ISSN: 2573-9565

Review Article

Journal of Clinical Review & Case Reports

Understanding Energy Infusion and Energy Diffusion through Glucose Wave Fluctuation Leading Into Glucose Control via Optimized Combination of Food and Exercise (Math-Physical Medicine)

Gerald C Hsu

eclaireMD Foundation, USA

***Corresponding author**
Dr. Gerald C Hsu, eclaireMD Foundation, USA

Submitted: 06 Apr 2020; **Accepted**: 13 Apr 2020; **Published**: 20 Apr 2020

Introduction

The author used wave theory from electronics engineering and energy theory from mechanical engineering combined with his developed math-physical medicine to research the following topic: energy imbalance between infusion and diffusion through glucose wave fluctuations resulting from weight change, food intake, and exercise activities.

By conducting his quantitative analytics on a new big data set containing almost twice the amount of the daily glucose "small data set" (4 points per day), he can further observe, understand, and analyze the newly available daily glucose *waveform*, a curve with ~80 data points per day, in detail from a mathematician, physicist, and engineer's point of view.

From his research, he was able to derive some practical guiding principles for type 2 diabetes (T2D) patients on how to control their glucose variance via fine-tuning the combination of food and exercise.

Methods

The author has been collecting a total of 9,246 glucose data by finger-piercing and test strip, including both fasting plasma glucose (FPG) once a day since 1/1/2014 (1,764 days) and postprandial plasma glucose (PPG) three times a day since 1/1/2012 (2,494 days). During this period, he could only analyze the glucose's "macro-behavior" by studying its daily data fluctuation over a longer period of time (5 to 7 years) because of the finger--piercing glucose measurement method, collecting four data points per day.

Recently, he has further collected 14,400 glucose data by applying a Libre sensor on his upper arm to continuously collect glucose values. This sensor measurement was conducted in parallel with his routine finger-piercing measurements. During the period of 5/5/2018 to 10/31/2018 (180 days), he measured and recorded his glucose values ~80 times per day. The sensor measurement rate is approximately every 15 minute during the day and every hour during the night. With the massive data, he can then investigate the glucose's "micro-behavior" via a daily "waveform or curve" instead of using the finger-piercing's four daily "data points". Now, with 80 numbers per day, he has sufficient data to construct a glucose wave within a particular day in order to investigate its fluctuations, phenomena, and wave characters (e.g. rising and dropping speed, frequency, period, amplitude, etc.) and the comparison of glucose data between the liber sensor and the finger-piercing technique.

In combing these macro-view and micro-view of both FPG and PPG, particularly PPG, he can conduct a quantitative analysis to identify the detailed relationship between glucose and energy, which is generated, represented, and consumed via weight, food, exercise, and other secondary factors. Please note that weight is both an input and an output element of glucose. The ultimate purpose of this research is to figure out how severely the patient's health situation would develop due to this "energy disequilibrium" resulting from "excessive glucose" generated by the imbalance between food and exercise. Hopefully, through this effort, he will eventually be able to numerically calculate and determine the degree of damage on different internal organs due to this "left-over energy" inside one's body.

Food is the most important factor of PPG, but it is also difficult to regulate or change a person's eating habit. The author created an artificial intelligent (AI) based software to collect and analyze his meal photo and its associated Meta data by utilizing optical physics at the front-end, signal processing at the back-end, and other techniques from mathematics, statistics, and machine learning in between. He developed a PPG prediction model in 2015 based on his large food bank with ~8 million data. This bank contains 6M food and nutrition data from the United States Department of Agriculture (USDA), 500 franchised restaurants, and his own collected 4,300 meal photos. Each meal photo links with multiple Meta data, such as nation, meal location, food type, menu or dish name, and nutritional ingredients. The system can estimate consumed amount of carbs, sugar, and then predict PPG value prior to eating.

