Skin Tissue Water Assessments in Different Races via Tissue Dielectric Constant Measurements

Sharien Amarnani[1] OMS-II, Eric Pitts[1] OMS-II, Louis Michaelos[1] OMS-II, Harvey N. Mayrovitz[2] PhD
[1]College of Osteopathic Medicine, [2]College of Medical Sciences, Nova Southeaster University

This research is self-supported; the authors declare no competing financial interests.

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 any skin location. 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 lymphedema in patients with post-mastectomy lymphedema[5] and in patients with swollen extremities[6-7]. TDC values so obtained have been used to characterize features of a given abnormal condition in which STW is of relevance and also to evaluate treatment related changes. 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.

Purpose

The purpose of this investigation is to quantitatively determine STW via measurements of TDC in five racial groups: Asian Indians, Hispanics, Asians, Blacks and Whites. The main purpose of these measurements is to characterize TDC distribution among these groups to determine if skin variations or other differences among the groups result in significant variability in STW. A second purpose is to determine if local tissue water is quantifiably related to the total body water and fat percentages as measured using whole body bioimpedance measurements. To date, measurements were done in five races; White(16), Black(4), Hispanic(5), Asian(7) and Asian Indian(10) for a total N=42 (23 male). The study design calls for N=100 with 20 per race.

Methods

TDC MEASUREMENTS are obtained using a battery operated hand-held device utilizing gold plated brass open-ended coaxial probes (MoistureMeter- D, Delfin Inc., Figure 1.). The probe measures TDC at a frequency of 300 MHz. In this study we used probes that have effective penetration depths of 1.5 mm and 5.0 mm. For reference, pure water has a TDC value of 78.5. The sites measured were (1) the anterior forearm 10 cm distal to the antecubital crease (Figure 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 (Figure 4). Each TDC measurement was done in triplicate and averaged

BIOIMPEDANCE MEASUREMENTS for the purpose of obtaining total body water are obtained using the Bodystat1500 (Figure 5) and also the Ironman InnerScan (Figure 6). The Bodystat1500 is a non-invasive, battery operated hand-held device that measures the electrical impedance value of the body while the subject is in the supine position (Figure 7). The subject's gender, age, height, and weight are entered into the device and a low level battery generated electrical signal is passed through the body via electrodes. Relevant parameters determined include: body fat, lean body mass, and total body water. The Ironman InnerScan is also battery operated and measures the electrical impedance value of the body while the subject is in the standing position (Figure 8).

Methods


Fig 1: From left to right, 5.0 mm-depth probe, MoistureMeter- D, and 1.5mm-depth probe


Figure 2: 1.5 mm- depth probe measuring TDC at the anterior forearm site


Figure 3: 1.5 mm- depth probe measuring TDC at the ankle site


Figure 4: 5.0 mm- depth probe measuring TDC at a chest site

Figure 5: Close up view of the BodyStat 1500

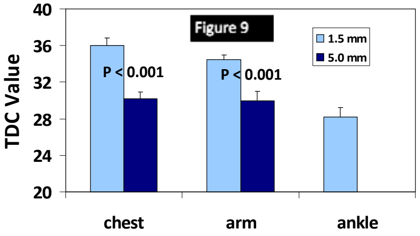

Figure 6: Close up view of the Ironman InnerScan.

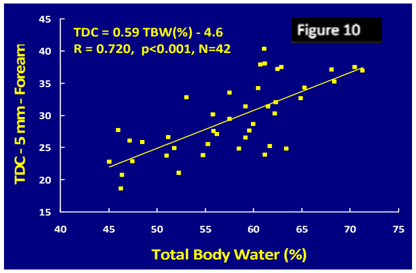

Figure 7. Total body water % measured in the supine position determined by bioimpedance


Figure 8: Total Body Water % measured in the standing position by bioimpedance.

Results

Composite TDC values (left and right sides) for chest, arm and ankle (n=84) were 36.0±5.3, 34.5±3.1 and 28.2 ± 6.4 ($p<0.001$) for 1.5mm effective depth measurements and for 5.0 mm depth at chest and arms were respectively 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 (FIGURE 9). 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 arm ($r =0.720$, $p<0.001$, FIGURE 10). TDC values were similar on right and left sides at forearm and ankle with (right/left) ratios of 0.998 ± 0.054 and 1.028 ± 0.144 at 1.5 mm and 1.035 ± 0.087 at forearm at a 5.0 mm depth. Contrastingly, at a 5 mm depth, the right subclavicular area demonstrated a slightly, but significantly greater TDC value than on the left side (31.2 ± 4.8 vs. 29.2 ± 4.5, $p<0.001$) with a (right/left) ratio of 1.071 ± 0.099.





Conclusions

The main focus of this presentation is on site and depth variations in TDC values and on characterizing possible TDC – TBW relationships. The data confirm that TDC values are less at greater depths at arm and chest and show TDC values to be least at the ankle. In addition, we demonstrate a significant positive correlation between arm TDC values and TBW% that has not previously been reported. These findings are useful additions to the evolving reference database to aid applications of TDC measurements in research and clinical practice including the possibility to monitor the progress and efficacy of OMT lymphatic treatments. The significant (right/left) subclavicular TDC differences herein reported may be due to different properties of the right lymphatic duct and the thoracic duct drainage territories.

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 Technology. 2012 (in press)
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.