

# The GH-Method

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## **Viscoelastic or Viscoplastic Glucose Theory (VGT #74): A Neuroscientific Study on the Neural Communication Model Between the Brain and Gastrointestinal Organs, Liver, and Pancreas with Regard to the Postprandial Plasma Glucose Levels and Insulin Using a Collected Data of 484 Meals with 247 Liquid Egg and 237 Solid Egg Meals Over the Past 4 Years from 5/8/2018 to 5/9/2022 Based on VGT Energy Tool and GH-Method: Math-Physical Medicine (No. 664)**

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### **Abstract**

Over the past 2+ years of the COVID pandemic period, the author conducted several medical research work based on the neuroscientific relationship between the brain and the liver's glucose production, and the pancreatic beta cell's insulin secretion based on glucose fluctuation. For the past 12 years, he collected data from his body to conduct certain useful biomedical experiments. After consuming ~500 experimental meals that include both soup-based meals (liquid egg) and solid food meals (pan-fried egg or hard-boiled egg), he noticed that there are differences in the peak and average postprandial plasma glucose (PPG) values by eating two different types of meals. The glucose reduction associated with consuming soup-based egg meals (around 4 grams of carbohydrates) extends beyond his domain of learned knowledge in the past 13 years of internal medicine and food nutrition. His normal routine, in the past 8 years, consists of consuming less than 15 grams of carbs/sugar for each meal and consistently walking ~4,000 steps post-meal. This article combines 247 PPG results from his meals with a liquid state of food or "liquid egg" meals. These meals have a carbs/sugar intake amount of 4.2 grams and post-meal walking exercise of 4,075 steps. In addition, he cooked 237 egg meals in a solid state. The solid food consisted of pan-fried and hard-boiled eggs known as "solid egg" meals. These meals have a carbs/sugar intake of 4.3 grams and post-meal walking exercise of 4,405 steps. This interesting discovery presented probable proof to spend additional time and effort to delve deeper into the related knowledge from a neural communication viewpoint; therefore, he

can reduce his average PPG, daily estimated average glucose (eAG), and hemoglobin A1C (HbA1C) level which can assist in his fight of type 2 diabetes (T2D). In conclusion, there are 3 observations listed as follows: (1) From the three PPG waveforms in a time domain, the 3-hour solid food PPG waveform has a mountain shape. This solid egg meal PPG waveform has an average PPG of 124 mg/dL and peak PPG at 60-minutes of 130 mg/dL. On the other hand, the 3-hour liquid food PPG waveform has a "flatline" shape, but with an upward titled tail between the second and third hour after the first bite of his meal. This liquid egg meal PPG waveform has an average PPG of 111 mg/dL and peak PPG at 60-minutes of 112 mg/dL. We should pay attention to the segment of 0-min to 120-min only while ignoring the segment of 120-min to 180-min since his post-meal exercise usually ends at around 120-min. In summary, the difference in the average PPG is 13 mg/dL and the peak PPG is 18 mg/dL, between 237 solid egg and 247 liquid egg meals. (2) Applying the viscoelastic or viscoplastic glucose (VGT) energy tool, his hysteresis loop's moving path looks like a "bow-tie" shape in which the strain value (total meals PPG) is moving from 112 (0-min) through 120 (60-min), 115 (120-min), 119 (165-min) and ending at 122 (180-min). His stress values also fluctuate between -2 to +3. The ratio of the two average stress values associated with solid eggs versus liquid eggs is 52% versus 48%, and the ratio of hysteresis loop areas associated with solid eggs versus liquid eggs is 53% versus 47% (similar results to each other). This indicates both solid egg meal energy and liquid egg meal energy are making an almost equal amount of contribution to

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the PPG of all egg meals. (3) The predicted PPG for all meals using a perturbation formula: Predicted PPG = strain + (stress from liquid egg + stress from the solid egg)/2; which has a prediction accuracy of 99% and correlation of 90% against the measured PPG of all egg meals. From a neuroscientific viewpoint, the author could utilize the developed GH-Method: math-physical medicine methodology (MPM) and learned biomedical knowledge from his medical research work to “trick” or “trigger” the cerebral cortex of the brain into producing or releasing a “lesser” amount of PPG via a liquid soup-based food,

without altering or disturbing the important food nutritional balance. In other words, by changing the food cooking method to transform his meals from a solid phase into a liquid phase, it can help lower both his peak PPG value and average PPG level without altering the required food nutritional balance. The brain actually considers liquid food “similar” to drinking tea or water. This article offers some practical ideas and effective ways how to control a T2D patient’s daily glucose situation through the biophysical findings related to the food preparation method.

