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GH.p-Modulus Study During Three Periods using Finger-Piercing Glucoses And Linear Elastic Glucose Theory of GH-Method: Math-Physical Medicine, Part 15 (No. 369)

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Abstract

This article is Part 15 of the author's linear elastic glucose behavior study. It focuses on a deeper investigation of GH.p-modulus over three periods: 2017-2019, 2020, and 2017-2020.

The author plans to conduct additional studies on linear elastic glucose behavior theory in order to obtain a solid and better understanding on the glucose coefficient of GH.p-modulus.

Here is the step-by-step explanation for the predicted postprandial plasma glucose (PPG) equation using linear elastic glucose theory as described in [9, 22]:

*(1) Baseline PPG equals to 97% of fasting plasma glucose (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,
(1) Incremental PPG = Predicted PPG - Baseline PPG + Exercise impact
(2) GH.f-modulus = FPG / Weight
(3) GH.p-modulus = Incremental PPG / Carbs intake

Therefore,

*GH.p-modulus = (PPG - (0.97 * FPG) + (post-meal walking k-steps * 5)) / (Carbs&Sugar intake)*

The study in this article calculates and analyzes the glucose coefficient of GH.p-modulus values for three periods. The variation range of GH.p-modulus values are between 1.8 for 2017-2019, and 2.2 for 2020 with an average of 1.8 for 2017-2020.

The average GH.p-modulus value of 1.8 for the 2017-2019 (pre-virus) period is quite close to his overall biomarker indicators for health and lifestyle. The average GH.p-modulus value of 2.2 for the 2020 (COVID-19) period is higher than the pre-virus sub-period due to the combination of his lower FPG (-10 mg/dL or -9%), lower PPG (-7 mg/dL or

-6%), along with lower carbs/sugar intake amount (-1.6 grams or -11%). However, the average GH.p-modulus value of 1.8 for the total period of 2017-2020 (both pre-virus and COVID-19) reflects his overall and normal situations for health and lifestyle.

This paper investigates the likely situations of the author's health conditions and lifestyle details. The GH.p-modulus values have a small variance between 1.8 to 2.2, where the differences are insignificant. Any number located between the range of 1.8 to 2.2, which skews toward the lower side of the scale, can be used as the application value for the GH.p-modulus in order to predict PPG.

The study utilizes a step-by-step illustration, moving from the difference between PPG and FPG, going through the Incremental PPG, then arriving at the Predicted PPG. In the described steps, the most important variable is the GH.p-modulus. That is why the author has conducted many parts of this research of linear elastic glucose theory in order to acquire a good and solid understanding for the GH.p-modulus.

Introduction

This article is Part 15 of the author's linear elastic glucose behavior study. It focuses on a deeper investigation of GH.p-modulus over three periods: 2017-2019, 2020, and 2017-2020.

The author plans to conduct additional studies on linear elastic glucose behavior theory in order to obtain a solid and better understanding on the glucose coefficient of 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 [1].

Stress, Strain, & Young's Modulus

Prior to his medical research work, he was an engineer in the various fields of structural engineering (aerospace, naval defense, and earthquake engineering), mechanical engineering (nuclear power plant equipments, and computer-aided-design), and electronics engineering (computers, semiconductors, and software robot).

The following excerpts comes from internet public domain, including Google and Wikipedia:

"Strain - ε:
Strain is the "deformation of a solid due to stress" - change in dimension divided by the original value of the dimension - and can be expressed as
$\varepsilon = dL / L$
where
ε *= strain (m/m, in/in)*
dL = elongation or compression (offset) of object (m, in)
L = length of object (m, in)

Stress - σ
Stress is force per unit area and can be expressed as
$\sigma = F / A$
where
σ *= stress (N/m2, lb./in2, psi)*
F = applied force (N, lb.)
A = stress area of object (m2, in2)

Stress includes tensile stress, compressible stress, shearing stress, etc.

E, Young's modulus
It can be expressed as:
$E = \text{stress} / \text{strain}$
$= \sigma / \varepsilon$
$= (F / A) / (dL / L)$
where
E = Young's Modulus of Elasticity (Pa, N/m2, lb./in2, psi) was named after the 18th-century English physicist Thomas Young.

Elasticity

Elasticity is a property of an object or material indicating how it will restore it to its original shape after distortion. A spring is an example of an elastic object - when stretched, it exerts a restoring force which tends to bring it back to its original length (Figure 1).

