The GH-Method

Nonlinear Plastic Glucose Theory (NPGT #1): Applying Elasticity Theory, Plasticity Theory, and Energy Theory to Investigate Collected Hyperglycemic Postprandial Plasma Glucose Behaviors Associated with 12 Days of Plastic Glucose Data from a Total of 52,195 Postprandial Plasma Glucose Data Over 4,015 Meals and Snacks of 1,323 Days Over ~3.5 Years from 5/8/2018 to 12/10/2021 Based on GH-Method: Math-Physical Medicine (No. 567)

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Note: Readers who want to get a quick overview can read the abstract, results, and graphs.

Abstract

The author's background covers mathematics, physics, and various engineering disciplines not including biology and chemistry. As a result, he can only investigate the collected biomedical phenomena using his ready-learned math-physical tools. For background information, he provides a detailed description of his self-study of medicine and medical research on endocrinology, chronic diseases, and related complications in the Methods section. The following paragraph offers certain key data and associated timelines within his 27-year history of type 2 diabetes (T2D). In 1995, he was diagnosed with T2D and started taking three different types of diabetes medications. Fifteen years after his initial diagnosis, his HBA1C in 2010 was 10% to 14.7% with an average glucose of ~278 mg/dL to 310 mg/dL. In addition, he suffered many complications, such as hypertension, hyperlipidemia, cardiac episodes, retinopathy, neuropathy, foot ulcer, bladder infection, hypothyroidism, kidney disease, diabetic constipation, and diabetic skin fungal infection, but no stroke. From 2011 to 2014, during the period of his self-study on internal medicine and food nutrition, his glucose range was 131 mg/dL to 156 mg/dL with an HbA1C between 6.8% to 7.7%. Since 2015, he started to research and identify several effective ways to predict and control his glucoses; therefore, from 2015 to 2017, his glucose range was 122 mg/dL to 144 mg/dL with an HbA1C between 6.6% to 7.2%. Furthermore, from 2018-2019, he maintained an extremely busy travel schedule to attend 65+ medical conferences while making 120+ presentations. As a result, during the pre-COVID period of 2018-2019, his glucose range only reduced slightly between 115 mg/dL to 134 mg/dL with an HbA1C of 6.7% to 6.8%. Over the past two years from 2020 to 2021 during the COVID-19 self-quarantine period, his glucose range is 105 mg/dL to 120 mg/dL with an HbA1C of 6.2% to 6.3%. His latest lab-tested A1C on 10/22/2021 was 5.8% with an average glucose of 102.7 mg/dL which are the lowest in his 27-year history of T2D. One special note is that the author ceased taking any diabetes medications since 12/08/2015. Starting on 1/1/2012, he began measuring his glucose using a finger-piercing device for 4 glucose data per day, and then supplementing with a continuous glucose monitoring (CGM) device since 5/8/2018 to gather 96 glucose data per day. During the 6.5-year period of finger-piercing measurements, he measured fasting plasma glucose (FPG) once in the morning and three times for postprandial plasma glucose (PPG) at 2-hours (120-minutes) after the first bite of meal. Therefore, using the finger-piercing method, he was unable to catch the "glucose peaks" which usually occur approximately 60-75 minutes after the first bite of meal (0-minute). Unfortunately, as explained earlier, using only daily average value from the finger-pierced glucose data at 120-minutes after the first bite of meal during his worst diabetes period from 2000 to 2011, not only are they insufficient for his usage but also irrelevant to conduct a meaningful research work on the verification of the applicability of "glucose plasticity theory". In order to obtain his maximum glucoses or PPG peaks, he must rely on the CGM sensor device data. Consequently, the glucose data used in this study are from the CGM sensor

