The GH-Method

Application of Linear Equations to Predict Sensor and Finger Based Postprandial Plasma Glucoses and Daily Glucoses During Pre-Covid-19, Covid-19, and Total Periods Using GH-Method: Math-Physical Medicine (No. 345)

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Abstract

In 2019, the author developed a simplified linear equation for predicting the complicated behaviors of postprandial plasma glucose (PPG) which has been presented in several published papers. In this article, he conducts a numerical analysis to compare the results and accuracies from the application of his developed linear prediction equation on his glucoses during a total period of approximately 2.5 years, from 5/5/2018 to 10/10/2020. Furthermore, he subdivides this total period into two sub-periods: the pre-Covid-19 (pre-Virus) period, from 5/5/2018 to 1/18/2020, and the Covid-19 (Virus) period, from 1/19/2020 to 10/10/2020. Special attention has been placed on the quantitative comparison of his linear equation's prediction accuracy using three glucose waveforms and components, including fasting plasma glucose (FPG), PPG, and daily average glucose via finger-piercing and test-strip device (finger) and a continuous glucose monitoring (CGM) device (sensor). Here is his proposed PPG prediction equation: Predicted PPG = (M1 * FPG) + (M2 * carbs/sugar grams) - (M3 * post-meal waking K-steps) = (0.97 * FPG) + (M2 * carbs/sugar grams) - (5 * post-meal waking K-steps), where, M2 = 2.0 for finger PPG, M2 = 3.4 for sensor PPG, M2 = 1.8 for finger daily glucose, M2 = 3.0 for sensor daily glucose. Please note that M2 values from the finger and sensor for the predicted daily glucose are 89% of M2 values of predicted PPG due to the 11% "dilution effect" by FPG components. Diabetes is an overly complicated disease that can result in many terrible and painful complications including heart attack, stroke, kidney failure, blindness, lower extremities amputation, and death. To control diabetes complications, the patients must understand the fundamental and natural behavior of this disease or the temptations of it, not just seeking a quick fix. In the author's opinion, there is no immediate solution for curing diabetes, at least not yet. Drugs cannot cure diabetes! Medications only suppress its symptoms and does not treat it at the core level. On the other hand, using a lifestyle management program to control diabetes is the most effective way. Initially, it requires plenty of academic information and complicated but accurate knowledge. The main obstacle is the person's willpower, focus, and persistence to execute the lifestyle change and maintenance which are lacking in most patients. The information mentioned above are the main reasons the author continuously refines his research results and seeks easier ways for patients to follow. He is not a medical doctor but is a severe type 2 diabetes (T2D) patient for over 25 years. About 11 years ago, he faced many complications leading to near death several times. As a result, this served as a wakeup call, which motivated him to initiate his own study of endocrinology and food nutrition. Since 2010, he conducted medical research work using his developed GH-Method: math-physical medicine (MPM). Over the past few years, he developed complex mathematical models for calculating metabolism, predicting body weight, FPG, PPG, and HbA1C. He also extended his research into cardiovascular disease, stroke, chronic kidney disease, diabetic retinopathy, hypothyroidism, neuroscience, cancer, and geriatrics. Starting in 2018, he further simplified his research work for patients and healthcare professionals to assist with diabetes control. He created an APP on the iPhone for metabolism and estimated health age for longevity, simple card for predicted PPG via food and exercise, and the linear equations of predicted glucoses with >95% prediction accuracy as discussed in this article. He wants to help other worldwide diabetes patients and for them to reverse the disease just like he has but with much less struggles and efforts. This is the ultimate motivation from his 11-years of medical research to save his own life and extend it, while helping others to accomplish similar goals.

