Non invasive Glucose Monitoring using a multisensor concept based on Impedance Spectroscopy

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Various approaches to non invasive glucose monitoring, including impedance Spectroscopy (IS) are known. Some of these techniques were mostly tested in an in-vitro setting or under controlled in-vivo conditions. It has been shown that under daily-life conditions, additional external or physiological factors can also effect the measurement. Here we report about two experimental clinical trials (part 1 & 2) which were set up to investigate these perturbing effects and the relation to glucose changes.

The first part was designed to specify, develop, characterise and optimise an array of non-invasive sensors based around IS. The relation between changes in blood perfusion/moisture characteristics of the skin and underlying tissue (SAUT) and the dielectric behaviour was investigated in 9 healthy subjects (5 male, 4 female, age 26±8 years; BMI 21.5±2.1 kg/m^2). The dielectric properties of the SAUT were measured in response to externally applied changes together with an optical, a acceleration/pressure and a temperature sensor.
The second experimental clinical part was designed to test this multisensor concept in patients with diabetes and healthy subjects. Four patients with type 1 diabetes mellitus (T1DM) age 35.8±10.4 years, BMI 23.8±1.6kg/m2 and HbA1c 7.0%±1.7; three patients with T2DM age 57±11.4 years, BMI 24.7±3.8kg/m^2, HbA1c 6.7%±0.7; four healthy subjects age 24.5±4.5 years, BMI 21.4±1.6 kg/m^2 participated in this study. Two hyperglycemic excursions were induced using a manual glucose clamp technique.

Results Part 1: The multisensor concept was providing additional information to compensate for perturbing effects allowing to demonstrate that e.g. changes in the IS signal are due to a changes in blood perfusion or sweat.
Results Part 2: An empirical data modelling process based on multiple regression with variable selection was used to derive a set of tentative models for glucose prediction based on the data of the second part. The model selection was carried out on 13 runs from 4 healthy subjects and 3 TIDM patients. The resulting squared multiple correlation coefficient was R^2=0.71 for the chosen model.

The multisensor concept has shown the possibility to account for and compensate the perturbing effects. From the data of the second study a global model family was derived including an individual parameter for baseline adjustment allowing glucose changes to be tracked. In a next step the concept will be studied more extensively (e.g. with oral carbohydrate intake).