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A Special Neuro-Communication Influences on GH.p-Modulus of Linear Elastic Glucose Theory Based on Data from 159 Liquid Egg and 126 Solid Egg Meals Using GH-Method: Math-Physical Medicine, Part 11 (No. 363)

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Abstract

This article is Part 11 of the author's linear elastic glucose behavior study. It focuses on a deeper investigation regarding the specific glucose coefficient of GH.p-modulus, which involves the influence of the neuro-communication between the stomach, brain, and liver pertaining to the postprandial plasma glucose (PPG) production amount (see Reference 6). When a person consumes a meal in a liquid state such as egg drop soup, the stomach would "trick" or "trigger" the brain to recognize the arrival of fluids, then it issues a marching order to the liver to produce a lesser amount of PPG. Due to the smaller value of carb intake and the mathematical definition of the incremental PPG, the value of GH.p-modulus must be raised to a higher value in order to achieve a high prediction accuracy for egg meals, especially for solid egg meals with the same small intake amount of carbs/sugar.

This article provides the background data, observed physical phenomena, and mathematical derivations to interpret and prove these higher values of GH.p-modulus for egg meals. By using two different time periods, it also demonstrates the strong linkage between GH.p-modulus and the patient's overall diabetes status, either it is improving (through a dropped GH.p-modulus) or worsening (through a raised GH.p-modulus).

Here is the step-by-step explanation of the predicted PPG equation from the six clinical cases using linear elastic glucose theory as described in References 9 through 18:

*(1) Baseline PPG equals to 97% of FPG value, or 97% * (weight * GH.f-Modulus).*
*(2) Baseline PPG plus increased amount of PPG due to food, i.e. plus (carbs/sugar intake amount * GH.p-Modulus).*
*(3) Baseline PPG plus increased PPG due to food, and then subtracts reduction amount of PPG due to exercise, i.e. minus (post-meal walking k-steps * 5).*
(4) The Predicted PPG equals to Baseline PPG plus the food influences, and then subtracts the exercise influences.

The linear elastic glucose equation is:
*Predicted PPG =(0.97 * GH.f-modulus * Weight) +(GH.p-modulus * Carbs&sugar) - (post-meal walking k-steps * 5)*

Where
Incremental PPG =Predicted PPG - Baseline PPG + Exercise impact
GH.f-modulus = FPG / Weight
GH.p-modulus =ncremental PPG / Carbs intake

This article uses the neuro-scientific experiment results of two physical states of egg meals to further investigate the two glucose coefficients, in particular the GH.p-modulus value and meaning.

The GH.p-modulus is not only the direct result of lifestyle difference (diet and exercise) but also includes the status difference of the chronic diseases (baseline PPG via weight and FPG). It also reflects the general health state of *pancreatic beta cells of a particular patient which can be described by the fasting plasma glucose (FPG) level. In addition, it further contains the neuroscience of communication model between the brain and stomach regarding the amount of glucose production or glucose release in response to a specific message of the timing of the food's entry and the physical state of the stomach and intestine. This neurology viewpoint makes the GH.p-modulus even more complex. Nevertheless, the linear elastic glucose theory still applies to the special case of the neuro-scientific egg meals, even though it creates a much higher GH.p-modulus value that can be considered as one of the boundary cases in this linear elasticity study.*

With the neuro-scientific case study, it is clear that this linear elastic glucose behavior is much more complicated than the classical engineering elasticity theory because the engineering inorganic materials do not change for a long period of time. The human body is made from organic living cells. For example, blood contains millions of organic living red blood cells with an average lifespan of 115 to 120 days and liver cells that last about 300 to 500 days. In addition, the glucose production and release are controlled by the brain. The glucose level is further regulated by insulin (a type of hormone) produced by the pancreas which is also controlled by the brain. The communication between the brain and nervous system can throw a curve ball into the glucoses game making this research work not only more complicated but also more interesting.

