

The GH-Method

Annual Relative Energy Amounts Associated with Elastic and Plastic Postprandial Plasma Glucose Data Using a Continuous Glucose Monitoring Sensor Over 3.7 Years from 5/5/2018 to 1/16/2022 Along with the Analyses of Time-Domain and Frequency Domain Based on GH-Method: Math-Physical Medicine (No. 585)

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Abstract

The author utilized a flash glucose monitoring (FGM) technique with 14-days of continuous glucose monitoring (CGM) sensor device to collect his data (sensor glucoses) from 5/5/2018 to 1/16/2022. He then selects the collected postprandial plasma glucose (PPG) data for four individual years, Y2018, Y2019, Y2020, and Y2021, to conduct an elastic glucose (<180 mg/dL) analysis and a plastic glucose (>180 mg/dL) analysis. Furthermore, he calculates the PPG associated “relative energy” level utilizing two different but related methods. First, he uses the squared value of the average PPG as his first estimated PPG energy. In basic physics, the energy associated with a wave is proportional to the square of this wave’s amplitude. Second, he uses Fast Fourier Transformation (FTT) to convert the PPG waves from a time-domain (TD) into a frequency domain (FD) and then chooses the y-axis amplitude of the frequency diagram as another estimated PPG energy. The two different estimated energy levels are not the same; however, their trends and patterns are closely related to each other. The author has applied a TD analysis to obtain the magnitude (Y-amplitude of TD space) of the average amplitudes of glucose itself and to observe the glucose fluctuation from the time analysis chart. He then utilized FFT to conduct his FD analysis to estimate the relative energy levels associated with the average glucose and glucose fluctuations (Y-amplitude of FD space). From the wave theory in physics and his previous research reports, he has already proven that the square of Y-axis magnitude (Y-amplitude) of TD is directly proportional to the relative energy level associated with glucose amplitude value in TD which is also proportional to the magnitude or

Y-amplitude of FD. In this way, he can quickly estimate the relative energy levels associated with different glucose levels. The relative energies are generated by glucose itself which are carried by red blood cells circulating in the blood vessels throughout the body. Human organs and glucoses have their biochemical reasonings and needed operations, but their biophysical behaviors also present certain phenomena following the physics theories and principles which can definitely be interpreted or solved using various mathematical equations or engineering tools. In summary, by observing different situations of normal elastic PPG (<180 mg/dL) and hyperglycemic plastic PPG (>180 mg/dL) of the four individual annual periods, both PPG levels and their associated relative energies have been improving year after year, except for Y2019 (using the square of Y-amplitude in TD) which was the worst year. The following paragraphs outline some of his detailed findings from this study: (1) Although the absolute values using square of y-amplitude in TD have exceeded the absolute values of y-amplitude in FD multiplying the number of meals by 4 times or higher, their general trends over these 4 years are almost identical. (2) The relative energy level in Y2019 is the highest due to his exceptionally busy travel schedule to attend 40+ international conferences which disturbed his normal life routine. (3) The percentage of his hyperglycemic plastic glucose meals versus the total number of meals per year (~1,100 meals) is also decreasing year after year, except for Y2019 which was the worst performing year having the highest “residual plastic PPG” from his 8 hyperglycemic meals and their associated higher energies that damaged his internal organs.

Keywords: Postprandial plasma glucose; Glucose; Diabetes

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

1. INTRODUCTION

The author utilized a flash glucose monitoring (FGM) technique with 14-days of continuous glucose monitoring (CGM) sensor device to collect his data (sensor glucoses) from 5/5/2018 to 1/16/2022. He then selects the collected postprandial plasma glucose (PPG) data for four individual years, Y2018, Y2019, Y2020, and Y2021, to conduct an elastic glucose (<180 mg/dL) analysis and a plastic glucose (>180 mg/dL) analysis. Furthermore, he calculates the PPG associated “relative energy” level utilizing two different but related methods. First, he uses the squared value of the average PPG as his first estimated PPG energy. In basic physics, the energy associated with a wave is proportional to the square of this wave’s amplitude. Second, he uses Fast Fourier Transformation (FTT) to convert the PPG waves from a time-domain (TD) into a frequency domain (FD) and then chooses the y-axis amplitude of the frequency diagram as another estimated PPG energy. The two different estimated energy levels are not the same; however, their trends and patterns are closely related to each other.

