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Using GH-Method: Math-Physical Medicine Methodology and Four Clinical Cases to Study Type 2 Diabetes Patients' Liver and Pancreas Baseline Conditions

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Introduction

The author developed his GH-Method: math-physical medicine methodology to conduct his research on endocrinological diseases, especially type 2 diabetes (T2D). The focus of this paper is to investigate a T2D patient's conditions in terms of the combination of glucose production capability by the liver and insulin production capability by beta cells in the pancreas (the "baseline condition").

Methods

The author has collected glucose data from four T2D patients within various timeframes, ranging from 7-months to 4-years. Glucose measurement counts include 4 times per day via finger-piercing and testing strip (*Finger*) and 74 times per day via a continuous blood glucose monitoring device or also known as CBGM (*Sensor*).

The objective of this study is to figure out "*Baseline Conditions*" of a particular T2D patient's natural production capabilities of both glucose (liver) and insulin (pancreas). This health status indication is a combination of liver function on glucose production plus pancreas function on glucose control; including beta cell's insulin production capability to lower those high glucoses and alpha cell's glycogen production capability to elevate those low glucoses.

He utilized a "divide & conquer or isolate & peel-off" approach of data analysis with postprandial plasma glucose (PPG) data of finger equation model to identify the lower bound of the baseline conditions. He also utilized a "simulated PPG triangular OHCA Model" (see references) and used the OHCA triangular area's mid-point value of its baseline to identify the upper bound of the baseline conditions.

First, by using finger data, he separate and remove those PPG components generated by major influential factors such as food and exercise from its linear equation model. This "subtraction" method will leave behind those glucose components which are not under direct influence by any significant glucose stimulator. The author named it *Baseline Conditions via Finger* which is the "lower-bound of the baseline conditions".

Listed below is this simplified two PPG stimulators based linear equation:

Predicted Finger PPG =

Baseline Condition

+ ((B*f(x) - C*f(y)) * D)

Where: f(x) is carbs/sugar intake in grams;

f(y) is post-meal walking in thousand step increments;

B, C, and D are different multipliers developed from his previous diabetes research results (see reference).

Secondly, by using finger PPG data and his developed OHCA model, he can directly develop a generalized or simulated sensor PPG OHCA triangular model which can provide an upper bound of the baseline conditions.

The author has collected >10,000 finger glucose data and >30,000 sensor glucose data. He further analyzed, categorized, and calculated various relationship between finger and sensor. For cases B, C, and D, which lack the sensor collected data, the author applied conclusions derived from Case A to extend into three simulated sensor OHCA models for those other three cases. Basically, those three simulated sensor models were converted from a rather limited size of their finger glucose data into a much wider range of the generalized PPG sensor glucose data patterns based on variables of Case A. Sensor PPG pattern is a

triangular mountain shape with a baseline connecting glucoses of the first-bite value and 180 minutes value. The 1/3 mid point's value of OHCA baseline represents the "upper-bound of Baseline Conditions".

Results

The author utilized four T2D clinic data to obtain the following four respective "Baseline Conditions Range" (see Table 1) in the format of:

Table 1. *Baseline Conditions of 4 clinical cases (both equation and sensor OHCA)*

Case	B(2.0); C(5.0)	Sensor: OHCA	Ranking
A	107	129	2nd
B	98	125	1st
C	166	170	4th
D	146	142	3rd

Case	B(2.5); C(7.5)	Sensor: OHCA	Ranking
A	108	129	2nd
B	96	125	1st
C	172	170	4th
D	150	142	3rd

