

The GH-Method

Viscoelastic Medicine Theory (VMT #286): Pathophysiological Explanations of Triglyceride-Glucose Index (TyG) versus Obesity via Body Mass Index (BMI), Inflammation via Hyperglycemia Intensity (HyGI), Insulin Resistance (IR) via Fasting Plasma Glucose (FPG), and Triglycerides (TG) During a Period of 10.5 Years from 1/1/2013 to 7/13/2023, and a Quantitative SD-VMT Energy Analysis of GH-Method: Math-Physical Medicine (No. 886)

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Abstract

The author commenced his research on a specific biomarker called the triglyceride-glucose index (TyG) on December 5, 2020, and has subsequently written and published 14 papers on this subject. His personal interest originates from his own 28-year experience as a type 2 diabetes sufferer. Additionally, between 1995 and 2012, he either endured or were suspected of having non-alcoholic fatty liver disease, during which period his body weight was around 220 lbs (100 kg) with a BMI of 32.5. Recently, the author augmented his biomedical research focus to incorporate the perspectives of pathology and physiology in relation to various metabolic syndromes, alongside his accustomed math-physical medicine research approach. Therefore, in this article, he not only provides a qualitative explanation from a pathophysiological standpoint but also retains his math-physical quantitative outcomes concerning the TyG biomarker's association with obesity, inflammation, insulin resistance, and triglycerides. Drawing upon his data collected over a span of approximately 10.5 years (from January 1, 2013, to July 13, 2023), the author analyzes the impact of four prevailing metabolic conditions – obesity, inflammation, insulin resistance, and triglycerides – on his TyG biomarker. Specifically,

he delves into the qualitative elucidations for these five biomarkers through pathology and physiology of biomedicine, while also endeavoring to establish a quantitative validation using a space-domain viscoplastic energy model to examine the interactions between TyG and the aforementioned four influential factors. In summary, three key findings are as follows: 1. TD analysis indicates a high correlation coefficient of above 80% between the TyG biomarker and these four influential factors. 2. Results from the SD-VMT energy model have demonstrate that inflammation, through HyGI, and insulin resistance, through FPG, have the highest energy levels at 28% each, surpassing obesity via BMI at 26%. Triglycerides (TG) exhibit the lowest energy level at 17%. This suggests a strong connection between the TyG biomarker and both inflammation and insulin resistance. 3. Time-zone analysis reveals that 61% of the total energy is concentrated in the Y13-Y16 period, characterized by higher fluctuation values (indicative of unhealthiness). But only 7% of the energy is concentrated in the Y17-Y19 period (indicative of healthiness), while 32% of the energy is concentrated during the recent COVID period in Y20-Y23 (only half of Y13-Y16).

Keywords: Viscoelastic; Viscoplastic; Triglycerides; Obesity; Body mass index; Hyperglycemia; Insulin resistance

Abbreviations: TyG: triglyceride-glucose index; BMI: body mass index; IR: insulin resistance; MI: metabolism index; T2D: type 2 diabetes; PPG: postprandial plasma glucose; FPG: fasting plasma glucose

1. INTRODUCTION

The author initiated research on neurology in October 2019 and published his first paper on this subject as Paper No. 130. The current article, Paper No. 885 (VMT#285), written on 7/12/2023, serves as an updated version of his previous paper, Paper No. 864 (VMT#265), written on 6/12/2023. The analysis in both papers, utilizing the SD-VMT energy model, exhibits a high level of similarity, with a distinction being the selected time period differing by one month.

Recently, he has shifted his focus towards studying the pathology and physiology of the neural communication system. Therefore, in this article (No. 885), he provides more extensive explanations of the pathophysiological aspects pertaining to neurological communication between the brain and organs.

To investigate the communication between brain and stomach, he has conducted personal experiments involving egg-based meals. These experiments place emphasis on the message transmission related to food arrival and food type, with various instructions from the brain regarding glucose production by the liver and insulin hormone production by pancreatic beta cells. Over an 8-year span, from 5/1/2015 to 7/11/2023, he has examined neurological and pathophysiological behaviors by consuming a total of 632 egg-only meals and 2,183 all egg-based meals (often mixed with vegetables).