**Keywords:** Viscoelastic; Viscoplastic; Neuroscientific; Brain; Gastrointestinal organs; Liver; Pancreas; Insulin; Type 2 diabetes; Glucose; Fasting plasma glucose; Postprandial plasma glucose

**Abbreviations:** eAG: estimated average glucose; T2D: type 2 diabetes; PPG: postprandial plasma glucose; FPG: fasting plasma glucose; MPM: math-physical medicine

## 1. INTRODUCTION

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After consuming ~500 experimental meals that include both soup-based meals (liquid egg) and solid food meals (pan-fried egg or hard-boiled egg), he noticed that there are differences in the peak and average postprandial plasma glucose (PPG) values by eating two different types of meals. The glucose reduction associated with consuming soup-based egg meals (around 4 grams of carbohydrates) extends beyond his domain of learned knowledge in the past 13 years of internal medicine and food nutrition. His normal routine, in the past 8 years, consists of consuming less than 15 grams of carbs/sugar for each meal and consistently walking ~4,000 steps post-meal.

This article combines 247 PPG results from his meals with a liquid state of food or "liquid egg" meals. These meals have a carbs/sugar intake amount of 4.2 grams and post-meal walking exercise of 4,075 steps. In addition, he cooked 237 egg meals in a solid state. The solid food consisted of pan-fried and hard-boiled eggs known as "solid egg" meals. These meals have a carbs/sugar intake of 4.3 grams and post-meal walking exercise of 4,405 steps.

This interesting discovery presented probable proof to spend additional time and effort to delve deeper into the related knowledge from a neural communication viewpoint; therefore, he can reduce his average PPG, daily estimated average glucose (eAG), and hemoglobin A1C (HbA1C) level which can assist in his fight of type 2 diabetes (T2D).

## 2. METHODS

### 2.1 MPM background

To learn more about his developed GH-Method: math-physical medicine or MPM methodology, readers can select the following three articles from the 400+ published 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 the 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 Reference section are 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 average daily glucose of 250 mg/dL (HbA1C of 10%). During that year, his triglycerides reached 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 need for kidney dialysis treatment and his future high risk of dying from his severe diabetic complications. Other than the cerebrovascular disease (stroke), he has suffered most of the known diabetic complications, including both macro-vascular and micro-vascular complications.

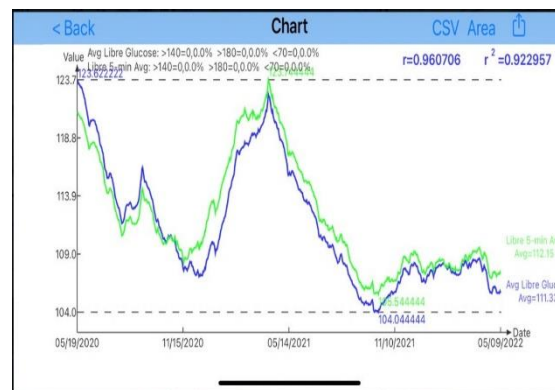
In 2010, he decided to launch his self-study on endocrinology, diabetes, and food nutrition to save his own life. During 2015 and 2016, he developed four prediction models related to diabetes conditions: weight, PPG, fasting plasma glucose (FPG), and A1C. As a result, from using his developed mathematical 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 as of 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 dining out frequently, post-meal exercise disruption, jet lag, and along with the overall metabolic 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.

Since 2020, living in a COVID-19 quarantined lifestyle, not only has he published 400+ medical papers in 100+ journals, but he has also reached his best health conditions in the past 26 years. By the beginning of 2022, his weight was further reduced to 168 lbs. (BMI 24.8) along with a 5.8% A1C value (beginning level of pre-diabetes), 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 development of various high-tech tools contribute to his excellent health status since 1/19/2020, the beginning date of his self-quarantined life.

