

## Research Article

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## Applying Segmentation Pattern Analysis to Investigate Postprandial Plasma Glucose Characteristics and Behaviors of the Carbs/Sugar Intake Amounts in Different Eating Places (GH Method: Math-Physical Medicine)

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**Introduction**

In this paper, the author presents the results of his segmentation pattern analysis based on different cooking and eating places with both high-carb and low-carb intake amounts. It also verified his earlier findings on the communication model between the brain along with some internal organs such as stomach, liver, and pancreas.

**Methods**

First, he reviews the overall combined PPG waveforms associated with various meals in different cooking and eating places ("Eating Places"). Secondly, he defines low-carb intake as 0-14.9 grams carbs/sugar intake amount per meal and high-carb intake as 15-150 grams carbs/sugar intake amount per meal, and then analyzes PPG accordingly. He then generates the PPG sub-waveforms associated with these two different carbs/sugar intake ranges. Thirdly, he calculates the data and plots the graphs of PPG differences ("delta") between high-carbs and low-carbs or each eating place. He utilizes this third step to reverify his earlier hypothesis and findings of the communication model between the brain along with stomach, liver, and pancreas.

**Results**

The national overall PPG combined waveform data: final results are shown in Figure 1. In summary, both home cooked meals and chain restaurants, 11-12 carbs grams, are better than the overall average number, 14.6 carbs grams. The individual restaurants and supermarket food courts, 21-23 grams, are much worse than the average number, 14.6 carbs grams. It should be noted that the author only ate part of his breakfasts at chain restaurants and rarely ate any lunches or dinners there. Due to concerns involving economics and pricing of meals, breakfasts at chain restaurants have smaller portion in general. Therefore, those breakfasts contain lesser amounts of carbs/sugar which is better for diabetes patients. Conversely, individual restaurants, which lack consistent control of the ingredient contents and standard cooking procedures, usually use much higher amounts of carbs, sugar, salt, and fat in order to attract more customers. In conclusion, generally speaking,

individual restaurants do not offer healthy options for diabetes patients.

Lastly, all of the post-meal exercise amounts associated with eating places are very comparable. Figures 1 and 2 show the overall analysis results of four different eating places. It should also be pointed out that the average sensor PPG is 18% higher than the average finger PPG.

Nations	Meal #	Meal %	Avg Grams	Avg Steps	Finger	Avg Sensor	Sensor/Finger
Home Cook	854	47%	11	4434	110.4	131.73	119%
Chain	290	16%	11.9	4667	118.1	137.93	117%
Individual	501	27%	20.6	4157	121.3	140.82	116%
Supermarket	32	2%	23	3872	124.0	154.54	125%
Sub-Total	1825	100%	14.6	4252	115.8	136.29	118%

