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Research Article

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An Investigation and Comparison of Weight and Glucose Changes, Including Glucose Fluctuations, Among Two Non-Fasting Periods with 115 Breakfasts each and 115 Breakfasts with tea only with 16-Hours Intermittent Fasting Using GH-Method: Math-Physical Medicine (No. 438)

Gerald C Hsu

EclaireMD Foundation, USA

***Corresponding author**
Gerald C Hsu, EclaireMD Foundation, USA

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Abstract

The author uses a continuously monitoring glucose sensor (CMGS) device to collect his glucose data (sensor glucoses) from 5/5/2018 to 3/1/2021 which contain a total of 1,023 breakfasts. He selects a special shorter period of 130 days with two equal length periods of 65 days each for non-fasting breakfasts and fasting days (16-hours each day of intermittent fasting or IF).

This investigation contains two parts. The first part is the study of sensor-collected postprandial plasma glucoses (PPG) magnitude and their associated relative energies. The second part is the study of PPG wave fluctuations or glycemic variability (GV) i.e., maximum PPG value minus minimum PPG value, of PPG fluctuations and their associated relative energy.

At first, the author utilizes wave theory to study the mean values of PPG waves, which is the Y-amplitude of a curve in a time domain (TD). He then applies signal processing techniques and Fast Fourier Transform (FFT) operation to convert these PPG wave data of TD into a frequency domain (FD). In his previous research, he has proven that the Y-axis magnitude (Y-amplitude) of FD is directly proportional to the level of relative energy associated with glucose amplitude value in TD that is the glucose magnitude or Y-amplitude of TD. In this way, he can then quickly estimate the relative energy levels associated with different glucose levels in order to understand the varying degree of organ impact due to these relative energies. The relative energies are generated by glucose and carried out by red blood cells circulating in the blood vessels throughout the body.

In addition, from basic physics, he has learned that a TD wave's energy is proportional to the square of TD Y-amplitude. Therefore, using the PPG magnitude in TD of these two equal-length non-fasting and fasting periods, he further verifies that the described approach of using "amplitude square" has achieved a similar pattern and is also directly proportional to the calculated energy levels using the approaches of both "frequency domain's Y-amplitude" and "frequency domain area".

Human organs and glucoses have their biochemical reasonings and needed operations, but they also present certain biophysical phenomena following the basic physics theories and principles which can definitely be interpreted or solved using various mathematical equations or tools.

There are five key conclusions drawn from this investigation:

1. From a macro-viewpoint, the overall data pattern is that all TD and FD numbers associated with the fasting period are lower than the non-fasting period. This means that ***IF is better for diabetes control. (Note: diabetes patients must be careful on exercising IF and they should consult with their physicians or healthcare professional prior.).***
2. From a micro-viewpoint, the glucose differences between the wake-up moment and the first bite of breakfast, within ~45 minutes, are 4-9 mg/dL for 3 different periods. This observed phenomenon of pre-breakfast glucose jump is a result of neuroscience due to the brain sensing the "body wakening-up" situation and then sends a marching order to both liver for glucose production and pancreas for insulin secretion.
3. Overall, the PPG fluctuation magnitudes and their associated energies are much bigger than the average peak PPG minus PPG at the moment of first-bite from the TD's PPG wave. From both TD and FD analyses, the PPG fluctuation

carries more energy than the PPG value itself, and a more violent PPG fluctuation could cause more damage to the internal organs than the mean or average glucose value, such as the HbA1C.

4. Using data from this particular IF study, the author has reconfirmed that the Y-amplitude of glucose FD and its frequency domain area are indeed directly proportional to the relative energy associated with glucose, which is the square of Y-amplitude of glucose TD.
5. The high correlation coefficients of 82%-98% between weight vs. FPG and 88%-98% between FPG vs. PPG are preserved in this study of 65 non-fasting breakfasts and 65 IF days.

Introduction

The author uses a continuously monitoring glucose sensor (CMGS) device to collect his glucose data (sensor glucoses) from 5/5/2018 to 3/1/2021 which contain a total of 1,023 breakfasts. He selects a special shorter period of 130 days with two equal length periods of 65 days each for non-fasting breakfasts and fasting days (16-hours each day of ***intermittent fasting or IF).***

This investigation contains two parts. The first part is the study of sensor-collected ***postprandial plasma glucoses (PPG)*** magnitude and their associated relative energies. The second part is the study of ***PPG wave fluctuations or glycemic variability (GV)*** i.e., maximum PPG value minus minimum PPG value, of PPG fluctuations and their associated relative energy.