On 5/5/2018, he applied a 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 the present day. In his research work, he uses his CGM sensor glucose at a time interval of 15 minutes (96 data per day). Incidentally, the difference in average sensor glucoses between 5-minute intervals and 15-minute intervals is only 0.7% (average glucose of 112.15 mg/dL for 5-minutes and average glucose of 111.33 mg/dL for 15-minutes with a correlation of 96% between these two sensor glucose curves) during the period from 2/19/20- to 5/9/212.



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 research 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 in 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.

2022: Applications of viscoelastic/viscoplastic glucose theory (LEGT) on 73 biomedical research cases.

Again, to date, he has spent around 40,000 hours studying and researching medicine. He has collected more than three million pieces of data regarding his medical conditions and lifestyle details. In addition, he has written 663 medical research notes and published ~600 papers in 100+ various medical and engineering journals. Moreover, he has also given ~120 presentations at ~65 international medical conferences. He has continuously dedicated his time and efforts to his medical research work and shared his findings and learnings with other patients worldwide.

### 2.3 History of his neuroscience study

Since 1/1/2012, the author developed a research-oriented software on his iPhone to collect all of his diabetes-related medical data and lifestyle details. In addition, he started to collect his glucose data using a CGM sensor device on 5/5/2018. He accumulated approximately 96 glucose data per day with 13 glucose data per meal over 3 hours or 9 glucose data per meal over 2 hours.

In mid-2018, he noticed some differences in his PPG results from his variety of meals. Therefore, he started to use his own body to conduct the necessary experiments by eating certain meals with simple food ingredients with low carbs/sugar amounts and preparing them with different cooking methods. For example, he started to eat a “pan-fried egg” meal with one single large egg on 5/11/2018, an “egg drop soup” meal with one single large egg on 12/30/2019, and a “hard-boiled egg” meal with one single large egg on 6/28/2020. As of 9/25/2019, he launched a special research project regarding various meal

preparation methods or food cooking methods using one large egg as the major food nutritional ingredient, resulting in quite different PPG results. In the second half of 2020, he noticed the PPG waveform patterns and peak PPG values were fairly close to each other between the pan-fried egg and hard-boiled egg meals; therefore, he combined these two types of meals into one group of “solid egg” meals.

He described the results from Phase 1 of his research work, from 9/25/2019 to 2/11/2020, by utilizing the collected data from the 30 egg drop soup and 30 pan-fried egg meals.

For Phase 2 of his research work, from 9/25/2019 to 5/29/2020, he further collected an additional 39 liquid meals and 36 solid meals with identical food materials and cooking methods. During this phase, he accumulated a total of 69 liquid meals (egg drop soup) and 66 solid meals (pan-fried egg). He also enhanced his software program to present the collected glucose data using the Candlestick K-Line chart. The chart reflects five key PPG values at different time instants between liquid food and solid food.

For Phase 3, from 9/25/2019 through 8/13/2020, he accrued additional data from a total of 95 liquid egg meals (egg drop soup) and 110 solid egg meals (68 pan-fried eggs and 42 hardboiled eggs). In comparison to the Phase 2 data, he collected an additional 26 liquid meals and 44 solid meals over 76 days.

In Phase 4, from 8/14/2020 through 11/25/2020, he gathered more data to reach a total of 159 liquid egg and 126 solid egg meals. In comparison to the Phase 3 data, he collected an extra 64 liquid meals and 16 solid meals over 100 days. During Phase 4, he started to add in 17 tea-only meals to serve as the baseline for PPG comparison.

In Phase 5, from 11/26/2020 through 12/26/2020, he accumulated additional data to reach a total of 165 liquid egg meals, 133 solid egg meals, and 30 tea-only meals. In comparison to the Phase 4 data, he collected an additional 6 liquid meals, 7 solid meals, and 13 tea-only meals.

