

The GH-Method

Viscoelastic or Viscoplastic Glucose Theory (VGT #111): Using Time-Domain Statistical Correlation Analysis and Space-Domain VGT Analysis to Study the Influence of Sleep Hours on Body Weight and Fasting Plasma Glucose of a Type 2 Diabetes Patient's Data Collected Over 7.5 Years from 1/1/2015 to 7/12/2022 Based on GH-Method: Math-Physical Medicine (No. 701)

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Keywords: Viscoelastic; Viscoplastic; Sleep hours; Body weight; Carbohydrates; Sugar; Postprandial plasma glucose; Fasting plasma glucose; Type 2 diabetes

Abbreviations: T2D: type 2 diabetes; PPG: postprandial plasma glucose; FPG: fasting plasma glucose; SD: space domain; TD: time domain; MPM: math-physical medicine

1. INTRODUCTION

The purpose of this article is to demonstrate the result differences between using the traditional statistics correlation coefficient method and the math-physics VGT method for biomedical research work. The findings will present the pros and cons of each method along with their subtle distinctions.

Utilizing the author's collected and processed 3+ million personal health data over 13 years, the study investigates the close relationship of two outputs of body weight (BW) and fasting plasma glucose (FPG) versus total sleeping hours (SH) at night. The data covers from 1/1/2015, the starting date of accumulating his sleep data, to 7/12/2022, when he prepared the graphs. The statistical correlation study used 3 types of data: monthly, quarterly, and annually. However, the VGT analysis only demonstrated his 7.5-year annual data results due to concerns about VGT's operational complexity. Once the developed new VGT module is available on the APP, he can then conduct his complex VGT analysis work rapidly.

The two VGT outputs, BW and FPG, have gone through a "normalization process" by dividing BW by 170 lbs. and FPG by 120 mg/dL. The two values are the dividing line between healthy and unhealthy. It should be pointed out that, in this study, he has chosen to normalize two outputs or symptoms with the intent to compare BW and FPG resulting from the same input of SH.

Using the "normalization process", he can remove the dependency of the individual unit or certain unique characteristics associated with each viscosity factor.

The author is an engineer who has conducted medical research work over the past 13 years in the fields of endocrinology, metabolic disorder-induced chronic diseases (especially diabetes), and their resulting various medical complications. Thus far, he has written 700 papers and published 650+ papers in various medical journals using math-physical medicine methodology (MPM).

Beginning with paper No. 578 dated 1/8/2022, he has written 107 medical papers and 4 economics papers using viscoelasticity and viscoplasticity theories (VGT) tools from

physics and engineering disciplines. These papers aim to explore some hidden physical behaviors and provide a deeper quantitative understanding of the inter-relationships of a selected biomarker output (symptom) versus singular input or multiple biomarker inputs (root causes, risk factors, or influential factors). For this study, he used two case studies with single output versus single inputs.

In the field of medical research, the hidden biophysical behaviors and possible inter-relationships exist among lifestyle details, medical conditions, chronic diseases, and certain medical complications, such as heart attacks, stroke, kidney failure, cancers, dementia, and even longevity concerns. He has noticed that most medical subjects with their associated data, multiple symptoms, and influential factors are “time-dependent” which means that all biomedical variables change from time to time because body living cells are organic and dynamically changing. This is what Professor Norman Jones, the author’s adviser at MIT, suggested to him in December of 2021 and why he utilizes the VGT tools from physics and engineering to conduct his medical research work since then.

The established engineering theory of viscoelasticity and viscoplasticity should not only be limited to the scope of engineering applications. Its ability to link certain time-dependent variables and their physical characteristics and associated energy estimation via the hysteresis loop area is equally powerful for applications in many other research fields, such as economics, psychology, social science, etc. Of course, one of the major challenges of VGT analysis is always related to data mining, selection, and preparation.

Paper No. 701 discusses the inter-relationship findings regarding his body weights in the early morning and FPG levels in the early morning related to his sleep hours at night. After having a restful and sufficient amount of sleep at night, his weight and FPG level would decrease, except the reduced rates and scales are different. The varying biomarker reduction rates between BW and FPG have caused different hysteresis loop areas which indicate various degrees of influence from SH.

The author will describe in plain English the 6 steps of the VGT method, instead of using mathematical equations to explain it. This description is aimed at readers who do not have an extensive background in the academic fields of engineering, physics & mathematics - several excerpts from Wikipedia are included in the Method section of this full-text article.

