CALIBRATION AND EVALUATION OF A PHYSIOLOGICAL ODE MODEL FOR BLOOD GLUCOSE DYNAMICS IN TYPE 2 DIABETES MELLITUS

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Abstract

Developing physiologically interpretable mathematical models of blood glucose dynamics is an important challenge in the personalized management of Type 2 Diabetes Mellitus (T2DM). This study applies a five-state physiological ordinary differential equation (ODE) model, adapted from established glucose–insulin modelling frameworks, to the Shanghai T2DM continuous glucose monitoring (CGM) dataset. The model consists of five coupled ODEs describing glucose absorption, insulin action, and glucose regulation, drawing on concepts from the classical Bergman and Dalla Man models. Seven model parameters were estimated using Genetic Algorithm (GA)-based calibration by minimizing the mean squared error between observed and simulated glucose trajectories for a single patient. Model fit was assessed using the Root Mean Square Error (RMSE) and the Coefficient of Determination (R^2), calculated from the same CGM observations used for calibration. The calibrated model achieved an RMSE of 33.89 mg/dL and an R^2 of 0.386, indicating a limited fit to the calibration data. This result does not establish independent predictive performance, as no separate test set, temporal holdout, or independent validation data were used. Parameter stability across multiple GA runs was not assessed, as calibration was performed using a single run with one random seed. The study provides an initial patient-specific application of the five-state physiological ODE model to real-world CGM data. Future work will extend calibration and evaluation to multiple patients, assess parameter stability through repeated GA runs, and investigate potential improvements in model structure, parameter estimation, and uncertainty quantification to address the limitations observed in the current model while preserving physiological interpretability.

Keywords: Type 2 diabetes mellitus, Blood glucose dynamics, Physiological ODE model, Genetic algorithm, Mathematical modelling.