1.1 Pathophysiological interpretation

The TyG index, or Triglyceride-glucose index, is an emerging marker used to evaluate insulin resistance. It is calculated based on fasting levels of triglycerides (TG) and glucose, using the formula:

$$\text{TyG} = \ln[\text{fasting triglycerides (mg/dL)} \times \text{fasting glucose (mg/dL)} / 2]$$

Several studies have suggested a strong relationship between the TyG index and various metabolic and cardiovascular conditions, including obesity, inflammation, and insulin resistance. Now let's go through these complex pathophysiological relationships between the TyG index and

obesity, inflammation, insulin resistance, and triglycerides:

1. TyG and obesity: Obesity is typically associated with a state of insulin resistance. The adipose tissue in individuals with obesity tends to have an increased release of free fatty acids, which can lead to increased production of glucose and triglycerides, hence the elevation of the TyG index. Furthermore, obesity-associated inflammation can impair insulin signaling, leading to both insulin resistance and hyperinsulinemia. Therefore, a higher TyG index is often seen in people with obesity. Let us explain above statement deeper and more. The relationship between the TyG index and obesity is complex and multifaceted. Obesity, particularly visceral obesity, is associated with an increased amount of adipose tissue. This adipose tissue can secrete a variety of substances known as adipocytokines (like leptin and adiponectin), which can influence glucose and lipid metabolism. In obesity, there is a state of adipocytokine imbalance, often with increased leptin and reduced adiponectin, leading to insulin resistance. Furthermore, the excessive adipose tissue can cause an over-release of free fatty acids into the bloodstream, which get taken up by the liver and contribute to the production of triglycerides, thus increasing the TyG index. In this article, the author uses his body mass index (BMI) = weight / (height * height, to represent his obesity condition.

2. TyG and inflammation: Chronic inflammation is a key component of metabolic syndrome, and this can be triggered by obesity and insulin resistance. Inflammatory cytokines can disrupt the normal functioning of insulin, leading to insulin resistance. Also, inflammation can stimulate the production of triglycerides, contributing to a higher TyG index. Let us explain above statement deeper and more. Chronic inflammation, often present in obesity, plays a significant role in the pathogenesis of insulin resistance. The inflammation induces the production of several pro-inflammatory cytokines (such as TNF-alpha, IL-6), which can impair insulin signaling. This disturbance of the insulin pathway results in less glucose being taken up by cells and more remaining in the blood, thereby contributing to a higher TyG index. Also, inflammation can trigger the release of

stress hormones that promote lipolysis, the breakdown of fats leading to increased triglycerides, further raising the TyG index. In this article, the author uses his hypoglycemia intensity (HyGI) = averaged hyperglycemia (>180 mg/dL) * frequency % of hyperglycemia happening occurrence, to represent his inflammation condition.

3. TyG and insulin resistance: The TyG index has been found to be a reliable marker of insulin resistance. Insulin resistance is a state in which cells fail to respond normally to insulin, leading to elevated blood glucose levels. Over time, the pancreas beta cells produces more insulin to compensate, leading to hyperinsulinemia. This can promote the synthesis of triglycerides, raising both the components used to calculate the TyG index. Triglycerides are a type of fat (lipid) found in your blood. When you eat, your body converts any calories it doesn't need to use right away into triglycerides, which are stored in fat cells. High triglyceride levels could be an indicator of a condition that increases the risk of heart disease, including obesity and metabolic syndrome, both of which can be related to insulin resistance (IR). The triglycerides themselves form part of the TyG index, and so an increase would result in a higher TyG score. Let us explain above statement deeper and more. Insulin resistance (IR) is a central component in the relationship between the TyG index and metabolic disorders. When cells become resistant to the effects of insulin, the hormone can no longer effectively regulate glucose and lipid metabolism. The body compensates by producing more insulin, which can exacerbate the situation by increasing triglyceride synthesis in the liver. This scenario results in both higher glucose and triglyceride levels - the two factors used to calculate the TyG index, thereby leading to an increased index. Fasting plasma glucose in early morning (FPG) is one of the best and a convenient biomarker indicating a person's health state of pancreatic beta cells since FPG is not under the influences from both food and exercise. In this article, the author uses his fasting plasma glucose in early morning (FPG) to represent his insulin resistance condition.

4. TyG and triglycerides: Triglycerides (TG) are a type of fat (i.e. lipid) found in our blood. When we eat, our body converts any calories it doesn't need to use right away into

triglycerides, which are stored in our fat cells. High triglyceride levels could be an indicator of a condition that increases the risk of heart disease, including obesity and metabolic syndrome, both of which can be related to insulin resistance. The triglycerides themselves form part of the TyG index, and so an increase of TG would result in a higher TyG score. Let us explain above statement deeper and more. The relationship between TyG and triglycerides (TH) is direct, given that triglycerides are part of the calculation for the TyG index. When insulin resistance occurs, it can disrupt the normal metabolic processes, leading to hypertriglyceridemia. High levels of circulating triglycerides indicate the presence of excessive very low-density lipoproteins (VLDL), a type of lipoprotein produced by the liver when there is excessive free fatty acid influx, often secondary to insulin resistance.