The first step is to collect the output data or symptom (strain or ϵ) on a time scale. The second step is to calculate the output change rate with time ($d\epsilon/dt$), i.e. the change rate of strain or symptom over each period. The third step is to gather the input data or cause (viscosity or η) on a time scale. The fourth step is to calculate the time-dependent input or cause (time-dependent stress or σ) by multiplying $d\epsilon/dt$ and η together. The “time-dependent input or cause equation” of “stress $\sigma = \text{strain change rate of } d\epsilon/dt * \text{viscosity } \eta$ ” is the essential part of “time-dependency”. The fifth step is to plot the input-output (i.e. stress-strain or cause-symptom) curve in a 2-dimensional space domain or SD (x-axis versus y-axis) with strain (output or symptom) on the x-axis and stresses (time-dependent inputs, causes, or stresses) on the y-axis. The sixth step is to calculate the total enclosed area within these stress-strain curves or input-output curves (i.e. the hysteresis loops) using the trapezoid formula, which is also an indicator of associated energies or degrees of influences of input on output (either created energy or dissipated energy through this process of input and output).

After providing the above 6-step description, the author applies the following set of VGT stress-strain mathematical equations in a 2-dimensional SD to address the unique “time-dependency characteristics” of selected medical variables:

Strain

= ϵ

= individual strain value at the present time duration

Stress

= σ (based on the change rate of strain multiplying with a chosen viscosity factor η)

= $\eta * (d\epsilon/dt)$

= $\eta * (d\text{-strain}/d\text{-time})$

= (viscosity factor η using individual viscosity factor at present time duration) * (strain at

present quarter - strain at previous time duration)

Some of these inputs (causes or viscosity factors) are further normalized by dividing them by the average number of viscosity or a certain established health standard, such as 120 mg/dL for glucose, and 25.0 for body mass index (BMI). In the author's case, his BW at 170 lbs. and 25.0 BMI as different "break-even" levels of biomedical conditions. If using the originally collected data, i.e. the non-normalized data would distort the numerical comparison of the hysteresis loop areas. Using this "normalization process", he can remove the dependency of the individual unit or certain unique characteristics associated with each viscosity factor. This process allows him to convert the originally collected variables into a set of "dimensionless variables" for easier numerical comparison and result interpretation.

The organization of this article has three parts. The first part is the statistical correlation studies from various time windows for BW versus SH which validates his concerns about using the statistics method. The second part is the VGT studies of BW versus SH and FPG versus SH which explains different time-period contributions of the degree of influence from SH on BW and FPG. The third part is the comparison between lower FPG level (output) resulting from more SH (input), and less SH (output) associated with higher FPG level (input) which investigates two possible scenarios of SH influencing FPG or FPG influencing SH.

1.1 Specific medical information

The author's case of diabetes and obesity

The author has been a severe T2D patient since 1996. He weighed 220 lb. (100 kg, BMI 32.5) at that time. By 2010, he still weighed 198 lb. (BMI 29.2) with average daily glucose of 250 mg/dL (HbA1C of 10%). During that year, his triglycerides reached 1161 and his albumin-creatinine ratio (ACR) at 116. He also suffered from five cardiac episodes within a decade. In 2010, three independent physicians warned him regarding his need for kidney dialysis treatment and his future high risk of dying from his severe diabetic complications. Other than the cerebrovascular disease (stroke), he has suffered most of the known diabetic

complications, including both macro-vascular and micro-vascular complications.

In 2010, he decided to launch his self-study on endocrinology, diabetes, and food nutrition to save his own life. During 2015 and 2016, he developed four prediction models related to diabetes conditions: weight, PPG, fasting plasma glucose (FPG), and A1C. As a result, from using his developed mathematical metabolism index (MI) model in 2014 and the four prediction tools, by end of 2016, his weight was reduced from 220 lbs. (100 kg, BMI 32.5) to 176 lbs. (89 kg, BMI 26.0), waistline from 44 inches (112 cm) to 33 inches (84 cm), average finger glucose reading from 250 mg/dL to 120 mg/dL, and lab-tested A1C from 10% to ~6.5%. One of his major accomplishments is that he no longer takes any diabetes medications as of 12/8/2015.

In 2017, he has achieved excellent results on all fronts, especially glucose control. However, during the pre-COVID period of 2018 and 2019, he traveled to approximately 50+ international cities to attend 65+ medical conferences and made ~120 oral presentations. This hectic schedule inflicted damage to his diabetes control, through dining out frequently, post-meal exercise disruption, jet lag, and along with the overall metabolic impact due to his irregular life patterns through a busy travel schedule; therefore, his glucose control and overall metabolism state were somewhat affected during this two-year heavier traveling period.

