The GH-Method

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

Gerald C. Hsu*

eclaireMD Foundation, USA

Abstract

In 2019, the author introduced a simplified linear elasticity equation for predicting those complex postprandial plasma glucose (PPG) behaviors, which has been discussed in his multiple published papers. This particular article presents a numerical analysis comparing the results and accuracy of applying this developed linear prediction equation to the author's glucose data over approximately 2.5 years, from 5/5/2018 to 10/10/2020. Additionally, the total period is further divided 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. The study focuses on quantitatively comparing the prediction accuracy of the linear elasticity equation for three glucose waveforms and components, including fasting plasma glucose (FPG), PPG, and daily average glucose obtained through both finger-piercing and test-strip devices (finger) and continuous glucose monitoring (CGM) devices (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 a complex disease with potentially severe complications, such as heart attacks, strokes, kidney failure, blindness, amputations, and even death. To manage these complications, patients must grasp the fundamental nature of the condition rather than seeking quick fixes. In the author's perspective, a definitive cure for diabetes is not yet available; medications only alleviate symptoms without addressing the core issue. Instead, the most effective approach involves a lifestyle management program, demanding both academic knowledge and determination. The primary challenge lies in individuals' willpower, focus, and persistence, which many patients lack. The author continually refines his research work and seeks simpler methods for patients to follow. While not a medical doctor, the author has battled his severe type 2 diabetes (T2D) for over 25 years, experiencing life-threatening complications around 11 years ago. This served as a wake-up call, inspiring him to explore diabetes, endocrinology and food nutrition. Since 2010, he has conducted medical research using his GH-Method: math-physical medicine (MPM). In recent years, he has developed intricate mathematical models for metabolism, body weight prediction, as well as forecasting FPG, PPG, and HbA1C. His research extends to various health domains, including cardiovascular disease, stroke, chronic kidney disease, diabetic retinopathy, hypothyroidism, neuroscience, cancer, and geriatrics. Starting in 2018, he streamlined his research efforts to benefit both patients and healthcare professionals in managing diabetes. He created an iPhone app for assessing metabolism and estimating health age for longevity, a simple tool for predicting PPG based on diet and exercise, and linear elasticity equations for forecasting glucose levels with over 95% prediction accuracy, as discussed in this article. His ultimate goal is to assist diabetes patients worldwide in reversing their disease conditions, just as he has done, but with reduced amount of challenges and effort. This aspiration stems from 11 years of his personal medical research, aimed at not only extending his own life but also helping others achieve similar health goals.

Keywords: Type 2 diabetes; COVID-19; Body weight; Postprandial plasma glucose; Fasting plasma glucose

Abbreviations: T2D: type 2 diabetes; PPG: postprandial plasma glucose; FPG: fasting plasma glucose; MPM: math-physical medicine

---

Available online: 20 December 2023

*Corresponding author: Gerald C. Hsu, eclaireMD Foundation, USA

1. INTRODUCTION

In 2019, the author introduced a simplified linear elasticity equation for predicting those complex postprandial plasma glucose (PPG) behaviors, which has been discussed in his multiple published papers. This particular article presents a numerical analysis comparing the results and accuracy of applying this developed linear prediction equation to the author's glucose data over approximately 2.5 years, from 5/5/2018 to 10/10/2020. Additionally, the total period is further divided 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. The study focuses on quantitatively comparing the prediction accuracy of the linear elasticity equation for three glucose waveforms and components, including fasting plasma glucose (FPG), PPG, and daily average glucose obtained through both finger-piercing and test-strip devices (finger) and continuous glucose monitoring (CGM) devices (sensor).

2. METHODS

2.1 Background

For a comprehensive understanding of the GH-Method: math-physical medicine (MPM) methodology, readers are encouraged to consult Reference 1 for insights into the MPM analysis approach and Reference 2 for a detailed history of his personalized diabetes research and the development of application tools.