At first, he discovered and established the hidden link between color wavelength and carbs/sugar amount via molecular structural change and nutritional ingredient's amount. He then decomposed the measured PPG waveform into 19 sub-waveforms of components using signal-processing techniques from electronics communication engineering and geophysics research. Furthermore, using techniques he learned from mathematics, statistics, engineering, and computer science, he calculated each sub-wave's contribution to the total glucose amount and the complicated inter-relationship among those sub-waves. After understanding each sub-wave's role and contribution, he then re-integrated those 19 sub-waveforms back to a combined new waveform, forming the predicted PPG wave. He compared the predicted PPG value against the measured PPG value to get their accuracy rate. After a continuous refinement for over two years (6/1/2015 - 10/1/2017), he finally reached to a 99.9% linear accuracy after discovering the ambient temperature (weather) influenced both FPG and PPG in September 2017. During this analysis period, he also identified that food occupied ~39% of the contribution margin while exercise occupied ~41%. In total, combined food and exercise contributed ~80% of PPG formation.

During the period of 11/1/2016 to 10/31/2017, he also developed an FPG prediction model after reading more than 100 medical articles and finding no useful clues on solving his high FPG problem. On 3/17/2016 at 3:00 am, he had a dream about using an "out-of-box" thinking to look for inter-relationship among output elements instead of the traditional engineering training of always looking for inter-relationships between inputs and outputs. After conducting both time-series and spatial analysis between weight and FPG which are two separated output elements of human metabolism system, he discovered and proved that there is a very high correlation coefficient of 83% existing between weight and FPG. Body weight is the output of our metabolism system, which involves food, water, exercise, sleep, stress, regular routine, etc. Food portion in particular has a direct impact on our body weight. Currently, he realizes that food plays a vital role in both FPG and PPG. In early 2018, when he started to investigate glucose from the energy viewpoint, he suddenly realized that weight is merely a physical representation of internal energy exchange in human body. In other words, weight is the major input of FPG formation, but weight is also the obvious output and key appearance from our "internal energy imbalance". The energy infusion comes mainly from food, whereas energy diffusion derives through exercise and activities. We should avoid having energy imbalance (disequilibrium) situation; otherwise, the excessive (leftover) energy will damage our internal organs to varying degrees.

Finally, after summarizing his findings, he used layman's terms in his explanations to T2D patients, so that they can understand and follow his guidelines. He created simple, useful, and practical ways or tips to avoid the buildup of ultra-high glucose amplitude or how to wear off its cumulative massive energy quickly.

Results

(A) Macro-view: He selected a period of 1,194 days (6/1/2015-9/7/2018) with 3,721 meals (including snacks) and ~100,000 data for his micro-view food analysis.

First of all, it is necessary to describe the author's general lifestyle in order to have a better understanding of the background for these data. He travels quite frequently - a trip for every 14 days. He stays in a particular city based on the weather, where the ambient temperature (weather) ranges from 65 to 77-degree Fahrenheit (average 72-degree Fahrenheit). In a different research paper, he described that weather has ~10% impact or contribution to both FPG (-0.3 mg/dL per degree for temperature dropping below 67-degree Fahrenheit) and PPG (+0.9 mg/dL per degree for temperature increasing above 77-degree Fahrenheit).

It does not matter which city he resides in because his daily lifestyle always follows the same pattern. He spends ~8 hours per day studying, experimenting, researching, and writing on the subject of chronic diseases. He has his routine post-meal exercise in a large park, long ocean beach, inside a big shopping mall (avoiding any possibility of having injuries or accidents) to satisfy his ~4,000 walking steps of exercise requirement.

The summary results of this "macro-view" food study are listed by both nations and meal locations, and then sorted by PPG value with the format of PPG (mg/dL) & carbs/sugar (gram).

Food by Nation: In summary, he had 58% of meals within the USA (3 city residences) and 42% in other nations (more than 10 nations).

Airlines: cross-nations (137.3, 26.0g); Other Nations (123.7, 19.8g)
Taiwan (123.0, 14.9g)
USA (117.6, 13.0g)
Japan (117.4, 15.6g)
Canada (115.1, 14.3g)

It should be noted here that since his life involves a lot of air traveling, he decided to treat *airline* as an independent nation and a separate eating location. In total, there were 86 airline meals consumed during his 94 trips during this period.

The nation with the best score is Vancouver, Canada, due to its unique lifestyle focusing on nature and being more health conscious. The second-best score belongs to both Japan and USA because most of his meals were cooked at home. In reality, most of the eastern Asian cooking and some ethnic cooking (except Mediterranean) use too much sugar, salt, and fat, which are major causes of chronic diseases. Airline food has the worst score from a diabetes viewpoint due to its improper contents (high carbs/sugar in airline food) and tight immobile space (exercise difficulty).

