A Method to Early Detect Lower Extremity Edema Due to Congestive Heart Failure (CHF)

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Background
A common symptom of congestive heart failure is lower extremity edema, usually bilateral, that may affect foot dorsum, ankle and lower leg. Once edema is visually observed the consecutive process is usually well established. However, there is no method that can easily detect the early and potentially insidious changes in fluid content of these regions. One method to assess localized skin water via a non-invasive measurement of the skin-to-fat tissue dielectric constant (TDC) at 300 MHz that is strongly dependent on the free and bound water content of the skin tissue. Because of patient-to-patient variability in the absolute value of such TDC measurements it would be difficult to apply such measurements for the assessment of sub-clinical or low early levels of edema. Further complicating such detection processes is that the condition tends to be bilateral. However, if one were able to develop a suitable parameter in which each patient could be assessed based on a ratio of TDC values, the confounding nature of absolute values could be avoided. It is our objective to determine if the ratio of lower extremity to upper extremity TDC values may be used as such a reference. Since upper extremity values are essentially unaffected by lower extremity edema formation one would hypothesize that the lower extremity to upper extremity TDC ratio would indicate in the presence of edema.

Objective
Our goal of the research study is to provide reference ratios of healthy persons that will provide reference data that can subsequently be used for the early detection of lower extremity edema that usually accompanies congestive heart failure. Direct non-invasive measurements ratios of TDC values of hand to foot and leg and arm to foot and leg will be used to determine and establish reference values for future use. In addition, comparisons in these ratios by gender and age will be made to determine the extent to which such reference ratios are either age or gender dependent.

Subjects
A total of 80 subjects will be participating in this study once the data is completed. Both males and females of any race will be recruited. The subject pool will be divided into two groups; a younger group that includes subjects in the age range 18-30, and a mature group that includes subjects ages 50+. Recruitment is done by word of mouth to volunteers that are willing to offer approximately 30 minutes of their time. Exclusion criteria for this study include: open wounds at sites of measurements, current or prior history of edema, currently pregnant, current or prior history of diabetes or congestive heart failure.

Measurement Methods

TDC MEASUREMENTS:
Skin water was assessed by tissue dielectric constant measurements (TDC) at 300 MHz to approximate skin depths of 0.5 mm and 2.5 mm on five different anatomical sites: (Fig 1) hand, (Fig 2) forearm 4 cm distal to the antecubital fossa, dorsum of foot near 1st and 2nd toe, (Fig. 4) medial leg and (Fig. 3) lateral leg at about 6 cm above the malleolus. Each site measurement was repeated three times and averaged.

BIOIMPEDANCE MEASUREMENTS:
Body composition of each subject was measured using Ironman InnerScan body Composition monitor (Fig 5 & 6b). It is a battery operated device that measures the 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 15 seconds. Measured parameters include: total body weight, totally body fat %, total body water %, and fat percentages of limb segmental values (left arm, right arm, left leg, right left).

Preliminary Results

In graph 1 above, the y-axis describes the leg/arm ratio compared to the x-axis, which has lateral leg/arm ratio and medial leg/arm ratio. This preliminary data is expressed with a total of 26 subjects sample size, 16 female and 10 male, ages 23-75 years old (35.7 ± 17.9 years). The ratio seen in the medial leg/arm is consistently lower overall than in the lateral leg/arm. Medial leg/arm TDC values of the non-dominant ratio was the lowest value overall (1.087 ± 0.184), with the dominant value as the 2nd lowest value (1.125 ± 0.185). The TDC values of lateral leg/arm were significantly higher (P<0.001). Lateral leg/arm non-dominant was the highest value overall (1.358 ± 0.316), with the dominant lateral leg/arm value as the 2nd highest value (1.330 ± 0.304).

Conclusions
Our preliminary results of this study thus far seem to be useful in demonstrating a non-invasive suitable method to assess the presence of lower extremity edema. As the study progresses, additional reference data will provide more conclusive evidence on the initial hypothesis.

Selected References