Tissue Dielectric Constant

Prior research suggests that tissue dielectric constant (TDC) values are useful to assess localized skin water in females for early diagnosing breast cancer treatment-related lymphedema and TDC values in young adults have shown gender differences. However, no TDC data is available for older males or have the effects of aging studied despite known shifts in water status and other skin age-related changes.

Introduction

Prior studies used measurements of skin tissue dielectric constant (TDC) at 300 MHz to characterize and compare young adult male and female skin water content and age-related differences in tissue water status and to characterize the presence and extent of edema or lymphedema. It is unknown if values obtained in this young adult skin existence also applies to older age groups. This is especially relevant to TDC data for males as most prior data are based on female evaluations.

Relevances

Ageing increases the likelihood of prostate and breast cancer. Treatment of breast cancer increases the risk of related lymphedema and TDC values in young and older adults. Treatment-related lymphedema and TDC values in young and older adults. Additionally, other studies have been performed with increasing depth in the forearm.

What is Tissue Dielectric Constant?

Tissue dielectric constant (TDC) is a measure of the ability of tissue to store electrical energy. It is defined as the ratio of the electric modulus to the electric field strength and is expressed in terms of capacitance per unit area.

TDC Measurement

TDC measurements were made with the MoistureMeterD (figure 1). This device measures TDC by touching skin with a small-handled probe for about 10 s. Four probes ranging in diameter from 10mm to 0.5mm were used, giving an effective measurement depth of 0.5, 1.5, 2.5 and 5.0 mm. Measurements were taken with subjects seated with hands resting palms up on a pillow after they had been resting for at least 5 min. Measurement sites were both volar 6.0 mm distal to the antecubital fossa. Probe placement was such to avoid any visible skin surface veins in areas virtually free of heavy hair growth. Measurements were alternated between each arm until three values per arm were obtained for each depth. After all TDC measurements were completed, the girth of the forearm was measured. Subjects were then asked to remove their shoes and socks and to stand on a scale for the purpose of measuring their weight and various body composition parameters via 50KHz bioimpedance measurements. Subjects stood barefoot on the scale during which time they gripped an electrode in each hand. Parameters measured can be found in Table 1. Total and segmental percentages were determined using specific algorithms within the device based on the whole body and segmental bioimpedance values.

Body Composition Parameters

Table 1 summarizes the body composition data for each age group. For example, the body composition data for the young age group is given in Table 1.


t| Age (years)| TDC (mm)| A | B | C | P-Value |
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<td>71.0</td>
<td>0.985</td>
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<td>71.3</td>
<td>0.985</td>
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Figure 2 summarizes the age and depth dependence of measured TDC values for each of the age groups. For each age group, TDC arm average values decreased with increasing effective measurement depth (P < 0.001) in the forearm. TDC measurements for interarm ratios (IAR) were not dependent on depth or age with all ratio values summarized in Table 2 with no differences in ratios among age groups for any depth or any difference in ratios among age groups for any depth. By including the data for all 60 subjects, an overall IAR based on 60 subjects could be determined with values shown in Table 1. From these data, a conservative threshold ratio for detecting the presence of unilateral edema of lymphedema can be calculated by adding to the overall mean ratio a value of 2.5 SD. Threshold ratios calculated in this way range from 1.18 to 1.25 as shown in Table 2.

TDC Values by Age Group

Figure 4: TDC Values by Age group

TDC Values by depth and age group.

Figure 3: TDC Values by depth and age group.

TDC TDC Dependence on Measurement Depth

TDC values increased significantly with depth. This is expected since glycosaminoglycans, that have their greatest number just beneath the epidermis, have their concentration decreasing with increasing skin depth. These proteins can contribute to 0.1% to 1% of skin weight. Also, epidermal skin has at least twice the amount of mobile water as dermal skin. As TDC values are based on % of free and bound water, a decrease in TDC value is expected. With greater depths, more subcutaneous fat contributes to the TDC and a lower TDC is generated with increasing depth in the forearm.

TDC Age-Related Dependence

One new finding is that age-related differences in TDC occur only in the oldest group and only within the skin depth of 0.5 mm (Fig. 3). This depth includes dermal regions in which age-related shifts in water state have been identified. This deeper age-related shift may be due to increased interstitial water, increased fat, increased fluid movement or a combination of these factors.

TDC Dependence on Body Composition

The older group had more body and arm fat and less body water and muscle mass than young (Table 1). Data reveals that body composition influences TDC values but does not affect age-related depth shifts in TDC values. TDC values were highly correlated with body composition and that the strength of the correlations increased with increasing depth (Table 3). The negative correlation between TDC values and total body fat % is consistent with increased depth. As we age, the transition from mobile to free water, was most dominant in the oldest subjects thus affecting shallower depths.