The author has applied a TD analysis to obtain the magnitude (Y-amplitude of TD space) of the average amplitudes of glucose itself and to observe the glucose fluctuation from the time analysis chart. He then utilized FFT to conduct his FD analysis to estimate the relative energy levels associated with the average glucose and glucose fluctuations (Y-amplitude of FD space). From the wave theory in physics and his previous research reports, he has already proven that the square of Y-axis magnitude (Y-amplitude) of TD is directly proportional to the relative energy level associated with glucose amplitude value in TD which is also proportional to the magnitude or Y-amplitude of FD. In this way, he can quickly estimate the relative energy levels associated with different glucose levels. The relative energies are generated by glucose itself which are carried by red blood cells circulating in the blood vessels throughout the body.

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

2. METHODS

2.1 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, describes his MPM methodology in a general conceptual format. The second paper, No. 387, 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, depicts a general flow diagram containing ~10 key MPM research methods and different tools.

All of the listed papers in the References section are from his written and published medical research papers.

2.2 The author’s case of diabetes

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 2020-2021 with a COVID-19 quarantined lifestyle, not only has he published ~500 medical papers in 100+ journals, but he has also reached his best health conditions for the past 28 years. By Y2021, his weight was further reduced to 165 lbs. (BMI 24.4) along with a 5.8% A1C value on 10/22/2021, 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 developed various high-tech tools contribute to his excellent health status since 1/19/2020, the beginning date of his COVID-19 quarantined life.

On 5/5/2018, he applied a continuous glucose monitoring (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). By the way, the difference of 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 12 years, he could study and analyze the collected ~3 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 567 medical papers and published 500+ 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.

The following paragraphs are excerpts from Wikipedia:

“Elasticity (physics)

Physical property when materials or objects return to original shape after deformation.

In physics and materials science, elasticity is the ability of a body to resist a distorting influence and to return to its original size and shape when that influence or force is removed. Solid objects will deform when adequate loads are applied to them; if the material is elastic, the object will return to its initial shape and size after removal. This is in contrast to plasticity, in which the object fails to do so and instead remains in its deformed state.

The physical reasons for elastic behavior can be quite different for different materials. In metals, the atomic lattice changes size and shape when forces are applied (energy is added to the system). When forces are removed, the lattice goes back to the original lower energy state. For rubbers and other polymers, elasticity is caused by the

stretching of polymer chains when forces are applied.

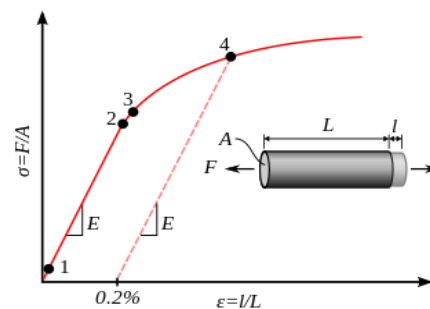
Hooke's law states that the force required to deform elastic objects should be directly proportional to the distance of deformation, regardless of how large that distance becomes. This is known as perfect elasticity, in which a given object will return to its original shape no matter how strongly it is deformed. This is an ideal concept only; most materials which possess elasticity in practice remain purely elastic only up to very small deformations, after which plastic (permanent) deformation occurs.

In engineering, the elasticity of a material is quantified by the elastic modulus such as the Young's modulus, bulk modulus or shear modulus which measure the amount of stress needed to achieve a unit of strain; a higher modulus indicates that the material is harder to deform. The material's elastic limit or yield strength is the maximum stress that can arise before the onset of plastic deformation.

