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Research Article

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Study of Annual CGM Sensor PPG Versus FPG Baseline, PPG Rise, PPG Drop Using Viscoplastic Energy Model of GH-Method: Math-Physical Medicine (No. 1027, Viscoelastic Medicine Theory #425)

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Category: Diabetes

Abstract

The author used his personally collected continuous glucose monitoring (CGM) sensor data to study the relationship between his postprandial glucose rising amount (PPG Rise) and carbohydrate/sugar intake in grams, as well as his postprandial glucose dropping amount (PPG Drop) and post-meal walking steps.

Initially, he calculated his averaged annual PPG Rise rate and PPG Drop rate as well as the total time period from 5/5/2018 to 1/30/2024 using simple statistical averaging calculations.

Subsequently, he applied a space-domain Viscoplastic medicine theory's stress-strain energy model to calculate the energy contribution percentages from PPG baseline, PPG Rise, and PPG Drop on annualized PPG output strain values.

***In summary,** the overall PPG Rise rate was found to be 2.8, and the PPG Drop rate was 6.5. This indicates that **every gram of carbohydrate/sugar intake increased the PPG level by 2.8 mg/dL, and every thousand post-meal walking steps (after 60 minutes from the first bite of the meal) brought down the PPG by 6.5 mg/dL**. For comparison, his previous findings based on much smaller dataset and shorter time period were 2.5 for PPG Rise and 5.0 for PPG Drop.*

The energy contribution percentages through SD-VMT were as follows:
- PPG base (90% of FPG) at 60%
- PPG Rise due to diet at 23%
- PPG Drop due to exercise at 17%

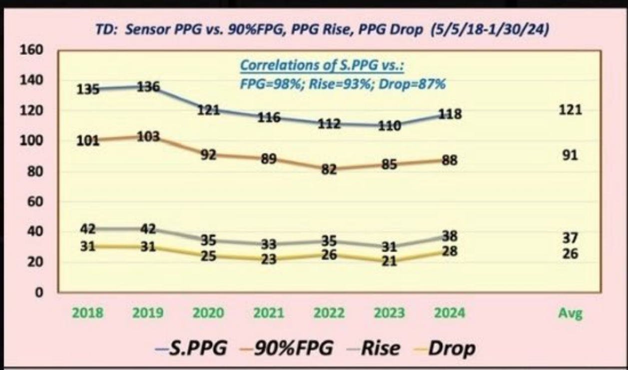
Key Message
*It is important to emphasis again that **every gram of carbohydrates or sugar consumption increases PPG by 2.8 mg/dL, and every thousand post-meal walking steps reduces PPG by 6.5 mg/dL.***

*The health state of pancreatic beta cells and their insulin quality and production contributed 60% to the overall CGM sensor PPG values. **Insulin resistance was identified as the most significant factor in diabetes condition**.*

*The ratio of diet versus exercise contribution was calculated to be 1.4 (23% divided by 17%). This suggests that **regardless of the level of exercise, it would not be able to counteract the damage caused by poor dietary choices**.*

1/31/24	PPG Analysis								PPG Baseline		PPG / grams		PPG / Ksteps
Dates	Carbs	Steps	(0-min)	(60-min)	(120-min)	(Max-Min)	S.FPG	S.PPG	90% FPG	Rise (60-Base)	Rise / Crbs	Drop (60-FPG)	Drop / Ksteps
2018	15.8	4538	127.3	143.2	133.5	48.1	112.0	134.6	100.78	42.4	2.7	31.2	6.9
2019	13.2	4038	130.1	145.6	132.9	48.6	114.7	136.3	103.26	42.4	3.2	30.9	7.7
2020	13.7	4468	119.9	126.7	117.3	37.6	101.9	120.9	91.70	35.0	2.6	24.8	5.6
2021	12.8	4057	115.8	121.5	110.8	37.8	98.9	115.9	88.98	32.5	2.5	22.6	5.6
2022	10.4	3823	109.4	116.7	106.6	37.7	91.2	111.7	82.04	34.7	3.3	25.6	6.7
2023	13.4	3243	109.7	116.1	103.1	36.3	94.9	110.3	85.38	30.7	2.3	21.2	6.5
2024	13.6	4059	120.8	126.0	106.2	43.3	98.0	118.1	88.20	37.8	2.8	28.0	6.9
Average	13.3	4032	119.0	128.0	115.8	41.3	101.6	121.1	91.5	36.5	2.8	26.3	6.5

