

## Research Article

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## Segmentation and Pattern Analyses for Three Meals of Postprandial Plasma Glucose Values and Associated Carbs/Sugar Amounts Using GH-Method: Math-Physical Medicine (No. 326)

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**ABSTRACT**

The author describes the results of segmentation and pattern analyses of postprandial plasma glucose levels (PPG) and carbs/sugar intake amount (carbs), which are associated with his three daily meals. In this paper, there are three consistent ranges of low, medium, and high for PPG values and carbs/sugar amounts that are used for each meal but with different units. One of the final objectives for this analysis is to calculate the most reasonable and effective conversion ratio between measured PPG in mg/dL and carbs/sugar intake amount in grams, by discovering how much PPG amount would be generated from 1 gram of carbs/sugar intake. This investigation utilized the PPG data and carbs/sugar amount collected during a period of 2+ years from 5/5/2018 to 9/6/2020 with a breakdown of 855 days, including 2,565 meals, 33,345 glucose data, and 33,345 carbs/sugar data.

By using the segmentation analysis of his 33,345 PPG data and 2,565 carbs/sugar data, the author has conducted a pattern recognition and segmentation analysis from his PPG profiles with its associated carbs/sugar intake of his food and meals in the past 855 days. Since 12/8/2015, he ceased taking any diabetes medications. In other words, his diabetes control is 100% dependent on his lifestyle management program with no chemical intervention from any medications. Subsequently, he has maintained a stringent exercise program after each meal; therefore, the development of his simplified PPG prediction model, excluding the exercise factor, can be expressed solely with carbs/sugar intake amount.

**Predicted PPG = (baseline glucose) + (conversion ratio \* carbs/sugar amount)**

In his research work, he found the reasonable and effective conversion ratio between PPG and carbs that ranges from 1.8 mg/dL per gram to 2.5 mg/dL per gram. This simple equation could assist many type 2 diabetes (T2D) patients in controlling their diabetes via carbs/sugar intake amount.

During this particular time period, his PPG control via a stringent lifestyle management without medication is highly successful. His estimated mathematically derived HbA1C values should be between 5.56% to 6.05%, which is a satisfactory HbA1C level for a 73-year-old male with a 25-year history of severe diabetes. It should be mentioned that he had an average daily glucose of 280 mg/dL and HbA1C of 11% in 2010.

This segmented pattern analyses based on his PPG data and carbs/sugar intake amount offer a useful tool for analyzing other types of biomarkers in a deeper investigation with a wider entry point of research.

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**Received:** September 30, 2020; **Accepted:** October 05, 2020; **Published:** October 08, 2020**Introduction**

The author describes the results of segmentation and pattern analyses of postprandial plasma glucose levels (PPG) and carbs/sugar intake amount (carbs), which are associated with his three daily meals. In this paper, there are three consistent ranges of low, medium, and high for PPG values and carbs/sugar amounts that are used for each meal but with different units. One of the final objectives for this analysis is to calculate the most reasonable and effective conversion ratio between measured PPG in mg/dL and carbs/sugar intake amount in grams, by discovering how much PPG amount would be generated from 1 gram of carbs/sugar intake. This investigation utilized the PPG data and carbs/sugar amount collected during a period of 2+ years from 5/5/2018 to 9/6/2020 with a breakdown of 855 days, including 2,565 meals, 33,345 glucose data, and 33,345 carbs/sugar data.

**Method****Data Collection**

The author started measuring his glucose since 1/1/2012 using the traditional finger-piercing and test strip (Finger glucose) 4 times each day, once in early morning (FPG) when he wakes up from sleeping, and three times at two-hours after each meal (PPG). In this particular analysis, he will not use his finger glucose data for this segmentation and pattern analyses.

In addition, since 5/5/2018, he applied a continuous glucose monitoring (CGM) device on his upper arm and collect ~96 glucoses each day at a time interval of each 15 minutes. With this CGM-based sensor collected glucoses (Sensor glucose), he has selected 3-hours (180 minute) timespan after the first bite of his meal as his standard Sensor PPG timeframe.

