Skin Water in Persons with Diabetes Mellitus (DM) Assessed by Tissue Dielectric Constant (TDC) Measured at 300 MHz
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Background
Worldwide, there are about 285 million people with Diabetes Mellitus (DM) and about 1/3 of them have skin related changes\(^1\). Prior research showed alterations in skin-to-fat tissue water especially prevalent in foot dorsum skin\(^2\) but specific mechanisms have not been clarified. Literature is consistent with the theory that hyperglycemia-induced non-enzymatic glycation of structural and regulatory proteins may play a role in the pathogenesis of diabetic complications. In this scenario, excess supply of glucose in the blood plasma leads to a non-enzymatic chemical reaction between the carboxyl group of glucose and the amino acid of proteins\(^3\). This glycation of structural and regulatory proteins might play a role in the pathogenesis of diabetic skin complications\(^4\).

Objectives
Our purpose was to test the hypothesis that in persons with DM the dermal collagen glycation displaces bound water and thereby decreases skin tissue water. If true then a measurable inverse relationship between skin water and HbA1c should be present. Hence, we tested for a negative relationship between skin-to-fat tissue water measured by Tissue dielectric constant (TDC) and HbA1c values in persons with DM. If a correlation were present it might be used to implement preventative care in patients with DM with a specific range of HbA1c values.

Subjects
A total of 48 persons (18 male) participated in this study after signing an IRB approved consent form. The data were collected after the scheduled appointment time of the patient at clinic. There were 39 Type II DM patients and 9 Type I DM patients included in the study. Other subject data is in Table 1.

Measurements and Protocol
TDC MEASUREMENTS were done using the MoistureMeter D (Fig 1). The MMD is a non-invasive, battery operated hand-held device utilizing gold plated brass open-ended coaxial probes (Fig 3a, b). The probe measures TDC at 300 MHz. For this study probes used had an effective penetration depths of 0.5, 1.5, 2.5 and 5.0 mm. Three sites were measured on one body side: (1) anterior forearm 6 cm distal to the antecubital fossa, (2) gaiter area 30 cm superior to the medial malleolus and (3) foot dorsum between the junction of the 1st and 2nd toes. Each site was measured in triplicate and averaged.

BIOMEDPENCE MEASUREMENTS were done to obtain total body composition using an Ironman InnerScan Body Composition Monitor (Figs 2 & 3c). It is a non-invasive, battery operated device that measures electrical impedance while the subject stands. The subject’s gender, birth date, and height are entered into the device after which the subject steps onto the scale and grips two attached handles for a period of about 20 seconds. Measured parameters include: weight, %body fat, %body water, muscle mass, and limb segmental values.

Results
The focus of this study was to test the initial hypothesis that HbA1c and skin-to-fat tissue water had an inverse relationship as measured at different depths and different sites of persons with diabetes mellitus. The hypothesis is not supported by present findings. No statistical significance was found between TDC values and HbA1c. We thus conclude that over the range of HbA1c values herein evaluated there is little effect of HbA1c on skin water as judged by TDC measurements at the level of dermis and hypodermis. This allows us to look for further possible studies to evaluate the epidermal layer. Further, the TDC values herein obtained provide a DM-related TDC reference data set.

References