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# Detailed GH.p-Modulus Values at 15-Minute Time Intervals for a Synthesized Sensor PPG Waveform of 159 Liquid Egg Meals, and 126 Solid Egg Meals Using Linear Elastic Glucose Theory of GH-Method: Math-Physical Medicine, Part 13 (No. 365)

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## Abstract

*This article is Part 13 of the author's linear elastic glucose behavior study. It focuses on a deeper investigation of GH.p-modulus at 15-minute time intervals for a synthesized PPG waveform based on the comparison of the results from his neuroscience study on two types of egg meals during the period from 5/5/2018 to 11/17/2020.*

*Here is the step by step explanation for the predicted postprandial plasma glucose (PPG) equation using linear elastic glucose theory as described in References 9 through 20:*

*(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*

*This study analyzes the glucose coefficient of GH.p-modulus at 15-minute intervals for two synthesized PPG waveforms associated with liquid eggs and solid eggs. The variation range of GH.p-modulus are between 15 and 22 with an average of 18.9 for solid eggs and between 10 and 14 with an average of 11.6 for liquid eggs.*

*The average GH.p-modulus values of 18.9 for solid eggs and 11.6 for liquid eggs using every 15-minute intervals of the PPG values are comparable with the average GH.p-modulus values of 20.7 for solid eggs and 12.7 for liquid eggs using the average glucose values of 285 egg meals (Reference 19 of paper no. 363).*

*However, a vast difference can be observed by comparing the 285 egg meals, where the GH.p-modulus are in double digits, against his 2,843 total meals (see Reference 19). His GH.p-modulus values of 2,483 total meals are 2.1 using finger PPG and 3.4 using sensor PPG, where the GH.p-modulus are in a single digit.*

*The differences are caused by the neural communication model between the brain and internal organs. This neuroscience contribution factor has caused the higher solid egg meals PPG magnitudes in comparison with the lower liquid egg meals PPG values. Actually, the different peak PPG values of the two different physical states of egg meals, resulting from varying cooking methods, have the same carbs/sugar intake amount of ~2 grams and comparable exercise amount of ~4,500 steps.*

*Although this paper does not focus on the neuroscience studies of egg meals, it is investigating the possible variance of GH.p-modulus. The study utilizes a step by step illustration of moving from (1) the difference between PPG and FPG, going through (2) Incremental PPG, then finally arriving at (3) Predicted PPG. By moving along with this calculation process, we can observe three waveform variances between liquid egg meals versus solid egg meals.*

*As a result, the author has gained a great deal of inside knowledge and a clear picture of the characteristics and behaviors of the most difficult glucose coefficient, GH.p-modulus, as presented in his research work on linear elastic glucose behaviors for Part 13.*

## Introduction

This article is Part 13 of the author's linear elastic glucose behavior study. It focuses on a deeper investigation of GH.p-modulus at 15-minute time intervals for a synthesized PPG waveform based on the comparison of the results from his neuroscience study on two types of egg meals during the period from 5/5/2018 to 11/17/2020.

## 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 for the predicted PPG equation using linear elastic glucose theory as described in References 9 through 20:

*(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***

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 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 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.

Second, 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.

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 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.

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 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 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 specific 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 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.

Ninth, based on his neuroscience research work using both 126 solid eggs and 159 liquid eggs with a very low carbs/sugar intake amount of ~2.5 grams producing two totally different sets of PPG values and waveforms, he identified a different set of much higher values of GH.p-modules for these egg meals. Even though this research served as a special boundary case in the study, nevertheless, it has further proven that the GH.p-modules is also influenced directly by the human brain.

Tenth, 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. 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 these 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.

## Meal Cases in this Article

In multiple published articles from his 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. This period is selected due to the same glucose measuring period via a continuous glucose monitoring (CGM) sensor device on his arm. His 285 egg meals have an average carb intake amount around 2.5 grams and his average post-meal walking approximately 4.5 k-steps. His sensor measured PPG levels are 111 mg/dL for liquid eggs PPG and 128 mg/dL for solid eggs PPG.

During the same time period, he has consumed a total of 2,843 meals with an average carb intake amount of 13.8 grams and his post-meal walking is 4.3 k-step. It should be mentioned that he also continued to measure his PPG using the traditional finger-piercing method at 120-minutes after the first bite of his meal. For this total meal's group, his measured PPG levels are 131 mg/dL for sensor PPG and 113 mg/dL for finger PPG.

At first, he calculates the estimated baseline PPG for these two types of egg meals and then uses the following two equations to calculate the incremental PPG and GH.p-modulus.