For the third set of data, he collected the carbs/sugar intake amount in grams contained in each meal that he ate. The author studied the relationship between food nutrition and chronic diseases since 2010. As a result, he found that food is the most complicated factor to control, because it requires deep and thorough knowledge along with strong willpower to keep glucose under control via diet management. In 2015, he developed an artificial intelligence (AI-based) software tool to predict his carbs/sugar intake amount in his food. He has already proven that his AI-predicted PPG values achieved a prediction accuracy between 98.8% to 99.3% based on a database of 6,309 meals [1].

### Background

To learn more about the GH-Method: math-physical medicine (MPM) research methodology, readers can review his specific article, Biomedical research methodology based on GH-Method: math-physical medicine (No. 310), to understand his MPM analysis method [2].

### Segmentation and Pattern Analyses

The author established two sets of standards. The first one has three consistent PPG segments and the second has three consistent carbs/sugar segments:

#### PPG Ranges

PPG Low: 0 - 107.7 mg/dL  
 PPG Medium: 107.8 - 124 mg/dL  
 PPG High: 124.1 - 200 mg/dL

#### Carbs Ranges

Carbs Low: 0 - 9.9 gram  
 Carbs Medium: 10 - 20 gram  
 Carbs High: 20.1 - 50 gram

He established these two different sets of segmentation ranges and dividing lines, because they would provide remarkably close contribution margin (percentage) associated with each range.

The contribution margins are as follows:

#### PPG contribution margin

PPG Low range: 28.6%  
 PPG Medium range: 57.8%  
 PPG High range: 13.6%

#### Carbs contribution margin

Carbs Low range: 28.2%  
 Carbs Medium range: 57.9%  
 Carbs High range: 13.7%

In the next step, he would then segregate his collected CGM sensor PPG of 33,345 data associated with carbs amounts of 2,565 meals into these three general ranges of both PPG and carbs/sugar into low, medium, and high ranges.

Finally, he would then distinguish the PPG and carbs patterns associated with each segment to examine the most reasonable and effective conversion ratio between measured PPG in mg/dL and carbs/sugar intake amount in grams. The purpose was to determine how much PPG amount would be generated from 1 gram of carbs/sugar intake amount.

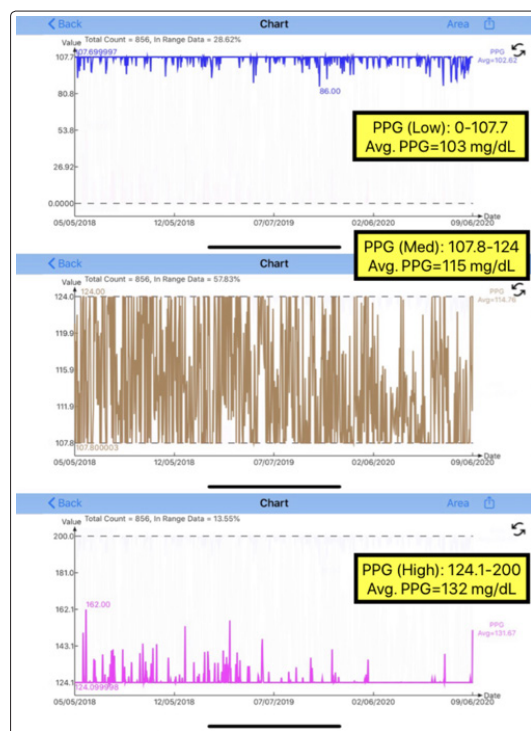


Figure 1: 3 segments of PPG values (5/5/2018 - 9/6/2020)

It shows the segmented time-series PPG curves of three ranges. The summarized information are listed below with the medium range as being the most significant one:

#### PPG Low (0-107.7 mg/dL)

Contribution: 28.6%  
 Average: 103 mg/dL

#### PPG Medium (107.8-124 mg/dL)

Contribution: 57.8%  
 Average: 115 mg/dL

#### PPG High (124.1-200 mg/dL)

Contribution: 13.6%  
 Average: 132 mg/dL

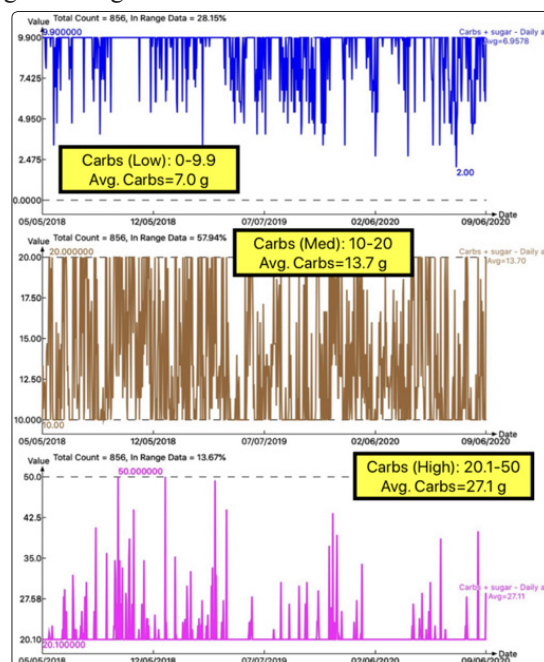


Figure 2: 3 segments of carbs amounts (5/5/2018 - 9/6/2020)

It illustrates the segmented time-series carbs/sugar amount curves of three ranges. The summarized information are listed below with the corresponding carbs/sugar medium range to PPG medium range as the most significant one:

**Carbs Low (0-9.9 gram)**

Contribution: 28.2%  
Average: 7.0 gram

**Carbs Medium (10-20 gram)**

Contribution: 57.9%  
Average: 13.7 gram

**Carbs High (20.1-50 gram)**

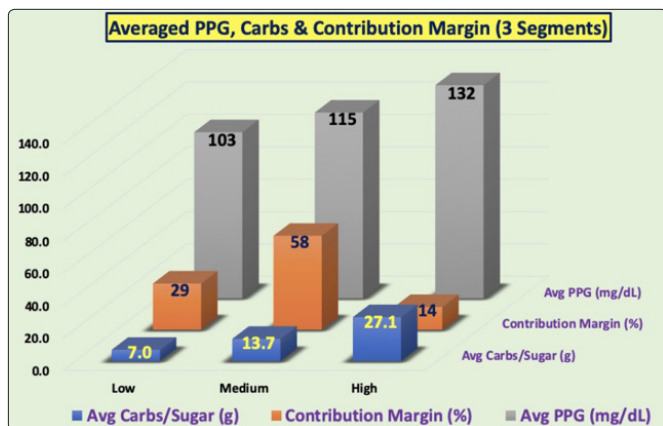
Contribution: 13.7%  
Average: 27.1 gram

Figure 3 depicts the background data table of this analysis.

5/5/2018-9/6/2020	Low	Medium	High
Carbs/Sugar (g)	0 - 9.8	9.9 - 20.0	20.1-50
PG (mg/dL)	0 - 107.7	107.8 - 124	124.1 - 200
5/5/2018-9/6/2020	Low	Medium	High
% of Carbs/Sugar	28.15%	57.94%	13.67%
% of PPG	28.62%	57.83%	13.55%
5/5/2018-9/6/2020	Low	Medium	High
Avg Carbs/Sugar (g)	7.0	13.7	27.1
Contribution Margin (%)	29	58	14
Avg PPG (mg/dL)	103	115	132
5/5/2018-9/6/2020	Low	Medium	High
Conversion use 90 baseline	1.8	1.8	1.5
Conversion use 85 baseline	2.5	2.5	1.9

**Figure 3:** Background data table (5/5/2018 - 9/6/2020)

The bar chart of his average PPG level, average carbs/sugar amount, and contribution margin of each segment is shown in Figure 4.



**Figure 4:** Average PPG level, Average Carbs/sugar amount, and Contribution Margin of 3 segments (5/5/2018 - 9/6/2020)

An outstanding observation is that the contribution margin for the medium range is 58%, which is the most substantial one. This finding means that, most of his PPG values are more likely located within the medium range between 107.8 mg/dL to 124 mg/dL. In fact, its averaged value is 115 mg/dL and most of his carbs/sugar amounts are mostly located within the medium range between 10 grams to 20 grams (actual average carbs/sugar is 13.7 grams).