PPG		Baseline			/ 100	/ 100	/ 100	S. Rate	Strain	Stress 1	Stress 2	Stress 3	Height 1	Height 2	Height 3	Area 1	Area 2	Area 3	Time-Zone
1/31/24	S.PPG	90%FPG	Rise	Drop	Base	Rise	Drop	S.PPG	S.PPG	Base	Rise	Drop	Base	Rise	Drop	Base	Rise	Drop	
2018	134.6	100.8	42.4	31.2	1.01	0.42	0.31	0.00	135	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	Y18--Y21
2019	136.3	103.3	42.4	30.9	1.03	0.42	0.31	1.70	136	1.76	0.72	0.53	0.88	0.36	0.26	1.5	0.6	0.5	235
2020	120.9	91.7	35.0	24.8	0.92	0.35	0.25	-15.40	121	-14.12	-5.39	-3.82	-6.18	-2.33	-1.65	95.2	36.0	25.4	76%
2021	115.9	89.0	32.5	22.6	0.89	0.33	0.23	-5.00	116	-4.45	-1.62	-1.13	-9.29	-3.51	-2.47	46.4	17.5	12.4	
2022	111.7	82.0	34.7	25.6	0.82	0.35	0.26	-4.20	112	-3.45	-1.46	-1.08	-3.95	-1.54	-1.10	16.6	6.5	4.6	Y22-Y24
2023	110.3	85.4	30.7	21.2	0.85	0.31	0.21	-1.40	110	-1.20	-0.43	-0.30	-2.32	-0.94	-0.69	3.3	1.3	1.0	73
2024	118.1	88.2	37.8	28.0	0.88	0.38	0.28	7.80	118	6.88	2.95	2.18	2.84	1.26	0.94	22.2	9.8	7.4	24%
Avg	121.1	91.5	36.5	26.3	0.91	0.37	0.26	-2.36	121	-2.08	-0.75	-0.52	-2.57	-0.96	-0.67	185.1	71.7	51.1	
Correl.	100%	98%	93%	87%										SD-E:	308	60%	23%	17%	



1. Introduction

The author used his personally collected continuous glucose monitoring (CGM) sensor data to study the relationship between his postprandial glucose rising amount (PPG Rise) and carbohydrate/sugar intake in grams, as well as his postprandial glucose dropping amount (PPG Drop) and post-meal walking steps.

Initially, he calculated his averaged annual PPG Rise rate and PPG Drop rate as well as the total time period from 5/5/2018 to 1/30/2024 using simple statistical averaging calculations.
Subsequently, he applied a space-domain Viscoplastic medicine theory's stress-strain energy model to calculate the energy contribution percentages from PPG baseline, PPG Rise, and PPG Drop on annualized PPG output strain values.

1.1 Biomedical and Engineering or Technical Information

The following sections contain excerpts and concise information on meticulously reviewed by the author of this paper. The author has adopted this approach as an alternative to including a conventional reference list at the end of this document, with the intention of optimizing his valuable research time. It is essential to clarify that these sections do not constitute part of the author's original contribution but have been included to aid the author in his future reviews and offer valuable insights to other readers with an interest in these subjects.

2. Pathophysiological Explanations of the PPG Relationship to Pancreatic Beta Cells Health State (Insulin Resistance), Carbs/Sugar Intake Amount and Post-Meal Exercise Intensity

The pathophysiological explanations of the relationship between postprandial plasma glucose (PPG) and the health state of pancreatic beta cells, including insulin resistance, carbohydrate/sugar intake amount, and post-meal exercise intensity can be complex and multifaceted.

2.1 Pancreatic Beta Cells Health State

The health state of pancreatic beta cells plays a crucial role in postprandial glucose regulation. Beta cells are responsible for producing insulin, which helps to regulate blood sugar levels. When the pancreatic beta cells are healthy, they can produce and release insulin effectively in response to glucose intake, helping to maintain stable postprandial glucose levels. However, if the pancreatic beta cells are compromised or damaged, insulin production and release may be impaired, leading to postprandial hyperglycemia.

2.2 Insulin Resistance

Insulin resistance refers to a condition in which the body's cells become less responsive to the effects of insulin, leading to an inability to efficiently take up and utilize glucose. In the context of postprandial glucose, insulin resistance can result in an inadequate response to carbohydrate/sugar intake, contributing to elevated PPG levels. Additionally, impaired insulin sensitivity can lead to reduced glucose uptake by skeletal muscles after meals, further exacerbating postprandial hyperglycemia.