Food by Eating Location: In summary, he had 59% of meals at home and 41% outside.

Airlines (137.3, 26.0g)
Supermarket (130.3, 25.7g)
Individual Restaurant (127.7, 20.6g)
Chain Restaurant (121.2, 11.7g)
Home Cooking (113.8, 11.5g)

It is obvious that home cooking provides the lowest PPG values provided by the cook, such as the author, who has sufficient knowledge of both food nutrition and chronic diseases. In this analysis, PPG data were collected from a few selective chain restaurants, which include their breakfast only. Due to economic reasons, most of the chain restaurants' breakfast menus have smaller meal portion; therefore, there are less amount of carbs and sugar. However, he avoided eating his meals during lunch and dinner at any chain restaurants due to his concerns of too much carbs and sugar. Individual restaurant provides variety of menu selections, which usually contain lots of carbohydrates and ample amount of sugar, salt, and fat. Individual cafe's main objectives are to attract more customers. As a result, they do not have much understanding or concern about food nutritional impact on a patient with chronic disease. Supermarket ready-cooked food is almost as bad as airline ready-made food.

Travel: Regarding traveling, during the period of six years (2012-2017), the author has made 160 trips where more than 98% was by air travel. The breakdown included 55 long-haul travels (more than 3 hours flying, impacted 2 meals per trip) and 105 short-distance travels (less than 3 hours flying, impacted 1 meal per trip). He uses the glucose target of 120 mg/dL to monitor his intake of food and meal.

Prior to 2015, his average glucose for both long trip and short trip during traveling days were 140 mg/dL and 133 mg/dL, respectively (unhealthy). After 2015, his average glucose for both long trip and short trip during traveling days were 126 mg/dL and 126 mg/dL, respectively (healthy). In the entire six-year period, his average glucose for both long trip and short trip during traveling days were 135 mg/dL and 130 mg/dL, respectively (borderline status).

Therefore, after 2015, he was cautious about the food he ate during his travel days and found ways to take 4,000 post-meal steps inside the airport. These dual improvements were reflected in his lower glucose value of 126 mg/dL.

(B) Micro-view: During the past 6-months period (5/5/2028 - 10/31/2018), he has collected 180 FPG waveforms and 540 PPG waveforms by using a continuous sensor device. Some examples of these waveforms are shown in the attached figures. In general, the amplitudes of FPG waves are lower and their pattern is calm, while the amplitudes of PPG waves are higher and their pattern is volatile. The author must study the characteristics of these waveforms, including their rising and dropping speed (strength of linkage between food and glucose), frequency (how often the wave fluctuates), period (how long the wave lasts), amplitude (how high the wave's peak rises). Those characters are important for calculating the energy associated with glucose wave.

Nation	No. Meals	PPG (mg/dL)	Carbs/Sugar (grams)	Nation %
USA	2148	117.6	13.0	58%
Taiwan	679	123.0	14.9	18%
Japan	294	117.4	15.6	8%
Canada	292	115.1	14.3	8%
Other Nations	222	123.7	19.8	6%
Airlines	86	137.3	26.0	2%
Grand Total	**3721**	**119.1**	**14.5**	**100%**

Figure 1: Nation Summary Results

Eating Place	No. Meals	PPG (mg/dL)	Carbs/Sugar (grams)	Place %
Home Cooking	2158	113.8	11.5	59%
Chain Restaurant	450	121.2	11.7	12%
Individual Restaurant	967	127.7	20.6	27%
Supermarket	59	130.2	25.7	2%
Airlines	86	137.3	26.0	2%
Grand Total	**3634**	**121.9**	**14.8**	**100%**

