Physiological Effects of Eccrine Gland Activation on Skin Tissue Dielectric Constant

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Background

Skin TDC values are usually measured using the open-ended coaxial transmission line method. At the normally used frequency (300 MHz) the TDC value, which is in effect the real part of the complex permittivity, is mainly dependent on skin water (free and bound). TDC measurements are noninvasive and require simple touching of the skin with a suitable probe for a few seconds to obtain a measurement. This method has been used to assess skin properties and their change in variety of conditions including diabetes, edema and lymphedema. However, because this is a skin-related measurement that includes within its measurement volume eccrine glands it is important to have an estimate of the impact of eccrine gland activation on the measured TDC value. There is essentially no information on this issue. In fact, the effect of eccrine glands and their activation on TDC values is unknown.

Objectives

To examine and clarify the potential role of eccrine gland activation on the tissue dielectric constant (TDC) measure on skin.

Methods

Two initial experimental approaches were formulated for evaluation. In both, skin water changes were assessed via TDC measurements. These are done by touching the skin with a device (MoistureMeter) that measures TDC via the open-ended transmission line method. The approaches, described below, were tested in a single subject as pilot work.

In TEST 1, TDC and skin temperature measurements were taken on the forehead and anterior forearm before, immediately after, and six-minutes after removal of heat that was applied by two standard heating pads. At each time point TDC was measured six times in rapid succession.

TEST 2 used Methyl Nicotinate (MN) applied to the anterior forearm (ArthArrest, 0.5% MN ≈ 35mM). TDC measurements were made before and after MN application. In addition, skin blood flow at the application site was measured before (baseline) and during MN using the method laser Doppler flowmetry. The response to MN application was monitored for about six minutes (Figure 3 and 4).

Results

Whole body has approximately 4 X 10^6 eccrine sweat glands with the forehead containing 360 ± 50 /cm^2 and forearm 225 ± 25 /cm^2. Eccrine tube length and diameter are on average 5mm and 0.02-0.05mm respectively. Sweat is composed of 99.0-99.5% water with about 75 Mm Na^+ and Cl^- thus is likely to affect TDC values in a pore-density and activation state dependent manner.