During the five phases of the food and glucose experiments, he focused on investigating the relationships among different food inputs, such as meal nutritional contents, cooking

methods, physical states (i.e., liquid vs. solid), peak and average PPG values, and PPG waveforms. When he observed the different physical phenomena of glucose waves from liquid and solid meals, he wondered why these two different cooking methods would end up with such large and obvious differences in the two PPG waveforms, regardless of having identical food nutritional ingredients and exercise input amounts. Most of his medical associates or colleagues, in the fields of internal medicine and food nutrition, have mentioned the important relationship between PPG level and food nutritional components, particularly carbohydrates and sugar intake amounts along with the intensity and duration of exercise influence PPG values. Therefore, he decided to experiment with eating the same food ingredients but with two different cooking or preparation methods. It should be noted that he has kept the intensity and duration of his post-meal walking at the same level of over 4,000 steps.

By 2/11/2020 with ~30 meals in each liquid and solid category, he already discovered the vast differences in PPG values existing between these two types of meals. At that moment, he came up with a preliminary neural communication hypothesis of his own regarding the brain and certain internal organs' communication via the nervous system. He then decided to extend his experiments to verify this neural communication model with the path of sending messages from the stomach to the brain and then forwarding the brain's feedback message, or marching order, to the liver and pancreas. This communication system carries the PPG production or release amount of information at different time instances. He also decided to use a larger experimental database with some mathematical tools for his follow-up analysis.

#### **2.4 Neuroscience article**

On May 27, 2020, David Templeton, a writer for the Pittsburgh Post-Gazette presented an excellent medical discovery report. On May 29, 2020, the author read this report regarding this specific research work performed at the University of Pittsburgh (Reference 5).

Here is an excerpt:

Published May 18th of 2020 in the Proceedings of the National Academy of Sciences, an important world first, a study co-authored by Dr. Levinthal and Dr. Peter Strick, both from the Pitt School of Medicine, has explained what parts of the brain's cerebral cortex influence stomach function and how it can impact health. Dr. Peter Strick is a world leader in establishing evidence that internal organs are strongly modulated at the highest levels by the cerebral cortex. It's been traditional in biology and medicine that the internal organs are self-regulatory through the autonomic nervous system, largely independent of higher brain regions. Dr. Strick's previous research, for instance, also showed that similar areas of the cerebral cortex also control kidney and adrenal function. That course of research now could extend to "the heart, liver, and pancreas to discover more about how the brain coordinates control of internal organs," said Mr. Sterling who holds a Ph.D. in neuroscience. When it comes to trusting your gut, it already is well-established that the stomach and gut send "ascending" signals to the brain in a way that influences brain function. But the study has found that the "central nervous system both influences and is influenced by the gastrointestinal system." What people haven't understood to date, Dr. Strick said, is that the brain also has "descending influences on the stomach" with various parts of the brain involved in that signaling, including those areas that control movement and emotions. Those areas control the stomach "as directly as cortical control of movement. These are not trivial influences."

This published report has described exactly what the author, for almost two years, guessed and felt about the neural communication model between the brain and other internal organs. Although he, by training, is a mathematician, software expert, physicist, and mechanical/structural engineer, he is not a medical doctor, neuroscientist, biologist, or chemist. However, during his research work in this area since 9/15/2019, he discovered and proven his "gut-feeling" or "hunch" regarding the existence of these "ascending" messages from the stomach to the brain regarding food entry, and "descending" messages from the brain to the liver and pancreas regarding glucose production or release amount. He also verified these physical observations

through his carefully developed mathematical models and numerical examinations. Specifically speaking, his biomedical interpretation of certain physical phenomena would be verified through a few carefully established mathematical models, and then confirmed his hypothesis or theory using artificial intelligence (AI) techniques, big data analytics, or straightforward numerical analysis.

In 2019, he was cautious in using the words, such as hypotheses, guess, and might be, to describe his gut feelings generated from the observed findings, but now he has found the supporting academic and biomedical proof from other neuroscientific experts.

His friend, Dr. Nelson Hendler, a nerve pain specialist and a neuroscientist from Johns Hopkins University provided the following comments:

“Embryologically, the brain and gut arise from the same neuroectodermal tissue. This is why the gut has many of the same neurosynaptic transmitters as the brain does. In fact, many pharmaceutical houses use gut preparation to predict how a drug may work in the brain. Chief differences among these receptors are various types of serotonin.”