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glucose period over the past 1,323 days (more than 4,000 meals and snacks/fruits) from 5/8/2018 to 12/10/2021. In total, there are 52,195 PPG data over 1,323 days covering 4,015 meals and snacks/fruits. However, while using the CGM database, he had to modify and enhance his developed software program to perform necessary data-mining tasks in order to extract the 12 worst days of the hyperglycemic cases (0.91% for PPG greater than 200 mg/dL) from a big database of a total of 1,323 days (100%). For the purpose of offering a simpler explanation to readers who are medical doctors or patients, the author includes a brief excerpt from Wikipedia regarding the basic concept description of elasticity theory and plasticity theory from physics and strength of engineering materials in the Method section. The analogy between physics and medicine are two-fold. First, the load or stress in physics and engineering (y-axis) corresponds to the influential force or load for pushing PPG upward in medicine, i.e. carbohydrates and sugar intake amount. Second, the deformation or strain in physics and engineering (x-axis) corresponds to the PPG level in medicine. Medicine field is different from engineering field, where the engineering materials such as steel, copper, concrete, and aluminum are inorganic in most cases. These material properties do not change significantly over their expected lifespans. However, in medicine, the body with its organs and cells are organic and go through many different stages over their natural lifespans, such as birth, splitting, growth, mutation, development, repair, sickness, and death. After declaring the analogy of elasticity and plasticity theories, the energy theory must be brought into context. The human body and organs are composed of different organic cells that require energy infusion from glucose carried in red blood cells and energy consumption through labor-work or exercise. When the residual energy, i.e. left-over energy, is stored in a plastic glucose scenario, it will cause different degrees of damage to certain organs. The energy associated with the residual glucose is proportional to the square of the residual glucose. 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. In addition, many types of processed food add unnecessary ingredients and chemicals that are toxic to the bodies, which lead to the development of different chronic diseases. In an engineering analysis, when the load is applied to the structure, it bends or twists; however, when the load is removed, it will either be restored (elastic) or remain in a permanent deformed (plastic) shape. In a medical analysis, after eating carbohydrates or sugar from food, our glucose level (sugar amount inside of blood) will increase, therefore, the carbs/sugar functions as the energy supply. But, after labor work or exercise, our glucose level will decrease, therefore, the exercise functions as the energy burn-off (similar to load removal from the engineering case). In the biomedical case, the energy consumption process takes time which is not as simple and quick as the structural load removal in the engineering case. Therefore, the glucose behaviors, for both elastic glucose and plastic glucose, are “dynamic” in nature, i.e. time dependent. Professor Norman Jones taught the author “dynamic plastic behaviors of various structural components” when he was a graduate student at the Massachusetts Institute of Technology from 1972-1976. Since 2014, based on his educational background, the author has always suspected the possible existence of this “plastic glucose behavior” in the biomedical environment. However, he could not verify this due to the lack of a suitable data-mining tool to investigate the related hyperglycemic data (high glucose level). As a professional engineer, he has already learned that most of his glucose data behavior would be following “elastic” pattern in a rather normal situation. In this study, he finally discovered that 99.1% of his maximum PPG data are actually below 200 mg/dL and behave elastically. The exceptional “plastic glucose” case (in this study, 0.9% of his total CGM sensor PPG data are located within the range from 200 mg/dL to 300 mg/dL) and its glucose behaviors possess a kind of abnormal situation of “plastic” pattern. This percentage division of majority % vs. minority % (e.g. for this case, 99.1% vs. 0.9%) matches with his personal experiences and previous findings from designing defense weapons, space shuttle, nuclear power plant, computer hardware devices, machine components, earthquake engineering, and semiconductor chips. From the viewpoints of complete coverage for the scope and possible severe damage on the object, a thorough understanding and deeper study of this low percentage of occurrence associated with “plastic” scenarios is absolutely necessary. For example, the majority of the population is diabetes-free (~80% to 90%) and the hyperglycemic percentages (extremely high glucose level) of existing diabetes patients is probably quite low as well. However, for severe diabetes patients, their lives are at high risk since diabetes leads to many complications and ultimately death which can be a very painful process. Therefore, the author decides to conduct his research on “plastic glucose theory” and hopefully be able to gain a better understanding of this extreme case scenario. Regarding the energy consumption, the author maintains a good exercise program over the years by walking ~4,000 steps after each meal and an average of ~15,000 steps daily. This post-meal walking will effectively bring his PPG level lower. As a matter of fact, 4,200 walking steps is the upper-bound limit for him. If he further increases his post-meal walking to 6,500 steps in hopes of reducing his plastic PPG at 180-minutes to the same level at 0-minute, he will have to walk continuously for more than one hour after each meal which is realistically difficult. Therefore, in this study, his post meal walking is maintained at 4.2 k-steps for both elastic glucose and plastic glucose scenarios. The