Introduction

This article is Part 11 of the author's linear elastic glucose behavior study. It focuses on a deeper investigation regarding the specific glucose coefficient of GH.p-modulus, which involves the influence of the neuro-communication between the stomach, brain, and liver pertaining to the postprandial plasma glucose (PPG) production amount (see Reference 6). When a person consumes a meal in a liquid state such as egg drop soup, the stomach would "trick" or "trigger" the brain to recognize the arrival of fluids, then it issues a marching order to the liver to produce a lesser amount of PPG. Due to the smaller value of carb intake and the mathematical definition of the incremental PPG, the value of GH.p-modulus must be raised to a higher value in order to achieve a high prediction accuracy for egg meals, especially for solid egg meals with the same small intake amount of carbs/sugar.

This article provides the background data, observed physical phenomena, and mathematical derivations to interpret and prove these higher values of GH.p-modulus for egg meals. By using two different time periods, it also demonstrates the strong linkage between GH.p-modulus and the patient's overall diabetes status, either it is improving (through a dropped GH.p-modulus) or worsening (through a raised GH.p-modulus).

Methods

Background

To learn more about the author's GH-Method: math-physical medicine (MPM) methodology, readers can refer to his article to understand his developed MPM analysis method in Reference 1.

Highlights of Linear Elastic Glucose Theory

Here is the step-by-step explanation of the predicted PPG equation using linear elastic glucose theory as described in References 9 through 18:

*(5) Baseline PPG equals to 97% of FPG value, or 97% * (weight * GH.f-Modulus).*
*(6) Baseline PPG plus increased amount of PPG due to food, i.e. plus (carbs/sugar intake amount * GH.p-Modulus).*
*(7) Baseline PPG plus increased PPG due to food, and then subtracts reduction amount of PPG due to exercise, i.e. minus (post-meal walking k-steps * 5).*
(8) The Predicted PPG equals to Baseline PPG plus the food influences, and then subtracts the exercise influences.

The linear elastic glucose equation is:

Predicted PPG = (0.97 * GH.f-modulus * Weight) +(GH.p-modulus * Carbs&sugar) - (post-meal walking k-steps * 5)

By using this linear equation, a diabetes patient only needs the input data of body weight, carbs & sugar intake amount, and post-meal walking steps in order to calculate the predicted PPG value without obtaining any measured glucose data except for data calibrating purposes.

The readers can view the details of his previous research work related to this subject listed in the Reference section.

In 2014, the author came up with the analogy between theory of elasticity and plasticity and the severity of diabetes when he was developing his mathematical model of metabolism.

On 10/14/2020, by utilizing the concept of Young's modulus with stress and strain, which was taught in engineering schools, he initiated and engaged this linear elastic glucose behaviors research. The following paragraphs describe his research findings at different stages of this research period:

First, he discovered that there is a "pseudo-linear" relationship existed between carbs & sugar intake amount and incremental PPG amount. Based on this finding, he defined his first glucose coefficient of GH.p-modulus for PPG.

Second, similar to Young's modulus relating to stiffness of engineering inorganic materials, he found that the GH.p-modulus is depended upon the patient's severity level of diabetes, i.e. patient's glucose sensitivity on carbs/sugar intake amount.

Third, comparable to GH.p-modulus for PPG, in 2017, he uncovered a similar pseudo-linear relationship existing between weight and FPG with high correlation coefficient of greater than 90%. Therefore, he defined his second glucose coefficient of GH.f-modulus as the FPG value divided by the weight value. This GH.f-modulus is related to the severity of chronic diseases, including both obesity and diabetes.

Fourth, he inserted these two glucose coefficients of GH.p-modulus and GH.f-modulus, into the predicted PPG equation to remove the burden of collecting measured glucoses by patients.