2.2 Overview of diabetes conditions

Between 2015 and 2016, he devoted substantial time to researching and crafting four prediction models related to his Type 2 Diabetes (T2D) conditions, encompassing weight, PPG, FPG, and HbA1C (A1C). Through the application of his own metabolism model and these prediction tools, notable transformations occurred: his weight decreased from 220 lbs. (100 kg) in 2010 to 171 lbs. (89 kg) in 2018, reaching 168 lbs. (76 kg) in 2020; his waistline reduced from 44 inches (112 cm) in 2010 to 33 inches (84 cm) in 2020; his average finger glucose value declined from 280 mg/dL in 2010 to 116 mg/dL in 2018, ultimately reaching 106 mg/dL in 2020; and his A1C dropped from 10% to 6.5% in 2018, reaching 6.1% in 2020. Notably, he has not required any diabetes medications since December 8, 2015.

Another research endeavor, initiated on February 19, 2020, involved investigating the self-recovery rate of his pancreatic beta cells through lifestyle improvements. In this study, he discovered that his FPG can serve as a baseline for his PPG waveform. By starting with the PPG baseline (i.e. FPG) and factoring in the impact of carbohydrate/sugar intake while offsetting the effects of post-meal walking steps, he can calculate his predicted PPG value.

In 2017, he achieved remarkable results, particularly in glucose control. However, during 2018 and 2019, which coincided with the pre-Virus period, he undertook extensive international travel, visiting over 50 cities, attending more than 60 medical conferences, and delivering approximately 120 oral presentations. This hectic travel schedule negatively impacted his diabetes management due to dining out, disruptions in exercise routines, jet lag, and disturbances in sleep patterns associated with irregular life routines during travel.

2.3 Data collection

Starting from January 1, 2012, he monitored his glucose levels through the finger-piercing method, once for FPG and three times for PPG daily. In the finger glucose database, FPG accounts for 25% of the daily glucose readings, while PPG makes up the remaining 75%. Notably, high level finger glucose (hyperglycemia) data was not included in this specific analysis.

On May 5, 2018, he adopted a CGM sensor device affixed to his upper arm, allowing him to record glucose measurements at 15-minute intervals, amounting to approximately 96 readings each day. Following his first meal bite, he monitored his PPG levels every 15 minutes for a continuous period of 3 hours or 180 minutes. This measurement pattern has been consistently maintained from May 5, 2018, to the present day (October 10, 2020). In the CGM sensor glucose database, FPG constitutes 29% of the daily glucose values, PPG occupies 38% of the daily glucose readings, and the remaining 33% pertains to pre-meal and pre-bedtime periods.

2.4 Mathematical tools utilized

In this glucose study, he employed a wide array of analytical techniques, including data mining, big data analytics, energy theory, wave theory, quantum mechanics, perturbation theory, segmentation analysis, pattern recognition methods, trial and error, curve fitting, time-series analysis, spatial analysis, and the candlestick K-line model.

2.5 Linear equation for predicted PPG

The biomedical system represents one of the most intricate, complex and dynamic systems the author has encountered in his professional journey. It is not only nonlinear but also organic, comprising different lifespans for various types of living cells with the capacity for growth, division, or mutation. Understanding and controlling the behavior of the biomedical system is an exceedingly challenging task for both patients and healthcare professionals. Hence, over the past decade, the author has strived to simplify this complex bio-system by developing a linear equation that accurately describes 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

In his first analysis, he presents his collected data, including carbohydrate/sugar intake in grams, post-meal walking (in k-steps), FPG, PPG, and daily glucose for the following three periods: pre-Virus, Virus, and total. He also provides a comparison between sensor glucose and finger glucose, calculated as the sensor value divided by the finger value.

It's worth noting that sensor FPG and finger FPG exhibit minimal differences. Sensor PPG values are approximately 13% to 18% higher than finger PPG, and sensor daily glucose values are 9% to 14% higher than finger daily glucose.

In his second analysis, he displays predicted PPG and daily glucose (both for finger and sensor) for the three periods using four different values of the M2 variable in the linear prediction equation. The primary focus of this linear equation is predicting PPG, which is a highly complex phenomenon. However, since PPG accounts for a significant portion of daily glucose (38% for sensor to 75% for finger), he applies the same linear equation with a different set of M2 values (89% of M2 values of PPG) to predict daily glucose values.

The goal in this analysis is to achieve a total prediction accuracy of 100%. This involves making a slight sacrifice in accuracy for the pre-Virus and Virus periods. The following list demonstrates the accuracy for each category (pre-Virus vs. Virus):

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

In summary, these minor variations in prediction accuracy fall within the range of +2% to -5% for the pre-Virus and Virus periods to attain 100% accuracy for the total period (5/5/2018 - 10/10/2020).

