Skin Tissue Water via Tissue Dielectric Constant Measurements in Persons with and without Diabetes Mellitus

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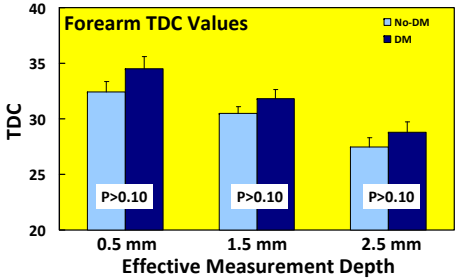
Background

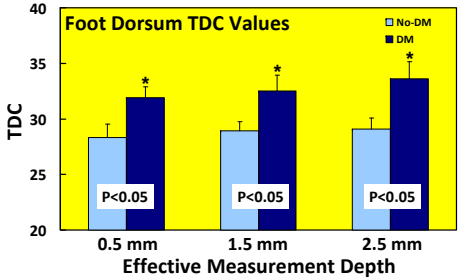
Measurements of local tissue dielectric constant (TDC) via the open-ended coaxial probe method are useful non-invasive measures of local tissue water[1-4]. The method permits assessment and tracking of changes in skin tissue water (STW) in many situations including lymphedema[5] and other conditions[6-10]. The operating principle depends on the direct relationship between TDC values and fluid content within skin that includes epidermal, dermal and vascular tissues. Our specific aim was to determine if STW in persons with diabetes mellitus (DM) is less than in persons without DM (NO-DM). Our motivation stems from the fact that although microvascular and other DM-related skin changes may cause skin dryness and other complications there is no definitive data describing possible DM VS. NO-DM STW differentials.

Methods

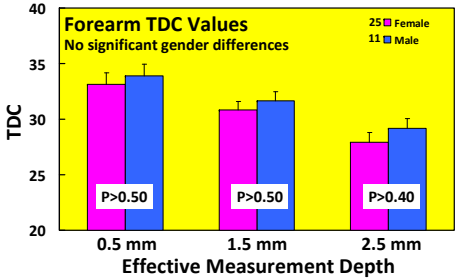
TDC values at depths of 2.5, 1.5 and 0.5 mm were measured bilaterally on anterior forearm and foot dorsum of 36 persons; 18 with DM II and 18 without DM II. Subjects removed shoes and socks/stockings and laid supine with both hands at their sides and their feet uncrossed. Marks were made on the target site of each forearm 8 cm distal to the antecubital fossa. The target site on the foot dorsum was then marked on a flat area between the great and 2nd toe. Girths of forearm and foot at target sites were measured with a calibrated tape measure. TDC measurements were then done in triplicate at each site and each depth. No-DM and DM groups did not differ by age (54.2 ± 18.4 vs. 62.7 ± 12.5 years, p=0.21) or BMI (28.4 ± 4.2 vs. 29.9 ± 5.2kg/m^2; p=0.36). DM duration was 133 ± 132 months and HbA1c was 7.4 ± 1.4. Graphic data are reported as bilateral averages (error bars = 1 sem).

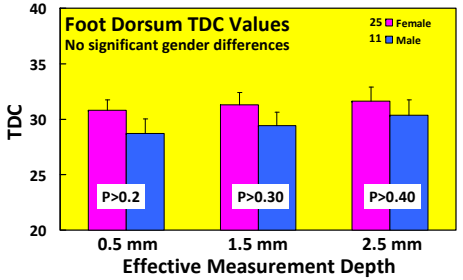
Results (TDC values are bilateral averages)





Forearm TDC values did not differ between NO-DM and DM groups at any depth. In contrast, TDC values of the DM group were significantly greater (p<0.05) at the foot at all depths. Interestingly, the previously observed increase in TDC value with decreasing depth[10] was here also observed at forearm but not at foot dorsum.





There was no significant difference In TDC values between genders at forearm or foot at any depth. Previous work[8] based on a larger sample had indicated a slight but significant gender difference at the forearm in which male values exceeded female values by 13%. An opposite tendency is here seen at the foot dorsum.

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Conclusions

The greater TDC values found in persons with diabetes was unexpected and contrary to expectations. It is not consistent with the presence of a decreased skin tissue water in DM as was originally hypothesized. It may be that this increased TDC (reflecting an increase in tissue water) may reflect preclinical edema not otherwise visualized. It is also interesting that this NO-DM vs. DM differential was significant only on the feet, an anatomical area that would be especially prone to edema formation. If true- the TDC method may be a useful screening tool for early detection of DM-related edema in certain patients. Further research into this emerging and potentially useful area is clearly indicated.

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