elastic PPG behavior (by eating less carbs/sugar with an average of 13 grams per meal) shows that his PPG at 180-minutes will be reduced to the same PPG level at 0-minute of 122 mg/dL, after exhausting the influential forces from carbs/sugar and 4.2k-steps of exercise. In other words, his PPG level will completely bounce back to its initial state. However, the plastic PPG behavior (by eating more carbs/sugar with an average of 83 grams per meal) indicates that his PPG at 180-minutes will only be lowered to 154 mg/dL, after exhausting both influential forces from carbs/sugar and 4.2k-steps of exercise. Unfortunately, there is still 24 mg/dL of glucose which is higher than his PPG at 0-minute of 130 mg/dL. This remaining 24 mg/dL of PPG will result in excessive residual energy or left-over energy which will cause different degrees of damage to various internal organs such as heart, brain, kidney, eyes, nerves, feet, toes, skin, bladder, and intestines.

Keywords: Elasticity theory; Plasticity theory; Energy theory; 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

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Starting on 1/1/2012, he began measuring his glucose using a finger-piercing device for 4 glucose data per day, and then supplementing with a continuous glucose monitoring (CGM) device since 5/8/2018 to gather 96 glucose data per day. During the 6.5-year period of finger-piercing measurements, he measured fasting plasma glucose (FPG) once in the morning and three times for postprandial plasma glucose (PPG) at 2-hours (120-minutes) after the first bite of meal. Therefore, using the finger-piercing method, he was unable to catch the "glucose peaks" which usually occur approximately 60-75 minutes after the first bite of meal (0-minute). Unfortunately, as explained earlier, using only daily average value from the finger-pierced glucose data at 120-minutes after the first bite of meal during his worst diabetes period from 2000 to 2011, not only are they insufficient for his usage but also irrelevant to conduct a meaningful research work on the verification of the applicability of "glucose plasticity theory". In order to obtain his maximum glucoses or PPG peaks, he must rely on the CGM sensor device data.

Consequently, the glucose data used in this study are from the CGM sensor glucose period over the past 1,323 days (more than 4,000 meals and snacks/fruits) from 5/8/2018 to 12/10/2021. In total, there are 52,195 PPG data over 1,323 days covering 4,015 meals and snacks/fruits. However, while using the CGM database, he had to modify and enhance his developed software program to perform necessary data-mining tasks in order to extract the 12 worst days of the hyperglycemic cases (0.91% for PPG greater than 200 mg/dL) from a big database of a total of 1,323 days (100%).

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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.

2.3 Elasticity and plasticity

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.

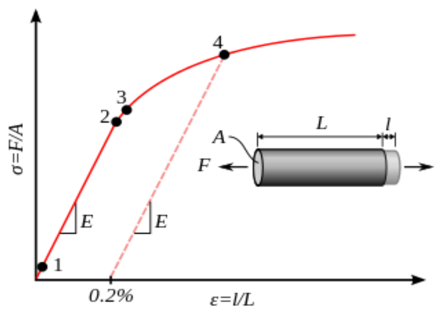
Hooke's law states that the force required to deform elastic objects should be directly proportional to the distance of deformation, regardless of how large that distance becomes. This is known as perfect elasticity, in which a given object will return to its original shape no matter how strongly it 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)

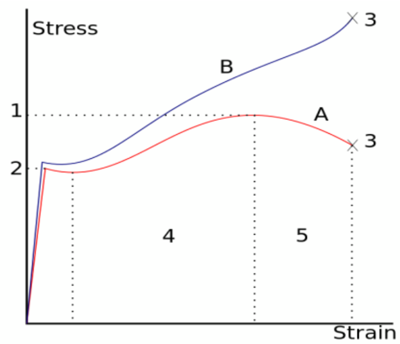
Deformation of a solid material undergoing non-reversible changes of shape in response to applied forces.

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/A0)
- 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 visco-plastically."