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Abbreviations: FPG: fasting plasma glucose; PPG: postprandial plasma glucose; CGM: continuous glucose monitoring; MPM: math-physical medicine

1. INTRODUCTION

In 2019, the author developed a simplified linear equation for predicting the complicated behaviors of postprandial plasma glucose (PPG) which has been presented in several published papers. In this article, he conducts a numerical analysis to compare the results and accuracies from the application of his developed linear prediction equation on his glucoses during a total period of approximately 2.5 years, from 5/5/2018 to 10/10/2020. Furthermore, he subdivides this total period into two sub-periods: the pre-Covid-19 (pre-Virus) period, from 5/5/2018 to 1/18/2020, and the Covid-19 (Virus) period, from 1/19/2020 to 10/10/2020. Special attention has been placed on the quantitative comparison of his linear equation's prediction accuracy using three glucose waveforms and components, including fasting plasma glucose (FPG), PPG, and daily average glucose via finger-piercing and test-strip device (finger) and a continuous glucose monitoring (CGM) device (sensor).

2. METHODS

2.1 Background

To learn more about the GH-Method: math-physical medicine (MPM) methodology, readers can review his article to understand his MPM analysis method in Reference 1, along with the outlined history of his personalized diabetes research and application tools development in Reference 2.

2.2 Overview of diabetes conditions

During 2015 and 2016, he dedicated his time to research and develop four prediction models related to his T2D conditions such as weight, PPG, FPG, and HbA1C (A1C). As a result from using his own developed metabolism model and four prediction tools, his weight reduced from 220 lbs. (100 kg) in 2010 to 171 lbs. (89 kg) in 2018, and reached 168 lbs. (76 kg) in 2020; his waistline decreased from 44 inches (112 cm) in 2010 to 33 inches (84 cm) in 2020; his average finger glucose value reduced from 280 mg/dL in 2010 to 116 mg/dL in 2018, and reached 106 mg/dL in 2020; and his A1C from 10% to 6.5% in 2018, and reached 6.1% in 2020. One of his major accomplishments is that he no longer takes any diabetes medications since 12/8/2015.

Another research project he conducted since 2/19/2020 is the investigation of his pancreatic beta cells' self-recovery rate via lifestyle improvement. In that research, he discovered that his FPG can serve as the baseline for his PPG waveform. Starting with the PPG baseline (i.e., FPG), he can add the influence of carbs/sugar intake amount, while subtracting the influence from post-meal walking steps to calculate his predicted PPG value.

In 2017, he achieved excellent results on all fronts, especially on glucose control. However, during 2018 and 2019 (overlapping the pre-Virus period), he traveled to 50+ international cities to attend 60+ medical conferences and made ~120 oral presentations. This kind of hectic travel schedule inflicted damage to his diabetes control, through dinning out along with exercise disruption, plus jet-leg and sleep pattern disturbance, due to irregular life routines through traveling.

2.3 Data collection

Since 1/1/2012, he measured his glucose values using the finger-piercing method: once for FPG and three times for PPG each day. In the finger glucose database, FPG occupies 25% of daily glucose while PPG occupies 75% of daily glucose. He did not use high finger glucose data in this particular analysis.

On 5/5/2018, he applied a CGM sensor device on his upper arm and checked his glucose measurements every 15 minutes, a total of ~96 times each day. After the first bite of his meal, he measured his PPG level every 15 minutes for a total of 3-hours or 180 minutes. He has maintained the same measurement pattern since 5/5/2018 until present day

(10/10/2020). In this CGM sensor glucose database, FPG occupies 29% of daily glucose, PPG takes up 38% of daily glucose, and pre-meals plus pre-bed periods occupy 33% of his daily glucose.

2.4 Mathematical tools utilized

In this glucose study, he utilized data mining, big data analytics, energy theory, wave theory, quantum mechanics, perturbation theory, segmentation analysis, pattern recognition method, trial and error, curve fitting, time-series analysis, spatial analysis, and candlestick K-line model.

2.5 Linear equation of predicted PPG

The biomedical system is the most sophisticated and complex system the author has ever dealt with in his professional experiences. Not only is it a nonlinear system, but also a dynamic one, where the material is organic consisting of different lifespans for different types of living cells which have the capability of growth, division, or mutation. By understanding the biomedical system and having the ability to control its behavior is an almost impossible task for the patient and healthcare professionals. Therefore, over the past decade, the author has tried to simplify this complicated system by developing a linear equation to accurately describe the glucose behavior to the best of his ability.

