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SYMPOSIUM

Physical Activity into the Meal Glucose–Insulin Model of Type 1 Diabetes: *In Silico* Studies

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Abstract

Introduction:
A simulation model of a glucose–insulin system accounting for physical activity is needed to reliably simulate normal life conditions, thus accelerating the development of an artificial pancreas. In fact, exercise causes a transient increase of insulin action and may lead to hypoglycemia. However, physical activity is difficult to model. In the past, it was described indirectly as a rise in insulin. Recently, a new parsimonious model of exercise effect on glucose homeostasis has been proposed that links the change in insulin action and glucose effectiveness to heart rate (HR). The aim of this study was to plug this exercise model into our recently proposed large-scale simulation model of glucose metabolism in type 1 diabetes to better describe normal life conditions.

Methods:
The exercise model describes changes in glucose–insulin dynamics in two phases: a rapid on-and-off change in insulin-independent glucose clearance and a rapid-on/slow-off change in insulin sensitivity. Three candidate models of glucose effectiveness and insulin sensitivity as a function of HR have been considered, both during exercise and recovery after exercise. By incorporating these three models into the type 1 diabetes model, we simulated different levels (from mild to moderate) and duration of exercise (15 and 30 minutes), both in steady-state (e.g., during euglycemic–hyperinsulinemic clamp) and in nonsteady state (e.g., after a meal) conditions.

Results:
One candidate exercise model was selected as the most reliable.

Conclusions:
A type 1 diabetes model also describing physical activity is proposed. The model represents a step forward to accurately describe glucose homeostasis in normal life conditions; however, further studies are needed to validate it against data.

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Abbreviations: (bpm) beats per minute, (FDA) Food and Drug Administration, (GLUT-4) glucose transporter-4, (HR) heart rate, (MPC) model predictive control

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