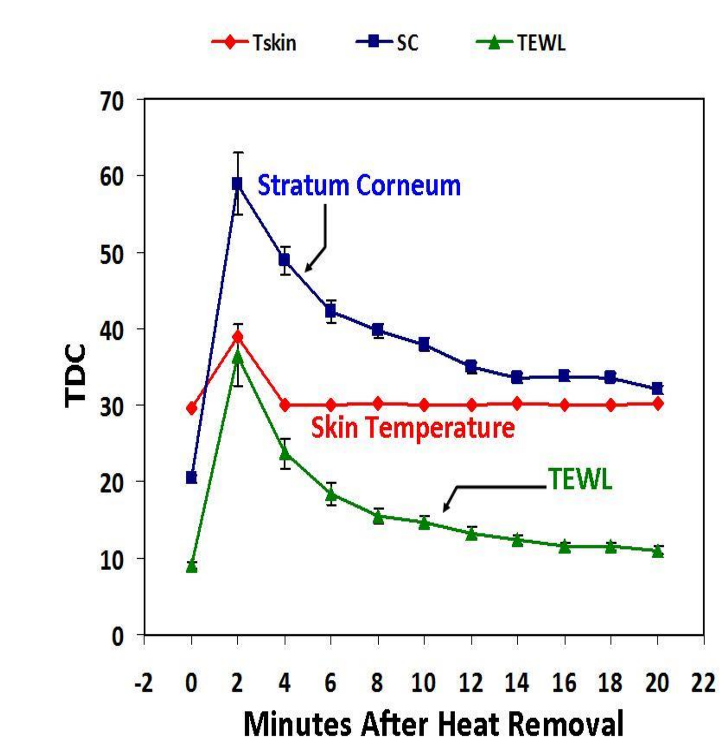

Figure 7: SC, skin temperature and TEWL after heating skin to 39 degrees C on average.

Conclusions

Alhough the present results show major changes in skin water parameters accompanying heat-induced hyperemia and a small correlation between the hyperemia and the 2.5 mm depth TDC value, the absence of a demonstrable relationship between the hyperemia and the other skin water parameter causes us to tentatively reject our initial hypothesis and conclude that processes associated with altering skin water parameters are not importantly dependent on heat-induced vasodilation in healthy young adults. However, the role of vascular components in this process in aged persons and persons with compromised circulations should not be ruled out. These possibilities represent areas needing further investigation that will be aided by using the present data for reference comparisons.