This particular article:

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Recently, the author augmented his biomedical research focus to incorporate the perspectives of pathology and physiology in relation to various metabolic syndromes, alongside his accustomed math-physical medicine research approach. Therefore, in this article, he not only provides a qualitative explanation from a pathophysiological standpoint but also retains his math-physical quantitative outcomes concerning the TyG biomarker's association with obesity, inflammation, insulin resistance, and triglycerides.

Drawing upon his data collected over a span of approximately 10.5 years (from January 1, 2013, to July 13, 2023), the author analyzes the impact of four prevailing metabolic conditions – obesity, inflammation, insulin resistance, and triglycerides – on his TyG biomarker. Specifically, he delves into the

qualitative elucidations for these five biomarkers through pathology and physiology of biomedicine, while also endeavoring to establish a quantitative validation using a space-domain viscoplastic energy model to examine the interactions between TyG and the aforementioned four influential factors.

| Condition | Cut-off value | Values below cut-off | Values above cut-off |
|----------------------------------|---------------|-----------------------------|----------------------------------|
| Insulin resistance | 4.49 | Insulin resistance unlikely | Suggestive of insulin resistance |
| Nonalcoholic fatty liver disease | 8.5 | NAFLD diagnosis is unlikely | High likelihood of NAFLD |

2. METHODS

2.1 MPM background

To learn more about his developed GH-Method: math-physical medicine (MPM) methodology, readers can read the following three papers selected from his published 760+ papers.

The first paper, No. 386 describes his MPM methodology in a general conceptual format. The second paper, No. 387 outlines the history of his personalized diabetes research, various application tools, and the differences between the biochemical medicine (BCM) approach versus the MPM approach. The third paper, No. 397 depicts a general flow diagram containing ~10 key MPM research methods and different tools.

2.2 The author's diabetes history

The author was a severe T2D patient since 1995. He weighed 220 lb. (100 kg) at that time. By 2010, he still weighed 198 lb. with average daily glucose of 250 mg/dL (HbA1C at 10%). During that year, his triglycerides reached 1161 (high risk for CVD and stroke) and his albumin-creatinine ratio (ACR) at 116 (high risk for chronic kidney disease). He also suffered from five cardiac episodes within a decade. In 2010, three independent physicians warned him regarding the need for kidney dialysis treatment and the future high risk of dying from his severe diabetic complications.

In 2010, he decided to self-study endocrinology with an emphasis on diabetes and food nutrition. He spent the entire year

of 2014 developing a metabolism index (MI) mathematical model. During 2015 and 2016, he developed four mathematical prediction models related to diabetes conditions: weight, PPG, fasting plasma glucose (FPG), and HbA1C (A1C). Through using his developed mathematical metabolism index (MI) model and the other four glucose prediction tools, by the end of 2016, his weight was reduced from 220 lb. (100 kg) to 176 lb. (89 kg), waistline from 44 inches (112 cm) to 33 inches (84 cm), average finger-piercing glucose from 250 mg/dL to 120 mg/dL, and A1C from 10% to ~6.5%. One of his major accomplishments is that he has no longer taken any diabetes-related medications since 12/8/2015.

In 2017, he achieved excellent results on all fronts, especially his glucose control. However, during the pre-COVID period, including both 2018 and 2019, he traveled to ~50 international cities to attend 65+ medical conferences and made ~120 oral presentations. This hectic schedule inflicted damage to his diabetes control caused by stress, dining out frequently, post-meal exercise disruption, and jet lag, along with the overall negative metabolic impact from the irregular life patterns; therefore, his glucose control was somewhat affected during the two-year traveling period of 2018-2019.

He started his COVID-19 self-quarantined life on 1/19/2020. By 10/16/2022, his weight was further reduced to ~164 lb. (BMI 24.22) and his A1C was at 6.0% without any medication intervention or insulin injection. In fact, with the special COVID-19 quarantine lifestyle since early 2020, not only has he written and published ~500 new research articles in various medical and engineering journals, but he has also achieved his best health conditions for the past 27 years. These achievements have resulted from his non-traveling, low-stress, and regular daily life routines. Of course, his in-depth knowledge of chronic diseases, sufficient practical lifestyle management experiences, and his developed high-tech tools have also contributed to his excellent health improvements.