Since the author has already published a few articles on this subject in early 2020, by using various food and glucose data, he will forgo the detailed explanations and similar conclusions based on this relatively “larger” size of data from egg meals experiments, including the data from drinking tea only. Although there are 30 tea-only meals included in this experiment, its results have demonstrated that the tea-only meals can serve as a useful baseline reference to support the relative positions of both solid and liquid egg waveforms in his 2+ year-long project on food and glucose neuroscientific experiment.

The reason he chose tea as his baseline is twofold. First, he hypothesizes that the stomach sends a food-arrival message and its associated physical state of either solid or liquid to the brain. The brain then considers the liquid egg drop soup as being “similar” to drinking water or tea. Second, he has conducted some experiments on drinking coffee only, both regular and decaffeinated. However, his exploration has found that

regular coffee produces an extremely high level of PPG which would damage his health. The decaffeinated coffee provides somewhat better PPG results, but they are still much higher than liquid eggs may be due to the added cream.

Starting from 11/8/2020, he initiated his experiments by adding in “tea only”. Finally, by 8/15/2021, he feels that he has collected sufficient data on both soup meals and intermittent fasting (IF) for writing another report. In addition, he includes his study of the glucose gap in the morning which is also resulted from the brain and neural functions.

As of 5/10/2022, he has collected even more data and decided to conduct one additional study with a VGT analysis finding regarding energies from liquid egg and solid egg meals.

## **2.5 Elasticity, plasticity, viscoelasticity, and viscoplasticity (LEGT & VGT)**

The difference between elastic materials and viscoelastic materials (from “Soborthans, innovating shock and vibration solutions”).

What are elastic materials?

Elasticity is the tendency of solid materials to return to their original shape after forces are applied on them. When the forces are removed, the object will return to its initial shape and size if the material is elastic.

Medical analogy: The medical application is when cause or risk factors are reduced or removed, the symptoms of certain disease would be improved or ceased.

What are viscous materials?

Viscosity is a measure of a fluid’s resistance to flow. A fluid with large viscosity resists motion. A fluid with low viscosity flows. For example, water flows more easily than syrup because it has a lower viscosity. High viscosity materials might include honey, syrups, or gels – generally things that resist flow. Water is a low viscosity material, as it flows readily. Viscous materials are thick or sticky or adhesive. Since heating reduces viscosity, these materials don’t flow easily. For example, warm syrup flows more easily than cold.

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What is viscoelastic?

Viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Synthetic polymers, wood, and human tissue, as well as metals at high temperature, display significant viscoelastic effects. In some applications, even a small viscoelastic response can be significant.

Medical analogy: Viscoelastic behavior means material has “time-dependent” characters. Biomedical data, i.e. biomarkers, are time-dependent due to body cells are organic which changes with time constantly.

Elastic behavior versus viscoelastic behavior

The difference between elastic materials and viscoelastic materials is that viscoelastic materials have a viscosity factor and the elastic ones don't. Because viscoelastic materials have the viscosity factor, they have a strain rate dependent on time. Purely elastic materials do not dissipate energy (heat) when a load is applied, then removed; however, a viscoelastic substance does.

Medical analogy: Most of the biomarkers display time-dependency; therefore they have both change-rate of time and viscosity factor behaviors. Viscoelastic biomarkers do dissipate energy when a cause force is applied on it.

The following brief introductions are excerpts from Wikipedia:

“Elasticity (physics):

The physical property is when materials or objects return to their 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.

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 that possess elasticity in practice remain purely elastic only up to very small deformations, after which plastic (permanent) deformation occurs.

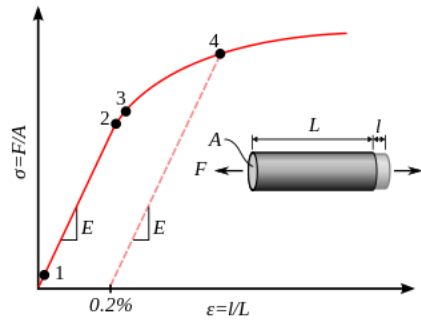
In engineering, the elasticity of a material is quantified by the elastic modulus such as the Young's modulus, bulk modulus or shear modulus which measure the amount of stress needed to achieve a unit of strain; a higher modulus indicates that the material is harder to deform. The material's elastic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

Medical analogy: The elastic behavior analogy in medicine can be expressed by the metal rod analogy for the postprandial plasma glucose (PPG). Consuming carbohydrates and/or sugar acts like a tensile force to stretch a metal rod longer, while post-meal exercise acts like a compressive force to suppress a metal rod shorter. If lacking food consumption and exercise, the metal rod (analogy of PPG) will remain its original length, for a non-diabetes or less severe type 2 diabetes (T2D) patient.