Here is his proposed PPG prediction equation:

Predicted PPG
= (M1 * FPG) + (M2 * carbs/sugar grams) - (M3 * post-meal waking K-steps)
= (0.97 * FPG) + (M2 * carbs/sugar grams) - (5 * post-meal waking K-steps)

Where

M2 = 2.0 for finger PPG
M2 = 3.4 for sensor PPG
M2 = 1.8 for finger daily glucose
M2 = 3.0 for sensor daily glucose

Please note that M2 values from the finger and sensor for the predicted daily glucose are 89% of M2 values of predicted PPG due to the 11% "dilution effect" by FPG components.

3. RESULTS

His first analysis results show his collected data, including cabs/sugar intake amount in grams, post-meal walking (k-steps), FPG, PPG, and daily glucose for the periods: pre-Virus, Virus, and total. He then lists the comparison percentages between sensor glucoses over finger glucoses using the sensor value divided by the finger value.

It should be noted that the sensor FPG and finger FPG are almost the same. Sensor PPG are 13% to 18% higher than finger PPG, while the sensor daily glucoses are 9% to 14% higher than finger daily glucoses.

His second analysis results depict the predicted PPG and daily glucose (both finger and sensor) for the three periods using four different values of M2 variable of linear prediction equation. It should be emphasized that this linear equation was developed to predict PPG since PPG formation is the most complex and sophisticated phenomenon. However, as mentioned in the Method section, the PPG takes approximately 38% (for sensor) to 75% (for finger) of daily glucose; therefore, he applies the same linear equation but with a different set of M2 values (89% of M2 values of PPG) to predict his daily glucose value.

In this analysis, he initially tried to make his prediction accuracy for the total period to reach 100%. In this way, his pre-Virus and Virus periods would sacrifice a small degree of accuracy.

The following list reflects the accuracy of each category (pre-Virus & Virus):

Predicted Finger PPG: 102% & 95%
Predicted Sensor PPG: 101% & 98%
Predicted Finger daily: 101% & 97%
Predicted Sensor daily: 101% & 98%

In summary, the small sacrifice of the prediction accuracy are within the range of +2% and -5% for the pre-Virus and Virus periods to provide 100% of the prediction accuracy for the total period (5/5/2018 - 10/10/2020).

His third analysis results show, predicted vs. measured PPG, and his fourth analysis results show, predicted vs. measured daily

glucose. The high prediction accuracy can be easily observed by the similar comparisons between predicted and measured glucose values.

His fifth analysis results illustrate the prediction accuracy in terms of percentages by a line chart which is the summary expressed from the data table in Figure 2. The high prediction accuracy percentages, within the range of 95% to 102% or -5% to +2%, can be seen in the line chart diagram (Figures 1–5).

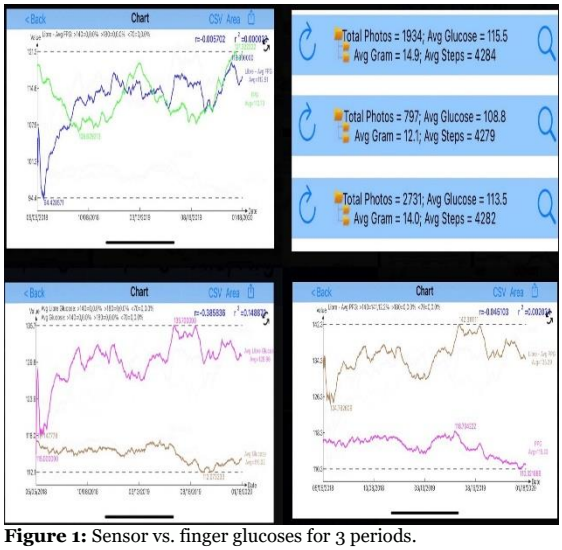

Figure 1: Sensor vs. finger glucoses for 3 periods.