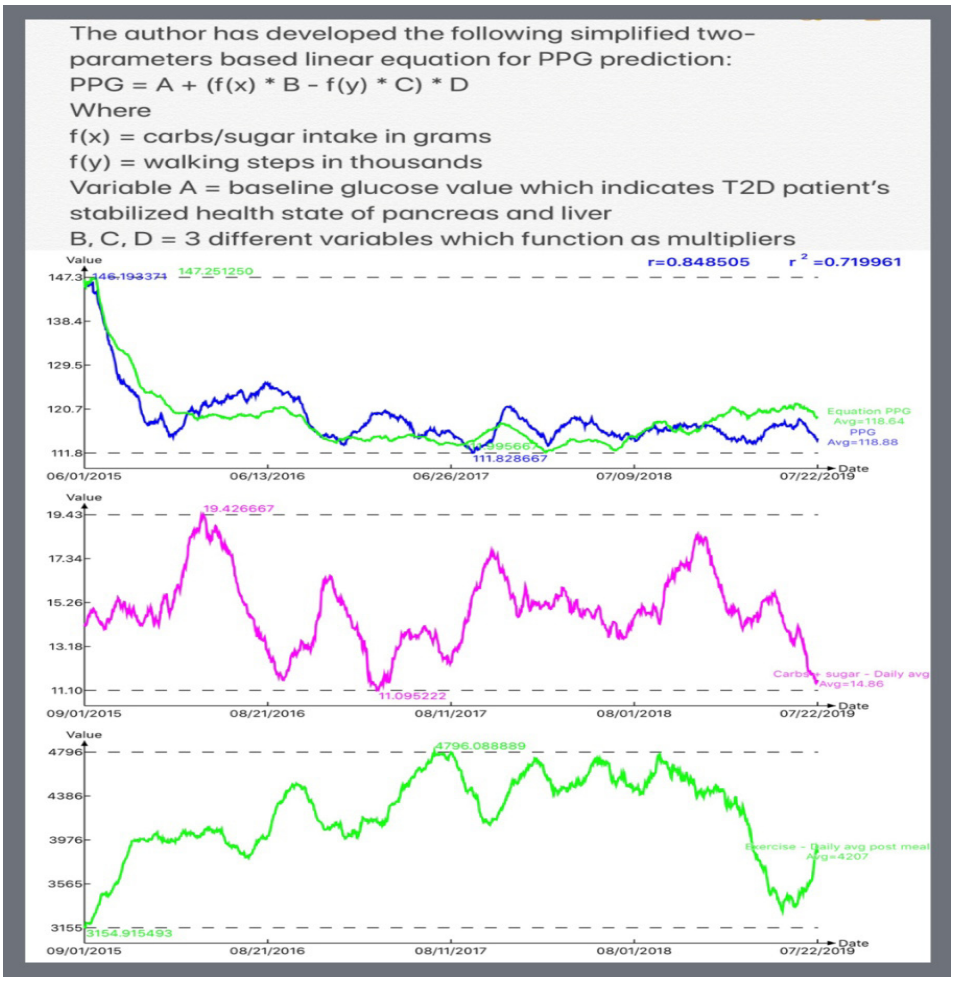
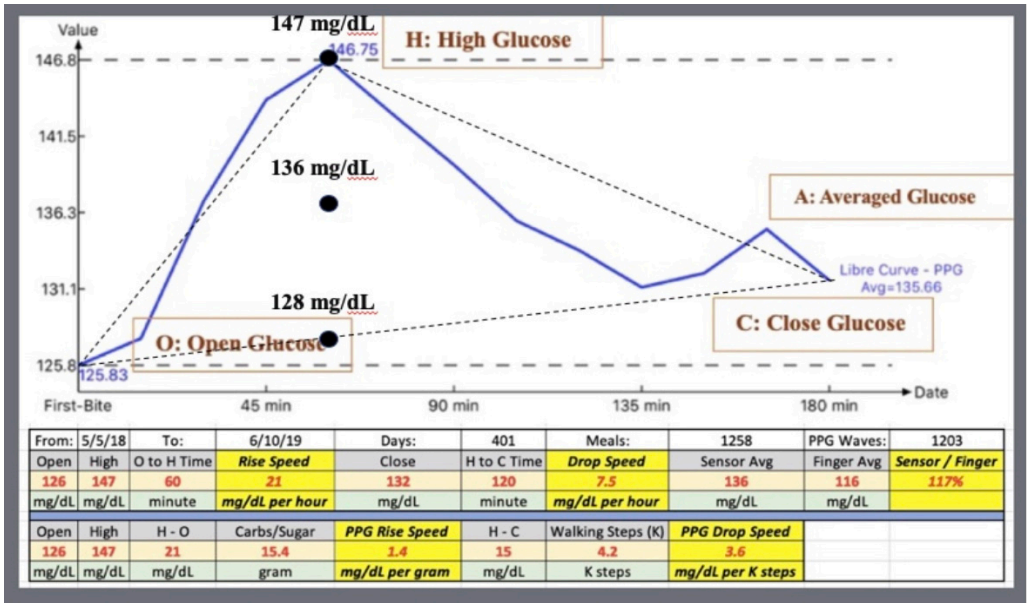