Plasticity (physics):

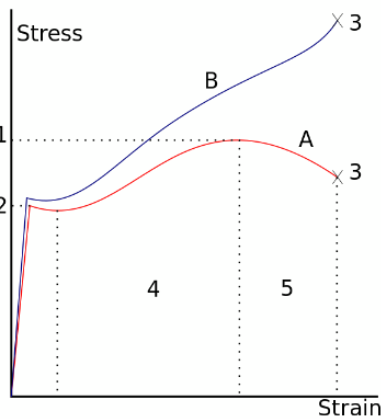
Deformation of a solid material undergoing non-reversible changes of shape in response to applied forces.

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. Plastic deformation is observed in most materials, particularly metals, soils, rocks, concrete, and foams.



A 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 is 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 ( $F/A$ )

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.

Medical analogy: A plastic behavior analogy in medicine is the PPG level of a severe T2D

patient. Even consuming a smaller amount of carbs/sugar, the patient’s PPG will rise sharply which cannot be totally brought down to a healthy PPG level even with a significant amount of exercise. This means the PPG level has exceeded its “elastic limit” and entering into a “plastic range”.

Viscoelasticity:

Property of materials with both viscous and elastic characteristics under deformation.

In materials science and continuum mechanics, viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Viscous materials, like water, resist shear flow and strain linearly with time when a stress is applied. Elastic materials strain when stretched and immediately return to their original state once the stress is removed.

Viscoelastic materials have elements of both of these properties and, as such, exhibit time-dependent strain. Whereas elasticity is usually the result of bond stretching along crystallographic planes in an ordered solid, viscosity is the result of the diffusion of atoms or molecules inside an amorphous material.

In the nineteenth century, physicists such as Maxwell, Boltzmann, and Kelvin researched and experimented with creep and recovery of glasses, metals, and rubbers. Viscoelasticity was further examined in the late twentieth century when synthetic polymers were engineered and used in a variety of applications. Viscoelasticity calculations depend heavily on the viscosity variable,  $\eta$ . The inverse of  $\eta$  is also known as fluidity,  $\phi$ . The value of either can be derived as a function of temperature or as a given value (i.e. for a dashpot).

Depending on the change of strain rate versus stress inside a material, the viscosity can be categorized as having a linear, non-linear, or plastic response. In addition, when the stress is independent of this strain rate, the material exhibits plastic deformation. Many viscoelastic materials exhibit rubber-like behaviors explained by the thermodynamic theory of polymer elasticity.

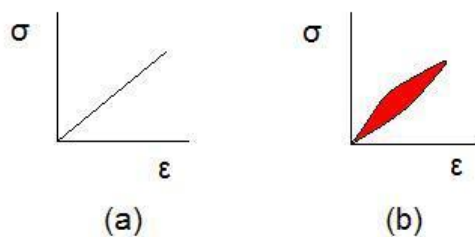
Cracking occurs when the strain is applied quickly and outside of the elastic limit.

Ligaments and tendons are viscoelastic, so the extent of the potential damage to them depends both on the rate of the change of their length as well as on the force applied.

A viscoelastic material has the following properties:

- hysteresis is seen in the stress-strain
- stress relaxation occurs: step constant strain causes decreasing stress
- creep occurs: step constant stress causes increasing strain
- its stiffness depends on the strain rate or the stress rate.

Elastic versus viscoelastic behavior:



Stress-strain curves for a purely elastic material (a) and a viscoelastic material (b). The red area is a hysteresis loop and shows the amount of energy lost (as heat) in a loading and unloading cycle. It is equal to  $\oint \sigma d\epsilon$  where  $\sigma$  is stress and  $\epsilon$  is strain. In other words, the hysteresis loop area represents the amount of energy during the loading and unloading process.

