GH-Method: Math-Physical Medicine
Special Issue

Glucose Trend Pattern Analysis and Progressive Behavior Modification of a Type 2 Diabetes Patient Using GH-Method: Math-Physical Medicine (No. 305)

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Abstract

In this article, the author used data based on 10 years' worth of glucoses and prominent lifestyle details such as diet and exercise to address his glucose trend pattern analysis and progressive lifestyle behavior modifications. The research methodology used is the GH-method: math-physical medicine (MPM) approach which has been developed by the author over the past decade. This progressive behavior modification concept is also a part of his mentality-personality modeling. He addresses the quantitative linkage between diabetes physiological phenomena and behavior psychological influences of a type 2 diabetes (T2D) patient. He has created a geometric presentation model with carbs/sugar intake amount as the x-axis, post-meal walking steps as the y-axis, and daily glucose as the z-axis. He decided to "fold over" the z-axis and superimpose it with the x-y planar space in a form of "radio wave" format. Under his created 3D presentation on a 2D planar space, the glucose trend pattern becomes ultra-clear. For over the past 10 years, his annual glucose movement path started in the upper right corner (subregion E5 in 2010), moving at a ~30-degree downward slope before arriving to the location near the upper middle but skewed to the left (subregion B3 in 2014), and then continuously dropping to the lower left corner (subregion B1 in 2020). In summary, his glucose moving path is a 30-degree downward angle to the left and then straight downward to the bottom. His annualized average daily glucoses have been reduced from the starting point of 250 mg/dL in 2010 through the "reflection point" of 135 mg/dL in 2014, and then straight down to the ending point of 110 mg/dL in 2020. The triangular relationship among diet, exercise, and daily glucose can be easily observed on the "glucose trend pattern" diagram. Through analyzing those distinctive daily glucose trend patterns, the personality traits and behavior psychological characteristics of this T2D patient can be revealed instantly and clearly. As a result, a more practical guidance of "progressive behavior modification" can be provided to other T2D patients in order to improve their medical conditions for chronic diseases.

Keywords: glucose, diabetes, diet, exercise, lifestyle

Abbreviations: MPM: math-physical medicine; T2D: type 2 diabetes; PPG: postprandial plasma glucose; FPG: fasting plasma glucose; HbA1C: hemoglobin A1C; CGM: continuous glucose monitor

Introduction

In this article, the author used data based on 10 years' worth of glucoses and prominent lifestyle details such as diet and exercise to address his glucose trend pattern analysis and progressive lifestyle behavior modifications. The research methodology used is the GH-method: math-physical medicine (MPM) approach which has been developed by the author over the past decade. This progressive behavior modification concept is also a part of his mentality-personality modeling. He addresses the quantitative linkage between physiological diabetes phenomena and behavior psychological influences of a type 2 diabetes (T2D) patient.

Methods

GH-method: math-physical medicine methodology

The description below explains the GH-method: MPM research methodology developed by the author utilized in his biomedical research [1].

Any system, whether medical, political, economic, engineering, biological, chemical, and even psychological have causes or triggers (inputs) and consequences (outputs). There are some existing connections between inputs and outputs that can be either simple or complicated. The inputs and outputs of any type of system, including biomedical system, can be observed visually, or measured by certain instruments. These physically observed phenomena, including features, images, incidents, or numbers are merely the partial "physical expression" of these underneath system structure. This system structure includes human organs for a biomedical system, the human brain for a neurological or mental system, or steel plate for structural or mechanical engineering system.

Once we have collected these readings of the physical phenomena (external expression, similar to a behavior, symptom, or response), through either incident, image, or data, we should be able to organize or categorize them in a logical manner. When we check or analyze these partial physical phenomena outputs and cannot figure out why they act or behave in certain way due to internal causes, reasons, or stressors, we can try to develop some guesses or formulate some reasonable hypotheses based on some available basic principles, theories, or concepts from physics. At this point, we just cannot pull out an existing equation from a physics textbook and insert these input variables in to conduct a "plug and play" game. An equation is an expression of a concept or a theory, which is usually associated with some existing conditions, either initial or boundary; however, a biomedical system usually has different kind of conditions from other systems.