Figure 2: Eating Location Summary Results

By Nation	Within Each Nation	No. Meals	PPG (mg/dL)	Carbs/Sugar (grams)	Place %
USA	National Total	2148	117.6	13.0	100%
	Home Cooking	1389	113.7	11.3	65%
	Chain Restaurant	265	120.1	11.0	12%
	Individual Restaurant	453	125.6	18.2	21%
	Supermarket	40	132.4	27.1	2%
Taiwan	National Total	679	123.0	14.9	100%
	Home Cooking	355	117.4	11.7	52%
	Chain Restaurant	87	124.0	9.0	13%
	Individual Restaurant	237	129.9	22.6	35%
Japan	National Total	294	117.4	15.6	100%
	Home Cooking	151	110.7	11.6	51%
	Chain Restaurant	64	124.2	17.1	22%
	Individual Restaurant	71	133.8	25.4	24%
	Supermarket	8	126.1	20.9	3%
Canada	National Total	292	115.1	14.3	100%
	Home Cooking	220	110.0	10.8	75%
	Chain Restaurant	17	122.1	19.3	6%
	Individual Restaurant	55	129.4	25.8	19%
Other Nations	National Total	222	123.7	19.8	100%
	Home Cooking	43	116.2	15.2	19%
	Chain Restaurant	17	116.3	15.9	8%
	Individual Restaurant	151	127.3	21.6	68%
	Supermarket	11	125.1	24.2	5%
Airlines	Total	86	137.3	26.0	100%
	Airline In-flight Food	48	134.2	26.4	56%
	Airline Lounge Food	14	150.4	35.3	16%

Figure 3: Detailed Meal Analysis

Figure 4: Using AI Glucometer to Predict Glucose Value via Meal Photos

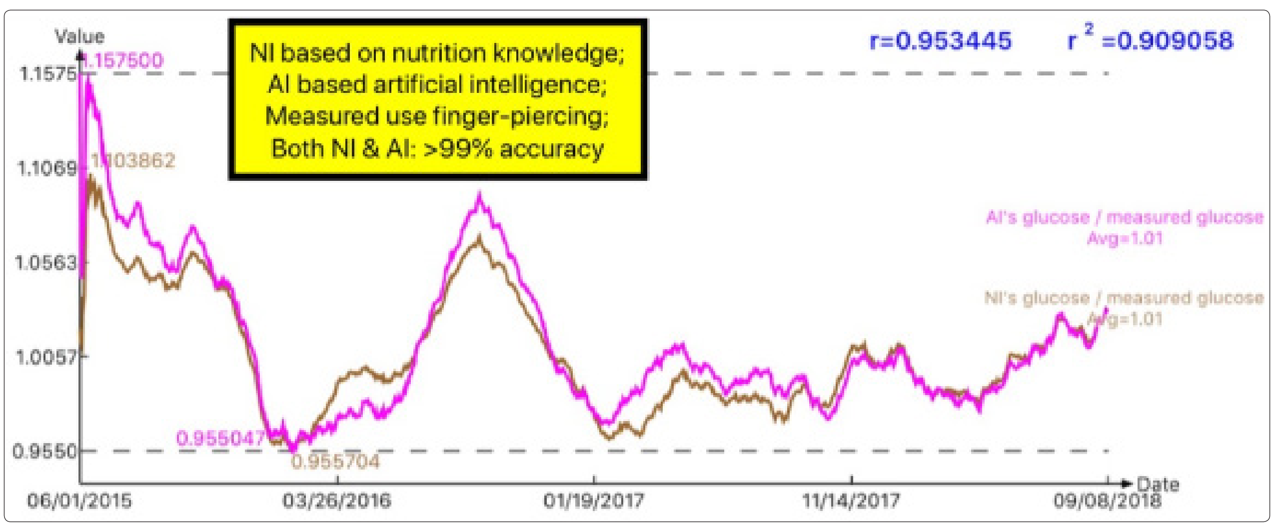

Figure 5: Accuracy Comparison between Nutritional Intelligence (NI) and Artificial Intelligence (AI)

Figure 6: Samples of meals with glucose values

	Original Measured Glucose	Add-in portion (g)	Add-in Carbs/Sugar (g)	Increase on Weight (lbs)	Increase on FPG (mg/dL)	Increase on PPG (mg/dL)	New Measured PPG
Meal A	123	400	4	0.65	3	8	131
Meal B	120	800	8	1.30	6	16	136
Meal C	90	1000	24	1.63	7.5	48	138

