Background and Objectives

BACKGROUND: Worldwide, there are about 285 million people with Diabetes Mellitus and about 1/3 of them manifest with skin changes. Research using ultrasound indicates that patients with DM have thinner skin and less subcutaneous fat than age-matched controls (ref). This finding is consistent with the idea that such biophysical changes may alter the skin-to-fat tissue water content that then alters skin functions. Literature is consistent with the theory that hyperglycemia-induced non-enzymatic glycation of structural and regulatory proteins plays a major 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 carbonyl group of glucose and the amino acid of proteins. This glycation of structural and regulatory proteins plays a key role in the pathogenesis of diabetic skin complications such as diabetic ulcer or diabetic foot syndrome; however, it is not clear how changes in tissue water content affect this process.

Purpose

We hypothesize that in persons with DM dermal collagen glycation displaces bound water and thereby decreases free water space and that this leads to a reduction in skin tissue water. The purpose of this study is to test this hypothesis by determining if there is an inverse relationship between HbA1c and skin-to-fat tissue water as measured by tissue dielectric constant (TDC) values. Further, because of demonstrated differences in TDC values between genders these measurements are being conducted in both male and female subjects. To date, measurements were done in 28 subjects, 25 type II DM and 3 type I DM, 8 males, 20 females.

Protocol

TDC MEASUREMENTS were done using the MoistureMeter-D (Fig 1) at the forearm, leg and foot. The device acts as an open ended coaxial probe that measures at a frequency of 300 MHz. For this purpose of the study the probes used had an effective penetration depths of 0.5 mm, 1.5 mm, 2.5 mm and 5.0 mm (Fig 1 d and e). For reference, pure water has a TDC value of 76 at 34°.C. The specific sites measured were the anterior forearm 6 cm distal to the antecubital fossa, 10 cm superior to the medial malleolus and at dorsum of the foot between the junction of the 1st and 2nd toes. All measurements are done on the dominant side of the subject. Each TDC measurement was done in triplicate and averaged.

BIOMEDPEANCE MEASUREMENTS were done to obtain total body composition using the Ironman InnerScan Body Composition Monitor (Fig 2a and 2b). The Ironman is a non-invasive, battery operated device that measures the electrical impedance value of the body while the subject is in the standing position. The subject’s gender, birth date, and height are entered into the device after which the subject removes shoes and socks and step onto the scale and grip two attached handles for a period of about 20 seconds (Fig 2a). Measured parameters include: weight, body fat percent, body water percent, muscle mass, visceral composition.

Skin-to-fat Water in Diabetes Mellitus Assessed by Tissue Dielectric Constant (TDC): Variations with Respect to Depth, Anatomical Site and HbA1C

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Measurement Methods

FIG 1. TDC Measurements

Tissue Dielectric Constant is directly related to H₂O in the measuring volume. A coaxial probe contacts skin for about 10 seconds. The probe, connected to a control and display device, measures TDC at 300 MHz. At this frequency the TDC value depends on both free and bound H₂O. TDC was measured to effective depths of 0.5 mm, 1.5 mm, 2.5 mm and 5.0 mm as shown in Fig 1e.

FIG 2. Body Composition

Biompedance was used to estimate total body and segmental composition parameters including total body fat (%Fat) and %Fat. The device measured biompedance at a frequency of 50 KHz. Algorithms to estimate body parameters are usually company private.

Subject Descriptive Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>31-86</td>
<td>65.9 ± 14.7</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>18.1-36.9</td>
<td>27.1 ± 5.1</td>
</tr>
<tr>
<td>HbA1C (%)</td>
<td>5.5-12.9</td>
<td>8.1 ± 1.8</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>92-349</td>
<td>171.3 ± 61.7</td>
</tr>
<tr>
<td>Total Body Water (%)</td>
<td>40.6-60.4</td>
<td>48.6 ± 5.4</td>
</tr>
<tr>
<td>Total Body Fat (%)</td>
<td>15.6-43.8</td>
<td>32.4 ± 7.5</td>
</tr>
<tr>
<td>BP Systolic (mmHg)</td>
<td>98-180</td>
<td>121.2 ± 20</td>
</tr>
<tr>
<td>BP Diastolic (mmHg)</td>
<td>50-100</td>
<td>72 ± 11.9</td>
</tr>
</tbody>
</table>

Results

FIG 1d. Effective Penetration Depth

The main focus of the study was to test the hypothesis that there is an inverse correlation between HbA1c and skin-to-fat tissue water measured at different depths and different sites of persons with DM. The trend for a negative correlation between TDC values and HbA1c is not statistically significant at any measured depth. Therefore, with respect to tissue water it is unlikely that HbA1c is of significant clinical importance. However, the depth and site data provide baseline information on patients with diabetes for subsequent use.

Conclusion

The main focus of the study was to test the hypothesis that there is an inverse correlation between HbA1c and skin-to-fat tissue water measured at different depths and different sites of persons with DM. The trend for a negative correlation between TDC values and HbA1c is not statistically significant at any measured depth. Therefore, with respect to tissue water it is unlikely that HbA1c is of significant clinical importance. However, the depth and site data provide baseline information on patients with diabetes for subsequent use.

References


FIG 1

FIG 2a

FIG 2b

FIG 2c

FIG 2d

FIG 2e

FIG 3

FIG 4

FIG 1a

FIG 1b

FIG 1c

FIG 1f

FIG 1g

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FIG 1r

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FIG 1w

FIG 1x

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FIG 2a

FIG 2b

FIG 2c

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FIG 2m

FIG 2n

FIG 2o

FIG 2p

FIG 2q

FIG 2r

FIG 2s

FIG 2t

FIG 2u

FIG 2v

FIG 2w

FIG 2x

FIG 2y

FIG 2z

FIG 3

FIG 4

FIG 1

FIG 2

FIG 3

FIG 4

FIG 1

FIG 2

FIG 3

FIG 4

FIG 1

FIG 2

FIG 3

FIG 4