Fifth, by experimenting and calculating many predicted PPG values over a variety of time length from different diabetes patients with varying health conditions, he finally revealed that GH.p-modulus seems to be "near-constant" or "pseudo-linearized" over a short period of 3 to 4 months. This short period is compatible with the known lifespan of red blood cells, which are living organic cells, that are different from the engineering inorganic materials, such as steel or concrete. The same conclusion was observed using his monthly GH.p-modulus data during the COVID-19 period in 2010 when his lifestyle became routine and stabilized.

Sixth, he used three US clinical cases during the 2020 COVID-19 period to delve into the hidden characteristics of the physical parameters and their biomedical relationships. More importantly, through the comparison study in Part 7, he found explainable biomedical interpretations of his two defined glucose coefficients of GH.p-modulus and GH.f-modulus.

Seventh, he conducted a PPG boundary analysis by discovering a lower bound and an upper bound of predicted PPG values for eight hypothetical standard cases and three US clinical cases. The derived numerical values of these two boundaries make sense from a biomedical viewpoint and also matched with the situations of the three US clinical cases. He even conducted two extreme stress tests, i.e. increasing carbs/sugar intake amount to 50 grams per meal and boosting post-meal walking steps to 5k after each meal, to examine the impacts on the lower bound and upper bound of PPG values.

Eighth, based on six international clinical cases, he further explored the influences from the combination of obesity and diabetes. Using a lifestyle medicine approach, he offered suggestions to reduce their PPG from 130-150 mg/dL down to below 120 mg/dL via reducing carbs/sugar intake and increasing exercise such as walking steps.

Egg Meal Cases in this Article

In multiple published articles from his previous neuroscience research work, he separated his egg meals into two distinctive physical states, liquid state (159 egg drop soup) and solid state (126 pan-fried egg or hard broiled egg), during the period from 5/5/2018 to 11/17/2020. The majority of his egg meals data are concentrated in 2020; therefore, he further established two sub-periods, the first half from 5/5/2018 to 6/30/2020 (pre-virus period) and the second half from 7/1/2020 to 11/17/2020 (virus period). It happens that the second half sub-period matches with his COVID-19 quarantined period. Due to a special quiet and routine lifestyle without any traveling, his overall health conditions, including both weights and glucoses, have reached to his "best-performed" status over the past 25 years. This special characteristic also contributed to the values of GH-modulus.

He then segregated his collected data according to the categories of weight, FPG, carbs, walking, and PPG. By using the average data within each sub-period and the total period, he then calculated his corresponding glucose coefficients of GH.f-modulus and GH.f-modulus.

Finally, he compared his calculated coefficients of three periods to study their biomedical meaning and interpretation.

Results

Figure 1 shows the comparison of PPG waveforms between solid egg meals and liquid egg meals. It is obvious that the solid egg PPG values are higher than the liquid egg PPG values, with a difference of 18 mg/dL higher at 0-minute (open moment), 24 mg/dL higher at 45-minutes (maximum moment), and 15 mg/dL higher at 120-minutes (moment of finger-piercing PPG measurement). In paper No. 340 (Reference 6), the author explained his hypothesis and offered the neuroscientific interpretation and proof regarding the communication model among the stomach, brain, and liver to determine the glucose level based on the incoming food's physical state, i.e. liquid vs. solid. It should be noted that both solid egg meals and liquid egg meals are based on one large egg which has a minimal amount of carbohydrates around 2 grams. Furthermore, his post-meal walking exercises are usually around 4,500 steps.

