

## Temporal and Depth Variations in Skin Water Assessed via Skin's Tissue Dielectric Constant

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## Abstract

Tissue dielectric constant (TDC) measurements are used to assess local skin water as an index of the presence and extent of breast cancer treatment-related lymphedema (BCRL) in clinical and research settings. Such measurements are made at various times during a 16-hour cycle, over different days, and skin depths.

**Objective:** The objective was to determine if there is a time-of-day at which TDC values differed least from day-to-day, during a 16-hour cycle, and different skin depths. The clinical importance of these three main considerations were investigated in this self-measurement study.

**Methods:** TDC values at increasing skin depths (0.5mm, 1.5mm, 2.5mm, and 5.0 mm) were self-measured, every two hours from 0800h to 2400h, over two consecutive days using the Delfin Technologies MoistureMeterD device by seven male and five female medical students trained in the measurement method. On measurement days, participants maintained their daily routines, while avoiding strenuous exercise and skin products. Prior to TDC measurements, participants recorded room temperature (TRM), relative humidity (RH), and skin temperature (TSK). Triplicate measurements with each probe were made perpendicularly to the participants' skin 5cm distal to the antecubital fossa of the non-dominant forearm while seated.

**Results:** TDC daily variability: Except for the deepest measurement depth (5mm), there was a small but statistically significant decline in mean TDC values from morning to night determined via linear regression analysis. Associated Pearson correlation coefficients (*r*) decreased with increasing measurement depth (0.5mm to 1.5mm to 2.5mm to 5.0 mm) from 0.891 to 0.829 to 0.679 to 0.471. Corresponding *p*-values were 0.001, 0.006, 0.044 and 0.200 respectively. Considering both days, the maximum difference between maximum and minimum TDC values ranged from <1 % for the 1.5mm depth to <3% for the 2.5mm depth. TDC variability by depth: TDC values decreased with increasing depth (*p*<0.001) with values for 0.5, 1.5, 2.5 and 5.0 mm being (mean ± SD) 40.6 ± 8.0, 35.5 ± 3.6, 30.5 ± 6.7 and 29.7 ± 7.5 respectively. The regression equation describing this relationship is  $TDC = 36.9 - 5.0 \ln(\text{depth})$  in mm with *r* = 0.969. Day-to-day variability: Considering the difference in TDC values between day1 and day2 at each measured time point, the least day-to-day difference occurred for measurements taken at different times depending on measurement depth. The overall average day-to-day difference in TDC values did not exceed 3% but at one time (2200) it was 9% for the 0.5mm depth.

**Conclusions:** Results show differences in TDC values at varying skin depths and time of day. At the deepest skin layers measured, TDC values were more constant from morning to night compared to superficial depths. Although TDC values differ between different skin depths, the values within the same skin depth remain relatively constant over the 16-hour interval studied. This suggests that the specific skin depth measured is more important to keep constant than the time-of-day differences for a specific probe measurement. The data suggests TDC values are a relatively reliable method to evaluate skin water content over the 16-hour interval studied, with little variability between consecutive days assessed in the healthy population. When evaluating BCRL, TDC measurement reproducibility is optimized when consistent probe depth is maintained over a 16-hour interval and over consecutive days.