

Depth Distribution of Thigh Skin-to-Fat Tissue Water

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Background

A useful non-invasive measure of local tissue water is the skin tissue dielectric constant (TDC). The TDC measurement is done via the use of an open-ended coaxial probe in contact with skin^[1-2]. The TDC measurement (Figures 2 -4) includes contributions from the epidermis, dermis and depending on penetration depth also the subcutaneous tissues. The TDC value is directly proportional to the amount of water in the tissue. Previous work^[3-7] has shown this method to be useful for measuring forearm skin TDC values for a variety of conditions, however, there is limited data on TDC values in the lower extremities and no data regarding TDC values in the thigh of normal persons. Because local tissue water varies with anatomical site, this information would be valuable in determining an appropriate measurement depth for a given physiological or pathological condition for both research and possible clinical assessments.

Methods

Six male student research-trainees performed self-TDC measurements on one of their anterior thighs while in a seated position (Figures 2-4). TDC values were obtained to effective depths of 0.5mm, 1.5mm, 2.5mm and 5.0mm at two sessions 28 days apart. These measurements include contributions from epidermis and dermis with different amounts of subcutaneous fat at the deeper depths.

Subjects were seated in a chair that was sized appropriately to ensure that both legs were resting on the floor for 5 minutes prior to any measurements being taken. The leg measurement site was shaved 24 hours earlier to avoid variability with probe contact and possible hair effects. The target measurement site was distal to the hip by an amount equal to 1/3 of the distance between the hip and the knee. The target point was marked with a dot using a permanent marker and served as the center point of each probe in subsequent measurements. At each session, TDC was measured in triplicate to skin depths of 5.0mm, 2.5mm, 1.5mm and 0.5mm, in that order. Data was analyzed by a person not involved with the measurements.

TDC Method

The device used to measure TDC was the MoistureMeter-D (Delfin Technologies). It consists of cylindrical probes (figure 1) that can be connected to a control unit that then displays the TDC value when the probe is placed in contact with the skin. A very low intensity 300MHz signal is generated within the control unit and is transmitted to the tissue via the probe that is in contact with the skin (figures 2-4). The probe acts as an open-ended coaxial transmission line. The portion of the incident electromagnetic wave that is reflected depends on the tissue dielectric constant, which itself depends on the amount of free and bound water in the tissue volume through which the wave passes. Reflected wave information is processed and the dielectric constant is displayed. For reference, pure water has a value of about 78. The effective measurement depth depends on probe dimensions, with larger spacing between inner and outer conductors corresponding to greater penetration depths.



Figure 1: The Delfin MoistureMeter-D device and probes used to measure TDC. From left to right the probes measure to effective depths of 0.5mm, 1.5mm, 2.5mm and 5mm.

Figures 2 & 3. The 2.5 mm probe shown measuring at a target site located at the proximal 1/3 point on the anterior thigh



Figure 2



Figure 3

Figure 4: The 5 mm depth probe at the same anterior site.

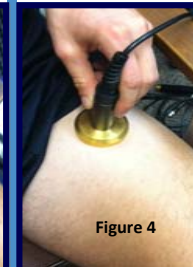


Figure 4

Results

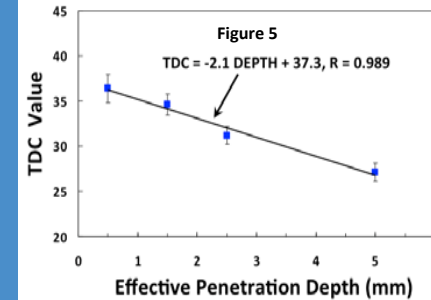


Figure 5 Demonstrates the dependence of TDC on tissue measurement depth at day 0. Greater depths are associated with lesser TDC values in part due to the greater fat content at greater depths.

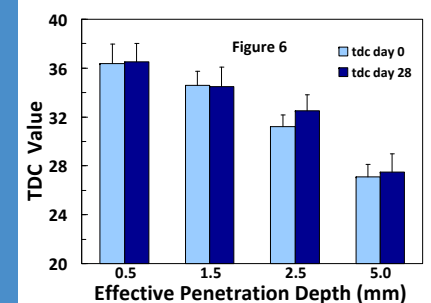


Figure 6 Compares TDC values obtained 28 days apart for all measurement depths. There were no significant differences between day 0 and day 28 TDC values at any depth.

Conclusions

The anticipated reduction in tissue water with measured depth is consistent with the inclusion of increasing amounts of low-water content fat tissue as previously observed in the forearm^[7]. The similarity of the distribution over 28 days suggests that the depth-distribution of water-to-fat is maintained over this time interval. These findings further indicate that the anterior thigh represents a stable area for studies related to tissue water measurements over time.

References

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