2.3 Carbohydrate/Sugar Intake

The consumption of carbohydrates and sugars directly influences postprandial glucose levels. Following the ingestion of carbohydrates and sugars, blood glucose levels rise, triggering insulin release from the pancreatic beta cells in individuals with healthy insulin function. However, excessive or rapid carbohydrate/sugar intake can overwhelm the capacity of the pancreatic beta cells, leading to postprandial glucose spikes. In individuals with insulin resistance, the impairment of glucose uptake exacerbates the impact of carbohydrate/sugar intake on PPG levels.

2.4 Post-Meal Exercise

Post-meal exercise can have a significant impact on postprandial glucose levels. Physical activity can enhance insulin sensitivity, facilitating the uptake of glucose by skeletal muscles and other tissues. This can help to mitigate postprandial hyperglycemia by promoting the clearance of glucose from the bloodstream. Additionally, exercise can improve pancreatic beta cell function and insulin secretion, supporting more effective postprandial glucose regulation.

In summary, the relationship between PPG and the health state of pancreatic beta cells, insulin resistance, carbohydrate/sugar intake, and post-meal exercise involves complex interactions. ***Healthy pancreatic beta cells and efficient insulin sensitivity are critical for regulating postprandial glucose levels, while excessive carbohydrate/sugar intake and sedentary behavior can contribute to postprandial hyperglycemia.*** Incorporating post-meal exercise and making dietary modifications to support healthy insulin function can play a role in managing postprandial glucose levels.

3. MPM Background

To learn more about his developed GH-Method: math-physical medicine (MPM) methodology, readers can read the following three papers selected from his published 760+ 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.

4. The Author's Diabetes History

The author was a severe T2D patient since 1995. 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 at 10%). During that year, his triglycerides reached 1161 (high risk for CVD and stroke) and his albumin-creatinine ratio (ACR) at 116 (high risk for chronic kidney disease). He also suffered from five cardiac episodes within a decade. In 2010, three independent physicians warned him regarding the need for kidney dialysis treatment and the future high risk of dying from his severe diabetic complications.

In 2010, he decided to self-study endocrinology with an emphasis on diabetes and food nutrition. He spent the entire year of 2014 to develop a metabolism index (MI) mathematical model. During 2015 and 2016, he developed four mathematical prediction models related to diabetes conditions: weight, PPG, fasting plasma glucose (FPG), and HbA1C (A1C). Through using his developed mathematical metabolism index (MI) model and the other four glucose prediction tools, by the 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), average finger-piercing glucose from 250 mg/dL to 120 mg/dL, and A1C from 10% to ~6.5%. One of his major accomplishments is that he no longer takes any diabetes-related medications since 12/8/2015.

In 2017, he achieved excellent results on all fronts, especially his glucose control. However, during the pre-COVID period, including both 2018 and 2019, he traveled to ~50 international cities to attend 65+ medical conferences and made ~120 oral presentations. This hectic schedule inflicted damage to his diabetes control caused by stress, dining out frequently, post-meal exercise disruption, and jet lag, along with the overall negative metabolic impact from the irregular life patterns; therefore, his glucose control was somewhat affected during the two-year traveling period of 2018-2019.

He started his COVID-19 self-quarantined life on 1/19/2020. By 10/16/2022, his weight was further reduced to ~164 lbs. (BMI 24.22) and his A1C was at 6.0% without any medication intervention or insulin injection. In fact, with the special COVID-19 quarantine lifestyle since early 2020, not only has he written and published ~500 new research articles in various medical and engineering journals, but he has also achieved his best health conditions for the past 27 years. These achievements have resulted from his non-traveling, low-stress, and regular daily life routines. Of course, his in-depth knowledge of chronic diseases, sufficient practical lifestyle management experiences, and his own developed high-tech tools have also contributed to his excellent health improvements.

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. Furthermore, he extracted the 5-minute intervals from every 15-minute interval for a total of 96 glucose data each day stored in his computer software.