Figure 1. *Two-parameters based linear equation of Finger PPG*



From:	5/5/18	To:	6/10/19	Days:	401	Meals:	1258	PPG Waves:	1203
Open	High	O to H Time	*Rise Speed*	Close	H to C Time	*Drop Speed*	Sensor Avg	Finger Avg	*Sensor / Finger*
126	147	60	*21*	132	120	*7.5*	136	116	*117%*
mg/dL	mg/dL	minute	*mg/dL per hour*	mg/dL	minute	*mg/dL per hour*	mg/dL	mg/dL	

Open	High	H - O	Carbs/Sugar	*PPG Rise Speed*	H - C	Walking Steps (K)	*PPG Drop Speed*
126	147	21	15.4	*1.4*	15	4.2	*3.6*
mg/dL	mg/dL	mg/dL	gram	*mg/dL per gram*	mg/dL	K steps	*mg/dL per K steps*

Figure 2. *Synthesized Triangular Geometry of Sensor PPG*

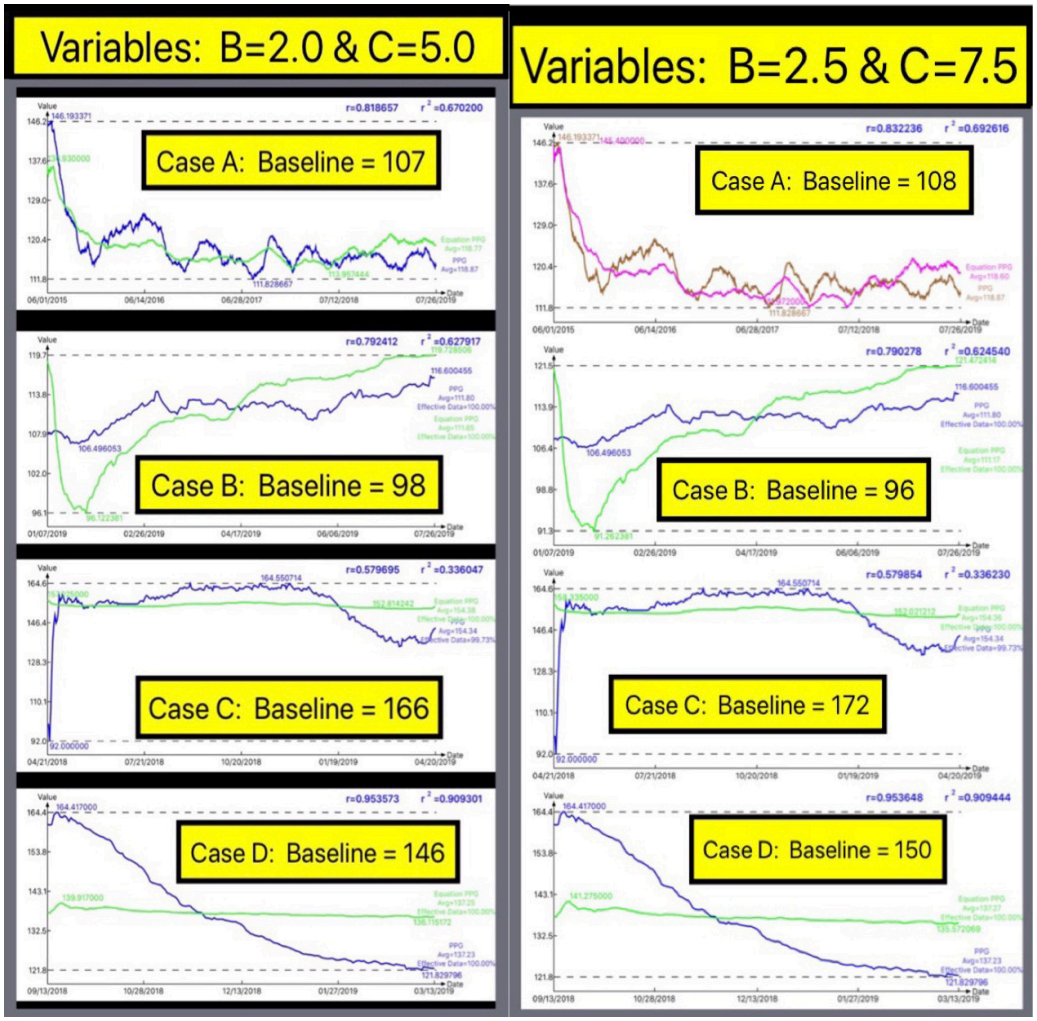
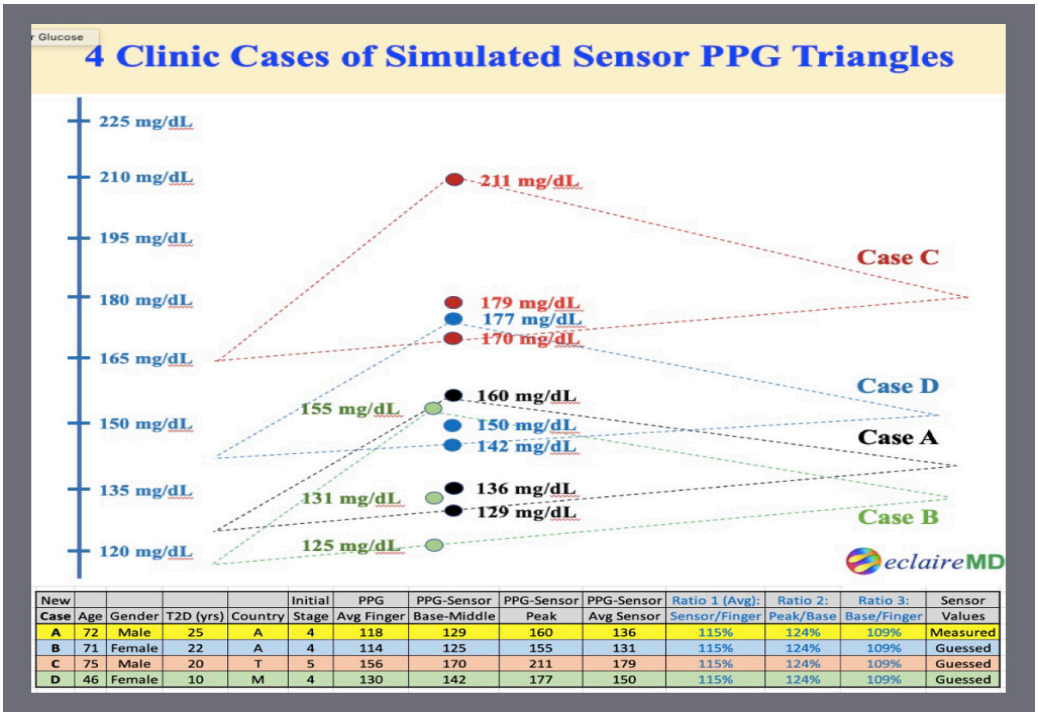


Figure 3. *Two Calculations of Lower Bound of Baseline Conditions via Finger Equation PPG*



New Case	Age	Gender	T2D (yrs)	Country	Initial Stage	PPG Avg Finger	PPG-Sensor Base-Middle	PPG-Sensor Peak	PPG-Sensor Avg Sensor	Ratio 1 (Avg): Sensor/Finger	Ratio 2: Peak/Base	Ratio 3: Base/Finger	Sensor Values
A	72	Male	25	A	4	118	129	160	136	115%	124%	109%	Measured
B	71	Female	22	A	4	114	125	155	131	115%	124%	109%	Guessed
C	75	Male	20	T	5	156	170	211	179	115%	124%	109%	Guessed
D	46	Female	10	M	4	130	142	177	150	115%	124%	109%	Guessed