The third analysis shows predicted vs. measured PPG, while the fourth analysis illustrates predicted vs. measured daily glucose. High prediction accuracy is evident through the close match between predicted and measured glucose values.

In the fifth analysis, prediction accuracy is presented as percentages through a line chart. The chart highlights high prediction accuracy percentages within the range of 95% to 102% or -5% to +2% (Figures 1–5).

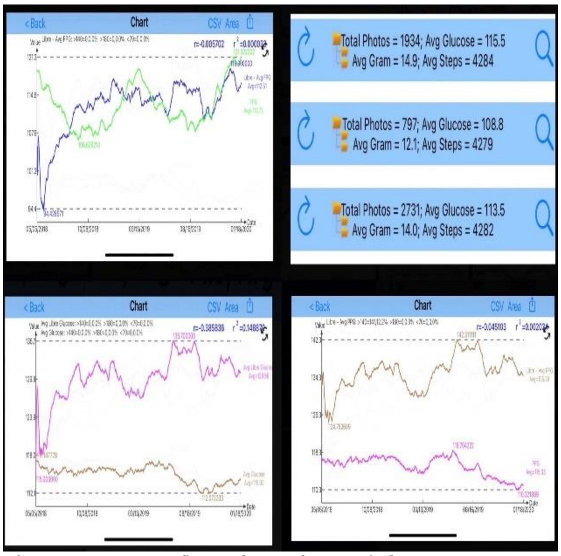

Figure 1: Sensor vs. finger glucose for 3 periods.

Date	Pre-	Virus	Z
First-Bite	130.64	121.26	
15 min	133.83	123.11	
30 min	140.07	127.55	
45 min	143.07	130.38	
60 min	142.55	128.41	
75 min	139.58	125.20	
90 min	133.93	122.82	
105 min	130.36	120.77	
120 min	126.70	119.09	
135 min	125.72	118.24	
150 min	125.30	118.07	
165 min	126.74	118.61	
180 min	126.12	118.89	

USA Sensor PPG

Date	Virus	Pre-	Z
00:00	110.69	124.29	
02:00	98	113.35	
03:00	96	109.2	
04:00	94.5	107.54	
05:00	97	109	
07:00	108	119	

Sensor FPG

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

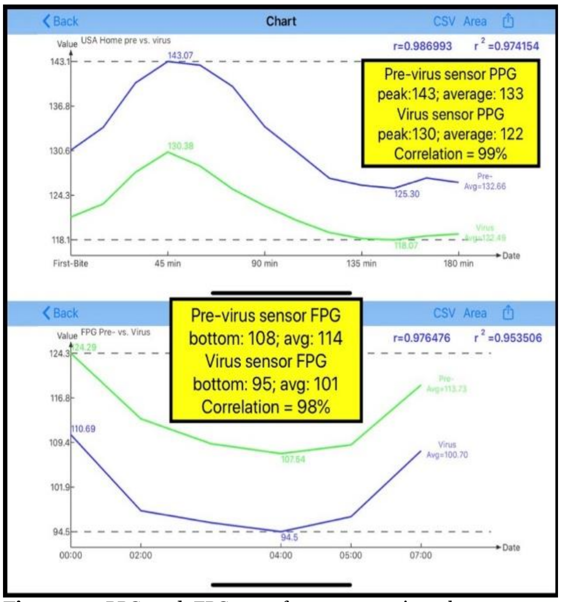

Figure 3: PPG and FPG waveforms comparison between two periods.