Through the author's medical research work over 40,000 hours and read over 4,000 published medical papers online in the past 13 years, he discovered and became convinced that good life habits of not smoking, moderate or no alcohol intake, avoiding illicit drugs; along with eating the right food with well-balanced nutrition, persistent exercise, having a sufficient and good quality of sleep, reducing all kinds of unnecessary stress, maintaining a regular daily life routine contribute to the risk reduction of having many diseases, including CVD, stroke, kidney problems, micro blood vessels issues, peripheral nervous system problems, and even cancers and dementia. In addition, a long-term healthy lifestyle can even "repair" some damaged internal organs, with different required time-length depending on the particular organ's cell lifespan. For example, he has "selfrepaired" about 35% of his damaged pancreatic beta cells during the past 10 years.

5. Energy Theory

The human body and organs have around 37 trillion live cells which are composed of different organic cells that require energy infusion from glucose carried by red blood cells; and energy consumption from labor-work or exercise. When the residual energy (resulting from the plastic glucose scenario) is stored inside our bodies, it will cause different degrees of damage or influence to many of our internal organs.

According to physics, energies associated with the glucose waves are proportional to the square of the glucose amplitude. The residual energies from elevated glucoses are circulating inside the body via blood vessels which then impact all of the internal organs to cause different degrees of damage or influence, e.g. diabetic complications. Elevated glucose (hyperglycemia) causes damage to the structural integrity of blood vessels. When it combines with both hypertension (rupture of arteries) and hyperlipidemia (blockage of arteries), CVD or Stroke happens. Similarly, many other deadly diseases could result from these excessive energies which would finally shorten our lifespan. For an example, the combination of hyperglycemia and hypertension would cause micro-blood vessel's leakage in kidney systems which is one of the major cause of CKD.

The author then applied Fast Fourier Transform (FFT) operations to convert the input wave from a time domain into a frequency domain. The y-axis amplitude values in the frequency domain indicate the proportional energy levels associated with each different frequency component of input occurrence. ***Both output symptom value (i.e. strain amplitude in the time domain) and output symptom fluctuation rate (i.e. the strain rate and strain frequency) are influencing the energy level (i.e. the Y-amplitude in the frequency domain).***

Currently, many people live a sedentary lifestyle and lack sufficient exercise to burn off the energy influx which causes them to become overweight or obese. Being overweight and having obesity leads to a variety of chronic diseases, particularly diabetes. In addition, many types of processed food add unnecessary ingredients and harmful chemicals that are toxic to the bodies, which lead to the development of many other deadly diseases, such as cancers. For example, ~85% of worldwide diabetes patients are overweight, and ~75% of patients with cardiac illnesses or surgeries have diabetes conditions.

In engineering analysis, when the load is applied to the structure, it bends or twists, i.e. deform; however, when the load is removed, it will either be restored to its original shape (i.e, elastic case) or remain in a deformed shape (i.e. plastic case). In a biomedical system, the glucose level will increase after eating carbohydrates or sugar from food; therefore, the carbohydrates and sugar function as the energy supply. After having labor work or exercise, the glucose level will decrease. As a result, the exercise burns off the energy, which is similar to load removal in the engineering case. In the biomedical case, both processes of energy influx and energy dissipation take some time which is not as simple and quick as the structural load removal in the engineering case. Therefore, the age difference and 3 input behaviors are "dynamic" in nature, i.e. time-dependent. *This time-dependent nature leads to a "viscoelastic or viscoplastic" situation.* ***For the author's case, it is "viscoplastic" since most of his biomarkers are continuously improved during the past 13-year time window.***

Time-dependent output strain and stress of (viscous input*output rate)

Hooke's law of linear elasticity is expressed as:

Strain (ε: epsilon)
= Stress (σ: sigma) / Young's modulus (E)

For biomedical glucose application, his developed linear elastic glucose theory (LEGT) is expressed as:

PPG (strain) = carbs/sugar (stress) * GH.p-Modulus (a positive number) + post-meal walking k-steps * GH.w-Modulus (a negative number)

Where GH.p-Modulus is reciprocal of Young's modulus E.

However, in viscoelasticity or viscoplasticity theory, the stress is expressed as:

Stress
= viscosity factor (η: eta) * strain rate (dε/dt)

Where strain is expressed as Greek epsilon or ε.