After understanding the meaning of observed physical phenomena, the next step is to prove the hypothesis, guess, or interpretation of the phenomenon being correct or incorrect. At this stage, a solid understanding of mathematics becomes extremely useful to develop a meaningful model which could represent or interpret these observed physical phenomena and created hypothesis. In addition, some engineering modeling techniques, such as finite element method and computer science tools, including software, artificial intelligence (AI), and big data analytics can offer great assistance on verification of analysis results from these mathematical operations.

If the mathematical results cannot support the created hypothesis, then a new hypothesis needs to be formulated. When this new hypothesis is proven to be correct, then we can extend or convert this hypothesis into a useful mathematical equation or into a simpler arithmetical formula for others to adopt this easier way of thinking and understanding of the results. In the final stage, the derived mathematical equation or arithmetical formula can then be used to "predict" future outcomes of the selected system based on other different sets of inputs.

Diabetes research

The author has been a severe T2D patient since 1995. He has developed many serious complications and finally, in 2010, they became life-threatening. Therefore, he has spent the next 10 years to self-study and research diabetes, metabolism, and endocrinology, to save his own life.

He spent his first 4 years, from 2010–2013, to self-study 6 chronic diseases, *i.e.*, obesity, diabetes, hypertension, hyperlipidemia, cardiovascular diseases, stroke, as well as food nutrition. Food is probably the most important and complicated input element to influence these chronic diseases. After his first 4 years of self-learning, he then spent the entire year of 2014 to develop a complex model of metabolism. This mathematical model contains 4 biomarkers of medical conditions (weight, glucose, blood pressure, and lipids) along with 6 lifestyle details (food portion and nutritional balance, drinking water intake, adequate exercise, sufficient sleep amount and quality, stress reduction, and daily life routines regularity). He applied the concept of topology from mathematics and the approximation modeling technique of finite element method from engineering to develop this metabolism model which became the cornerstone of his future medical research work. As a result, his overall health conditions also started to improve.

Starting from 2015, he spent 3 consecutive years, from 2015–2017, to discover the characteristics and behaviors of this complex "wild beast" of glucose. His major objective is to truly understand the "inner characteristics" of the glucose, not just using medication's chemical power to control the disease' external biological "symptoms". His research work is similar to a horseman trying to tame a horse by understanding its temperament first, not just giving a tranquilizer to calm it down. As a result, during this period of 3 years, he has developed 4 prediction models, which include weight, postprandial plasma glucose (PPG), fasting plasma glucose (FPG), and hemoglobin A1C (HbA1C) with extremely high prediction accuracy (95–99%) to reach to his purpose of "understanding glucoses".

The author estimated and proved that PPG contributes approximately 75–80% towards HbA1C formation. Therefore, he tried to unravel the mystery of PPG first. Through his diabetes research, he has identified at least 19 influential factors associated with PPG formation. Among those influential factors, diet (carbs/sugar intake amount) would provide ~38% and exercise (post-meal walking) would contribute ~41%. Combining these two primary influential factors, it gives ~80% of the PPG formation. Among the rest of the 17 secondary factors, a high weather temperature contributes ~5%, whereas stress and illness only make noticeable contributions when they occur.

For most T2D patients who take medication, its biochemical effect would become the most significant influential factor of glucose. However, as we know, medication cannot cure diabetes and only control its symptoms. Therefore, the author decided to focus on controlling diabetes at the most fundamental core level by investigating its root cause. Previously, he has taken high doses of three prescribed diabetes medications for 18 years since 1997; however, in 2013, he started to reduce the number of prescriptions and dosages of his daily medications. By 12/8/2015, he finally ceased taking any diabetes medications.

From 2016–2017, he discovered a solid statistical connection between his FPG and his body weight with a > 90% correlation coefficient. In addition, like his PPG research, he also recognized that there are about 5 influential factors of FPG formation with weight alone contributing > 85% and cold weather temperature influencing ~5%.

Since July 2019, he also launched a special investigation on the degree of damage to his pancreatic beta cells. During the past 12 months of research work, he noticed that both of his FPG and PPG have been decreased in the past 6–8 years at an annual rate of 2.2–3.2%. In other words, his pancreatic beta cells have been self-regenerating or self-repairing about 13–26% over these 6–8 years. He then thought about FPG as being a good indicator on how healthy his pancreatic beta cells are since there are no food intake and exercise while sleeping. In addition, during the last 5 years, his body weight has been maintained around 172 lbs. Besides, his body has been medication-free over the past 5 years as well. It makes sense that FPG carries a significant and clear message about his health status of pancreatic beta cells; therefore, it can be served as the baseline of his overall glucose predications.