The most important and conclusive chart in this article is Figure 5. Since the post-meal walking exercise during this timeframe, from 5/5/2018 to 9/6/2020, is more than 4,000 steps (average

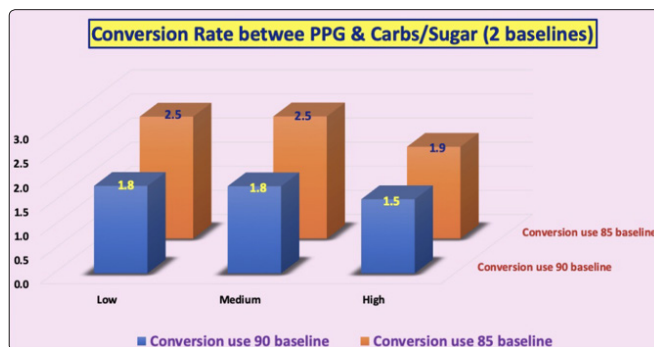
post-meal walking of 4,251 steps) regardless of different segments. Therefore, he can develop a simplified arithmetic formula to predict his PPG, without exercise input, as follows:

$$\text{Predicted PPG} = (\text{baseline glucose}) + (\text{conversion ratio} * \text{carbs/sugar amount})$$

The baseline glucose is defined as the natural production of glucose by the liver along with the insulin produced by the pancreatic beta cells, depending on the severity of the T2D patient's conditions. In this analysis, the author chose two baseline glucoses: 85 mg/dL and 90 mg/dL, respectively. These two values are chosen based on his previous research papers [3].

The "conversion ratio" is defined as the average segment's PPG level divided by average segment's carbs/sugar amount, which means how much glucose would be generated by 1 gram of carbs/sugar intake amount.

Here are the final results of the segmented conversion ratio analyses as tabulated below (also in Figure 5):



**Figure 5:** Conversion Ratio of PPG value per one gram of carbs/sugar amount (5/5/2018 - 9/6/2020)

**Conversion based on Baseline of 90**

Low: 1.8; Medium: 1.8; High: 1.5

**Conversion based on Baseline of 85**

Low: 2.5; Medium: 2.5; High: 1.9

The contribution margin of the high segments for both PPG and carbs are relatively small, approximately 14%; therefore, we can focus on both of the low segment and medium segment (total 86%). It is obvious that the most reasonable and effective conversion ratio between PPG and carbs ranges from 1.8 mg/dL per gram to 2.5 mg/dL per gram. This range of conversion ratio has matched with many of the author's previous research findings [4-8].

**Conclusions**

By using the segmentation analysis of his 33,345 PPG data and 2,565 carbs/sugar data, the author has conducted a pattern recognition and segmentation analysis from his PPG profiles with its associated carbs/sugar intake of his food and meals in the past 855 days. Since 12/8/2015, he ceased taking any diabetes medications. In other words, his diabetes control is 100% dependent on his lifestyle management program with no chemical intervention from any medications. Subsequently, he has maintained a stringent exercise program after each meal; therefore, the development of his simplified PPG prediction model, excluding the exercise factor, can be expressed solely with carbs/sugar intake amount.

**Predicted PPG = (baseline glucose) + (conversion ratio \* carbs/sugar amount)**

In his research work, he found the reasonable and effective conversion ratio between PPG and carbs that ranges from 1.8 mg/dL per gram to 2.5 mg/dL per gram. This simple equation could assist many type 2 diabetes (T2D) patients in controlling their diabetes via carbs/sugar intake amount. During this particular time period, his PPG control via a stringent lifestyle management without medication is highly successful. His estimated mathematically derived HbA1C values should be between 5.56% to 6.05%, which is a satisfactory HbA1C level for a 73-year-old male with a 25-year history of severe diabetes. It should be mentioned that he had an average daily glucose of 280 mg/dL and HbA1C of 11% in 2010.

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