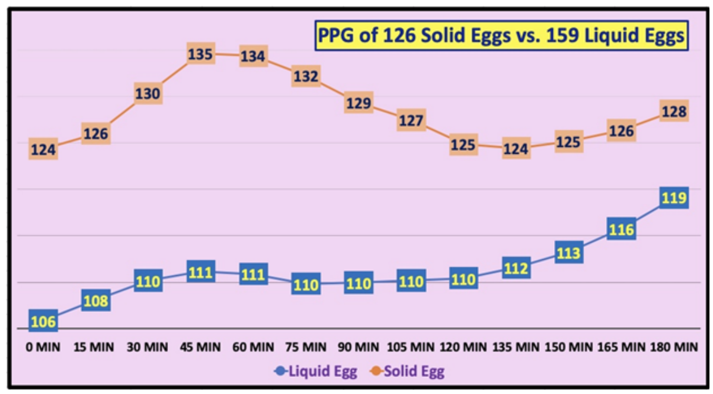

Figure 1: PPG waveform comparison between 159 egg drop soups vs. 126 solid eggs (pan-fried egg and hard broiled egg)

Figure 2 depicts the background data for calculations of predicted PPG and derivations of 2 glucose coefficients, both GH.f-modulus and GH.p-modulus.

Total: 5/5/2018-11/7/2020	Meals:	159	72	87	126	65	61
1st half: 5/5/18-6/30/20	The Author	Liquid, Total	Liquid, 1st Half	Liquid, 2nd Half	Solid, Total	Solid, 1st Half	Solid, 2nd Half
2nd half: 7/1/20-11/7/20	GH.f-modulus (%)	59	62	56	64	66	60
	Sensor FPG (mg/dL)	100	107	95	109	114	102
Formula	Weight (pound)	170	172	169	172	172	170
= FPG / Weight	GH.f-modulus	0.59	0.62	0.56	0.64	0.66	0.60
= 0.97 * Weight * GH.f-modulus	Baseline PPG (mg/dL)	97	103	92	106	111	99
	GH.p-modulus	12.7	18.0	10.1	20.7	27.1	16.6
	Carbs&Sugar (gram)	2.8	2.0	3.4	2.2	1.7	2.8
	Carbs *GH.p-modulus	35	36	34	46	46	47
	Walking (k-steps)	4.2	4.4	4.1	4.7	4.7	4.6
= Baseline+Carbs*GH.p-Walk*5	Predicted PPG	111.3	117.4	106.2	128.3	133.6	122.8
	Measured Sensor PPG (mg/dL)	111.3	117.4	106.2	128.3	133.6	122.8
= Predicted PPG / Measured PPG	Accuracy of Predicted PPG	100%	100%	100%	100%	100%	100%
	The Author	Liquid, Total	Liquid, 1st Half	Liquid, 2nd Half	Solid, Total	Solid, 1st Half	Solid, 2nd Half
	Carbs&Sugar (gram)	2.8	2.0	3.4	2.2	1.7	2.8
= predcted PPG - Baseline PPG + K-steps*5	Incremental PPG (mg/dL)	35.4	36.0	34.4	45.6	46.1	46.6
= Incremental PPG / Carbs&Sugar	GH.p-modulus	12.7	18.0	10.1	20.7	27.1	16.6

Figure 2: Definition of GH.f-modulus, GH.p-modulus, Baseline PPG, Incremental PPG and calculation of Predicted PPG with comparison against Measured PPG during various time periods

Figure 3 reveals the GH.f-modulus linking Weight and Sensor FPG to indicate a patient's (with chronic diseases) relative health state in terms of both obesity and diabetes. These two meals associated with the GH.f-modulus value, 59 for liquid eggs and 64 for solid eggs, are within the general range of his recorded weight and FPG from 5/5/2018 to 11/17/2020. It should be pointed out that the GH.f-modulus has no “direct” relationship with diet and exercise, however, they do have some “indirect” relationships with food and exercise through body weight.