At first, the author utilizes wave theory to study the mean values of PPG waves, which is the Y-amplitude of a curve in a time domain (TD). He then applies signal processing techniques and Fast Fourier Transform (FFT) operation to convert these PPG wave data of TD into a frequency domain (FD). In his previous research, he has proven that the Y-axis magnitude (Y-amplitude) of FD is directly proportional to the level of relative energy associated with glucose amplitude value in TD that is the glucose magnitude or Y-amplitude of TD. In this way, he can then quickly estimate the relative energy levels associated with different glucose levels in order to understand the varying degree of organ impact due to these relative energies. The relative energies are generated by glucose and carried out by red blood cells circulating in the blood vessels throughout the body.

In addition, from basic physics, he has learned that a TD wave's energy is proportional to the square of TD Y-amplitude. Therefore, using the PPG magnitude in TD of these two equal-length non-fasting and fasting periods, he further verifies that the described approach of using "amplitude square" has achieved a similar pattern and is also directly proportional to the calculated energy levels using the approaches of both "frequency domain's Y-amplitude" and "frequency domain area".

Methods and Results

MPM Background

To learn more about his developed GH-Method: math-physical medicine (MPM) methodology, readers can read the following three papers selected from the published 400+ medical papers.

The first paper, No. 386 (Reference 1) describes his MPM methodology in a general conceptual format. The second paper, No. 387 (Reference 2) outlines the history of his personalized diabetes research, various application tools, and the differences between biochemical medicine (BCM) approach versus the MPM approach. The third paper, No. 397 (Reference 3) depicts a general flow diagram containing ~10 key MPM research methods and different tools.

The Author'S Case of Diabetes

The author was a severe type 2 diabetes patient since 1996. He weighed 220 lb. (100 kg) at that time. By 2010, he still weighed 198 lb. 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.

In 2010, he decided to self-study endocrinology, diabetes and food nutrition. During 2015 and 2016, he developed four prediction models related to diabetes conditions, i.e., weight, postprandial plasma glucose (PPG), fasting plasma glucose (FPG), and HbA1C (A1C). As a result, from using his developed mathematical metabolism index (MI) model and those four prediction tools, by end of 2016, his weight was reduced from 220 lbs. (100 kg) to 176 lbs. (89 kg), waistline from 44 inches (112 cm) to 33 inches (84 cm), averaged finger glucose from 250 mg/dL to 120 mg/dL, and HbA1C 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 had 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 was affected during this two-year period.

By 2020, his weight was further reduced to 165 lbs. (BMI 24.4) and his HbA1C was at 6.2% without any medications intervention or insulin injection. Actually, during 2020 with the special COVID-19 quarantined lifestyle, not only has he published approximately 400 medical papers in journals, but he has also achieved his best health conditions for the past 26 years. These good results are due to his non-traveling, low-stress, and regular daily life routines. Of course, his strong 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.

On 5/5/2018, he applied a continuous glucose monitoring (CGM) sensor device on his upper arm and checks his glucose measurements every 15 minutes for a total of ~96 times each day. He has maintained the same measurement pattern to present day.

Therefore, during the past 11 years, he could study and analyze his 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 his medical findings.

Input Data for Time Domain
During the period from 10/19/2020 to 3/1/2021, he segregated his collected glucose data into two separated groups:

Non-fasting: (65days)
Fasting: (65 days)

Furthermore, for the purpose of comparison, he also uses his collected sensor glucose data in a period from 5/5/2018 to 3/1/2021 as the "total period" in this study with 1,023 breakfasts.

Frequency Domain of PPG Wave
After conducting the TD analysis, he then utilizes signal process concept and Fast Fourier Transform (FFT) algorithm with his developed software program to convert his PPG waves from a TD into a FD to conduct his desired analysis.

PPG Fluctuation in TD and FD
He utilizes the maximum PPG minus the minimum PPG values as the breakfast PPG wave fluctuations data to conduct both TD analysis and FD analysis on the Postprandial plasma glucose fluctuation (GF), which is similar to the concept of the defined Glycemic Variability (GV).