The detailed explanation of his glucose research work is provided because this study is based on “glucoses”.

Glucose trend-pattern diagram

A typical T2D patient faces three major challenges:

1) Availability of accurate and precise disease information with either physical evidence or quantitative proofs, not just some general qualitative descriptions that may include false or commercial driven news over the internet (knowledge issue).
2) Awareness of his disease’s specific status and overcome self-denial to take effective actions. The most difficult barrier to overcome is having determination, willpower, and persistence on lifestyle change (behavior issue).
3) A non-invasive, effective, and ease of use technology-based tool to accurately predict biomedical outcomes and guide patients (technology issue).

The MPM methodology and its related diabetes research work covers the scope of this first issue, knowledge. The third issue, technology, has also been discussed in his previously published papers [2]. This investigation report addresses the second issue, behavior, specifically, *i.e.*, a patient’s lifestyle behavior on his diet control and exercise. Beyond acquiring accurate and sufficient knowledge of diabetes, the resistance of food temptation and diligence on post-meal exercise occur with every patient at a frequency of 3 times a day. These lifestyle behaviors require strong determination, willpower, and persistence to achieve the goal of diabetes control. These concerns are related to a patient’s personality traits.

The author has collected a total of two million data of his medical conditions and lifestyle details for the past 10 years (2010–2020). In this study, he only utilized 3 subsets of his collected and stored data such as finger-piercing measured glucoses, carbs/sugar intake amount, and post-meal walking steps.

As he described in his diabetes research section, his learned knowledge and research results of diabetes control are progressively introduced and added into his data collection software from earlier years moving into later years. In short, he studied both diseases and nutrition from 2010–2013, then started collecting weight data since 2011, PPG data since 2014, carbs/sugar and post-meal walking data since 2015, and FPG data since 2016. Before accumulating this additional data, he already collected some partial data, but not daily and with an organized fashion similar to those periods after the starting years. However, his best guesstimated annualized data, prior to those starting years, are still able to provide an accurate annualized information. Therefore, in the data table, the red-colored data are his guesstimated annual data based on partial collected data, while the black-colored data are collected real data based on each meal and each day within an entire year (Figure 1).

To demonstrate the results of his trend pattern analysis, he created a modified two-dimensional (2D) planar space which can describe a three-dimensional (3D) data information. Initially, he set his x-coordinate as his carbs/sugar intake amount from low scale to high scale with the following 5 segments:

Segment A: 0–10 g; Segment B: 10–20 g; Segment C: 20–30 g; Segment D: 30–40 g; Segment E: 40–50 g

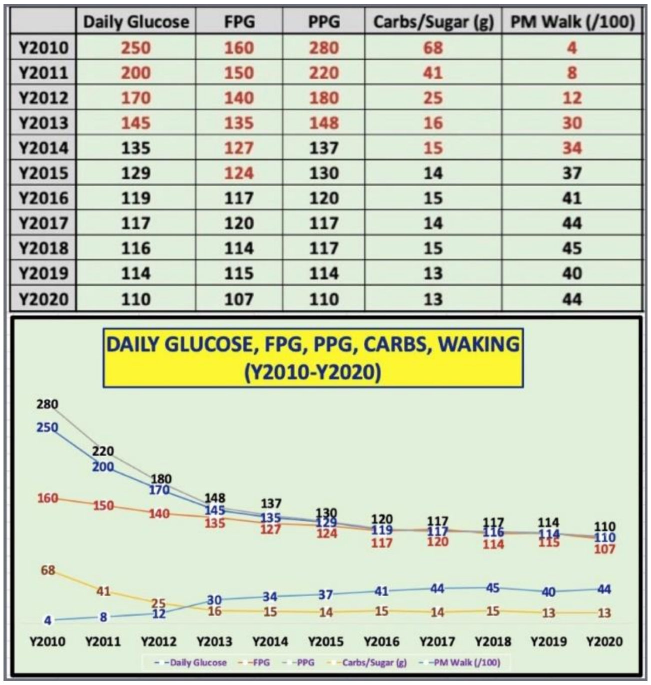
Secondly, he set his y-coordinate as his post-meal walking steps from high scale to low scale with the following 5 segments:

Segment 1: 4–5 k steps; Segment 2: 3–4 k steps; Segment 3: 2–3 k steps; Segment 4: 1–2 k steps; Segment 5: 0-1k steps

Therefore, these x and y axis constitute a 2D planar space with a total of 25 sub-regions inside, such as A1 through E5.