3. RESULTS

Figure 1 shows the author's collected data of maximum PPG, PPG at 0-min, PPG at 180-min, carbs/sugar intake grams, post-meal walking k-steps, glucose differences between 0-min and max, glucose differences between 180-min and max. These hyperglycemia data of 12-days (0.91% of plastic PPG) are discovered via a data-mining effort from a total of 52,195 PPG data of 1,323 days data with 4,015 meals and snacks/fruits. Also, it contains the 1,311 days of PPG values below 200 mg/dL (99.1%), which reveal an elastic PPG behavior.

Plasticity Theory:					Eff. "+PPG" =				Eff. "-PPG" =	
Max. PPG (200-300)	Max. F.PPG	Carbs/Sugar	S.FPG	PPG @ 0-min	Max-0min	(Eff.+PPG) / Carbs	K-Steps	PPG @ 180-min	Max-180min	(Eff.-PPG) / K-steps
9/6/20	228.00	100	121	146	82	0.8	4.253	172	56	13.2
11/9/19	213.00	100	114	141	72	0.7	4.625	161	52	11.2
10/29/19	300.00	160	111	100	200	1.3	5.631	130	170	30.2
6/12/19	200.00	40	120	124	76	1.9	4.207	167	33	7.8
4/25/19	213.00	110	90	100	113	1.0	2.912	148	65	22.3
4/3/19	203.00	100	120	144	59	0.6	2.067	189	14	6.8
2/8/19	200.00	40	109	135	65	1.6	4.033	135	65	16.1
2/5/19	205.00	16	152	122	83	5.2	5.052	137	68	13.5
12/28/18	210.00	140	106	130	80	0.6	6.063	155	55	9.1
11/22/18	200.00	50	151	137	63	1.3	4.234	158	42	9.9
9/28/18	202.00	120	128	137	65	0.5	3.55	132	70	19.7
5/29/18	235.00	14	104	143	92	6.6	4.215	166	69	16.4
12 days (0.91%)	217	82.5	119	130	88	1.8	4.237	154	63	14.7
Plasticity Theory:					Eff. "+PPG" =				Eff. "-PPG" =	
5/8/18-12/10/21	Max. F.PPG	Carbs/Sugar	S.FPG	PPG @ 0-min	Max-0min	(Eff.+PPG) / Carbs	K-Steps	PPG @ 180-min	Max-180min	(Eff.-PPG) / K-steps
1323 days (100%)	149	14	107	123	26	1.9	4.258	123	26	6.1
1311 daya (99.1%)	147	12.9	105	122	25	2.0	4.219	122	26	6.0
	Max. PPG	Carbs/Sugar	S.FPG	PPG @ 0-min	Max-0min	(Eff.+PPG) / Carbs	K-Steps	PPG @ 180-min	Max-180min	(Eff.-PPG) / K-steps
Elastic Range (1311 days)	147	13	105	122	25	2.0	4.219	122	26	6.0
Plastic Days (12 days)	217	83	119	130	88	1.8	4.237	154	63	14.7
Difference (Plastic - Elastic)	70	70	13	8	62	-0.1	0	33	38	8.6
Plastic (What-if 6.5k-steps)							6.500	122		14.7

Figure 1: Data table for both 12-days plastic PPG and 1,311-days elastic PPG cases.

Figure 2 reflects two PPG waveforms in a time-domain. The red curve is the plastic case while the blue curve is the elastic case. It should be emphasized that the PPG values are the average value of 12 days plastic data, not the maximum peak value of each day. In the blue curve, its 0-min PPG and 180-min PPG are identical at 122 mg/dL, with a peak occurring ~60-min of 134 mg/dL (this is average PPG value). This curve has an "elastic" behavior. On the other hand, the synthesized average PPG of the red curve has elevated PPG above 200 mg/dL, within the range from 90-min to 180-min. The difference between 180-min of 205 mg/dL and 0-min of 145 mg/dL is 60 mg/dL. This 60 mg/dL glucose gap indicates that PPG is unable to bounce back to its original state at 0-min, which is in a plastic state.

