Glucose Rate of Appearance and Subcutaneous Insulin Absorption Models for Use in Prediction Algorithms

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INTRODUCTION

The 7th framework European Project DIAdvisor [1] aims to develop of an **advisory** system for Type 1 Diabetes Patients. This device will generate **alarms** and give **suggestions** for the optimal disease management based on short-term glucose prediction and control algorithms.
Glucose prediction algorithms usually use the information on ingested CHO and insulin administration to improve their performance (e.g. ARX models). However since the dynamics of the system are non linear the knowledge of meal glucose rate of appearance and Insulin concentration could be more valuable than the simple time and dose information.

AIM

The aim of this work is to propose 2 models to provide a rough estimation of the rate of appearance (Ra) of glucose and of insulin concentration in plasma based on the knowledge of meals and injections times/doses.

METHODS

Database: Data from 14 Type-1 Diabetics subjects from the DIAdvisor Clinical Data Acquisition Trial sudied at the CHU, Montpellier and at the DMCS in Padova were employed for the identification of the models.

Protocol: The subjects received 3 controlled meals for 3 days (CHO: 40g breakfast, 70g lunch, 70g dinner). Plasma glucose and insulin concentration were frequently measured.

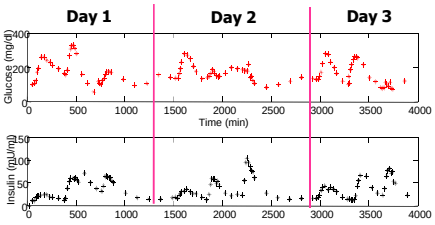


Figure 1. Example of Blood Glucose (top) and Insulin Concentration (bottom) profiles.

The Glucose Ra Model: The model used to generate the Rate of appearance of glucose into the plasma after transit through the gastrointestinal tract is that proposed in [2].

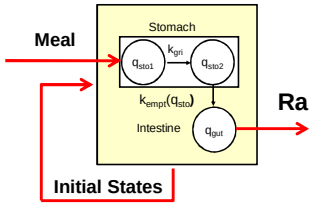
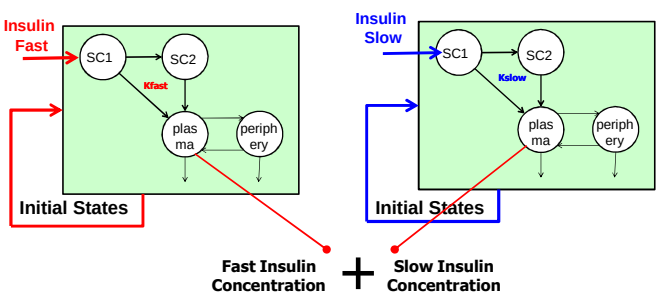


Figure 2. Glucose Rate of appearance Model

- Model parameters were estimated. The models were identified on each meal separately.
- The implementation of the function is suitable to be used online.

The Subcutaneous Insulin Absorption Model: The model used to generate the insulin concentration in plasma is that proposed in [3].
It can be solved with two different sets of **mean** absorption parameters (Kfast/Kslow) to account for the different absorption dynamics of slow and fast insulin. The predicted slow and fast insulin concentrations are summed up to obtain the total concentration of insulin in plasma.



RESULTS

Model Simulation: Different scenarios of meal intake and insulin adminitration were simulated.

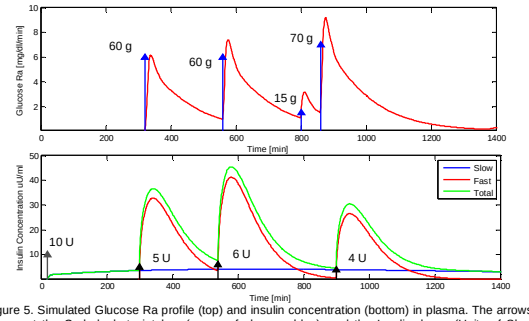
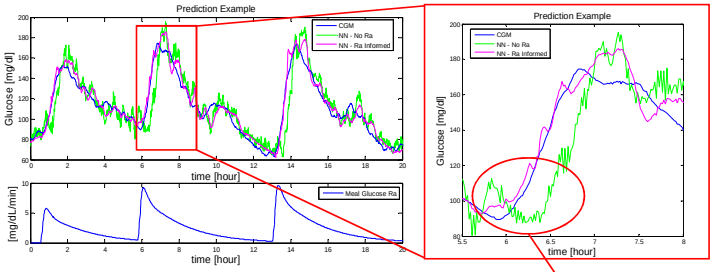


Figure 5. Simulated Glucose Ra profile (top) and insulin concentration (bottom) in plasma. The arrows represent the Carbohydrate intakes (grams of glucose, blue), and the Insulin doses (Units of Slow Insulin, gray, Units of Fast Insulin, black)

Model Employement: Several feed forward neural network (FFNN) prediction algorithms (see Facchinetti et al. DTM 2010, Poster 23) were tested in silico with and without the aid of the Ra model (External Inputs). The CGM traces were simulated with the Type-1 Diabetic Simulator [4].



FFNN – No External Input	FFNN – External Input
RMSE NN = 10.7	RMSE NN = 8.5
Time Gain = 17 min	Time Gain = 23 min

The meal information allows a faster detection of the rising pattern

CONCLUSIONS

The proposed models allow a reliable prediction of the glucose rate of appearance and insulin concentration in plasma.

Prediction algorithms may benefit from the knowledge of these signals. For Instance, the performance of a FFNN prediction algorithm improved both in terms of RMSE and of Time Gain when exploiting the external Input provided by the Glucose Ra Model.

ACKNOLEDGEMENT

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