Figure 2: Data table of US sensor PPG and worldwide sensor FPG.

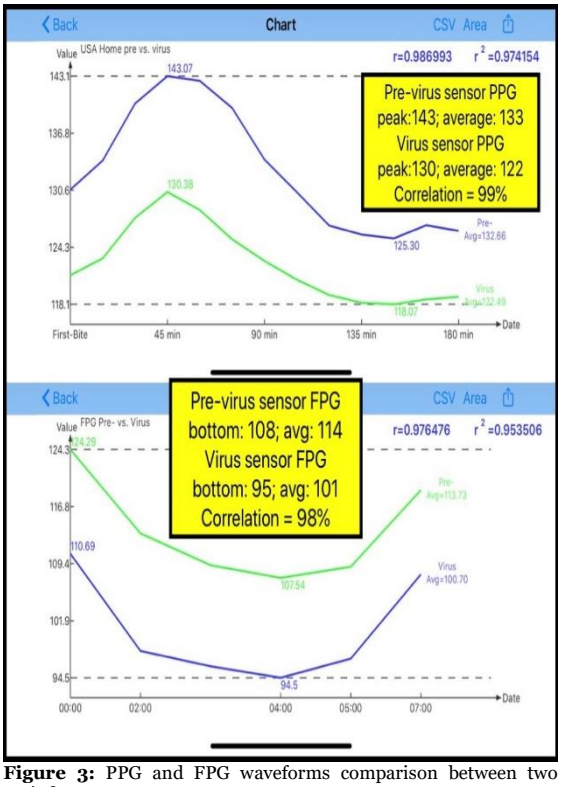

Figure 3: PPG and FPG waveforms comparison between two periods.

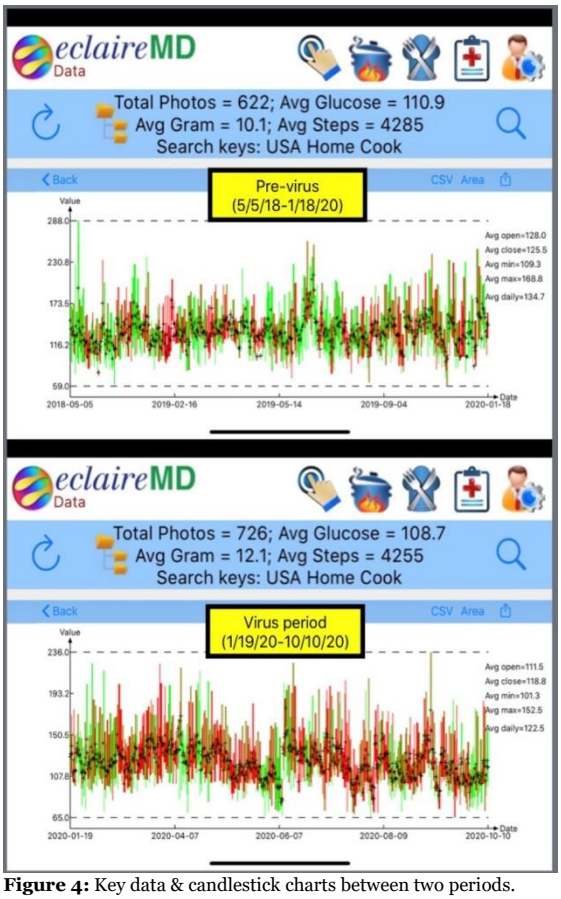

Figure 4: Key data & candlestick charts between two periods.