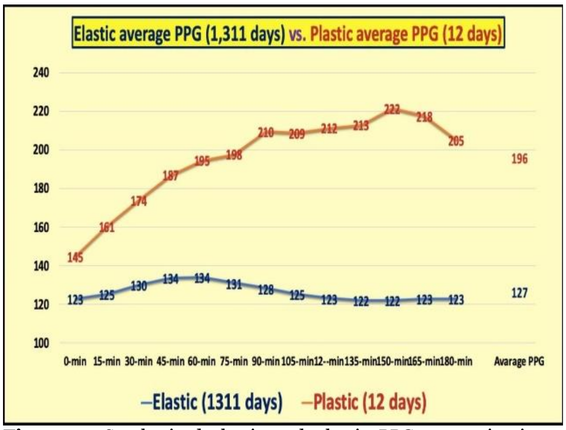


Figure 2: Synthesized elastic and plastic PPG curves in time-domain, using averaged PPG as inputs.

Figure 3 illustrates a simplified triangular linear PPG diagram using the maximum PPG or Peak PPG (not averaged peaks) as inputs. Again, the 0-min PPG and 180-min PPG for the elastic case are identical at 122 mg/dL with a peak of 147 mg/dL (this is max. PPG value). On the other hand, the red PPG curve has a difference gap of 24 mg/dL between 180-min of 154 mg/dL and 0-min of 130 mg/dL. This indicates that glucose is unable to bounce back to its original state, which is in a plastic state.

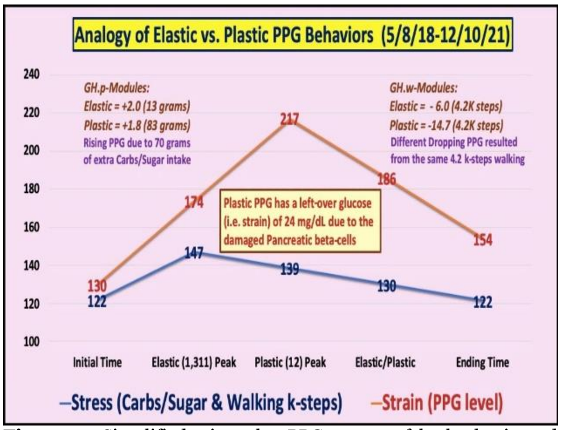


Figure 3: Simplified triangular PPG curves of both elastic and plastic cases, using maximum PPG as inputs.

Figure 4 demonstrates the analogy of elastic theory and plastic theory applied on the biomedical glucose behavior study. An interpretation using energy theory is also inserted in this figure. The lower diagram is a copy from Wikipedia which can also be found in any engineering or physics textbook. It shows a standard plastic behavior between stress and strain that appears similar to the upper diagram of the biomedical plastic PPG behaviors.

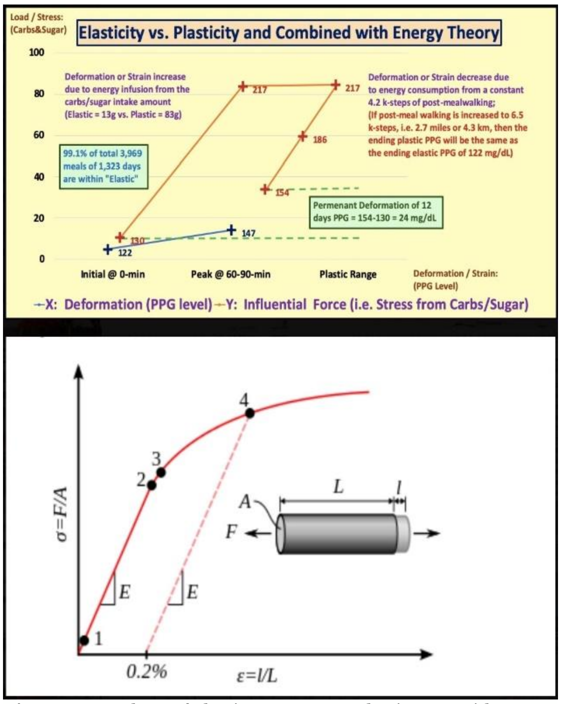


Figure 4: Analogy of elastic PPG versus plastic PPG with energy theory interpretation (upper diagram), and text book's stress-strain diagram (lower diagram).

