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Comparison of Postprandial Plasma Glucoses and HbA1C Values Collected via Finger-Piercing and Continuous Glucose Monitoring Sensor Collection Methods over a 3+ Year Period Based on GH-Method: Math-Physical Medicine (No. 493)

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Abstract

The author utilizes his postprandial plasma glucose (PPG) and Hemoglobin A1C (HbA1C or A1C) data accumulated over a 3+ year period from 5/8/2018 to 8/13/2021 for this particular study. Since 5/8/2018, he has collected his daily glucoses via finger-piercing method (Finger) at 4 times each day and continuous glucose monitoring device (Sensor) at 96 times each day. Furthermore, he has developed two simple A1C equations based on finger daily average glucose (finger eAG) and sensor eAG to compare against his collected 14 lab-tested A1C results during the same time period. He has chosen PPG instead of the daily average glucose (eAG) for this study due to the fact that the PPG wave excursions are more violent than the FPG and daily glucose waves.

In conclusion, the average sensor PPG (128 mg/dL) is 15% higher than his finger PPG (112 mg/dL). Both PPG values at 0-minutes and at 120-minutes are similar (125 mg/dL) and are 12% higher than his average finger PPG (112 mg/dL). Usually, many diabetes clinicians advise their patients to measure PPG at "2-hours" after the first bite of meals. By following this method, the patients would catch the low-end of their PPG wave excursion. On the other hand, his PPG at 60-minutes (136 mg/dL) is 22% higher than the average finger PPG (112 mg/dL) and 10% higher than the initial PPG and PPG at 60-minutes (125 mg/dL).

The author developed two simple arithmetic formulas to estimate his finger-A1C (finger A1C = finger eAG / 16.7) and his sensor-A1C (sensor A1C = sensor eAG / 18.7). These two formulas are far simpler and easier to remember for diabetes patients. As a reference, the American Diabetes Association (ADA) equation is: A1C=(eAG+46.7)/28.7. The author understands the background for formulating the ADA's A1C equation. However, as a 26-year T2D patient whose glucoses fluctuates between 50 mg/dL and 400 mg/dL over the past 11 years, his glucose excursion range should cover most other T2D patients.

The conclusive finding of his two predicted average A1C values are 6.61% for both finger A1C and sensor A1C, which are comparable to the average 14 lab-tested A1C results of 6.60% over the same period.

Introduction

The author utilizes his postprandial plasma glucose (PPG) and Hemoglobin A1C (HbA1C or A1C) data accumulated over a 3+ year period from 5/8/2018 to 8/13/2021 for this particular study. Since 5/8/2018, he has collected his daily glucoses via finger-piercing method (Finger) at 4 times each day and continuous glucose monitoring device (Sensor) at 96 times each day. Furthermore, he has developed two simple A1C equations based on finger daily average glucose (finger eAG) and sensor eAG to compare against his collected 14 lab-tested A1C results during the same time period. He has chosen PPG instead of the daily average glucose (eAG) for this study due to the fact that the PPG wave excursions are more violent than the FPG and daily glucose waves.

Preface

The author has been a severe T2D patient since 1996. He weighed 220 lb. (100 kg, BMI 32.5) at that time. By 2010, he still weighed 198 lb. (BMI 29.2) with an average daily glucose of 250 mg/dL (HbA1C of 10%). During that year, his triglycerides reached to 1161 and albumin-creatinine ratio (ACR) at 116. He also suffered from five cardiac episodes within a decade. In 2010, three independent physicians warned him regarding his needs of kidney dialysis treatment and his future high risk of dying from his severe diabetic complications. Other than cerebrovascular disease (stroke), he has suffered most of known diabetic complications, including both macro-vascular and micro-vascular complications.

In 2010, he decided to launch his self-study on endocrinology, diabetes, and food nutrition in order to save his own life. During 2015 and 2016, he developed four prediction models related to diabetes conditions: weight, postprandial plasma glucose (PPG), fasting plasma glucose (FPG), and A1C. As a result, from using his developed mathematical metabolism index (MI) model in 2014 and the four prediction tools, by end of 2016, his weight was reduced from 220 lbs. (100 kg, BMI 32.5) to 176 lbs. (89 kg, BMI 26.0), waistline from 44 inches (112 cm) to 33 inches (84 cm), average finger glucose reading from 250 mg/dL to 120 mg/dL, and lab-tested A1C from 10% to ~6.5%. One of his major accomplishments is that he no longer takes any diabetes medications since 12/8/2015.

In 2017, he has achieved excellent results on all fronts, especially glucose control. However, during the pre-COVID period of 2018 and 2019, he traveled to approximately 50+ international cities to attend 65+ medical conferences and made ~120 oral presentations. This hectic schedule inflicted damage to his diabetes control, through dinning out frequently, post-meal exercise disruption, jet lag, and along with the overall metabolism impact due to his irregular life patterns through a busy travel schedule; therefore, his glucose control and overall metabolism state were somewhat affected during this two-year heavier traveling period.