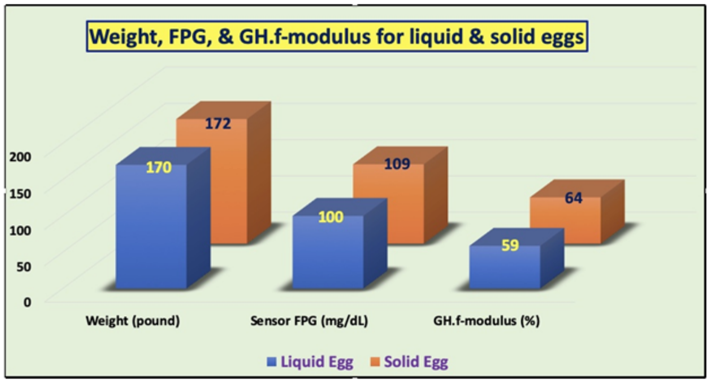

Figure 3: GH.f-modulus linking Weight and Sensor FPG to show a patient’s relative health state in terms of both obesity and diabetes

Figures 4 illustrates the GH.p-modulus linking Carbs/Sugar amount and Incremental PPG value to indicate a patient’s glucose sensitivity to carbs & sugar amount related to the two types of egg meals. The linear elastic glucose behavior can be expressed via the following linear equation:

Incremental PPG =
*Carbs/Sugar intake * GH.p-modulus*

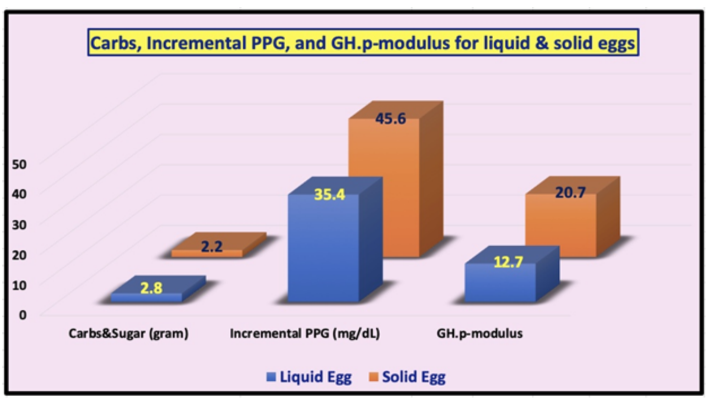

Figure 4: GH.p-modulus linking Carbs and Incremental PPG to show a patient’s glucose sensitivity to carbs & sugar intake amount relative to egg meals

The two GH.p-modulus values are 12.7 for liquid eggs and 20.7 for solid eggs which are much higher than the author’s previously acquired research knowledge and learned PPG prediction experience regarding the GH.p-modulus values. The author guesses that the general GH.p-modulus range of 1.0 to 5.0 is probably suitable for the majority of clinical cases (the author’s GH.p-modulus range is between 2.1 and 3.4). For a period of 5 years, the author has maintained an average carbs/sugar intake amount approximately less than 15 grams per meal in order to control his severe diabetes conditions without taking any medication. However, in order to conduct his own neuroscience experiments, he chose only one egg per meal which contains a mere ~2 grams of carbs/sugar. This extremely low carb amount must accompany with a much higher GH.p-modulus value in order to accomplish his desired health maintenance goal via his predicted PPG level matching with his measured PPG.

Here is a summary:

Liquid Eggs
2g * 12.7 = 25.4
Solid eggs:
2g * 20.7 = 41.4
Normal meals:
15g * 1.7 = 25.5
15g * 2.75 = 41.3

Figure 5 shows GH.f-modulus, Weight, Sensor FPG for both liquid egg meals and solid egg meals for three different periods, including the total period, first half period (non-virus), and second half period (virus period).

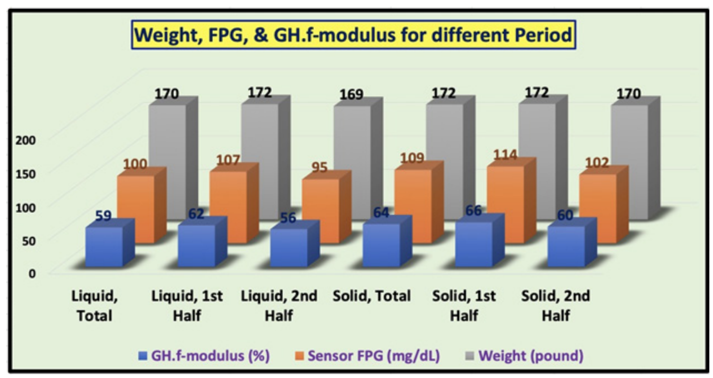

Figure 5: GH.f-modulus, Weight, Sensor FPG for both liquid egg meals and solid egg meals for different periods