Figure 1: Eating places PPG summary

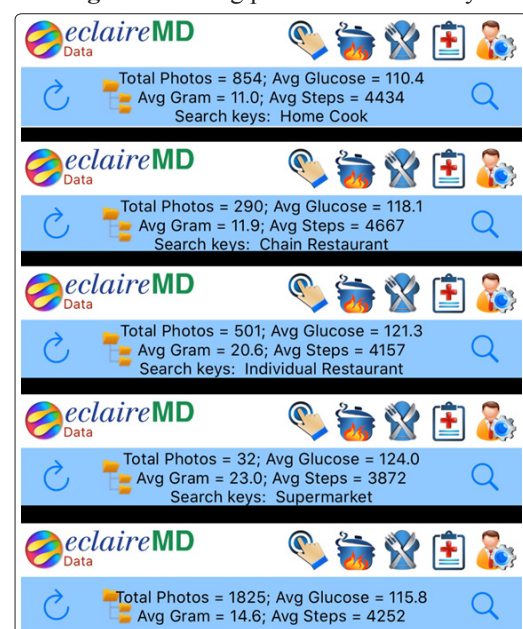
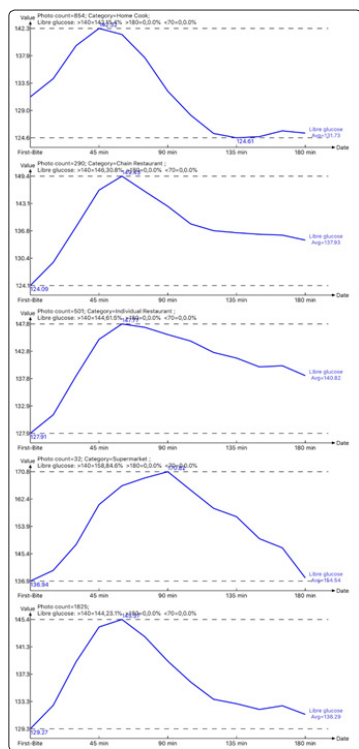
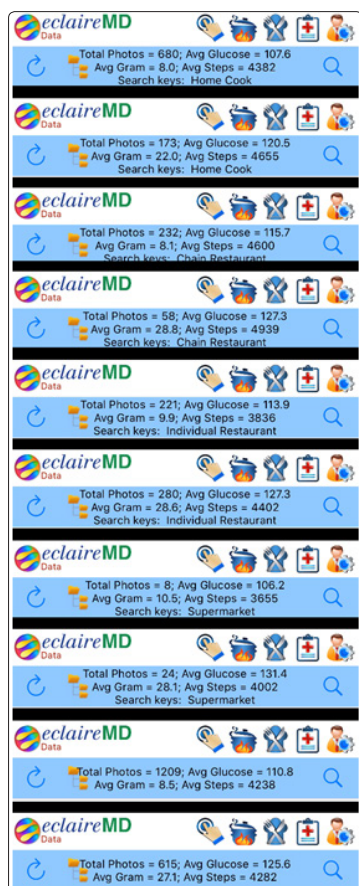


Figure 2: Detailed PPG information of four eating places and overall

Eating places with low-carb vs. high-carb segmented data: final results are shown in Figures 3, 4, 5 and 6. The conclusions are listed below in the format of (low-carbs; high-carbs; average carbs; low finger PPG; high finger PPG; and average finger PPG)



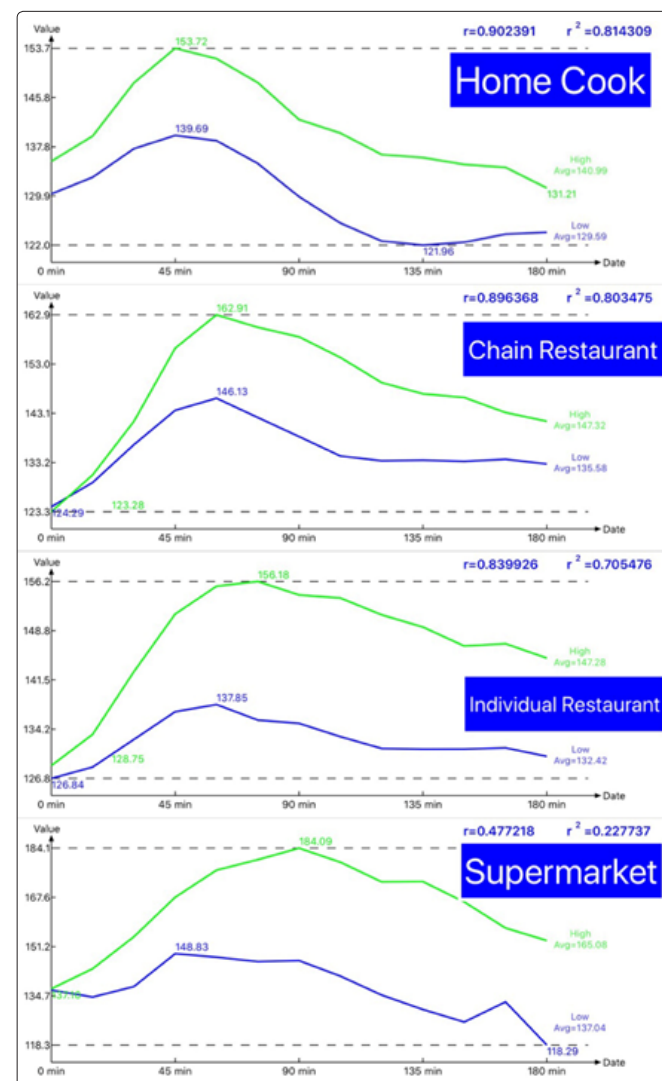
**Figure 3:** Waveforms of PPG of each eating place (low-carbs vs. high-carbs)