Graphic Results
Figure 1 shows the data table containing the number of breakfasts, carbs/sugar intake, post-breakfast walking steps, finger-piercing measured FPG and PPG, sensor collected average PPG, and body weight in the morning.

The table in Figure 1 depicts the direct comparison of his weight among non-fasting (167 lbs.), fasting (167 lbs.) and total (171 lbs.). These two measured weights are identical between non-fasting and fasting, which have a 4 lbs. weight reduction from the total period. ***This is due to the weight impact from IF which is a slower process that takes a longer period of time to observe the weight fluctuation*** (see Reference 17).

The data also demonstrate the high correlations between weight vs. FPG, FPG vs. PPG, and Carbs/sugar vs. PPG which were presented in previous papers. (Figure 3 also provides a graphic view of these high correlations.)

10/19/20-3/1/21 (Breakfast) Time-D	Non-Fasting (NF)	Fasting (F)	Ratio (F/NF)	Avg. of F & NF	Total (5/5/18-3/1/21)	Ratio ((F+NF)/(Total))
Total no. of meals/days	65	65	100%	130	1023	13%
Weight	167	167	100%	167	171	98%
Sensor FPG	104	101	97%	103	109	94%
Syn. PPG (Start @ 0-min)	114	105	93%	109	118	93%
Syn. PPG (Start - FPG)	9	4	45%	7	8	80%
Syn. PPG (Peak @ 60 min)	126	113	90%	119	139	86%
Syn. PPG (Peak - Start)	12	8	61%	10	21	47%
Syn. PPG (Mean)	120	111	92%	115	130	89%
K-line PPG (Max)	137	122	89%	129	152	85%
K-line PPG (Min)	106	102	96%	104	111	93%
K-line PPG Fluctuation (Max-Min)	31	20	65%	26	40	63%
Carbs/Sugar intake grams	6.5	0.0	0%	3.3	8.6	38%
Post-Breakfast Walking Steps	4327	4182	97%	4255	4376	97%
Finger PPG	111	106	96%	109	114	95%
10/19/20-3/1/21 (Breakfast) Freq.-D	Non-Fasting (NF)	Fasting (F)	Ratio (F/NF)	Avg. of F & NF	Total (5/5/18-3/1/21)	Ratio ((F+NF)/(Total))
FD (PPG Energy Y)	96	88	92%	92	441	21%
FD (PPG Max-Min Energy Y)	125	58	46%	92	591	15%
FD (PPG Energy Total Area)	6101	5567	91%	5834	452121	1%
FD (PPG Max-Min Energy Area)	8007	3679	46%	5843	607768	1%

10/19/20-3/1/21 (Breakfast) Time-D	Non-Fasting (NF)	Fasting (F)	10/19/20-3/1/21 (Breakfast) Time-D	Avg. of F & NF	Total (5/5/18-3/1/21)
Syn. PPG (Start - FPG)	9	4	Syn. PPG (Start - FPG)	7	9
Syn. PPG (Peak - Start)	12	8	Syn. PPG (Peak - Start)	10	21
K-line PPG Fluctuation (Max-Min)	31	20	K-line PPG Fluctuation (Max-Min)	26	40
10/19/20-3/1/21 (Breakfast) Freq.-D	Non-Fasting (NF)	Fasting (F)	10/19/20-3/1/21 (Breakfast) Freq.-D	Avg. of F & NF	Total (5/5/18-3/1/21)
FD (PPG Energy Y)	96	88	FD (PPG Energy Y)	92	441
FD (PPG Max-Min Energy Y)	125	58	FD (PPG Max-Min Energy Y)	92	591
FD (PPG Energy Total Area)/100	61	56	FD (PPG Energy Total Area)	58	4521
FD (PPG Max-Min Energy Area)/100	80	37	FD (PPG Max-Min Energy Area)	58	6078

Figure 1: Data table of input data and calculated data

10/19/20-3/1/21 (Breakfast)	Ratio (F/NF)	Non-Fasting (NF)	Fasting (F)
Syn. PPG (Mean)	92%	120	111
PPG**2	85%	14330	12252
FD (PPG Energy Y)	92%	96	88
FD (PPG Energy Total Area)	91%	6101	5567
10/19/20-3/1/21 (Breakfast)	Ratio (F/NF)	Non-Fasting (NF)	Fasting (F)
K-line PPG Fluctuation	65%	31	20
(Max-Min)**2	42%	967	404
FD (PPG Max-Min Energy Y)	46%	125	58
FD (PPG Max-Min Energy Area)	46%	8007	3679