Figure 5 shows a group of pictures of 10 meals with their maximum PPG beyond 200 mg/dL. It can be seen that they are highly carbs/sugar loaded meals of noddles, lasagna, breads, and snack of Japanese mochi rice cake. Most of those meals were taken on board of an airplane flight or a cross-Europe train. In other words, they were dine-out meals since the author has already learned how to prepare his healthy home-cooked meals by 5/8/2018.

Figure 5: Sample photos of 10 hyperglycemia meals for the period from 5/8/2018 to 12/20/2021.

4. CONCLUSION

Professor Norman Jones taught the author "dynamic plastic behaviors of various structural components" when he was a graduate student at the Massachusetts Institute of Technology from 1972-1976.

Since 2014, based on his educational background, the author has always suspected the possible existence of this "plastic glucose behavior" in the biomedical environment. However, he could not verify this due to the lack of a suitable data-mining tool to investigate the related hyperglycemic data (high glucose level). As a professional engineer, he has already learned that most of his glucose data behavior would be following "elastic" pattern in a rather normal situation. In this study, he finally discovered that 99.1% of his maximum PPG data are actually below 200 mg/dL and behave elastically. The exceptional "plastic glucose" case (in this study, 0.9% of his total CGM sensor PPG data are located within the range from 200 mg/dL to 300 mg/dL) and its glucose behaviors possess a kind of abnormal situation of "plastic" pattern. This percentage division of majority % vs. minority % (e.g. for this case, 99.1% vs. 0.9%) matches with his personal experiences and previous findings from designing defense weapons, space shuttle, nuclear power plant, computer hardware devices, machine components, earthquake engineering, and semiconductor chips.

From the viewpoints of complete coverage for the scope and possible severe damage on the object, a thorough understanding and deeper study of this low percentage of occurrence associated with "plastic" scenarios is absolutely necessary. For example, the majority of the population is diabetes-free (~80% to 90%) and the hyperglycemic percentages (extremely high glucose level) of existing diabetes patients is probably quite low as well. However, for severe diabetes patients, their lives are at high risk since diabetes leads to many complications and ultimately death which can be a very painful process. Therefore, the author decides to conduct his research on "plastic glucose theory" and hopefully be able to gain a better understanding of this extreme case scenario.

Regarding the energy consumption, the author maintains a good exercise program over the years by walking ~4,000 steps after each meal and an average of ~15,000 steps daily. This post-meal walking will effectively bring his PPG level lower. As a matter of fact, 4,200 walking steps is the upper-bound limit for him. If he further increases his post-meal walking to 6,500 steps in hopes of reducing his plastic PPG at 180-minutes to the same level at 0-minute, he will have to walk continuously for more than one hour after each meal which is realistically difficult. Therefore, in this study, his post meal walking is maintained at 4.2 k-steps for both elastic glucose and plastic glucose scenarios.

The elastic PPG behavior (by eating less carbs/sugar with an average of 13 grams per meal) shows that his PPG at 180-minutes will be reduced to the same PPG level at 0-minute of 122 mg/dL, after exhausting the influential forces from carbs/sugar and 4.2k-steps of exercise. In other words, his PPG level will completely bounce back to its initial state.

However, the plastic PPG behavior (by eating more carbs/sugar with an average of 83 grams per meal) indicates that his PPG at 180-minutes will only be lowered to 154 mg/dL, after exhausting both influential forces from carbs/sugar and 4.2k-steps of exercise. Unfortunately, there is still 24 mg/dL of glucose which is higher than his PPG at 0-minute of 130 mg/dL. This remaining 24 mg/dL of PPG will result in excessive residual energy or left-over energy which will cause different degrees of damage to various internal organs such as heart, brain, kidney, eyes, nerves, feet, toes, skin, bladder, and intestines.

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.eclairemd.com.

6. ACKNOWLEDGEMENT

Without Professor Norman Jones at MIT as his academic advisor, the author would not be able to conduct this particular research project and also published 500+ medical research papers. The author has never forgotten his advice to him that he should always enhance his strength on foundations, such as mathematics and physics, in order to make further improvement and

advancement. Professor Jones has also provided him a personal example of doing outstanding teaching and research job with an excellent work attitude, extreme dedication, and ultimate commitment on advancing both science and engineering.