During 2020 with a COVID-19 quarantined lifestyle, not only has he published ~400 medical papers in 100+ journals, but he has also reached his best health conditions for the past 26 years. By the beginning of 2021, his weight was further reduced to 165 lbs. (BMI 24.4) along with a 6.1% A1C value, without having any medication interventions or insulin injections. These good results are due to his non-traveling, low-stress, and regular daily life routines. Of course, his knowledge of chronic diseases, practical lifestyle management experiences, and his developed various high-tech tools contribute to his excellent health status since 1/19/2020, the beginning date of his self-quarantined life.

On 5/5/2018, he applied a CGM sensor device on his upper arm and checks his glucose measurements every 5 minutes for a total of ~288 times each day. He has maintained the same measurement pattern to present day. In his research work, he uses his CGM sensor glucose at time-interval of 15 minutes (96 data per day). The difference of the average sensor glucoses between 5-minute intervals and 15-minute intervals is only 0.4% (average glucose of 114.81 mg/dL for 5-minutes and average glucose of 114.35 mg/dL for 15-minutes with a correlation of 93% between these two sensor glucose curves) during the period from 2/19/20 to 8/13/21.

Therefore, over the past 11 years, he could study and analyze the collected 2+ million data regarding his health status, medical conditions, and lifestyle details. He applies his knowledge, models, and tools from mathematics, physics, engineering, and computer science to conduct his medical research work. His medical research work is based on the aims of achieving both "high precision" with "quantitative proof" in the medical findings.
The following timetable provides a rough sketch of the emphasis of his medical research during each stage:

- 2000-2013: Self-study diabetes and food nutrition, developing a data collection and analysis software.
- 2014: Develop a mathematical model of metabolism, using engineering modeling and advanced mathematics.
- 2015: Weight & FPG prediction models, using neuroscience.
- 2016: PPG & HbA1C prediction models, using optical physics, artificial intelligence (AI), and neuroscience.
- 2017: Complications due to macro-vascular research, such as Cardiovascular disease (CVD), coronary heart diseases (CHD) and stroke, using pattern analysis and segmentation analysis.
- 2018: Complications due to micro-vascular research such as kidney (CKD), bladder, foot, and eye issues (DR).
- 2019: CGM big data analysis, using wave theory, energy theory, frequency domain analysis, quantum mechanics, and AI.
- 2020: Cancer, dementia, longevity, geriatrics, DR, hypothyroidism, diabetic foot, diabetic fungal infection, and linkage between metabolism and immunity, learning about certain infectious diseases, such as COVID-19.
- 2021: Applications of linear elastic glucose theory (LEGT) and perturbation theory from quantum mechanics on medical research subjects, such as chronic diseases and their complications, cancer, and dementia.

Again, to date, he has collected more than two million data regarding his medical conditions and lifestyle details. In addition, he has written 493 medical papers and published 400+ paper in 100+ various medical journals. Moreover, he has also given ~120 presentations at ~65 international medical conferences. He has continuously dedicated his time and efforts on his medical research work and shared his findings and learnings with other patients worldwide.

Method and Results

All numbers cited in this article are the average number over a period of 3+ years from 5/5/2015 to 8/13/2021.

Figure 1 shows the results of PPG waveform comparison between finger and sensor (upper diagram), his predicted A1C waveform comparison between finger and sensor (middle diagram), and 14 lab-tested A1C results.