Figure 6 represents the GH.p-modulus, Carbs amount, incremental FPG for both liquid egg meals and solid egg meals for three different periods, periods, including the total period, first half period (pre-virus), and second half period (virus period).

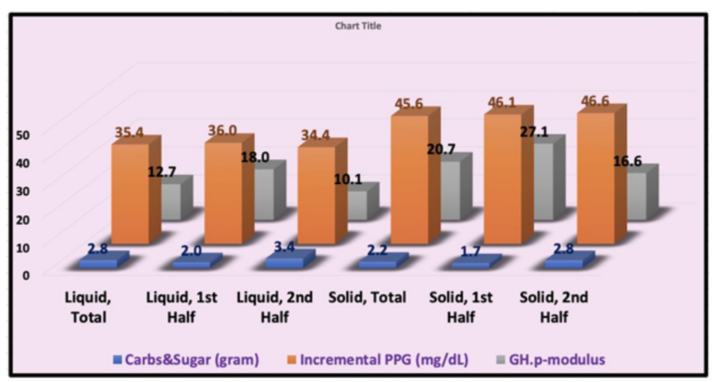

Figure 6: GH.p-modulus, Carbs, incremental FPG for both liquid egg meals and solid egg meals for different periods. The difference of GH.p-modulus between first-half period and second-half

periods are also shown.

Figure 5 and Figure 6 provide a comparison of the two glucose coefficients, GH.f-modulus and GH.p-modulus between two sub-periods, the first half and second half. There is not much difference between the first-half period and second-half period on the GH.f-modulus values due to both weight and FPG not changing significantly.

However, the difference of the GH.p-modulus value between the first-half period versus second-half period are more obvious, i.e. 18 vs. 10 and 27 vs. 17. The bigger differences are caused by the combined effect of value reduction on weight, FPG, Baseline PPG, and measured PPG from the pre-virus period to virus period. In other words, the patient's overall diabetes conditions have been improving in the second half of the virus sub-period.

Conclusions

This article uses the neuro-scientific experiment results of two physical states of egg meals to further investigate the two glucose coefficients, in particular the GH.p-modulus value and meaning.

The GH.p-modulus is not only the direct result of lifestyle difference (diet and exercise) but also includes the status difference of the chronic diseases (baseline PPG via weight and FPG). It also reflects the general health state of pancreatic beta cells of a particular patient which can be described by the fasting plasma glucose (FPG) level. In addition, it further contains the neuroscience of communication model between the brain and stomach regarding the amount of glucose production or glucose release in response to a specific message of the timing of the food's entry and the physical state of the stomach and intestine. This neurology viewpoint makes the GH.p-modulus even more complex. Nevertheless, the linear elastic glucose theory still applies to the special case of the neuro-scientific egg meals, even though it creates a much higher GH.p-modulus value that can be considered as one of the boundary cases in this linear elasticity study.

With the neuro-scientific case study, it is clear that this linear elastic glucose behavior is much more complicated than the classical engineering theory of elasticity because the engineering inorganic materials do not change for a long period of time. The human body is made from organic living cells. For example, blood contains millions of organic living red blood cells with an average lifespan of 115 to 120 days and liver cells that last about 300 to 500 days. In addition, the glucose production and release are controlled by the brain. The glucose level is further regulated by insulin (a type of hormone) produced by the pancreas which is also controlled by the brain. The communication between the brain and nervous system can throw a curve ball into the glucoses game making this research work not only more complicated but also more interesting.

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