Plasticity (physics)

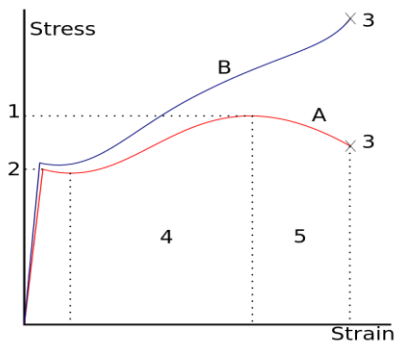
Deformation of a solid material undergoing non-reversible changes of shape in response to applied forces.

In physics and materials science, plasticity, also known as plastic deformation, is the ability of a solid material to undergo permanent deformation, a non-reversible change of shape in response to applied forces. For example, a solid piece of metal being bent or pounded into a new shape displays plasticity as permanent changes occur within the material itself. In engineering, the transition from elastic behavior to plastic behavior is known as yielding.



Stress–strain curve showing typical yield behavior for nonferrous alloys.

1. True elastic limit
2. Proportionality limit
3. Elastic limit
4. Offset yield strength



A stress–strain curve typical of structural steel.

- 1: Ultimate strength
- 2: Yield strength (yield point)
- 3: Rupture
- 4: Strain hardening region
- 5: Necking region
- A: Apparent stress (F/A_0)
- B: Actual stress (F/A)

Plastic deformation is observed in most materials, particularly metals, soils, rocks, concrete, and foams. However, the physical mechanisms that cause plastic deformation can vary widely. At a crystalline scale, plasticity in metals is usually a consequence of dislocations. Such defects are relatively rare in most crystalline materials, but are numerous in some and part of their crystal structure; in such cases, plastic crystallinity can result. In brittle materials such as rock, concrete and bone, plasticity is caused predominantly by slip at microcracks. In cellular materials such as liquid foams or biological tissues, plasticity is mainly a consequence of bubble or cell rearrangements, notably T1 processes.

For many ductile metals, tensile loading applied to a sample will cause it to behave in an elastic manner. Each increment of load is accompanied by a proportional increment in extension. When the load is removed, the piece returns to its original size. However, once the load exceeds a threshold – the yield strength – the extension increases more rapidly than in the elastic region; now when the load is removed, some degree of extension will remain.

Elastic deformation, however, is an approximation and its quality depends on the time frame considered and loading speed. If, as indicated in the graph opposite, the deformation includes elastic deformation, it is also often referred to as "elasto-plastic deformation" or "elastic-plastic deformation".

Perfect plasticity is a property of materials to undergo irreversible deformation without any increase in stresses or loads. Plastic materials that have been hardened by prior deformation, such as cold forming, may need increasingly higher stresses to deform further. Generally, plastic deformation is also dependent on the deformation speed, i.e. higher stresses usually have to be applied to increase the rate of deformation. Such materials are said to deform viscoplastically.”

Time–frequency analysis:

In signal processing, time–frequency analysis comprises those techniques that study a signal in both the time and frequency domains simultaneously, using various time–frequency representations. Rather than viewing a 1-dimensional signal (a function, real or complex-valued, whose domain is the real line) and some transform (another function whose domain is the real line, obtained from the original via some transform), time–frequency analysis studies a two-dimensional signal – a function whose domain is the two-dimensional real plane, obtained from the signal via a time–frequency transform.

The mathematical motivation for this study is that functions and their transform representation are tightly connected, and they can be understood better by studying them jointly, as a two-dimensional object, rather than separately.

The practical motivation for time–frequency analysis is that classical Fourier analysis assumes that signals are infinite in time or periodic, while many signals in practice are of short duration, and change substantially over their duration. For example, traditional musical instruments do not produce infinite duration sinusoids, but instead begin with an attack, then gradually decay. This is poorly represented by traditional methods, which motivates time–frequency analysis.”

3. RESULTS

Figure 1 shows the data table containing both input data and output data. It contains two calculations of both energy from the squared PPG in TD and energy from the Y-amplitude in FD.