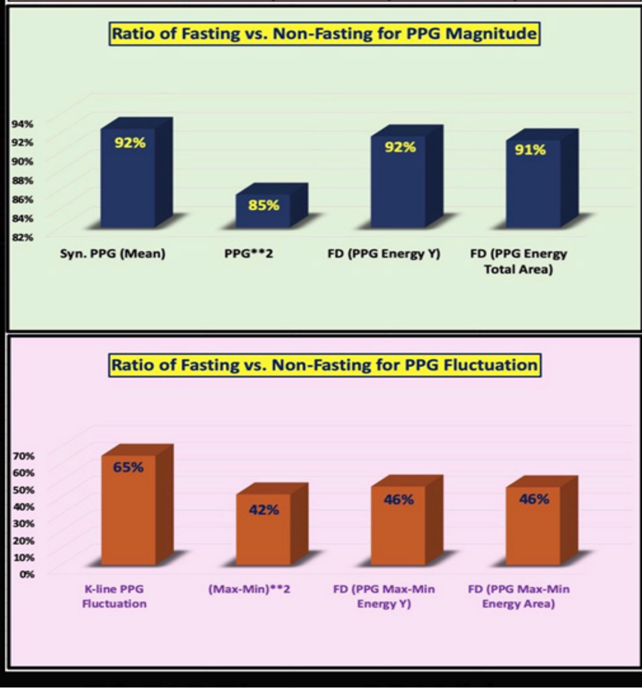

Figure 2: Comparison of PPG values and PPG fluctuations (Max-Min) comparison

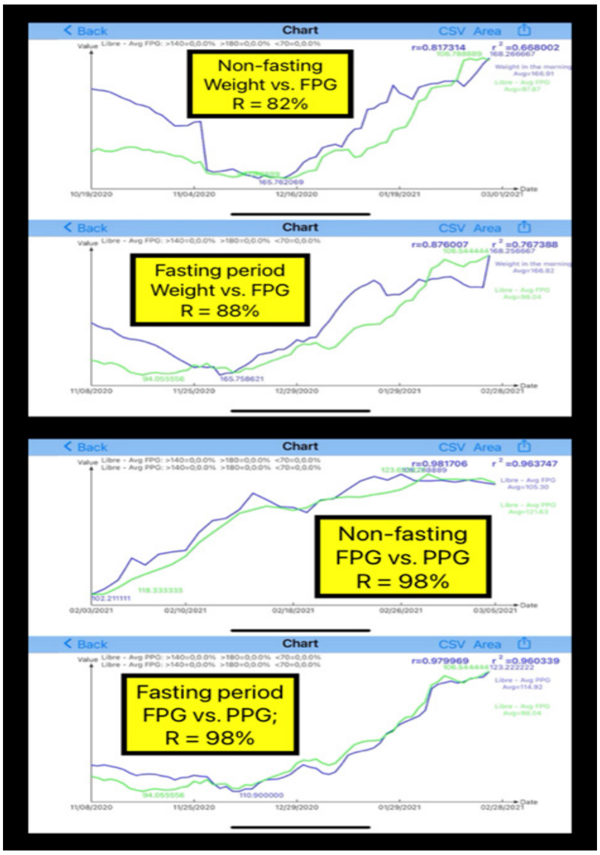

Figure 3: High correlation coefficients (R) are preserved for

weight vs. FPG and FPG vs. PPG

Figures 1, 2, 3 have illustrated the results from the FD analysis of both PPG value and PPG fluctuation.

Figure 2 reflects the results from the TD analysis of non-fasting vs. fasting and combined period (non-fasting plus fasting period of 10/19/2020 - 3/1/2021) vs. total period (5/5/2018 - 3/1/2921).

The table below summarizes the TD analysis results in a format of *synthesized PPG at first-bite moment minus FPG at wake-up moment, synthesized PPG at peak time minus first-bite, and Candlestick K-line PPG fluctuation* for 4 periods:

Non-fasting: (9, 12, 31)
Fasting: (4, 8, 20)
NF+F period: (7, 10, 26)
Total period: (9, 21, 40)

It should be pointed out that the Candlestick K-line PPG fluctuation (max-min) has the largest amounts compared to the other two glucose differences.