On 5/5/2018, he applied a continuous glucose monitoring (CGM) sensor device on his upper arm and checks his glucose measurements every 5 minutes for a total of 288 times each day. Furthermore, he extracted the 5-minute

intervals from every 15-minute interval for a total of 96 glucose data each day stored in his computer software.

Through the author's medical research work of over 40,000 hours and reading over 4,000 published medical papers online in the past 13 years, he discovered and became convinced that good life habits of not smoking, moderate or no alcohol intake, avoiding illicit drugs; along with eating the right food with well-balanced nutrition, persistent exercise, having a sufficient and good quality of sleep, reducing all kinds of unnecessary stress, maintaining a regular daily life routine contribute to the risk reduction of having many diseases, including CVD, stroke, kidney problems, micro blood vessels issues, peripheral nervous system problems, and even cancers and dementia. In addition, a long-term healthy lifestyle can even "repair" some damaged internal organs, with different required time-length depending on the particular organ's cell lifespan. For example, he has "self-repaired" about 35% of his damaged pancreatic beta cells during the past 10 years.

2.3 Energy theory

The human body and organs have around 37 trillion live cells which are composed of different organic cells that require energy infusion from glucose carried by red blood cells, and energy consumption from labor-work or exercise. When the residual energy (resulting from the plastic glucose scenario) is stored inside our bodies, it will cause different degrees of damage or influence to many of our internal organs.

According to physics, energies associated with the glucose waves are proportional to the square of the glucose amplitude. The residual energies from elevated glucoses are circulating inside the body via blood vessels which then impact all of the internal organs to cause different degrees of damage or influence, e.g. diabetic complications. Elevated glucose (hyperglycemia) causes damage to the structural integrity of blood vessels. When it combines with both hypertension (rupture of arteries) and hyperlipidemia (blockage of arteries), CVD or Stroke happens. Similarly, many other deadly diseases could result from these excessive energies which would finally shorten our lifespan. For example, the

combination of hyperglycemia and hypertension would cause micro-blood vessel leakage in kidney systems which is one of the major causes of CKD.

The author then applied Fast Fourier Transform (FFT) operations to convert the input wave from a time domain into a frequency domain. The y-axis amplitude values in the frequency domain indicate the proportional energy levels associated with each different frequency component of input occurrence. Both output symptom value (i.e. strain amplitude in the time domain) and output symptom fluctuation rate (i.e. the strain rate and strain frequency) are influencing the energy level (i.e. the Y-amplitude in the frequency domain).

Many people live a sedentary lifestyle and lack sufficient exercise to burn off the energy influx which causes them to become overweight or obese. Being overweight and having obesity leads to a variety of chronic diseases, particularly diabetes. In addition, many types of processed food add unnecessary ingredients and harmful chemicals that are toxic to the bodies, which lead to the development of many other deadly diseases, such as cancers. For example, ~85% of worldwide diabetes patients are overweight, and ~75% of patients with cardiac illnesses or surgeries have diabetes conditions.

In engineering analysis, when the load is applied to the structure, it bends or twists, i.e. deforms; however, when the load is removed, it will either be restored to its original shape (i.e. elastic case) or remain in a deformed shape (i.e. plastic case). In a biomedical system, the glucose level will increase after eating carbohydrates or sugar from food; therefore, carbohydrates and sugar function as the energy supply. After having labor work or exercise, the glucose level will decrease. As a result, the exercise burns off the energy, which is similar to load removal in the engineering case. In the biomedical case, both energy influx and dissipation processes take some time, which is not as simple and quick as the structural load removal in the engineering case. Therefore, the age difference and 3 input behaviors are "dynamic" in nature, i.e. time-dependent. This time-dependent nature leads to a "viscoelastic or viscoplastic" situation. For the author's case, it is "viscoplastic" since

most of his biomarkers are continuously improved during the past 13-year time window.

2.4 Time-dependent output strain and stress of (viscous input*output rate)

Hooke’s law of linear elasticity is expressed as:

Strain (ϵ : epsilon)
 = Stress (σ : sigma) / Young’s modulus (E)

For biomedical glucose application, his developed linear elastic glucose theory (LEGT) is expressed as:

PPG (strain)
 = carbs/sugar (stress) * GH.p-Modulus (a positive number) + post-meal walking k-steps * GH.w-Modulus (a negative number)

Where GH.p-Modulus is the reciprocal of Young’s modulus E.

However, in viscoelasticity or viscoplasticity theory, the stress is expressed as:

Stress
 = viscosity factor (η : eta) * strain rate (d ϵ /dt)

Where strain is expressed as Greek epsilon or ϵ .