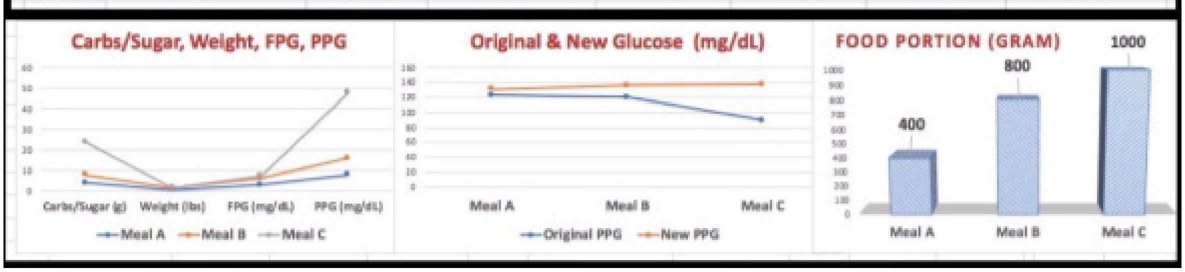

Figure 7: Original and New Glucose (mg/dL)

Figure 8: Excessive or leftover energy

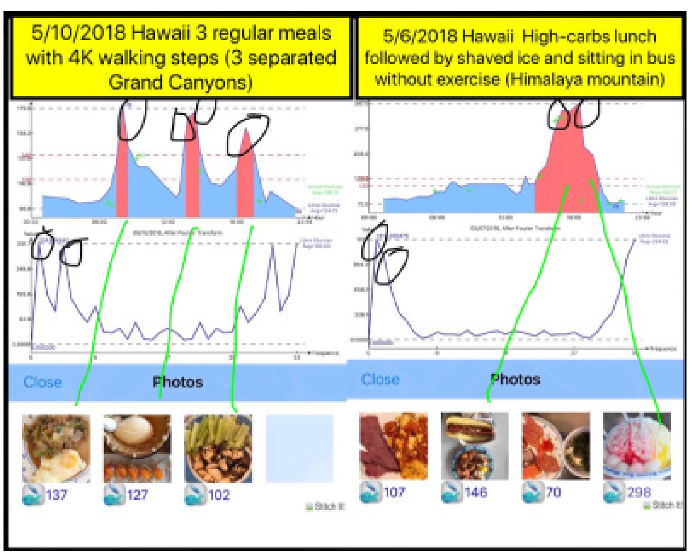

Figure 9: Hawaiian meals showing Grand Canyon and Himalayan charts

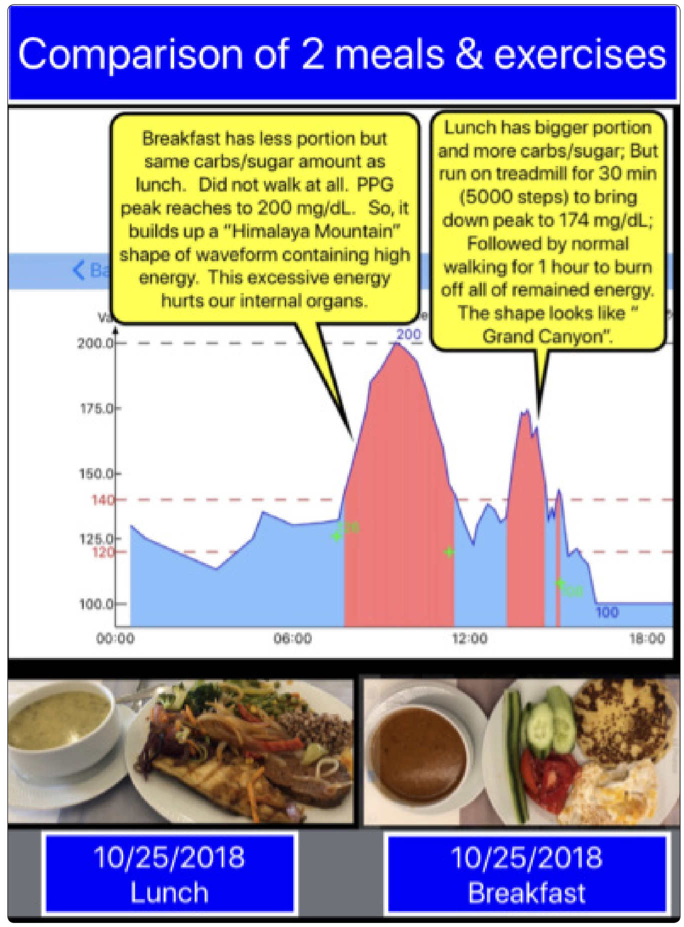

Figure 10: A comparison of two meals and exercise

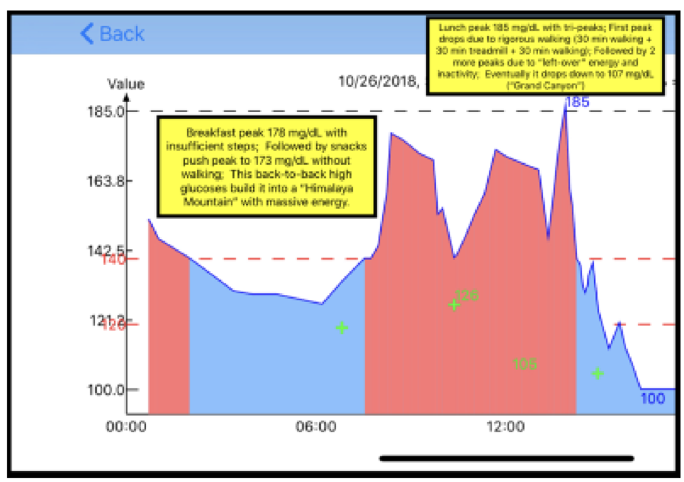

Figure 11: A comparison between meals reflecting Himalaya Mountain and Grand Canyon

Thus far, he has collected 14,400 glucose data via a sensor, which is equivalent to 10 years of data using finger-piercing method. He is able to draw some preliminary conclusions from this study. In general, he has summarized the glucose waveforms into three general different patterns. He named them as (1) Himalaya Mountain, (2) Grand Canyon, and (3) Twin Peaks.

The Himalaya pattern is that glucose rises to its peak around 45-75 minutes after the first bite of a meal and lasts for over 1 to 2 hours of high glucose values before descending. The height of this mountain varies such as it could be a high amplitude or medium amplitude, depending on food quality and quantity. The higher amplitude situation is normally caused by eating too much carbs or overly sweet food and not exercising at all after eating. Exercise plays a very important role in forming the shape and height of the mountain. This high plateau of glucose storage caused by big energy infusion and little energy diffusion, which builds up a massive stored energy.

The Grand Canyon pattern is that glucose rises to its peak around 45-75 minutes after the first bite of a meal and reached to a peak, which could be higher or slightly lower than the Himalaya's height. However, after reaching to its peak, it immediately descends to a low valley and stays there. This sharp triangular shape of energy storage has far less stored energy than a Himalaya mountain pattern.