**Figure 4:** Detailed PPG information of each eating place (low-carbs vs. high-carbs)

Home Cook			Chain Restaurant			Individual Restaurant			Supermarket						
	Low	High		Low	High		Low	High		Low	High				
2	Avg	129.59	140.99	2	Avg	135.58	147.32	2	Avg	132.42	147.28	2	Avg	137.04	165.08
3	0 min	130.25	135.51	3	0 min	124.29	123.28	3	0 min	126.84	128.75	3	0 min	136.67	137.10
4	15 min	132.95	139.58	4	15 min	129.16	130.70	4	15 min	128.53	133.40	4	15 min	134.33	143.80
5	30 min	137.54	148.16	5	30 min	136.79	141.48	5	30 min	132.65	142.75	5	30 min	137.84	154.50
6	45 min	139.69	153.72	6	45 min	143.70	156.21	6	45 min	136.78	151.34	6	45 min	148.83	167.70
7	60 min	138.83	152.04	7	60 min	146.13	162.91	7	60 min	137.85	155.48	7	60 min	147.67	176.73
8	75 min	135.16	148.19	8	75 min	142.25	160.40	8	75 min	135.53	156.18	8	75 min	146.17	180.25
9	90 min	129.79	142.23	9	90 min	138.41	158.48	9	90 min	135.04	154.18	9	90 min	146.50	184.09
10	105 min	125.54	140.06	10	105 min	134.50	154.33	10	105 min	133.06	153.72	10	105 min	141.33	179.40
11	120 min	122.64	136.60	11	120 min	133.54	149.27	11	120 min	131.30	151.22	11	120 min	135.00	172.82
12	135 min	121.96	136.10	12	135 min	133.66	147.02	12	135 min	131.20	149.39	12	135 min	130.17	172.90
13	150 min	122.44	135.00	13	150 min	133.43	146.28	13	150 min	131.21	146.57	13	150 min	126.00	166.11
14	165 min	123.76	134.53	14	165 min	133.84	143.25	14	165 min	131.39	146.91	14	165 min	132.71	157.40
15	180 min	124.06	131.21	15	180 min	132.90	141.49	15	180 min	130.13	144.77	15	180 min	118.29	153.22

**Figure 5:** Detailed data of overall PPG and PPG difference between low-carbs and high-carbs



**Figure 6:** PPG waveforms of each eating place (low-carbs vs. high-carbs)

Home cooked: (8.0; 22.0; 11.0; 107.6; 120.5; 110.4)  
 Chain: (8.1; 28.8; 11.9; 115.7; 127.3; 118.1)  
 Individual: (9.9; 28.6; 20.6; 113.9; 127.3; 121.3)  
 Supermarket: (10.5; 28.1; 23.0; 106.2; 131.4; 124.0)  
**Total: (8.5; 27.1; 14.6; 110.8; 125.6; 115.8)**

All of the low-carb intakes are in the range of 8-11 grams and high-carbs are in the range of 22-29 grams. The high-carb grams are ~3x of the low-carb grams. All of the low-carb finger PPG are in a narrow range of 106 - 114 mg/dL and high-carb finger PPG are in a narrow range of 121 - 131 mg/dL. These eating places segmented analysis findings are quite similar to the national segmentation analysis findings.

(3) Differences between high-carb PPG and low-carb PPG (delta) for these four eating places subgroups are also quite similar to the national carbs segmentation glucose differences (delta).