Test 1 Heating Pad

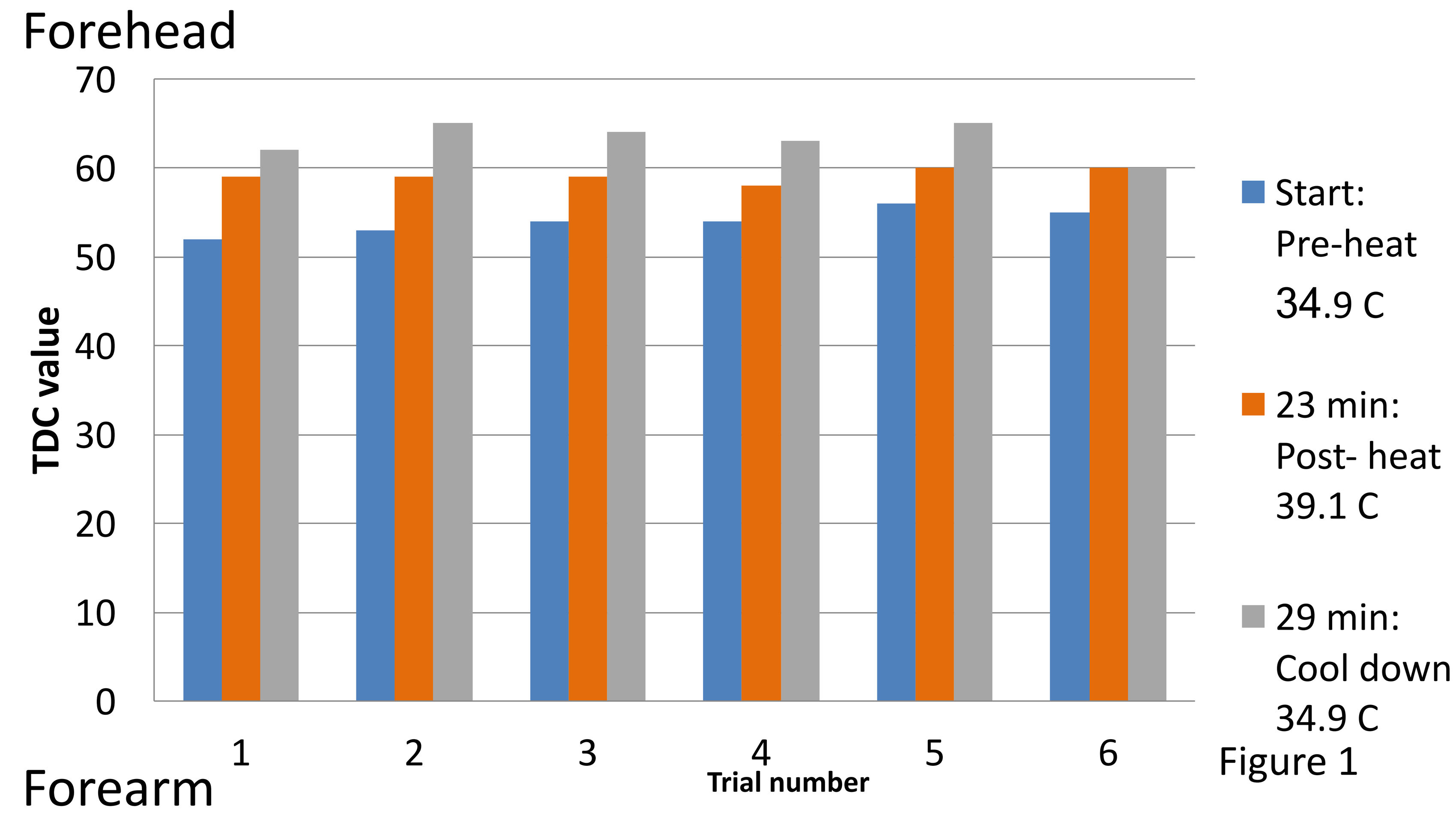

Figure 1

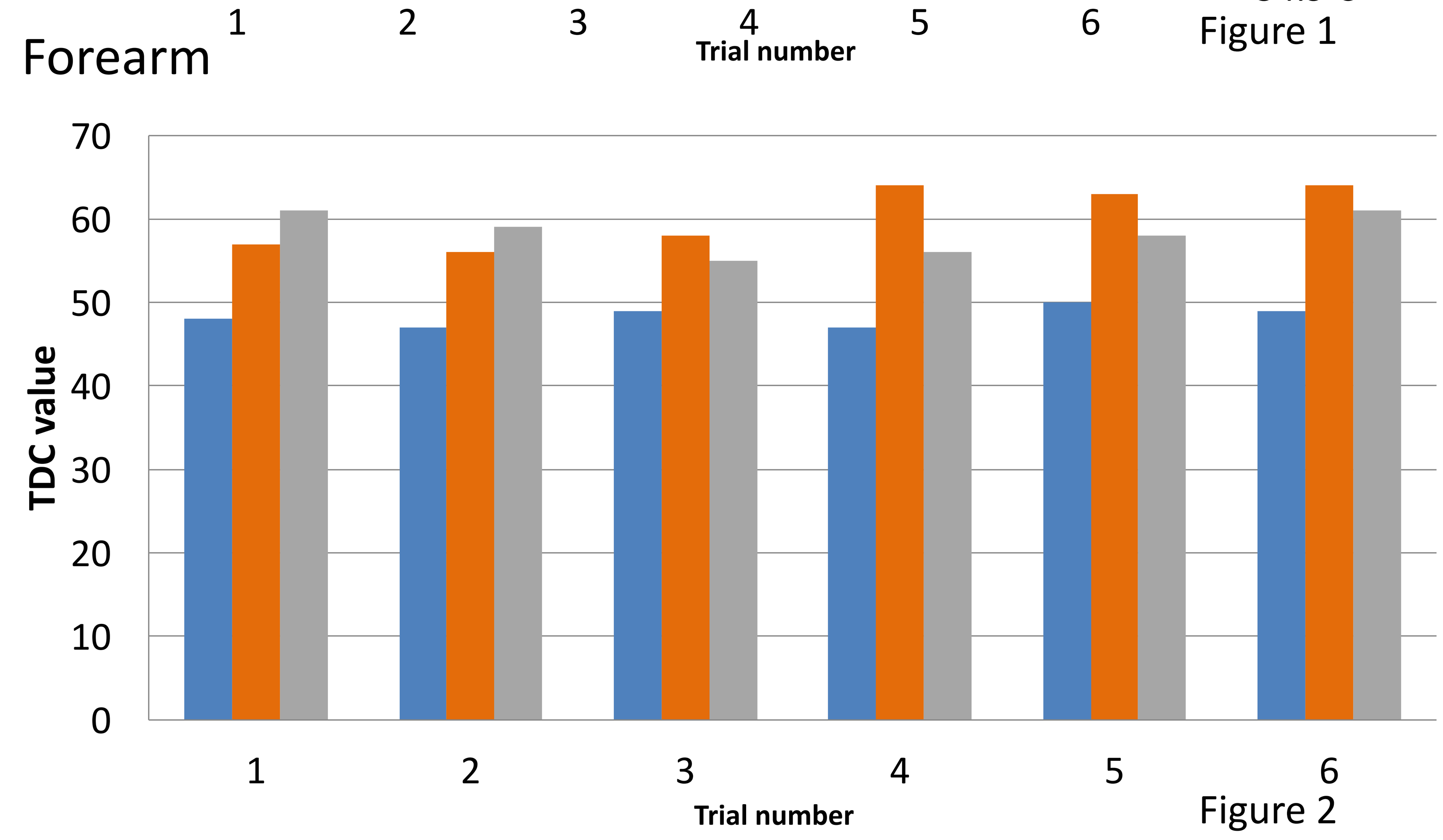

Figure 2

Test 2 Methyl Nicotinate

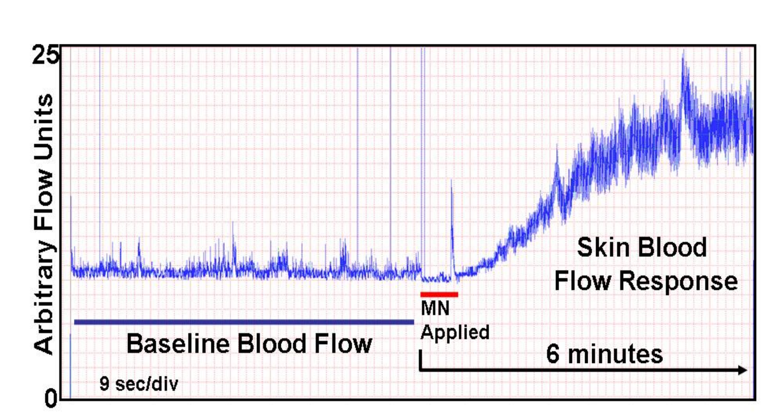

Figure 3

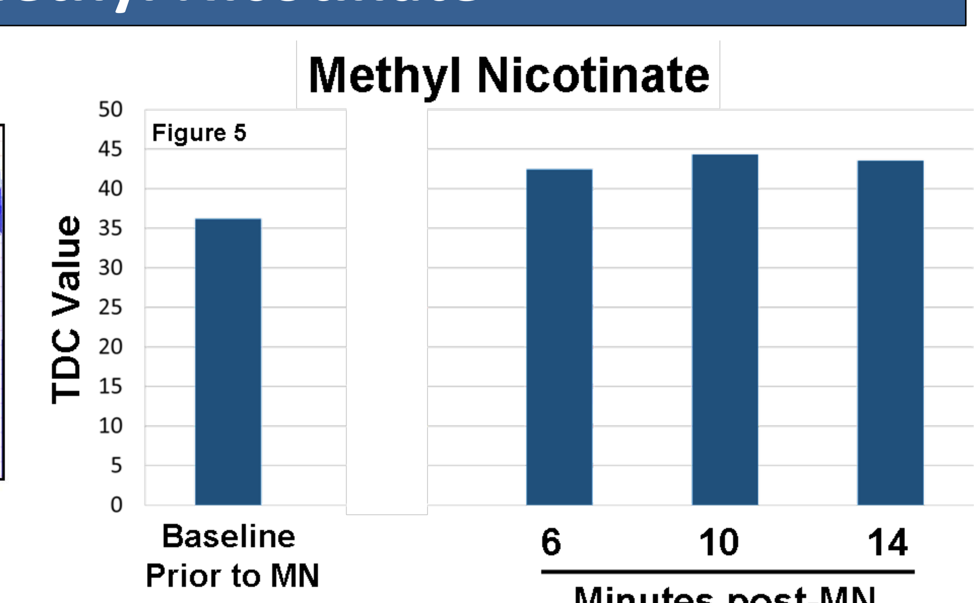

Figure 4

In TEST 1, with only heat applied, TDC values increased on forehead (Figure 1) and on forearm (Figure 2) as determined immediately after removal of the heat source and TDC continued to increase during the cool down process. This was attributed in part to the sweating increase. In TEST 2, with MN application, skin blood flow (Figure 3) increased without inducing any detectible sweat increase in the area. As illustrated in figure 4 there was also a concomitant increase in measured TDC values as compared to the baseline measurements.

Conclusions

The amount and content of activated eccrine glands appears to have the potential to impact TDC values. The significance of this fact lies in the way such activation may confound TDC measurements aimed at detecting and tracking edema or lymphedema or other conditions. Our future research focus is thus to fully develop both the analytical and experimental procedures to better characterize the impact range of such eccrine gland activation on measured TDC values.