Skin Tissue Water Variations in Different Races Measured via the 300 MHz Tissue Dielectric Constant Method

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Background

The Tissue Dielectric Constant (TDC) is directly related to the amount of free and bound water contained in the measuring volume[1-2]. Thus, local skin tissue water (STW) indices can be determined by measuring TDC of skin in any location of the body. TDC has been used as an index of change in STW at different sites on the human body in healthy persons[3-4], in conditions such as with post-mastectomy lymphedema[5] and other conditions[6-7]. Measurements in normal tissues have been used to establish a continuously developing reference data base from which judgments as to deviations from normality might be judged. However, to date most of such measurements have been made on Caucasians, so that the extent of STW variations in individuals of different racial backgrounds is largely unknown. Elucidating skin property differences between ethnicities may help the employment of more selective skin clinical strategies making the treatment and diagnoses more efficacious.

Purpose

One purpose of this study was to provide a normal reference range for skin water via TDC measurements in five self-described racial groups: Asian-Indian, Hispanic, Asian, African-American and Caucasian. A 2nd purpose was to determine if variation in TDC values are dependent on race since skin-related race differences are likely dependent on water content. A 3rd purpose was to determine if local tissue water is quantifiably related to the total body water and fat percentages as measured using whole body bioimpedance values.

Methods

SUBJECTS were young (20-30 yrs) self reported healthy subjects of five self reported races: Caucasian (20), African-American (20), Hispanic (20), Asian(20) and Asian-Indian (20) for a total N=100 (50 males and 50 females with 10 males and 10 females per ethnic group).

TDC MEASUREMENTS were done using the MoistureMeter- D (Delfin Technologies, Kuopio Finland). The device (Fig 1) measures TDC at a frequency of 300 MHz using probes that act as open-ended coaxial lines. The probes used in this investigation measured to depths of 1.5mm and 5.0mm. For reference, the dielectric constant of distilled water at 32°C is 76. TDC measurements were made at three different sites in the body; (1) the anterior forearm 10 cm distal to the antecubital crease (Fig 2), (2) 2.5 cm posterior and slightly inferior to the medial malleolus area (Figure 3) and (3) the subclavicular area at the 2nd intercostal space midclavicularly (Fig 4). Each TDC measurement was done bilaterally and in triplicate.

BIOIMPEDANCE MEASUREMENTS were done to obtain total body water. This was done using the Bodystat1500 and also the Ironman InnerScan. The Bodystat1500 is a non-invasive, battery operated device that measures the electrical impedance value of the body while the subject is in the supine position (Fig 5). The subject's gender, age, height, and weight are entered into the device and a low level electrical signal is passed through the body via electrodes. Relevant parameters determined include: total body fat, lean body mass, and total body water. The Ironman InnerScan measures the electrical impedance value of the body while the subject is in the standing position (Fig 6).

Methods

Fig 1. Delfin MoistureMeter-D Control unit with 5.0 and 1.5 mm effective depth probes used in this study

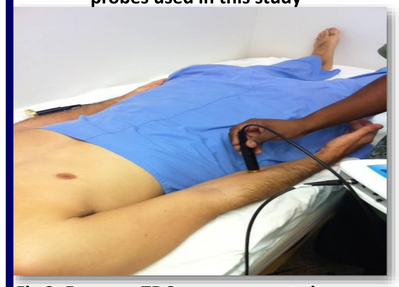


Fig 2. Forearm TDC measurement site

Fig 3. Ankle TDC measurement site

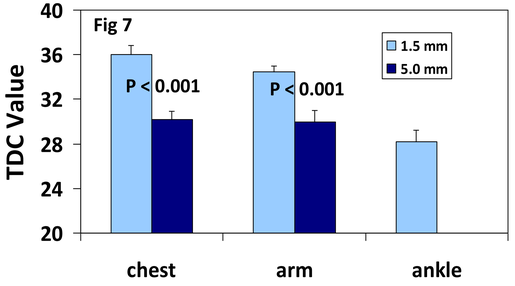
Fig 4. Chest TDC measurement site

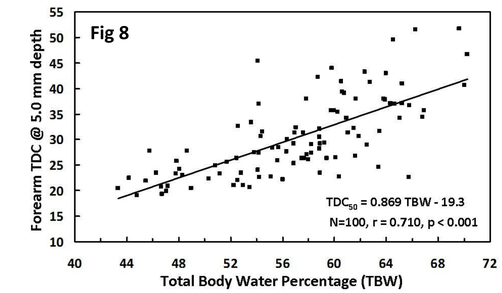
Fig 5. Bodystat bioimpedance device for supine body composition Measurements (TBW% and FAT%)

Fig 6. Ironman InnerScan Bioimpedance device to measure standing body composition Parameters (TBW% and FAT%)

Results

TDC values (left & right sides) for chest, arm and ankle (n=100) were (mean ± SD) 36.0 ± 5.3, 34.5 ± 3.1 and 28.2 ± 6.4 (p<0.001) for 1.5mm depth. For 5.0 mm depth at chest and arms TDC was 30.2 ± 4.7 vs. 30.0 ± 6.3 (p=0.751). For all sites the 5.0 mm depth values were significantly less (p<0.001) than corresponding 1.5 mm depth values (Fig 7). In males, TDC values showed a decrease from chest to arm to ankle (p<0.01) for all races except Caucasians and Hispanics. Forearm and ankle TDC values at 1.5mm differed significantly among races (p<0.01) for females. African-Americans had higher chest TDC values while Caucasians had higher ankle TDC values (p<0.01). Standing and supine TBW% were 57.7 ± 6.9% vs. 56.3 ± 5.79%. TBW% correlated best with the TDC values measured to an effective depth of 5.0mm on the forearm (r =0.710, p<0.001, Fig 8). Correlations between TDC values and either TBZ or AFP were always less than those between TBW or TBF.





Conclusions

These results characterize skin water differences among racial groups by TDC measurements. Results showed that TDC values differ by site, side, gender, and ethnicity. TDC tended to decrease from chest to forearm to ankle and decreased with increasing depth. Males had higher TDC values than females. Chest and ankle TDC values were shown to differ considerably among races in males. Also, a positive correlation between TDC and TBW, not previously known was discovered. The differences uncovered suggests a need for further research into mechanism for these differences. The findings also are relevant for clinical work using TDC and TBF between genders and ethnicities.

References

[1] Alanen E et al. Measurement of dielectric properties of subcutaneous fat with open-ended coaxial sensors. Phys Med Biol; 1998;43: 475–485. **[2]** Nuutinen J et al. Validation of a new dielectric device to assess changes of tissue water in skin and subcutaneous fat. Physiol Meas. 2004: 25: 447-54. **[3]** Mayrovitz HN, Luis M. Spatial Variations in Forearm Skin Tissue Dielectric Constant. Skin and Research Technology. 2010: 16 : 438-443 **[4]** Mayrovitz HN et al. Gender Differences in Facial Skin Dielectric Constant Measured at 300MHz. Skin and Research and Technology 2012;18:504-510 **[5]** Mayrovitz HN. Assessing local tissue edema in postmastectomy lymphedema. Lymphology. 2007: 40(2): 87-94. **[6]** Mayrovitz HN et al. Localized tissue water changes accompanying one manual lymphatic drainage (MLD) therapy session assessed by changes in tissue dielectric constant inpatients with lower extremity lymphedema. Lymphology. 2008: 41(2): 87-92. **[7]** Mayrovitz HN et al. Measurement decisions for clinical assessment of limb volume changes in patients with bilateral and unilateral limb edema. Physical Therapy 2007: 87:1362-1368.