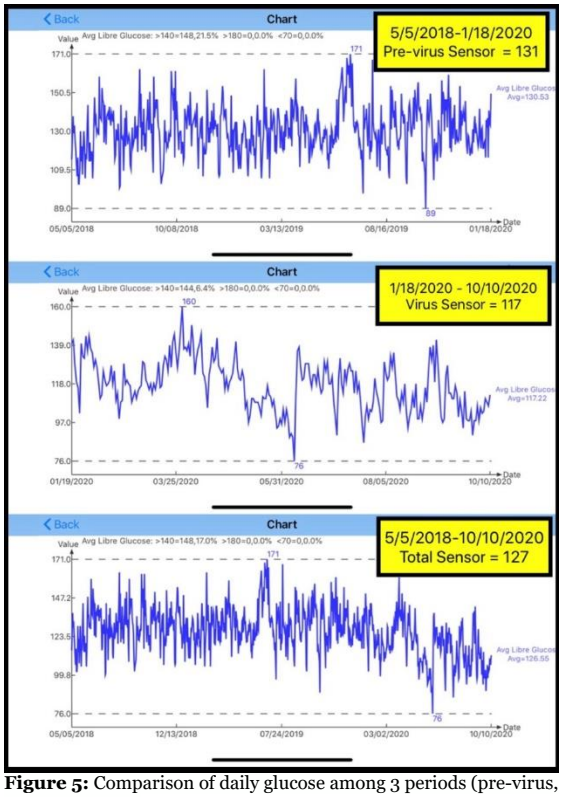

Figure 5: Comparison of daily glucose among 3 periods (pre-virus, virus, and total).

4. CONCLUSION

Diabetes is an overly complicated disease that can result in many terrible and painful complications including heart attack, stroke, kidney failure, blindness, lower extremities amputation, and death. To control diabetes complications, the patients must understand the fundamental and natural behavior of this disease or the temptations of it, not just seeking a quick fix. In the author's opinion, there is no immediate solution for curing diabetes, at least not yet. Drugs cannot cure diabetes! Medications only suppress its symptoms and does not treat it at the core level. On the other hand, using a lifestyle management program to control diabetes is the most effective way. Initially, it requires plenty of academic information and complicated but accurate knowledge. The main obstacle is the person's willpower, focus, and persistence to execute the lifestyle change and maintenance which are lacking in most patients.

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5. REFERENCES

1) Hsu, Gerald C., eclaireMD Foundation, USA, No. 310 "Biomedical research methodology based on GH-Method: math-physical medicine"

2) Hsu, Gerald C., eclaireMD Foundation, USA, No. 305: "Glucose trend pattern analysis and progressive behavior modification of a T2D patient using GH-Method: math-physical medicine"

3) Gerald C. Hsu, eclaireMD Foundation, USA. March 2019. No. 235: "Linkage among metabolism, immune system, and various diseases using GH-Method: math-physical medicine (MPM)."

4) Gerald C. Hsu, eclaireMD Foundation, USA. May 2020. No. 253: "Building up fundamental strength to fight against COVID-19 for patients with chronic diseases and complications."

5) Gerald C. Hsu, eclaireMD Foundation, USA. No. 262: "A Case Study on the Prediction of A1C Variances over Seven Periods with guidelines Using GH-Method: math-physical medicine".

6) Gerald C. Hsu, eclaireMD Foundation, USA. No. 297: "Self-recovery of pancreatic beta cell's insulin secretion based on annualized fasting plasma glucose, baseline postprandial plasma glucose, and baseline daily glucose data using GH-Method: math-physical medicine".

7) Gerald C. Hsu, eclaireMD Foundation, USA. No. 318: "Glucoses and HbA1C comparison study between pre- COVID-19 and COVID-19 using GH-Method: math-physical medicine".

8) Hsu, Gerald C., eclaireMD Foundation, USA; No. 76: "Using Candlestick Charting Techniques to Investigate Glucose Behaviors (GH-Method: Math-Physical Medicine)".

9) Hsu, Gerald C., eclaireMD Foundation, USA; No. 344: "Comparison sensor study of US cooked meals postprandial plasma glucose and worldwide fasting plasma glucose between pre-Virus and Virus periods using GH-Method: math-physical medicine".