Incremental PPG =baseline PPG (i.e. 0.97*FPG or FPG) + exercise impact (walking ksteps*5)

GH.p-modulus = (Incremental PPG) / (Carbs amount)

Above two equations are based on his developed "***linear elastic glucose theory***" which can be described as follows:

***FPG = (Weight) * (GH.f-modulus)***
***And***
***(Incremental PPG) = (Carbs amount) * (GH.p-modulus)***

## Results

Figure 1 shows the comparison of PPG waveforms between 126 ***solid egg meals and 159 liquid egg meals. It is obvious that the solid egg PPG waveform (peak PPG 135 mg/dL at 45-minutes, average PPG 128 g/dL, and carbs 2.2 grams) is higher than the liquid egg PPG waveform (peak PPG 111 mg/dL at 45-minutes, average PPG 111 g/dL and carbs 2.8 grams).*** The reason for the PPG differences with the same inputs of both carbs/sugar amount and exercise steps is due to the neural communication between the brain and internal organs regarding the physical states of the food, which is not the main focus in this article.

Of course, in this two-year period of diabetes research and food nutrition experiment, he did not consume both liquid eggs and solid eggs in the same meal. He also knows that different days would have different FPG values which can be served as the baseline PPG for one particular meal. Therefore, the author has modified his software program such that he could extract the FPG values corresponding to the days with one particular type of meals of the same day.

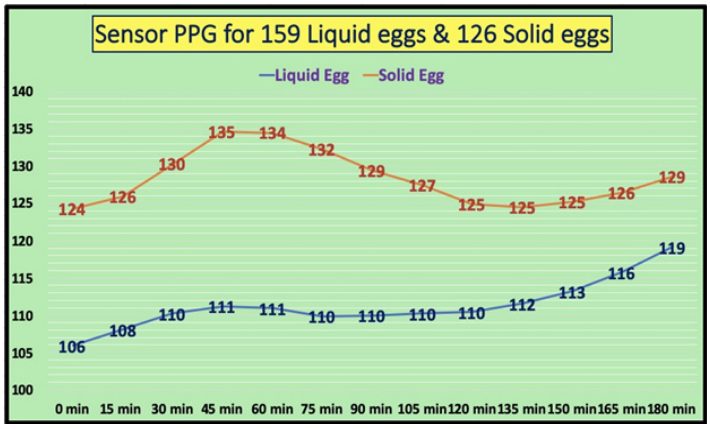


**Figure 1:** Two PPG waveforms comparison between 159 liquid eggs (egg drop soup) and 126 solid eggs (pan-fried egg and hard

broiled egg) using CGM sensor device for measuring PPG values

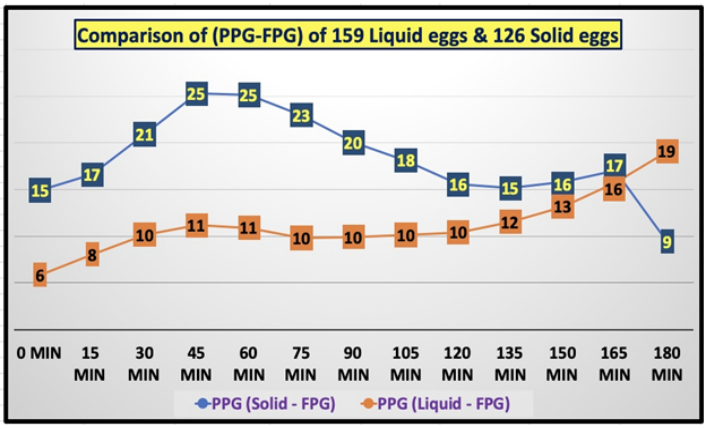


**Figure 2:** Comparison of values of (PPG minus FPG) between 159 liquid eggs (egg drop soup) and 126 solid eggs (pan-fried egg and hard broiled egg)

Figure 3 reflects the waveforms of Incremental PPG for these two egg meals. These 2 Incremental PPG waveform patterns are very similar to those 2 waveforms of (PPG-FPG) in Figure 2, except for the solid egg meals have a peak incremental PPG of 49 mg/dL around 45-60 minutes, while the liquid egg meals have a peak incremental PPG of 32 mg/dL around 45-60 minutes. Again, at the peak PPG time (45-min to 60-min), the solid egg meal is 17 mg/dL higher than liquid egg meal where both have almost identical carbs/sugar intake amount and post-meal walking steps. Once again, from a neuroscience viewpoint, a reasonable explanation could be offered to explain this strange physical phenomenon.