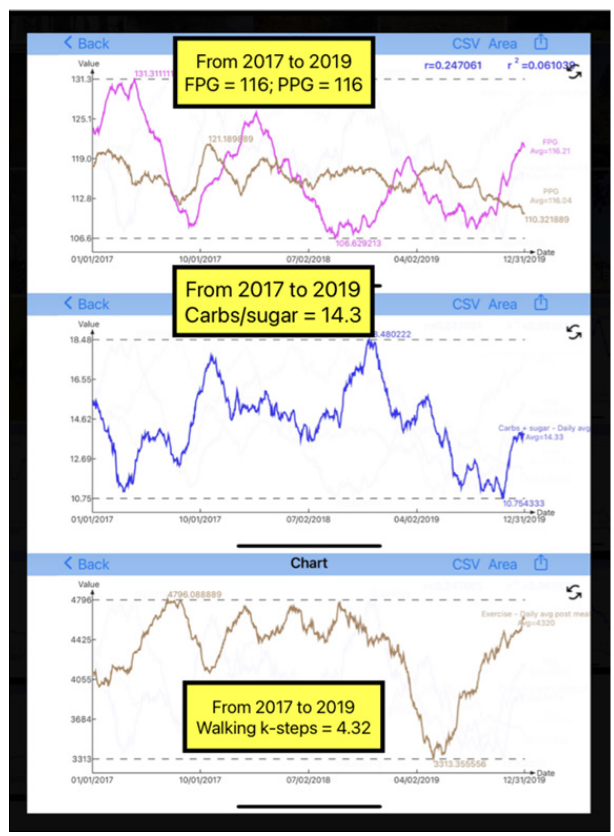

Figure 1: FPG, PPG, Carbs, Walking during 2017-2019

Plasticity

When the force is going beyond the elastic limit of material, it is into a "plastic' zone which means even when force is removed, the material will not return back to its original state.

Based on various experimental results, the following table lists some of Young's modulus associated with different materials:

Nylon: 2.7 GPa
Concrete: 17-30 GPa
Glass fibers: 72 GPa
Copper: 117 GPa
Steel: 190-215 GPa
Diamond: 1220 GPa

Young's modules in the above table are ranked from soft material (low E) to stiff material (higher E)."

Professor James Andrews taught the author strength of materials and linear elasticity at the University of Iowa and Professor Norman Jones taught him nonlinear and dynamic plastic behaviors of structures at Massachusetts Institute of Technology. These two great academic mentors provided him with the foundational knowledge to understand these two important subjects in engineering.

Highlights of Linear Elastic Glucose Theory

Here is the step-by-step explanation for the predicted PPG equation using linear elastic glucose theory as described in [9, 22]:

(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
1. *Incremental PPG = Predicted PPG - Baseline PPG + Exercise impact*
2. *GH.f-modulus = FPG / Weight*
3. *GH.p-modulus = Incremental PPG / Carbs intake*

Therefore,

GH.p-modulus = (PPG - (0.97 * FPG) + (post-meal walking k-steps * 5)) / (Carbs&Sugar intake)

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.

In 2014, the author came up with the analogy between theory of elasticity and plasticity and the severity of his diabetes conditions when he was developing his mathematical model of metabolism using topology concept and finite element method.

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:

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

2. Similar to Young's modulus relating to stiffness of engineering inorganic materials, he found that the GH.p-modulus is dependent upon the patient's severity level of diabetes, i.e., the patient's glucose sensitivity on carbs/sugar intake amount, which reflects this patient's health state of liver cells and pancreatic beta cells.

3. 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 above 90%. Therefore, he defined the 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 combined chronic diseases, including both obesity and diabetes. More than 33 million Americans, about 1 in 10, have diabetes, and approximately 90% to 95% of them have type 2 diabetes (T2D), where 86% also have problems with being overweight or obese. In other words, 7.7% to 8.2 % of the US population or 25 to 27 million Americans have issues with both obesity and diabetes.

4. 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.

5. By experimenting and calculating many predicted PPG values over a variety of time length from different diabetes patients with different 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 human red blood cells, which are living organic cells. This is quite different from the engineering inorganic materials, such as steel or concrete, which can last for an exceptionally long period of time. The same conclusion was observed using his monthly GH.p-modulus data during the COVID-19 period in 2020 when his lifestyle became routine and stabilized.

6. He used three US clinical cases during the 2020 COVID-19 period to delve into the hidden characteristics of the physi-

cal 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.

7. 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 specific clinical cases. The derived numerical values of these two boundaries make sense from a biomedical viewpoint and also matched the situations of the three US clinical cases. He 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.

