Modell alapú diabetes életmód-támogatás

Model based diabetes lifestyle counseling

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Introduction

In our work, we focus on outpatients treated with insulin injections no matter having type 1, type 2 or other type of diabetes. The basic motivation of our efforts is to provide diabetics with a mobile tool that they can use in everyday life to predict their short time blood glucose levels. Such a tool can be implemented as a smart phone application with a comprehensive food and dish database. The basis of our implementation is the Lavinia lifestyle mirror application developed at the University of Pannonia. This presentation focuses on the efficiency of the blood glucose model.

Methods

The modeling problem can be divided in two parts. The first one is glucose absorption from meals and the second one is the glucose controlling system including insulin evolution. Our model uses a combination of two existing models for nutrient absorption[1] and glucose control[2].
In contrast to simpler methods, our model takes protein, lipid, monosaccharide, fiber and starch as input, each one having its own effect during the absorption. Besides, the method can deal with mixed meals by using glycemic indexes, and digestion overlap is handled properly as well. The whole process is based on mass balance equations. The output of the model is the estimated blood glucose curve in the function of time. A novelty of our method is that we personalize the model parameters to fit the individual patient, using a learning scheme based on genetic algorithms.

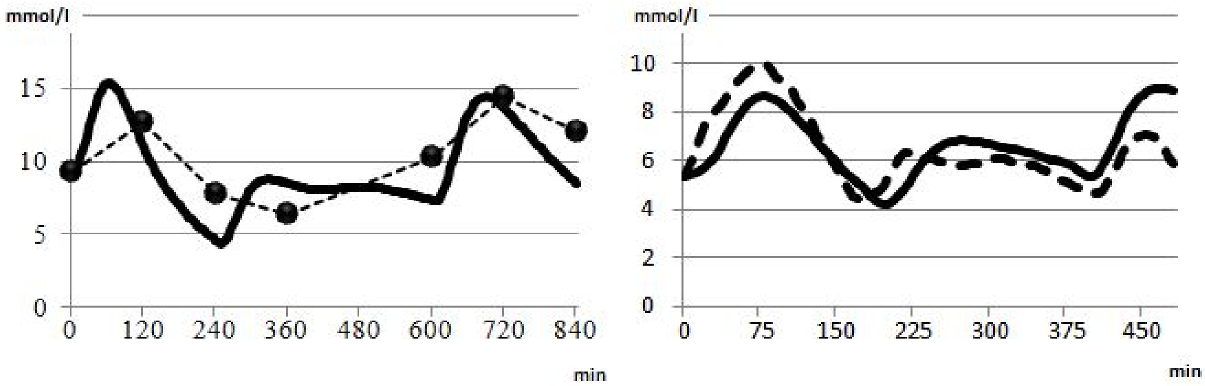
Results

To validate the model as a first step we have done tests on virtual patients, then several tests were made on outpatients. Two persons with diabetes mellitus were examined. The first test involved a woman with Type 2 diabetes (A), while the second patient was Type 1 diabetic man (B). Both patients were cured with similar protocol using subcutaneous insulin injections. The tests were executed with the same parameters. Patient A was treated as inpatient to adjust her inordinate blood glucose levels. Medication, glucose readings and meals were logged during 6 days including 15 meals and 45 glucose level measurements by ordinary blood glucose meter. In the case of outpatient B a controlled experiment was made during 3 days with 13 meals. The blood sugar level was monitored by a Medtronic Guardian Real-Time Continuous Glucose Monitoring (CGM) System, measuring the actual value every 5 minutes. The resulting blood

[1] Arleth, T., Andreassen, S., Orsini-Federiri, M., Timi, A., Massi-Benedetti, M., A model of glucose absorption from mixed meals, IFAC, 2000

[2] Pasquale Palumbo, Ditlevsen S., Alessandro Bertuzzi, Andrea De Gaetano: Mathematical modeling of the glucose-insulin system: a review, Mathematical Biosciences 244, 69-81, 2013

glucose curves are shown in the figure below. The model yielded an average error of 3.22/2.46 mmol/l fot the Patient A/B. The difference between the predicted and measured value was less than 3 mmol/l in 61/73% of the cases, less than 5 mmol/l in 86/77% of the cases, and less than 8 mmol/l in 96/100% of the cases.



The fifth day of patient A (left) and the first eight hours of the whole third day of patient B (right) (solid line – model estimations, dashed line – measured values).

Discussion

The results are satisfactory without any a priori identification protocol, but using genetic algorithms for model training. Further research is needed for training the model to support personal variations in model parameters and extending the model to use also other physiological data available like physical activity and stress. Our aim is to decrease the average error under 1 mmol/l, which is a significant and sufficient margin of error considering that the currently used real measurements have a similar margin of error. The model is currently being further evaluated in a clinical study with 20 rehabilitation patients, as an add-on module to the Lavinia application.

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