Another area should be highlighted is the glucose difference between the wake-up moment and the first-bite moment of breakfast. During the period from 5/5/2018 to 3/5/2021, his starting sensor PPG at the first-bite is moment 118 mg/dL, his sensor FPG at wake-up moment is 109 mg/dL, and his finger-pierced FPG at wake-up moment is 108 mg/dL. Therefore, the average glucose difference within 1,025 days is caused by the brain's decision and communication via the nervous system from the gastrointestinal system to the brain and then from the brain to both the liver and pancreas is about 9-10 mg/dL.

However, when fasting, the glucose difference between his wake-up moment and his sensor PPG's starting moment at the first moment of drinking tea is much less than 4 mg/dL.

Figures 1 and 2 also reveals the results from the FD analysis of non-fasting vs. fasting and combined period (non-fasting plus fasting period of 10/19/2020 - 3/1/2021) vs. total period (5/5/2018 - 3/1/2921).

The table below summarizes the FD analysis results in a format of *PPG value Energy from Y-amplitude, PPG fluctuation Energy from Y-amplitude, PPG value Energy from frequency area, and PPG fluctuation Energy from frequency area* for 4 periods:

Non-fasting: (96, 125, 61, 80)
Fasting: (88, 58, 56, 37)
NF+F period: (92, 92, 58, 58)
Total period: (441, 591, 4521, 6078)

Again, non-fasting has higher relative energies than fasting. The total period has the largest energies due to its long period of time (1,023 days and 1,023 frequency components).

Figures 1 and 2 also illustrates the ratios of fasting (lower values) versus non-fasting (higher values) for both PPG magnitude and PPG fluctuation.

The table below summarizes the ratios of calculated results between fasting and non-fasting from both TD and FD analyses, in a format of *PPG value or PPG fluctuation, PPG value square or PPG fluctuation square, PPG Energy from FD Y-amplitude, and PPG Energy from frequency area:*

PPG magnitude:
(92%, 85%, 92%, 91%)
PPG fluctuation:
(65%, 42%, 46%, 46%)

The ratios of PPG Energy from FD's Y-amplitude and PPG Energy from the frequency area are similar due to the frequency area equals to the Y-amplitude times the 65 days or frequency components. The most significant discovery is that ***the ratios using the PPG's TD square approach are proportional to using the frequency area approach e.g., 85% vs. 91-92% and 42% vs. 46%. This verifies the concept from basic physics of a wave's energy is proportional to the square of the wave's amplitude. This is why the author describes his calculated energy as "relative energy".***

Figure 3 signifies the ***high correlation coefficients of 82%-98% between weight vs. FPG and 88%-98% between FPG vs. PPG, which are also observed in this study of 65 non-fasting breakfasts and 65 fasting days.***

Conclusions

Human organs and glucoses have their biochemical reasonings and needed operations, but they also present certain biophysical phenomena following the basic physics theories and principles which can definitely be interpreted or solved using various mathematical equations or tools.

There are five key conclusions drawn from this investigation:

1. From a macro-viewpoint, the overall data pattern is that all TD and FD numbers associated with the fasting period are lower than the non-fasting period. This means that ***IF is better for diabetes control. (Note: diabetes patients must be careful on exercising IF and they should consult with their physicians or healthcare professional prior.).***
2. From a micro-viewpoint, the glucose differences between the wake-up moment and the first bite of breakfast, within ~45 minutes, are 4-9 mg/dL for 3 different periods. This observed phenomenon of pre-breakfast glucose jump is a result of neuroscience due to the brain sensing the "body wakening-up" situation and then sends a marching order to both liver for glucose production and pancreas for insulin secretion.
3. Overall, the PPG fluctuation magnitudes and their associated energies are much bigger than the average peak PPG minus PPG at the moment of first-bite from the TD's PPG wave. From both TD and FD analyses, the PPG fluctuation carries more energy than the PPG value itself, and a more violent PPG fluctuation could cause more damage to the internal organs than the mean or average glucose value, such as the HbA1C.
4. Using data from this particular IF study, the author has reconfirmed that the Y-amplitude of glucose FD and its frequency domain area are indeed directly proportional to the relative energy associated with glucose, which is the square of Y-amplitude of glucose TD.
5. The high correlation coefficients of 82%-98% between weight vs. FPG and 88%-98% between FPG vs. PPG are

preserved in this study of 65 non-fasting breakfasts and 65 IF days.

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