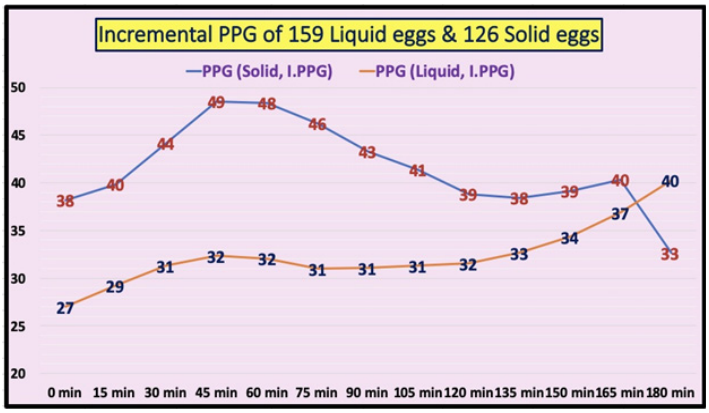


**Figure 3:** Comparison of Incremental PPG values (= predicted PPG - 0.97 * FPG + Walking's 1000 steps *5) between 159 liquid eggs (egg drop soup) and 126 solid eggs (pan-fried egg and hard broiled egg)

After conducting his calculations for both (PPG-FPG) and incremental PPG, he was able to figure out the different GH.p-modulus values at each 15-minute time interval of the synthesized PPG waveforms for both liquid egg meals and solid egg meals (Figure

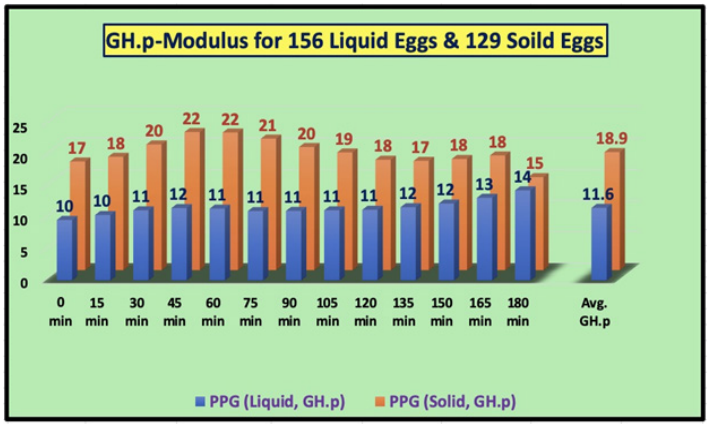


**Figure 4:** Comparison of GH.p-modulus values (= Incremental PPG divided by Carbs amount) at every 15-minute time intervals of a synthesized PPG waveform between 159 liquid eggs (egg drop soup) and 126 solid eggs (pan-fried egg and hard broiled egg)

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).*
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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***

Here is the list of his final calculated GH.f-modulus values in the form of liquid egg, solid egg at each 15-minute time intervals.

*0-min: (10, 17)*
*15-min: (10, 18)*
*30-min: (11, 20)*
*45-min: (12, 22)*
*60-min: (11, 22)*
*75-min: (11, 21)*
*90-min: (11, 20)*
*105-min: (11, 19)*

*120-min: (11, 18)*
*135-min: (12, 17)*
*150-min: (12, 18)*
*165-min: (13, 18)*
*180-min: (14, 15)*

***Average :( 11.6, 18.9)***

The average GH.p-modulus values of 11.6 for liquid eggs and 18.9 for solid eggs using every 15-minute intervals of the glucose values *are quite comparable with the average GH.p-modulus values of 12.7 for liquid eggs and 20.7 for solid* eggs using the average glucose values for the two types of egg meals (Reference 19).

## Conclusions

This study analyzes the glucose coefficient of GH.p-modulus at 15-minute intervals for two synthesized PPG waveforms associated with liquid eggs and solid eggs. The variation range of GH.p-modulus are between 15 and 22 with an average of 18.9 for solid eggs and between 10 and 14 with an average of 11.6 for liquid eggs.

The average GH.p-modulus values of 18.9 for solid eggs and 11.6 for liquid eggs using every 15-minute intervals of the PPG values are comparable with the average GH.p-modulus values of 20.7 for solid eggs and 12.7 for liquid eggs using the average glucose values of 285 egg meals (Reference 19 of paper no. 363).

However, a vast difference can be observed by comparing the 285 egg meals, where the GH.p-modulus are in double digits, against his 2,843 total meals (see Reference 19). His GH.p-modulus values of 2,483 total meals are 2.1 using finger PPG and 3.4 using sensor PPG, where the GH.p-modulus are in a single digit.

The differences are caused by the neural communication model between the brain and internal organs. This neuroscience contribution factor has caused the higher solid egg meals PPG magnitudes in comparison with the lower liquid egg meals PPG values. Actually, the different peak PPG values of the two different physical states of egg meals, resulting from varying cooking methods, have the same carbs/sugar intake amount of ~2 grams and comparable exercise amount of ~4,500 steps.

Although this paper does not focus on the neuroscience studies of egg meals, it is investigating the possible variance of GH.p-modulus. The study utilizes a step by step illustration of moving from (1) the difference between PPG and FPG, going through (2) Incremental PPG, then finally arriving at (3) Predicted PPG. By moving along with this calculation process, we can observe three waveform variances between liquid egg meals versus solid egg meals.

As a result, the author has gained a great deal of inside knowledge and a clear picture of the characteristics and behaviors of the most difficult glucose coefficient, GH.p-modulus, as presented in his research work on linear elastic glucose behaviors for Part 13.

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