The Twin Peaks pattern is that glucose rises to its peak around 45-75 minutes after the first bite of a meal and then descends to a valley, staying there for one hour or less, but it rises again to a second peak. However, the second peak's height is usually less than the first peak's height if you do not eat any snacks or fruits right after the meal. The total stored energy of these double-triangular patterns is usually close to or slightly higher than the total amount of energy from the Grand Canyon pattern. The reason of having the second peak is the total energy coming from the food consumption is not entirely burned out by the post-meal exercise and the patient stops exercising after a short period of time. Therefore, the "left-over" energy is kicked into his metabolism system to continuously pushing his glucose wave to a second peak. A suitable analogy can be used is driving a car. In the beginning, gasoline is pumped into the car (with either high-grade or low-grade gas). With both driving on the road and braking, dissipate the energy infusion from gas. After driving around for a while and then pressing on the brake, the driver then lifts his foot and lets the brake loose, the car will gain a new speed. The second driving speed depends upon the gas grade selection and leftover energy inside the car.

The major cause of peak height of these three patterns are quality and amount of carbs/sugar intake, which depends on food selection and portion. However, the dropping speed (i.e. descending slope) of glucose wave decides the formation of three patterns. The main controlling factor is the intensity and duration of the post-meal exercise. For example, patient would get a Grand Canyon pattern if he exercises rigorously and lasting for two hours; however, he might get a Twin Peak shape if he stops his exercise after 30 to 60 minutes and remains inactive.