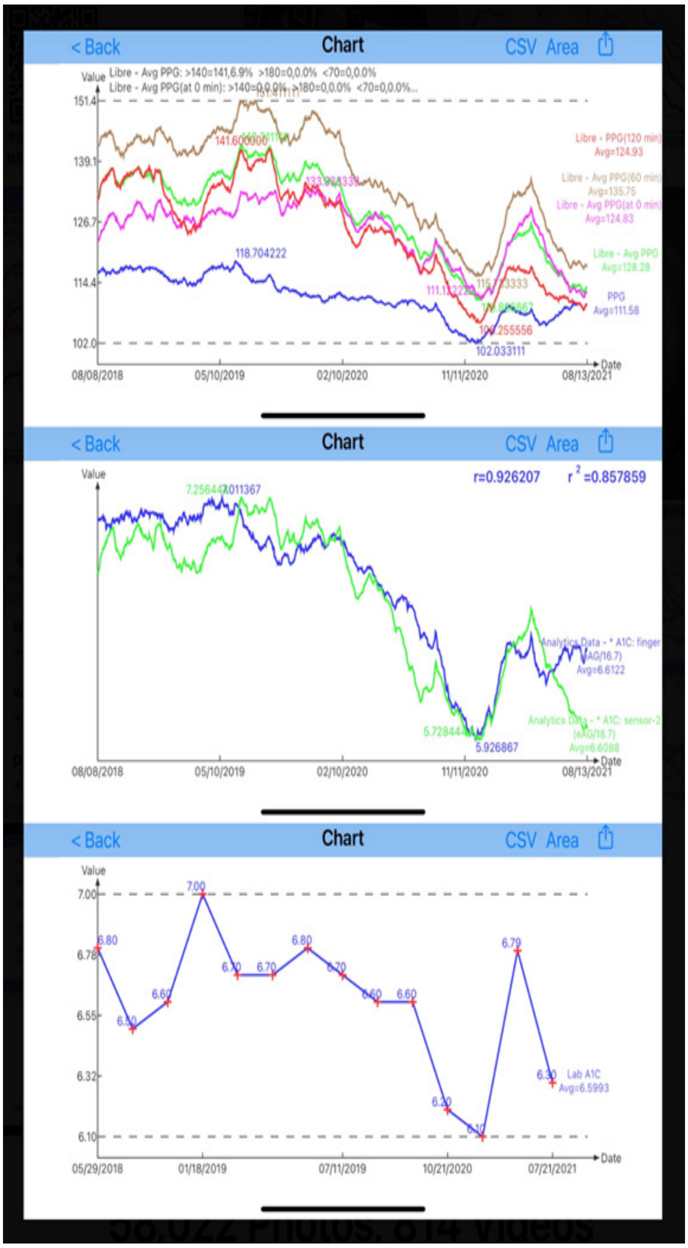

Figure 1: measured PPG & A1C comparisons

From the upper diagram, it is clearly observed that all 4 sensor PPG waveforms are similar to each other in terms of patterns, which are higher than the finger PPG curve with a slightly different waveform from sensor but still has a high degree of similarity.

The following table lists their average values:

Finger PPG = 111.58 mg/dL
Sensor PPG = 128.28 mg/dL
Sensor @ 0-min = 124.83 mg/dL
Sensor @ 60-min = 135.75 mg/dL
Sensor @ 120-min = 124.93 mg/dL

From the middle and bottom diagrams, the following table lists the A1C results:

Finger A1C = 6.6122%
Sensor A1C = 6.6088%
Lab-test A1C = 6.5993%

Here are his corresponding A1C formulas:

Finger A1C = (finger eAG) / 16.7
Sensor A1C = (sensor eAG) / 18.7

Figure 2 illustrates the relative comparison of PPG (upper diagram) and A1C (lower diagram). He uses the finger A1C as the baseline of 100%; therefore, the relative comparison are listed below:

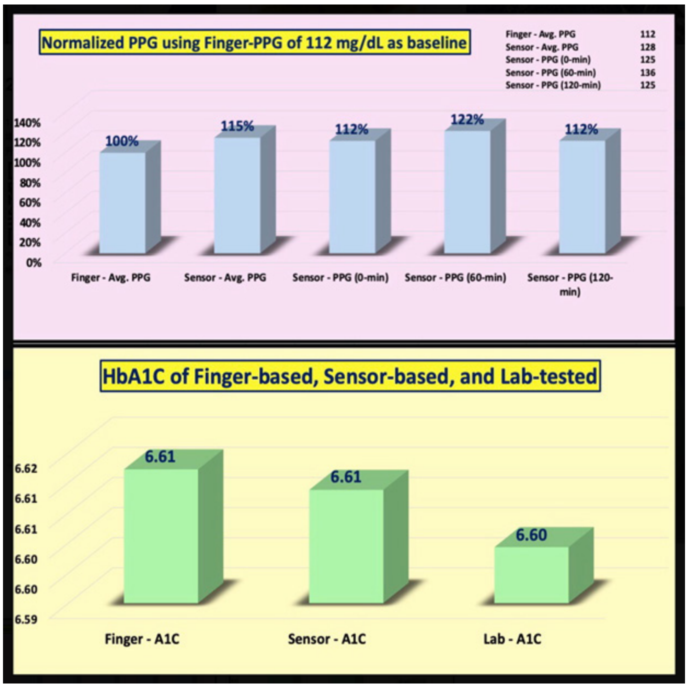

Figure 2: Relative PPG values against finger PPG value and predicted A1C versus lab-tested A1C

Finger PPG = 100%
Sensor PPG = 115%
Sensor @ 0-min = 112%
Sensor @ 60-min = 122%
Sensor @ 120-min = 112%

The lower diagram shows the direct comparison among three A1C values:

Finger A1C = 6.61%
Sensor A1C = 6.61%
Lab-test A1C = 6.60%

Conclusion

In conclusion, the average sensor PPG (128 mg/dL) is 15% higher than his finger PPG (112 mg/dL). Both PPG values at 0-minutes and at 120-minutes are similar (125 mg/dL) and are 12% higher than his average finger PPG (112 mg/dL). Usually, many diabetes clinicians advise their patients to measure PPG at "2-hours" after the first bite of meals. By following this method, the patients would catch the low-end of their PPG wave excursion. On the other hand, his PPG at 60-minutes (136 mg/dL) is 22% higher than the average finger PPG (112 mg/dL) and 10% higher than the initial PPG and PPG at 60-minutes (125 mg/dL).

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References

For editing purposes, majority of the references in this paper, which are self-references, have been removed for this article. Only references from other authors' published sources remain. The bibliography of the author's original self-references can be viewed at www.eclairemd.com.

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