Modelling of glucose dynamics and estimation of insulin sensitivity from glucose data only

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Objective:
The measurement of insulin is laborious, expensive and subject to significant inter-assay variability. Nevertheless, the vast majority of mathematical models for postprandial glucose metabolism and the estimation of insulin sensitivity rely upon the measurement of insulin, hindering their use in clinical practice. We therefore developed a mathematical model for the description of postprandial glucose dynamics and estimation of insulin sensitivity utilizing only glucose data.

Method:
A total of 66 postprandial glucose and insulin responses from healthy, young, non-obese subjects consuming three identical mixed meals in a single day were utilized to identify the well-established oral minimal model (OMM), yielding a description of glucose dynamics and estimate of insulin sensitivity from all responses. A newly developed adaptation of the OMM was subsequently identified from the glucose responses only. It utilizes a novel description for the meal related appearance of glucose and introduces a description for glucose dependent stimulation of the "active" insulin effect.

Result:
The model using glucose data only yields a similar description of glucose dynamics in comparison to the OMM, as assessed by the root mean-squared error (mean 0.28 vs 0.29 mmol/L, $p>0.5$). The newly introduced parameter governing the glucose dependent stimulation of the insulin effect in the glucose only model correlates well with OMM estimated insulin sensitivity ($r = 0.61$, $p < 10^{-6}$).

Conclusion:
This work is the first attempt at estimating insulin sensitivity from glucose data only and shows promising results. It uses minimal data collected under realistic experimental conditions. We therefore argue that this approach has the potential for the widespread quantification of insulin resistance in people with pre- and type 2 diabetes in clinical practice.