Characterizing blood glucose response to specific meals in pre-diabetes: a small scale study

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Abstract: **Our research area is prediction of blood glucose level. Usually, we use a combination of two state-of-the-art models reflecting the real process happening in the body. However, this model cannot handle the blood glucose control system for pre-diabetes cases. In this paper, we present an approach that tries to give prediction for two hours period after meals based on a dietary log and a calibration measurement.**

Introduction

Prediabetes is a "pre-diagnosis" of diabetes which is characterized by an elevated blood glucose level (BGL). Frackmann et al. [1] proved that the postprandial glucose profile depend on meal's absorption characteristics. The goal of the study was to characterize blood glucose response to specific types of meals using a continuous glucose monitor (CGM). If the response proves to be characteristic to the individual and the meal type, this could be used in short term postprandial blood glucose prediction for lifestyle support. Such a prediction, when implemented on a mobile device [2], can assist users in meals composition. For blood glucose prediction our research group already developed a method [3] that uses the combination of two state-of-the-art models reflecting the real process happening in the body. However, this method, running mathematical models for the digestion and blood glucose control system, is not feasible in pre-diabetes because the endogenous insulin production is hard to estimate.

Method

The study was performed with 6 healthy volunteers [2 female, 4 male, age 29.5 ± 8.5 years, body mass index 24.5 ± 5.4 kg/m2]. We performed 6 days CGM measurement, with 3 days of standardized diet with 5 meals per day, and 3 days normal meals according to the individual eating habits. Meals were designed according to daily energy needs. We had a lower

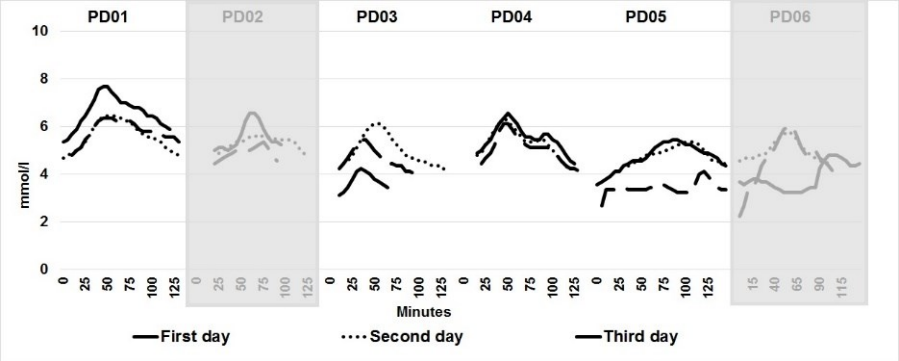
(2000 kcal) and an upper (2500 kcal) energy need group. The participants used the Lavinia dietary mirror application to log their meals. We carried out the trial with healthy people instead of pre-diabetes patients, since our experiment was designed to investigate the effect of meals on blood glucose level in short term, and also since pre-diabetes is very similar to the healthy state as in both cases the body has its own insulin production.

We characterized the postprandial glucose response profile with three numeric parameters, the first is the time to peak of glucose concentration in minutes, the second is the blood glucose level difference between the start and the peak in mmol/l, and the third is the time of the whole curve runoff. Our goal was to link these 3 parameters to the carbohydrate content and the glycemic composition of the meals [4, 5] for each investigated subject, thus setting up an 'impulse response' type method to predict the glucose concentration evolution for two hours after the meals.

Results

Due to measurement errors we cannot use two of the data sets (PD02 and PD06) but in the other data sets we can recognize the significant similarity of the three breakfast curves (FIGURE I).

FIGURE I. Blood glucose level curves in 2 hours after breakfast for 6 participants (PD01-06). The three curves were recorded on three consecutive days, with the same



breakfast.

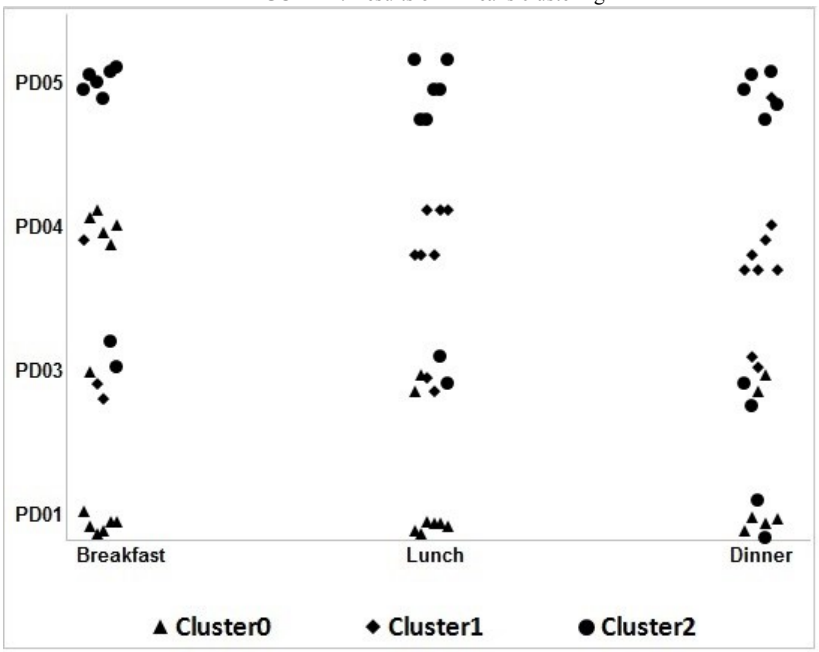
In order to define the postprandial glucose profiles we calculated the three vectors from the average of the three breakfast responses. (TABLE I).

TABLE I. Postprandial glucose curve parameters, average of three breakfast records

People	Avg. time to max (minutes)	Avg. difference (mmol/l)	Avg. time start->end (minutes)
PD01	42	3.48	128
PD03	28	1.33	90
PD04	30	1.63	115
PD05	80	1.45	133

In order to check the similarity of the response curves belonging to the same person, we performed k-means clustering based on the above parameters of all meals. The resulting 3 clusters show that three of the four persons (PD01, PD04, and PD05) have a response quite different from one another (FIGURE II).

FIGURE II. Results of k-means clustering



The results show that at least 3 (PD01, 04 and 05) of the 4 persons have a rather characteristic (personal) BGL response to the meal. This result can be a basis for personalized BGL predictions relying solely on the dietary log.

Discussion

We run this 6-person trial as a pre-study to investigate the feasibility of a more serious clinical trial. The results are yet in an initial phase. We plan to develop a numerical method based on the principles of the BGL prediction model used for diabetics, that uses such personalized vectors derived from the 'impulse responses' of a CGM-controlled meal and lifestyle log, to find and estimate for the responses belonging to other meals, possibly taking into account also the daily variations of insulin sensitivity.

If we can predict the postprandial BGL at least for the meals in the current 6-day experiment with acceptable reliability, e.g. the lunches using the breakfast profiles, then we must design a larger scope clinical trial (n>20) to be performed in the future.

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