8. 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 recommendations to reduce their PPG from 130-150 mg/dL down to below 120 mg/dL via reducing carbs/sugar intake and increasing exercise level in walking.

9. Based on his neuroscience research work using both 126 solid eggs and 159 liquid eggs with an extremely low carbs/sugar intake amount of ~2.5 grams, producing two totally different sets of PPG data and waveforms based on neurosciences viewpoint. He has also identified a different set of much higher values for GH.p-modules from the exceptionally low carbs/sugar intake of egg meals. Even though this egg neuroscience research results can be served as a special boundary case, it has also further proven that the GH.p-modules is influenced directly by the human brain and nervous system.

10. He compared the above two egg meals results, including PPG values and glucose coefficients, in particular the GH.p-modules, against the total results of his 2,843 meals. He discovered the vast differences of GH.p-modulus magnitudes and also learned the tight relationship between GH.p-modulus value and carbs/sugar intake amount. By distinguishing the GH.p-modulus results from the special boundary cases of 12.7 for liquid egg meals and 20.7 for solid egg meals, his general GH.p-modulus values from his 2,843 total meals are 2.1 using finger PPG and 3.4 using sensor PPG.

11. He used his 365 egg meal data from his neurosciences research papers to further calculate detailed variations of their associated GH.p-modulus.

12. He applied the linear elastic glucose theory to formulate certain guidelines as a part of his practical "lifestyle medicine" approach for family medicine.

Results

Figures 1, 2, and 3 show the 90-days moving average value of FPG, PPG, Carbs/sugar intake amount, and post-meal walking steps for periods of 2017-2019, 2020, and 2017-2020 respectively.

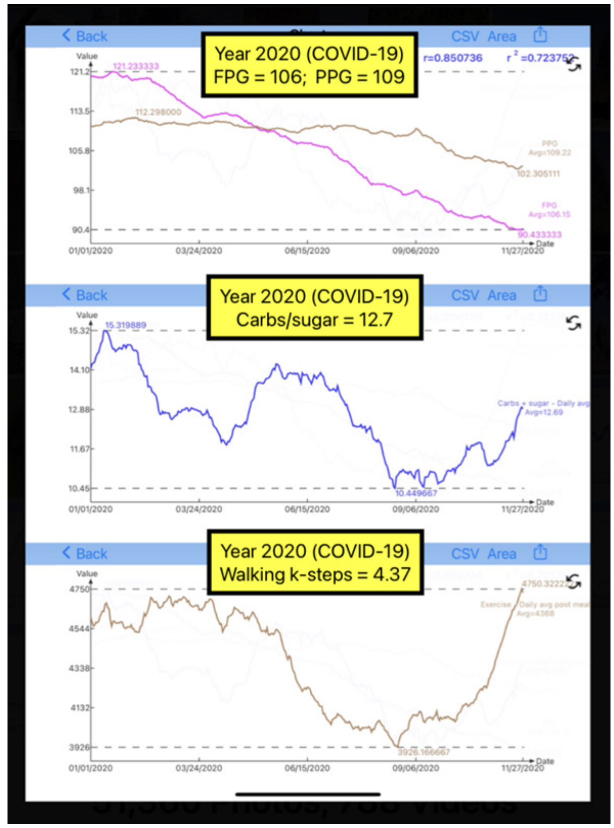

Figure 2: FPG, PPG, Carbs, Walking during 2020 COVID-19

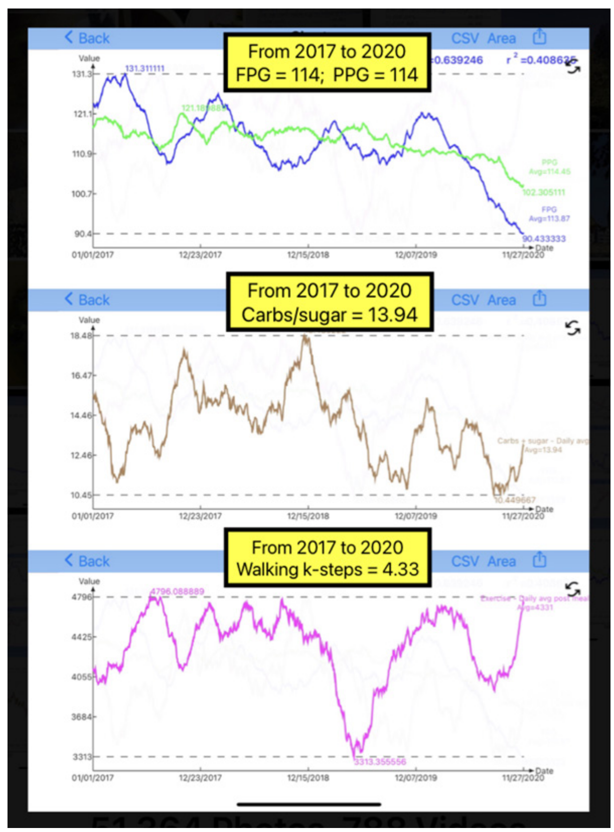

Figure 3: FPG, PPG, Carbs, Walking during 2017-2020

Here again is the step-by-step explanation for the predicted PPG equation:

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
(1) Incremental PPG = Predicted PPG - Baseline PPG + Exercise impact
(2) GH.f-modulus = FPG / Weight
(3) GH.p-modulus = Incremental PPG / Carbs intake
Therefore,

GH.p-modulus = (PPG - (0.97 * FPG) + (post-meal walking k-steps * 5)) / (Carbs&Sugar intake)

Here is the list of his average values in the form of FPG, PPG, Carbs&sugar intake grams, Walking k-steps during the three periods.

2017-2019: (116, 116, 14.3, 4.32)
2020 virus: (106, 109, 12.7, 4.37)
2017-2020: (114, 114, 13.9, 4.33)

Figure 4 is a data and calculation table that applies above equations. The final results reflect the calculated GH.p-modulus results for these three periods using the 90-days moving averaged input data. The average GH.p-modulus value for the pre-virus period of 2017-2019 is 1.8, while the average GH.p-modulus value for the COVID-19 period of 2020 is 2.2. This higher GH.p-modulus value for the COVID period in 2020 is resulted from the combination of his lower FPG (-10 mg/dL or -9%), lower PPG (-7 mg/dL or -6%), along with the lower carbs/sugar intake amount (-1.6 grams or -11%).

Finger	Y2017-2019	Y2020	Y2017-2020
PPG	116	109	114
FPG	116	106	114
Carbs gram	14.3	12.7	13.9
Walking k-steps	4.32	4.37	4.33
Finger	**Y2017-2019**	**Y2020**	**Y2017-2020**
GH.p (avg. data)	1.8	2.2	1.8

Figure 4: GH.p-modulus during three periods

However, the average GH.p-modulus value of 1.8, for the total period of 2017-2020 (both pre-virus and COVID-19) is reflecting his overall and normal situations for health and lifestyle. This GH.p-modulus value of 1.8 also matches his personal experiences of watching and researching his past glucose data and lifestyle details over the past 9 years (2012-2020).

In summary, the GH.p-modulus value coordinates with a patient's weight, FPG, PPG, carbs/sugar intake, and post-meal exercise that fluctuates within a reasonable numerical range. In this study, the GH.p-modulus actually reflects the general health conditions of the author.

Conclusions

The study in this article calculates and analyzes the glucose coefficient of GH.p-modulus values for three periods. The variation range of GH.p-modulus values are between 1.8 for 2017-2019, and 2.2 for 2020 with an average of 1.8 for 2017-2020.

The average GH.p-modulus value of 1.8 for the 2017-2019 (pre-virus) period is quite close to his overall biomarker indicators for health and lifestyle. The average GH.p-modulus value of 2.2 for the 2020 (COVID-19) period is higher than the pre-virus sub-period due to the combination of his lower FPG (-10 mg/dL or -9%), lower PPG (-7 mg/dL or -6%), along with lower carbs/sugar intake amount (-1.6 grams or -11%). However, the average GH.p-modulus value of 1.8 for the total period of 2017-2020 (both pre-virus and COVID-19) reflects his overall and normal situations for health and lifestyle.

This paper investigates the likely situations of the author's health conditions and lifestyle details. The GH.p-modulus values have a small variance between 1.8 to 2.2, where the differences are insignificant. Any number located between the range of 1.8 to 2.2, which skews toward the lower side of the scale, can be used as the application value for the GH.p-modulus in order to predict PPG.

The study utilizes a step-by-step illustration, moving from the difference between PPG and FPG, going through the Incremental PPG, then arriving at the Predicted PPG. In the described steps, the most important variable is the GH.p-modulus. That is why the author has conducted many parts of this research of linear elastic glucose theory in order to acquire a good and solid understanding for the GH.p-modulus [1-22].

Acknowledgement

Foremost, I would like to express my deep appreciation to my former professors: professor James Andrews at the University of Iowa, who helped develop my foundation in basic engineering and computer science, and professor Norman Jones at the Massachusetts Institute of Technology, who taught me how to solve tough scientific problem through the right attitude and methodology.

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