Figure 4. *Upper Bound of Baseline Conditions via Simulated Sensor PPG Triangular Geometry which are derived from Finger PPG*

"*finger baseline (for both B=2.0; C=5.0 and B=2.5; C=7.5) vs. sensor OHCA baseline".*

When B=2.0 and C=5.0:

Case A: 107 vs. 129 mg/dL (second)

Case B: 98 vs. 125 mg/dL (best)

Case C: 166 vs. 170 mg/dL (worst)

Case D: 146 vs. 142 mg/dL (third)

When B=2.5 and C=7.5:

Case A: 108 vs. 129 mg/dL (second)

Case B: 96 vs. 125 mg/dL (best)

Case C: 172 vs. 170 mg/dL (worst)

Case D: 150 vs. 142 mg/dL (third)

Varying from cases A and B, cases C and D have some of their upper end and lower end switched. This phenomenon is probably caused by inherited differences between "simulated sensor data model" and "real sensor data developed model".

These four cases' respective time frames are:

Case A: 6/1/2015 - 7/26/2019

Case B: 1/7/2019 - 7/26/2019

Case C: 4/21/2018 - 4/20/2019

Case D: 9/13/2018 - 3/13/2019

It should be noted that, only Case A has 4-years of completed PPG finger data, the other three cases have much shorter timeframes with smaller amounts of glucose data. Cases C and D have insufficient glucose input data after 4/21/2919 and 3/13/2019 respectively; therefore, their data timeframes for analysis are terminated on those days. With longer timeframe and more finger data collected or even better with directly measured sensor data input, Cases B, C, and D would have much higher accuracy and more reliable estimations of their baseline conditions.

The author has conducted one more analysis to validate his baseline condition research work. Using >30,000 sensor data from 5/5/2018 through 7/26/2019, he isolated glucoses of both pre-meals and pre-bed (the "pre-periods") and peeled off both FPG glucose (sleeping hours during 00:00 - 08:00) and three PPG glucoses (3-hours each post-meal period). Those pre-period glucoses are not influenced by any significant stimulator such as food and exercise. It only retained the body's natural glucose production and control capability and status. The results from Case A has indicated that there are 29% of total glucose data

belonging to the pre-periods with an average glucose value of 128 mg/dL which is almost identical with 129 mg/dL of mid-baseline value of OHCA PPG triangular area for this case. This finding shows that two different analysis methods yield the same conclusion of the upper bound of Baseline Conditions.

Nevertheless, the above listed four baseline ranges with both lower bound and upper bound values still provide clear and distinctive indications of the pancreas beta cells' health state for each T2D patient. The ranking order from best to worstof the pancreatic health status are: Case B, Case A, Case D, and Case C.

Conclusions

The above results were obtained from analyzing data within respective timeframes. Each particular patient's baseline condition will be somewhat different if utilized in a dissimilar timeframe; however, the author suspects that the variance could not be large since improvement on glucose conditions is not a rapid process which takes time and effort before significant changes can be observed. The minor changes between different timeframes depend on each patient's overall glucose situations during that particular period. Nevertheless, the results can still be served as a "snapshot" of a patient's pancreatic health state during that particular period of time.

Generally speaking, a T2D patient's beta cells health state degenerates over time. However, from this analysis and observation of Case A data, the author cannot help but to have an intuitive suspicion and a rational hypothesis that some patients may be able to "improve or recover" some degree of their beta cells' health state if those patients exercise a stringent lifestyle management program consistently over a longer period of time.

In conclusion, the method and analysis outlined in this paper are quite useful for providing some understanding of a T2D patient's pancreatic functional health status.

The most important point is that this particular baseline condition model and follow-on analysis methods based on the GH-Method: math-physical medicine offers extremely accurate results and is useful for identifying some hidden truth of many diseases. It further proves that we can discover many hidden facts or truth from deep mining of glucose data.

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