Based on his preliminary analysis of the 6-month data, the average PPG values and of the Grand Canyon and Twin Peaks are about 20-25% lower than the Himalaya. But, the associated energy amounts of the Grand Canyon and Twin Peaks are about 45-55% lower than the Himalaya. Furthermore, the extension of his calculations shows that his cardiovascular disease (CVD) risk would increase from 30% to 44% (about 50% more in comparison with either the Grand Canyon or Twin Peaks) if the patient continuously maintains his PPG at the Himalaya pattern. In summary, the Himalaya pattern is the worst kind for a T2D patient to face.

A small footnote should be mentioned here that FPG is mainly controlled by body weight, which is further controlled by both food portion and overall exercise as well.

Once the author understood the overall phenomena and basic characteristics of glucose from both wave and energy viewpoints, he then developed a few computational formulas and practical tips as described below to "fine-tune" both energy infusion by food and energy diffusion by exercise in order to "wear-off" the excessive energy generated by glucose to maintain the glucose-energy balance. In addition, he has also identified a more reasonable and narrower energy perturbation band within 15% to 37% range [1-5].

(C) Practical Guidelines: Therefore, it is very clear that a T2D patient can effectively control his daily glucose level at a healthy range (below 120 mg/dL target) if he knows how to fine-tune the combined effect of food and exercise.

1. Use an AI-based tool to predict PPG value before eating meal;
2. Don't consume more than 30 - 40 grams of carbs/sugar each meal which will push your PPG peak to exceed 160 - 180 mg/dL;
3. Walk at least 15 - 20 minutes (1500 - 2000 steps) after each meal. Walk 4,000 steps if you are a severe type 2 diabetes patient.
4. If overeaten, try to stretch walking time over a longer period, e.g. 2 hours, or use a pattern of resting for 5 minutes after walking 10 minutes and then repeating this exercise pattern within 2 hours post-meal.
5. Avoid eating snacks between two separate, close meals. If it is necessary to eat fruits, try not to have them right after a meal or close to the next meal. Otherwise, the glucose curve will turn into a "Himalaya Mountain" pattern that contains a massive stored energy.
6. Another suggestion is dividing your snacks and fruits in-between meals into several smaller portions and consume only a smaller amount each time.
7. Please remember that post-meal walking can bring down your glucose wave's peak rapidly or turn your glucose curve into a "Grand Canyon" pattern or "Twin Peaks" pattern which would have much less stored energy, even if it may still show a higher peak in your glucose waveform.

Conclusion

The author's research regarding the control of energy infusion through food intake and energy consumption by post-meal walking can provide T2D patients guidance to achieve a better control of their PPG conditions.

His math-physical medicine model and wave/energy theory applications have demonstrated the glucose formation through energy infusion by food intake and energy diffusion by post-meal exercise. Furthermore, his method has also proven the strong linkage between food/exercise and glucose/energy, as well as the impact of "energy imbalance" on chronic diseases, especially diabetes and CVD risk.

His practical tips can offer T2D patients with a "fine-tuning" of an optimal combination of food and exercise. The T2D patients can skip the theoretical discussions and dive directly into the practical tip section in order to learn how to achieve a better control of their glucose.

References

1. Hsu Gerald C (2018) Using Math-Physical Medicine to Control T2D via Metabolism Monitoring and Glucose Predictions. Journal of Endocrinology and Diabetes 1: 1-6.
2. Hsu Gerald C (2018) Using Math-Physical Medicine to Analyze Metabolism and Improve Health Conditions. Video presented at the meeting of the 3rd International Conference on Endocrinology and Metabolic Syndrome.
3. Hsu Gerald C (2018) Using Signal Processing Techniques to Predict PPG for T2D. International Journal of Diabetes & Metabolic Disorders 3: 1-3.
4. Hsu Gerald C (2018) Using Math-Physical Medicine and Artificial Intelligence Technology to Manage Lifestyle and Control Metabolic Conditions of T2D. International Journal of Diabetes & Its Complications 2: 1-7.
5. Hsu Gerald C (2018) A Clinic Case of Using Math-Physical Medicine to Study the Probability of Having a Heart Attack or Stroke Based on Combination of Metabolic Conditions, Lifestyle, and Metabolism Index. Journal of Clinical Review & Case Reports 3: 1-2.