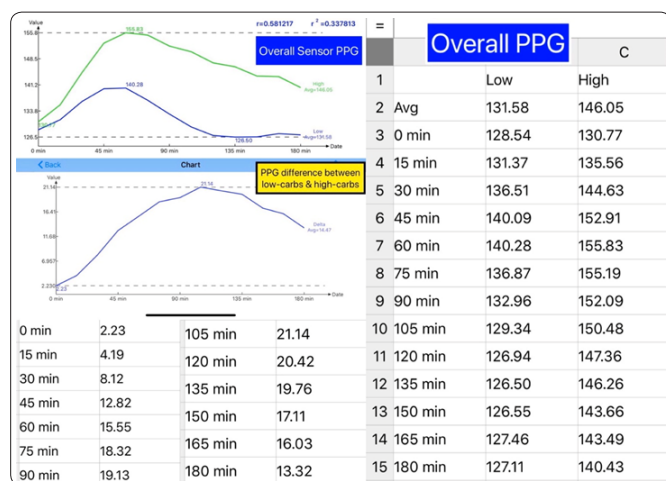
Observing from Figure 7, the author has summarized his findings as follows. At 0-minute, the PPG gap is ~2 mg/dL which is exceedingly small. At 30-minutes, initial digestion stage, the PPG gap grows to ~8 mg/dL which is larger (~4x). At 60 to 75-minutes, full digestion stage, the PPG gap grows further to 16 mg/dL which is huge (~8x). However, after the full digestion stage, the PPG gap becomes even slightly larger. This phenomenon is mainly due to the different decaying speeds of two PPG waves, and partially also due to the continuously burn off from the remaining energies associated with high carbs. At 120-minutes, the low-carb wave is almost completely deceased (at 112-minutes), while the high-carb wave still has a remaining glucose amount. At 180-minutes, the excessive amount of left-over energy (~10% of opening glucose and ~20% of leftover energy) associated with high-carb meals still remain inside the blood system, which causes a slower pace of damage on internal organs.

of glucoses based on his big data analytics and mathematical proof. They have reconfirmed the author’s previous hypothesis and findings regarding the communication model between the brain along with stomach, liver, and pancreas.

### Conclusions

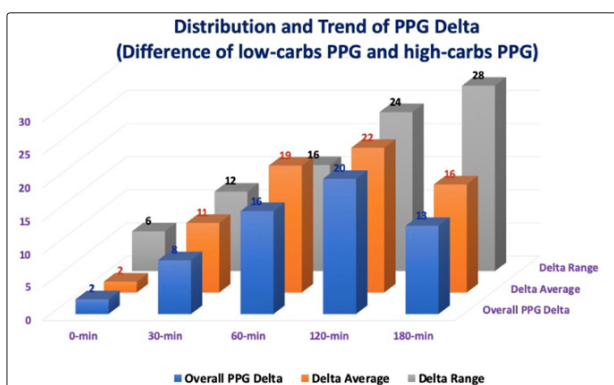
The conclusions from this analysis are based on his collected ~20,000 sensor glucose data during a period of ~20 months (5/5/2018 - 12/13/2019). These data behaviors, in many aspects, are quite similar to some of his previously published conclusions derived from the finger PPG data analysis.

However, the “waveform” created by massive sensor data have indeed offered much more insights regarding the PPG characteristics and unique behaviors. For example, the verification of his hypothesis regarding the communication model between the brain and some internal organs are similar to his previously published findings based on the overall PPG waveform study.



**Figure 7:** PPG waveforms and data of PPG delta (low-carbs vs. high-carbs)

Figure 8 shows the PPG Delta at different time instance, including the actual delta (high carbs minus low carbs), delta average (average of deltas of 4 eating places), and delta range (range between lowest delta and highest delta). Both the actual delta and average delta confirm the author’s physical phenomena, as well as the delta range showing the actual gap growth and delta deviation of four eating places.



**Figure 8:** PPG Delta variations study at different time instants

The above descriptions of the PPG Delta were derived from his careful physical observations of the complex biochemical behaviors

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