Unlike purely elastic substances, a viscoelastic substance has an elastic component and a viscous component. The viscosity of a viscoelastic substance gives the substance a strain rate dependence on time. Purely elastic materials do not dissipate energy (heat) when a load is applied, then removed. However, a viscoelastic substance dissipates energy when a load is applied, then removed. Hysteresis is observed in the stress-strain curve, with the area of the loop being equal to the energy lost during the loading cycle. Since viscosity is the resistance to thermally activated plastic deformation, a viscous material will lose energy through a loading cycle. Plastic deformation results in lost energy, which is uncharacteristic of a purely elastic material's reaction to a loading cycle.

Viscoplasticity:

Viscoplasticity is a theory in continuum mechanics that describes the rate-dependent inelastic behavior of solids. Rate-dependence in this context means that the deformation of the material depends on the rate at which loads are applied. The inelastic behavior that is the subject of viscoplasticity is plastic deformation which means that the material undergoes unrecoverable deformations when a load level is reached. Rate-dependent plasticity is important for transient plasticity calculations. The main difference between rate-independent plastic and viscoplastic material models is that the latter exhibit not only permanent deformations after the application of loads but continue to undergo a creep flow as a function of time under the influence of the applied load.

Medical analogy: In viscoelastic or viscoplastic analysis, the stress component equals the strain change rate of time multiplying with the viscosity factor, or

$$\begin{aligned} \text{Stress } (\sigma) &= \text{strain } (\epsilon) \text{ change rate} * \text{viscosity factor } (\eta) \\ &= d\epsilon/dt * \eta \end{aligned}$$

$$\begin{aligned} \text{The hysteresis loop area} &= \text{the integrated area of stress } (\sigma) \text{ and strain } (\epsilon) \text{ curve} \\ &= \oint \sigma d\epsilon \end{aligned}$$

**Note:** For a more detailed description, please refer to the “consolidated method” section which is given at the beginning of the special issue.

### 3. RESULTS

Figure 1 shows the data table of the source data and the VGT operations.

Figure 2 depicts three graphic results, three PPG waveforms in the time domain, a stress-strain diagram of VGT analysis, and predicted PPG for all egg meals using the perturbation method.

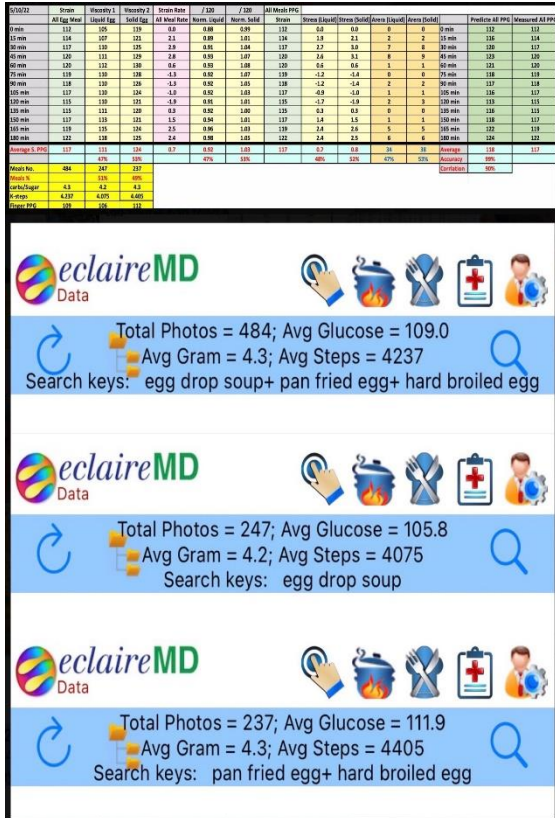


Figure 1: Data table of this study.