Thirdly, he set his “pseudo” z-coordinate” as his daily glucose levels from low scale (lower left corner) to high scale (upper right corner) in a “radio-wave” format with the following 6 segments:

Segment 1: 100–130 mg/dL; Segment 2: 130–160 mg/dL; Segment 3: 160–190 mg/dL; Segment 4: 190–220 mg/dL; Segment 5: 220–250 mg/dL; Segment 6: 250–280 mg/dL - this segment is not used for his daily glucose, but useful for his PPG data.



	Daily Glucose	FPG	PPG	Carbs/Sugar (g)	PM Walk (/100)
Y2010	250	160	280	68	4
Y2011	200	150	220	41	8
Y2012	170	140	180	25	12
Y2013	145	135	148	16	30
Y2014	135	127	137	15	34
Y2015	129	124	130	14	37
Y2016	119	117	120	15	41
Y2017	117	120	117	14	44
Y2018	116	114	117	15	45
Y2019	114	115	114	13	40
Y2020	110	107	110	13	44

Figure 1: Background data table and line chart of daily glucose, FPG, PPG, carbs/sugar intake, and post-meal walking steps (2010–2020).

However, for a better view, he “superimposes” his z-axis on his 2D planar x-y space with a “radio-wave” format to show their different levels (Figure 2). In this presentation, the reader of this article can easily observe the glucose trend pattern from 2010–2020 along with their respective relationship with carbs/sugar intake amount and post-meal walking steps.

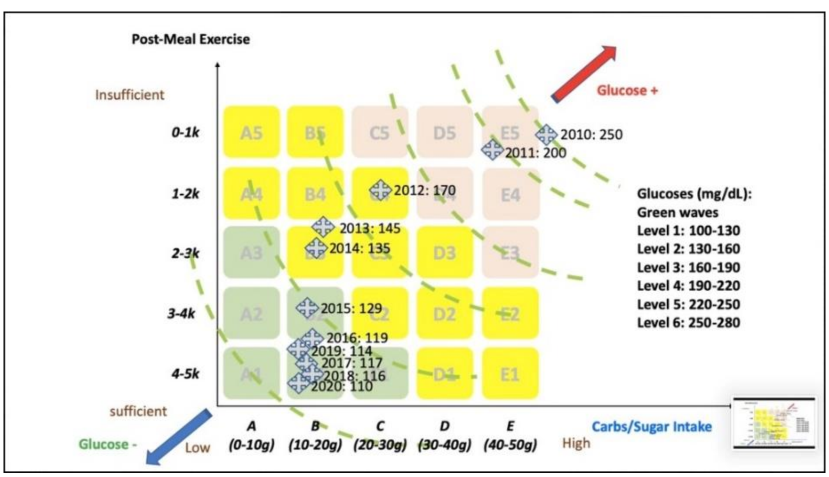


Figure 2: Glucose trend pattern diagram among daily glucoses, carbs/sugar intake amount, and post-meal walking steps in 10 years (2010–2020).

From observing this trend pattern diagram, patients can modify their behavior one step at a time, by taking little steps on a smaller scale. This is what the author defined as a progressive behavior modification.

Results

In figure 1, it shows background data table and line chart of 5 values, daily glucose, FPG, PPG, carbs/sugar intake amount in grams, and post-meal walking step. Since PPG occupies 75% of daily glucose, both daily glucose and PPG move in a similar pattern on this line chart of time-series diagram. The author started with his daily glucose at 250 mg/dL (PPG at 280 mg/dL) in 2010 and moving forward to a lower daily glucose at 129 mg/dL in 2015 (PPG at 130 mg/dL), and finally reached 110 mg/dL in 2020 (PPG at 110 mg/dL). The bottom two curves of "decreasing" carbs/sugar and "increasing" post-meal walking steps demonstrate their significant influences on both of his daily glucose and PPG.