In this article, in order to construct an "ellipse-like" diagram in a stress-strain space domain (e.g. "hysteresis loop") covering both the positive side and negative side of space, he has modified the definition of strain as follows:

Strain
= (body weight at certain specific time instant)

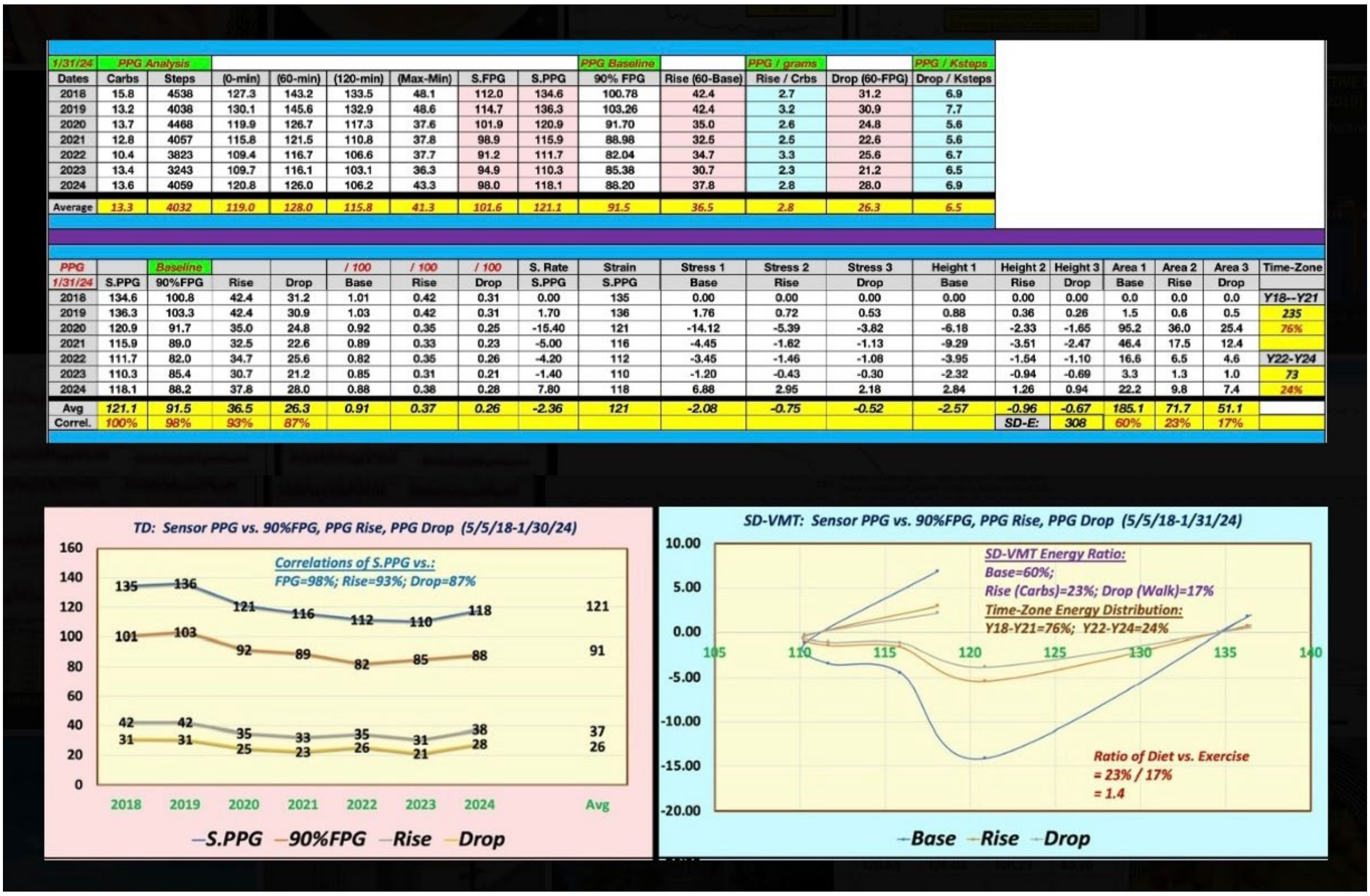
He also calculates his strain rate using the following formula:

Strain rate
= (body weight at next time instant) - (body weight at present time instant)

The risk probability % of developing into CVD, CKD, Cancer is calculated based on his developed metabolism index model (MI) in 2014. His MI value is calculated using inputs of 4 chronic conditions, i.e. weight, glucose, blood pressure, and lipids; and 6 lifestyle details, i.e. diet, drinking water, exercise, sleep, stress, and daily routines. These 10 metabolism categories further contain ~500 elements with millions of input data collected and processed since 2010. For individual deadly disease risk probability %, his mathematical model contains certain specific weighting factors for simulating certain risk percentages associated with different deadly diseases, such as metabolic disorder-induced CVD, stroke, kidney failure, cancers, dementia; artery damage in heart and brain, micro-vessel damage in kidney, and immunity-related infectious diseases, such as COVID death.