1/16/22	Normalized Y2018	Y2019	Y2020	Y2021	Y2018 (238 days)
Elastic PPG <180 mg/dL					
No. of meals	1152	1100	1094	1080	751
Avg Carbs/Sugar	15.5	13.0	13.5	12.6	15.5
Avg K-steps	4.592	4.071	4.486	4.100	4.592
Avg PPG mg/dL	135	136	121	116	135
Sq. of Avg PPG	18339	18545	14607	13405	18339
PPG @ 0-min	127	130	119.81	115.74	127
PPG peak @ 45-60 min	143	146	128.18	121.57	143
PPG @ 180-min	128	132	117.99	114.71	128
Avg Frequency Y-amp	13.2	12.04	8.20	7.6441	13.2
Freq. Y-amp* meals no.	15145	13244	8975	8256	9876
Plastic PPG >180 mg/dL					
No. of meals	17	8	3	1	11
Avg Carbs/Sugar	92	83.8	72.7	70.0	92
Avg K-steps	3.92	2.5	3.633	4.500	3.92
Avg PPG mg/dL	184	196	189	163	184
Sq. of Avg PPG	33989	38322	35759	26543	33989
PPG @ 0-min	147	123	162	127	147
PPG peak @ 105-150 min	202	229	215	156	202
PPG @ 180-min	180	213	185	208	180
Residual PPG	33	90	23	81	33
Avg Frequency Y-amp	16.77	30.99	13.03	33.38	16.77
Freq. Y-amp* meals no.	283	248	39	33	184
Normalized PPG Energy	Y2018	Y2019	Y2020	Y2021	Y2018
Total of Sq. Avg. PPG	52327	56867	50366	39948	52327
Total of Freq. Y * meals	15428	13492	9014	8289	10060
Normalized PPG Energy	Y2018	Y2019	Y2020	Y2021	Y2018
Total of Freq. Y * meals (%)	100%	87%	58%	54%	65%
Total of Sq. Avg. PPG (%)	100%	109%	96%	76%	100%

Figure 1: Data table of input data and calculated output data.

Figure 2 depicts these two relative energy levels by absolute numbers and percentages using Y2018 as the comparison standard of 100%.

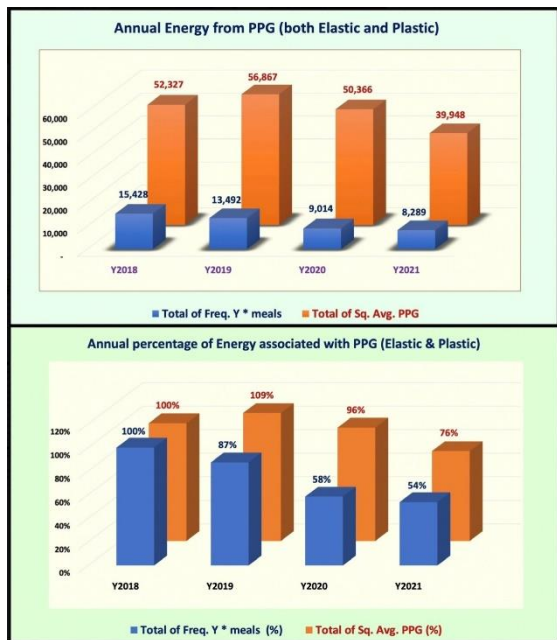


Figure 2: Relative energy analysis of 4 annual periods.

4. CONCLUSION

In summary, by observing different situations of normal elastic PPG (<180 mg/dL) and hyperglycemic plastic PPG (>180 mg/dL) of the four individual annual periods, both PPG levels and their associated relative energies have been improving year after year, except for Y2019 (using the square of Y-amplitude in TD) which was the worst year. The following paragraphs outline some of his detailed findings from this study:

(1) Although the absolute values using square of y-amplitude in TD have exceeded the absolute values of y-amplitude in FD multiplying the number of meals by 4 times or higher, their general trends over these 4 years are almost identical.

(2) The relative energy level in Y2019 is the highest due to his exceptionally busy travel schedule to attend 40+ international conferences which disturbed his normal life routine.

(3) The percentage of his hyperglycemic plastic glucose meals versus the total number of meals per year (~1,100 meals) is also decreasing year after year, except for Y2019 which was the worst performing year having the highest “residual plastic PPG” from his 8 hyperglycemic meals and their associated higher energies that damaged his internal organs.

5. 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.eclaircmd.com.

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