

Dynamic Modeling of Exercise Effects on Plasma Glucose and Insulin Levels

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Abstract

Background:

Regulation of plasma glucose concentration for type 1 diabetic patients is challenging, and exercise is an added complication. From a metabolic prospective, the significant exercise-induced effects are increased glucose uptake rate by the working tissues, increased hepatic glucose release to maintain overall glucose homeostasis, and decreased plasma insulin concentration. During prolonged exercise, glucose levels drop significantly because of the decrease in hepatic glucose production. With the long-term goal of developing a closed-loop insulin delivery system operating under various physiological conditions, it is necessary to develop a model that is capable of predicting blood glucose concentration at rest and during physical activity.

Methods:

A minimal model developed previously was extended to include the major effects of exercise on plasma glucose and insulin levels. Differential equations were developed to capture the exercise-induced dynamics of plasma insulin clearance and the elevation of glucose uptake and hepatic glucose production rates. The decreasing liver glucose output resulting from prolonged exercise was modeled using an equation depending on exercise intensity and duration.

Results:

The exercise model successfully captured the glucose and insulin dynamics during short- and long-term exercise. Model predictions of glucose and insulin dynamics during the postexercise recovery period were also consistent with literature data.

Conclusion:

The model successfully emulated the physiological effects of exercise on blood glucose and insulin levels. This extended model may provide a new disturbance test platform for the development of closed-loop glucose control algorithms.

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Abbreviations: (CI) confidence interval, (T1DM) type 1 diabetes mellitus

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