In this article, to construct an “ellipse-like” diagram in a stress-strain space domain (e.g. “hysteresis loop”) covering both the positive side and negative side of space, he has modified the definition of strain as follows:

Strain
 = (body weight at a certain specific time instant)

He also calculates his strain rate using the following formula:

Strain rate
 = (body weight at next time instant) - (body weight at present time instant)

The risk probability % of developing into CVD, CKD, and Cancer is calculated based on his developed metabolism index model (MI) in 2014. His MI value is calculated using inputs of 4 chronic conditions, i.e. weight, glucose, blood pressure, and lipids; and 6 lifestyle details, i.e. diet, drinking water,

exercise, sleep, stress, and daily routines. These 10 metabolism categories further contain ~500 elements with millions of input data collected and processed since 2010. For individual deadly disease risk probability %, his mathematical model contains certain specific weighting factors for simulating certain risk percentages associated with different deadly diseases, such as metabolic disorder-induced CVD, stroke, kidney failure, cancers, dementia; artery damage in heart and brain, micro-vessel damage in kidney, and immunity-related infectious diseases, such as COVID death.

Some of explored deadly diseases and longevity characteristics using the viscoplastic medicine theory (VMT) include stress relaxation, creep, hysteresis loop, and material stiffness, damping effect based on time-dependent stress and strain which are different from his previous research findings using linear elastic glucose theory (LEGT) and nonlinear plastic glucose theory (NPGT).

Note: For a more detailed description, please refer to the “consolidated method” section which is given at the beginning of the special issue.

3. RESULTS

Figure 1 shows the data table, TD, and SD-VMT analysis results.

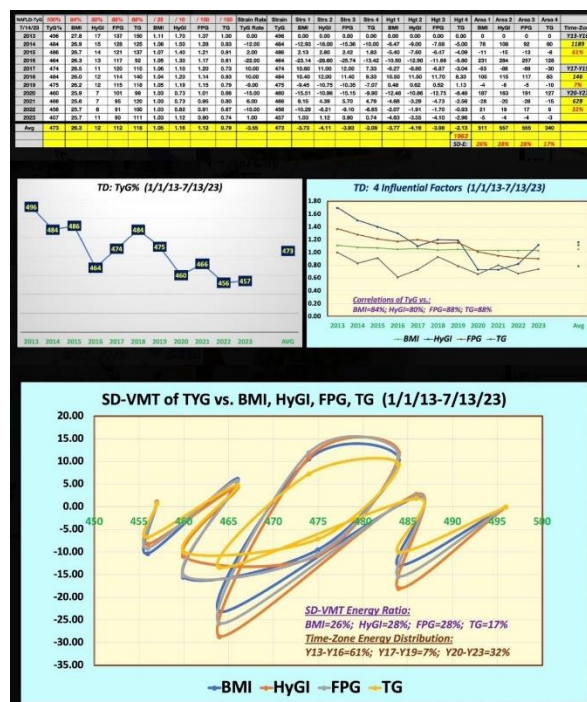


Figure 1: Two data tables, TD, and SD-VMT analysis results.

4. CONCLUSION

In summary, three key findings are as follows:

1. TD analysis indicates a high correlation coefficient of above 80% between the TyG biomarker and these four influential factors.
2. Results from the SD-VMT energy model have demonstrate that inflammation, through HyGI, and insulin resistance, through FPG, have the highest energy levels at 28% each, surpassing obesity via BMI at 26%. Triglycerides (TG) exhibit the lowest energy level at 17%. This suggests a strong connection between the TyG biomarker and both inflammation and insulin resistance.
3. Time-zone analysis reveals that 61% of the total energy is concentrated in the Y13-Y16 period, characterized by higher fluctuation values (indicative of unhealthiness). But only 7% of the energy is concentrated in the Y17-Y19 period (indicative of healthiness), while 32% of the energy is concentrated during the recent COVID period in Y20-Y23 (only half of Y13-Y16).

5. REFERENCES

For editing purposes, the majority of the references in this paper, which are self-references, have been removed. Only references from other authors' published sources remain. The bibliography of the author's original self-references can be viewed at www.eclairemd.com.

Readers may use this article as long as the work is properly cited, their use is educational and not for profit, and the author's original work is not altered.

For reading more of the author's published VGT or FD analysis results on medical applications, please locate them through three published special editions from the following three specific journals:

- (1) Special Issue. The GH-Method. (<https://www.theghmethod.com>).
- (2) Journal of Applied Material Science & Engineering Research (contact: Catherine).
- (3) Advances in Bioengineering and Biomedical Science Research (contact: Sony Hazi).

Viscoelastic and Viscoplastic Glucose Theory Application in Medicine

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