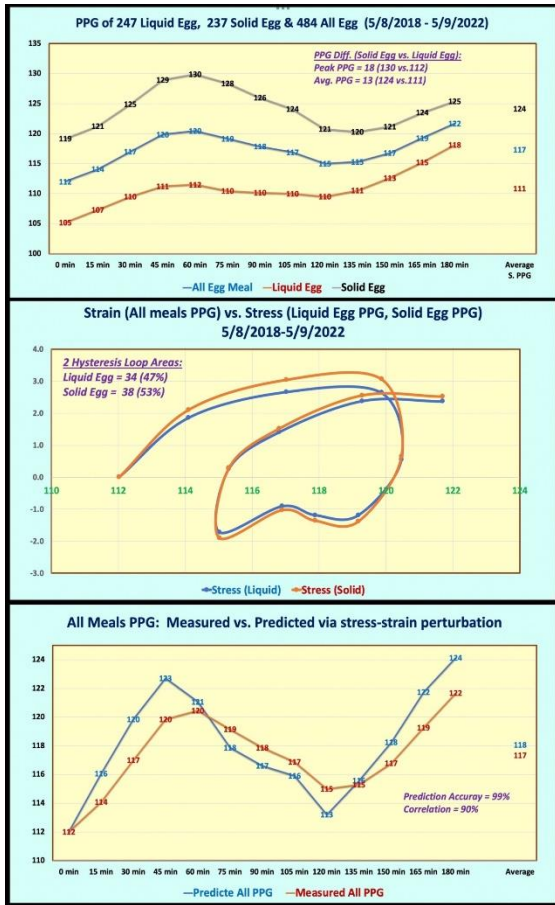


Figure 2: PPG in time-domain, VGT stress-strain diagram & predicted PPG for all egg meals.

## 4. CONCLUSION

In conclusion, there are 3 observations listed as follows:

(1) From the three PPG waveforms in a time domain, the 3-hour solid food PPG waveform has a mountain shape. This solid egg meal PPG waveform has an average PPG of 124 mg/dL and peak PPG at 60-minutes of 130 mg/dL. On the other hand, the 3-hour liquid food PPG waveform has a “flatline” shape, but with an upward titled tail between the second and third hour after the first bite of his meal. This liquid egg meal PPG waveform has an average PPG of 111 mg/dL and peak PPG at 60-minutes of 112 mg/dL. We should pay attention to the segment of 0-min to 120-min only while ignoring the segment of 120-min to 180-min since his post-meal exercise usually ends at around 120-min. In summary, the difference in the average PPG is 13 mg/dL and the peak PPG is 18 mg/dL, between 237 solid egg and 247 liquid egg meals.

(2) Applying the viscoelastic or viscoplastic glucose (VGT) energy tool, his hysteresis loop’s moving path looks like a “bow-tie” shape in which the strain value (total meals PPG) is moving from 112 (0-min) through 120 (60-min), 115 (120-min), 119 (165-min) and ending at 122 (180-min). His stress values also fluctuate between -2 to +3. The ratio of the two average stress values associated with solid eggs versus liquid eggs is 52% versus 48%, and the ratio of hysteresis loop areas associated with solid eggs versus liquid eggs is 53% versus 47% (similar results to each other). This indicates both solid egg meal energy and liquid egg meal energy are making an almost equal amount of contribution to the PPG of all egg meals.

(3) The predicted PPG for all meals using a perturbation formula:  $\text{Predicted PPG} = \text{strain} + (\text{stress from liquid egg} + \text{stress from the solid egg})/2$ ; which has a prediction accuracy of 99% and correlation of 90% against the measured PPG of all egg meals.

From a neuroscientific viewpoint, the author could utilize the developed GH-Method: math-physical medicine methodology (MPM) and learned biomedical knowledge from his medical research work to “trick” or “trigger”

the cerebral cortex of the brain into producing or releasing a “lesser” amount of PPG via a liquid soup-based food, without altering or disturbing the important food nutritional balance. In other words, by changing the food cooking method to transform his meals from a solid phase into a liquid phase, it can help lower both his peak PPG value and average PPG level without altering the required food nutritional balance. The brain actually considers liquid food “similar” to drinking tea or water.

This article offers some practical ideas and effective ways how to control a T2D patient’s daily glucose situation through the biophysical findings related to the food preparation method.

## **5. REFERENCES**

For editing purposes, the majority of the references in this paper, which are self-references, have been removed. Only references from other authors' published sources remain. The bibliography of the author’s original self-references can be viewed at [www.eclairemd.com](http://www.eclairemd.com).

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- 1) Templeton D. Pitt study shows brain and stomach connections are a two-way street. *Pittsburgh Post-Gazette*. 2020.

# Viscoelastic and Viscoplastic Glucose Theory Application in Medicine

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