In the early mornings, the author measures his finger FPG once he wakes up. There is no influence from both food and exercise on FPG. From his previous research results, the relationship between his weight and FPG has a high correlation coefficient (> 90%). In 2012, he weighed 220 lbs., then reduced his weight to 183 lbs. in 2013, and subsequently to 175 lbs. in 2015. Correspondingly, his FPG was 160 mg/dL in 2010, 135 mg/dL in 2013, and 124 mg/dL in 2015. It should be mentioned here again that he took 3 different diabetes medication before 2013, gradually reducing his dosages during 2013–2015, and completely ceased taking any medication on 12/8/2015. Obviously, the biological effect of taking medications produce strong influences on controlling glucose symptoms, in terms of the external appearance of diabetes, for both FPG and PPG. However, the most interesting fact is that his FPG levels continue to be reduced from 124 mg/dL in 2015 down to 107 mg/dL in 2020, while maintaining his weight at ~173 lbs. and living a total "medication-free" life. This FPG reduction could be interpreted as the health state of his pancreatic beta cells "self-repairing" between 13–26% over the past 6–8 years at an annual rate of 2.2–3.2% [3].

He decreased his carbs/sugar intake amount from 68 g per meal in 2010 down to 13 g per meal in 2020. During the same 10 year period, he increased his post-meal walking exercise from 400 steps per meal in 2010 up to 4,400 steps per meal in 2020. His glucose improvement in this trend pattern diagram demonstrates what the author has said previously is to control diabetes from the most fundamental core level.

In figure 2, he created a presentation diagram of "radio-wave" glucose format on a 2D planar space. This diagram depicts his "glucose trend pattern analysis" with his lifestyle behavior modifications together. It is not an easy task to reduce one's carbs/sugar intake below 15 g along with maintaining post-meal walking exercise of ~4,300 steps at a frequency of 3 times a day for many years. It takes an extraordinarily strong determination, willpower, and persistence for an individual to maintain this behavior for 8 years. The author has done this task successfully; therefore, he saved his own life from the life-threatening complications of diabetes, including 5 cardiovascular episodes and renal difficulties. In figure 2, we can see clearly that these lifestyle behavior modification efforts finally paid off in the long run. There is nothing better than living a healthier and longer life.

His daily glucoses (gray-colored star symbols in the pseudo z-axis data) starting from the upper right corner of 250 mg/dL at 2010, which moves toward the lower left direction with a ~30 degree downhill slope after acquiring correct knowledge and being persistent with his diet and exercise regimen. Regardless of his medication reduction process during this time frame of 3 years (2013–2015), his daily glucoses are further reduced from 145 mg/dL in 2013 to 129 mg/dL in 2015. During 2015–2019, he has mainly focused on increasing his post-meal walking steps from ~3,300 step to 4,400 steps. As a result, his daily glucoses dropped "straight downward" to the lower left corner of this planar space like a "free-falling" object. Finally, he reached to 110 mg/dL level in 2020 with an average glucose from 1/1/2020–8/6/2020. This case has demonstrated the patient's strong determination, willpower, and persistence along with his continuous struggle with maintaining his levels of diet and exercise over the past 10 years.

The author has written a few papers in 2019 with the subject of comparison and linkage between behavior psychology and diabetes physiology [4–8]. At that time, he considered his research work forward-thinking and foresaw big glucose data being easily collected from T2D patients with the availability of using a continuous glucose monitor (CGM) device [9]. Therefore, in early 2019, he was laying the necessary groundwork for a future endeavor. On 5/5/2018, he applied a CGM sensor device on his arm to collect about 80–96 glucoses per day; however, by March of 2019, he has not yet collected sufficient CGM glucose data that could be utilized in his research purpose. Besides, he has discovered that his sensor glucoses are about 13–17% higher than his finger glucoses. That is the reason he chose to use his finger-piercing measured glucoses during the past 10 years as his background database in this particular study report, which is a long-term effect on his glucose from both diet and exercise.

Conclusion

In summary, his entire glucose moving path is a 30-degree downward angle to the left and then straight downward to the bottom. His annualized average daily glucoses have been reduced from the starting point of 250 mg/dL in 2010 through the "reflection point" of 135 mg/dL in 2014, and then straight down to the ending point of 110 mg/dL in 2020. The triangular relationship among diet, exercise, and daily glucose can be easily observed on this "glucose trend pattern" diagram (Figure 2).

Through analyzing those distinctive daily glucose trend patterns, the personality traits and behavior psychological characteristics of this T2D patient can be revealed instantly and clearly. As a result, a more practical guidance of progressive behavior modification can be provided to other T2D patients to improve their medical conditions for chronic diseases.

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