Some of explored deadly diseases and longevity characteristics using the ***viscoplastic medicine theory (VMT)*** include stress relaxation, creep, hysteresis loop, and material stiffness, damping effect ***based on time-dependent stress and strain*** which are different from his previous research findings using ***linear elastic glucose theory (LEGT) and nonlinear plastic glucose theory (NPGT).***

6. Results



1/31/24	PPG Analysis								PPG Baseline		PPG / grams		PPG / Ksteps
Dates	Carbs	Steps	(0-min)	(60-min)	(120-min)	(Max-Min)	S.FPG	S.PPG	90% FPG	Rise (60-Base)	Rise / Crbs	Drop (60-FPG)	Drop / Ksteps
2018	15.8	4538	127.3	143.2	133.5	48.1	112.0	134.6	100.78	42.4	2.7	31.2	6.9
2019	13.2	4038	130.1	145.6	132.9	48.6	114.7	136.3	103.26	42.4	3.2	30.9	7.7
2020	13.7	4468	119.9	126.7	117.3	37.6	101.9	120.9	91.70	35.0	2.6	24.8	5.6
2021	12.8	4057	115.8	121.5	110.8	37.8	98.9	115.9	88.98	32.5	2.5	22.6	5.6
2022	10.4	3823	109.4	116.7	106.6	37.7	91.2	111.7	82.04	34.7	3.3	25.6	6.7
2023	13.4	3243	109.7	116.1	103.1	36.3	94.9	110.3	85.38	30.7	2.3	21.2	6.5
2024	13.6	4059	120.8	126.0	106.2	43.3	98.0	118.1	88.20	37.8	2.8	28.0	6.9
Average	13.3	4032	119.0	128.0	115.8	41.3	101.6	121.1	91.5	36.5	2.8	26.3	6.5

PPG		Baseline			/ 100	/ 100	/ 100	S. Rate	Strain	Stress 1	Stress 2	Stress 3	Height 1	Height 2	Height 3	Area 1	Area 2	Area 3	Time-Zone
1/31/24	S.PPG	90%FPG	Rise	Drop	Base	Rise	Drop	S.PPG	S.PPG	Base	Rise	Drop	Base	Rise	Drop	Base	Rise	Drop	
2018	134.6	100.8	42.4	31.2	1.01	0.42	0.31	0.00	135	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	Y18--Y21
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2023	110.3	85.4	30.7	21.2	0.85	0.31	0.21	-1.40	110	-1.20	-0.43	-0.30	-2.32	-0.94	-0.69	3.3	1.3	1.0	73
2024	118.1	88.2	37.8	28.0	0.88	0.38	0.28	7.80	118	6.88	2.95	2.18	2.84	1.26	0.94	22.2	9.8	7.4	24%
Avg	121.1	91.5	36.5	26.3	0.91	0.37	0.26	-2.36	121	-2.08	-0.75	-0.52	-2.57	-0.96	-0.67	185.1	71.7	51.1	
Correl.	100%	98%	93%	87%										SD-E:	308	60%	23%	17%	

Figure 1: Shows Input information, TD and SD results.

7. Conclusions

In summary, the overall PPG Rise rate was found to be 2.8, and the PPG Drop rate was 6.5. This indicates that ***every gram of carbohydrate/sugar intake increased the PPG level by 2.8 mg/dL, and every thousand post-meal walking steps (after 60 minutes from the first bite of the meal) brought down the PPG by 6.5 mg/dL***. For comparison, his previous findings based on much smaller dataset and shorter time period were 2.5 for PPG Rise and 5.0 for PPG Drop.

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Key Message

It is important to emphasis again that ***every gram of carbohydrates or sugar consumption increases PPG by 2.8 mg/dL, and every thousand post-meal walking steps reduces PPG by 6.5 mg/dL***.

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.

For reading more of the author's published VGT or FD analysis results on medical applications, please locate them through platforms for scientific research publications, such as ResearchGate, Google Scholar, etc.