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Simulation Environment to Evaluate Closed-Loop Insulin Delivery Systems in Type 1 Diabetes

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Abstract

Background:
Closed-loop insulin delivery systems linking subcutaneous insulin infusion to real-time continuous glucose monitoring need to be evaluated in humans, but progress can be accelerated with the use of *in silico* testing. We present a simulation environment designed to support the development and testing of closed-loop insulin delivery systems in type 1 diabetes mellitus (T1DM).

Methods:
The principal components of the simulation environment include a mathematical model of glucose regulation representing a virtual population with T1DM, the glucose measurement model, and the insulin delivery model. The simulation environment is highly flexible. The user can specify an experimental protocol, define a population of virtual subjects, choose glucose measurement and insulin delivery models, and specify outcome measures. The environment provides graphical as well as numerical outputs to enable a comprehensive analysis of *in silico* study results. The simulation environment is validated by comparing its predictions against a clinical study evaluating overnight closed-loop insulin delivery in young people with T1DM using a model predictive controller.

Results:
The simulation model of glucose regulation is described, and population values of 18 synthetic subjects are provided. The validation study demonstrated that the simulation environment was able to reproduce the population results of the clinical study conducted in young people with T1DM.

Conclusions:
Closed-loop trials in humans should be preceded and concurrently guided by highly efficient and resource-saving computer-based simulations. We demonstrate validity of population-based predictions obtained with our simulation environment.

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Abbreviations: (CGM) continuous glucose monitoring, (CHO) carbohydrate, (CV) coefficient of variation, (FSN) FreeStyle Navigator, (HBGI) high blood glucose index, (LBGI) low blood glucose index, (MPC) model predictive control, (sc) subcutaneous, (T1DM) type 1 diabetes mellitus

Keywords: artificial pancreas, compartment modeling, computer simulation, glucose regulation, simulation model

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