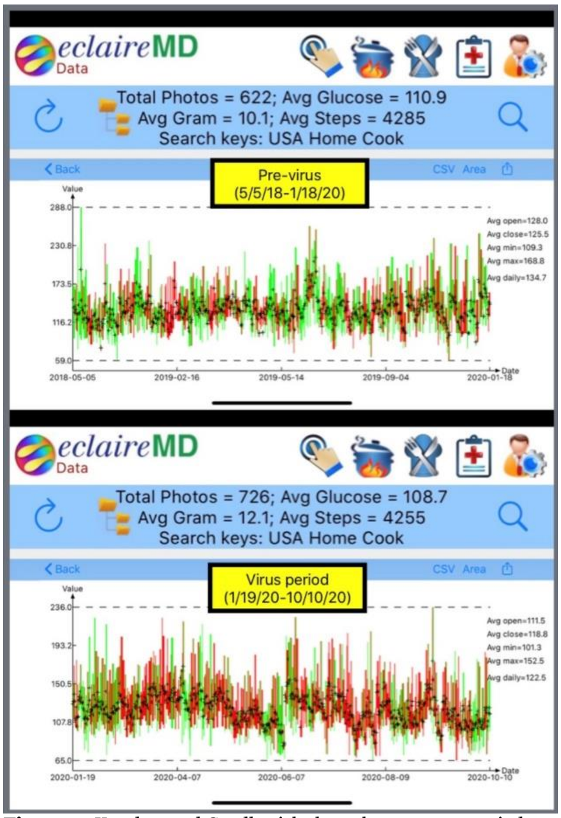

Figure 4: Key data and Candlestick charts between two periods.

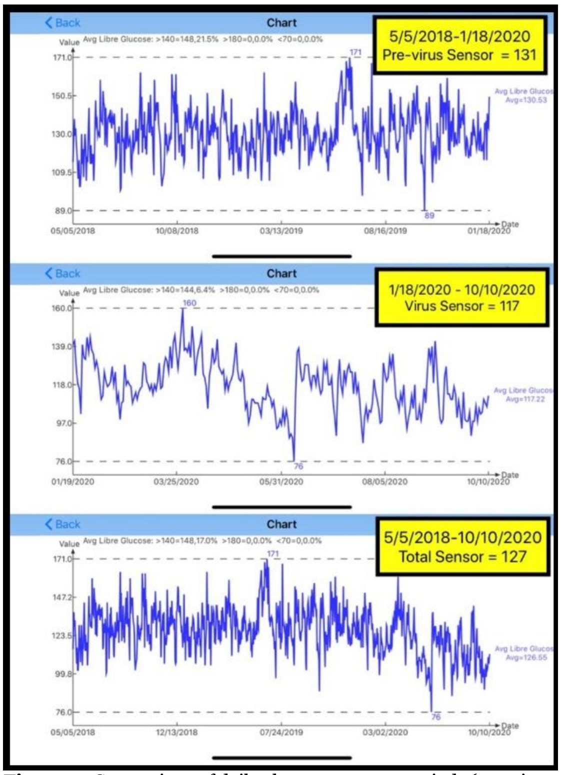

Figure 5: Comparison of daily glucose among 3 periods (pre-virus, virus, and total).

4. CONCLUSION

Diabetes is a complex and potentially devastating condition, linked to severe complications like heart attacks, strokes, kidney failure, blindness, amputations, and even mortality. To mitigate these complications, patients must grasp the fundamental nature of the disease and resist the allure of quick fixes. In the author's view, an immediate cure for diabetes remains elusive, as drugs can only alleviate symptoms without addressing the root cause. Instead, embracing a lifestyle management program is the most effective approach, although it demands significant academic knowledge and a commitment to change, which many patients find challenging.

These insights fuel the author's ongoing pursuit of refined research and user-friendly methods. While not a medical doctor, the author has been a severe type 2 diabetes (T2D) patient for over 25 years, and a life-threatening experience about 11 years ago spurred his exploration of diabetes, endocrinology and food nutrition. Since 2010, he has conducted medical research using his GH-Method: math-physical medicine (MPM).

In recent years, he has developed intricate mathematical models to calculate metabolism, predict body weight, and forecast values like FPG, PPG, and HbA1C. His research work has extended into various fields, encompassing cardiovascular disease, stroke, chronic kidney disease, diabetic retinopathy, hypothyroidism, neuroscience, cancer, and geriatrics.

From 2018 onward, he has strived to simplify his research for the benefit of patients and healthcare professionals involved in diabetes management. His initiatives include an iPhone app for metabolism assessment and estimated health age, a straightforward tool for predicting PPG through diet and exercise, and linear equations for forecasting glucose levels with over 95% accuracy, as discussed in this article.

His ultimate goal is to aid diabetes patients worldwide in reversing the disease, much as he has, but with reduced challenges and efforts. This mission stems from 11 years of dedicated self-study and medical research driven by a desire to not only extend his own life but also to assist others in achieving similar health objectives.

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".