Since 2020, living in a COVID-19 quarantined lifestyle, not only has he published 400+ medical papers in 100+ journals, but he has also reached his best health conditions in the past 26 years. By the beginning of 2022, his weight was further reduced to 168 lbs. (BMI 24.8) along with a 5.8% A1C value (beginning level of pre-diabetes), without having any medication interventions or insulin injections. These good results are due to his non-traveling, low-stress, and regular daily life routines. Of course, his knowledge of chronic diseases, practical lifestyle management experiences, and the development of various high-tech tools contribute to his excellent health status since 1/19/2020, the beginning date of his self-quarantined life.

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. He has maintained the same measurement pattern to the present day. In his research work, he uses his CGM sensor glucose at a time interval of 15 minutes (96 data per day). Incidentally, the difference in average sensor glucoses between 5-minute intervals and 15-minute intervals is only 0.7% (average glucose of 112.15 mg/dL for 5 minutes and average glucose of 111.33 mg/dL for 15 minutes with a correlation of 96% between these two sensor glucose curves) during the period from 2/19/20 to 5/9/22.

Therefore, over the past 13 years, he could study and analyze the collected ~3 million data regarding his health status, medical conditions, and lifestyle details. He applies his knowledge, models, and tools from mathematics, physics, engineering, and computer science to conduct his medical research work. His research is based on the aim of achieving both “high precision” with “quantitative proof” in the medical findings.

The following timetable provides a rough sketch of the emphasis in his medical research during each stage:

2000-2013: Self-study diabetes and food nutrition, developing a data collection and analysis software.

2014: Develop a mathematical model of metabolism, using engineering modeling and advanced mathematics.

2015: Weight & FPG prediction models, using neuroscience.

2016: PPG & HbA1C prediction models, using optical physics, artificial intelligence (AI), and neuroscience.

2017: Complications due to macro-vascular research, such as cardiovascular disease (CVD), coronary heart diseases (CHD), and stroke, using pattern analysis and segmentation analysis.

2018: Complications due to micro-vascular research such as kidney (CKD), bladder, foot, and eye issues (DR).

2019: CGM big data analysis, using wave theory, energy theory, frequency domain analysis, quantum mechanics, and AI.

2020: Cancer, dementia, longevity, geriatrics, DR, hypothyroidism, diabetic foot, diabetic fungal infection, and linkage between metabolism and immunity, learning about certain infectious diseases, such as COVID-19.

2021: Applications of linear elastic glucose theory (LEGT) and perturbation theory from quantum mechanics on medical research subjects, such as chronic diseases and their complications, cancer, and dementia.

2022: Applications of viscoelastic/viscoplastic glucose theory (LEGT) on 92 biomedical research cases and 4 economics research cases.

Again, to date, he has spent around 40,000 hours self-studying and researching medicine. He has collected and calculated more than three million pieces of data regarding his medical conditions and lifestyle details. In addition, he has written nearly 700 medical research notes and published 600+ papers in 100+ various medical and engineering journals. Moreover, he has also given ~120 presentations at ~65 international medical conferences. He has continuously dedicated his time (11-12 hours per day and work each day of a year, without rest) and efforts to his medical research work and shared his findings and learnings with other patients worldwide.

2. METHODS

2.1 MPM background

To learn more about his developed GH-Method: math-physical medicine or MPM methodology, readers can select the following three articles from the 400+ published medical 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.

All of the listed papers in the Reference section are his written and published medical research papers.

2.2 Elasticity, plasticity, viscoelasticity, and viscoplasticity (LEGT & VGT)

The difference between elastic materials and viscoelastic materials (from “Soborthans, innovating shock and vibration solutions”).

What are elastic materials?

Elasticity is the tendency of solid materials to return to their original shape after forces are applied on them. When the forces are removed, the object will return to its initial shape and size if the material is elastic.

Medical analogy: The medical application is when cause or risk factors are reduced or removed, the symptoms of certain disease would be improved or ceased.

What are viscous materials?

Viscosity is a measure of a fluid’s resistance to flow. A fluid with large viscosity resists motion. A fluid with low viscosity flows. For example, water flows more easily than syrup because it has a lower viscosity. High viscosity materials might include honey, syrups, or gels – generally things that resist flow. Water is a low viscosity material, as it flows readily. Viscous materials are thick or sticky or adhesive. Since heating reduces viscosity, these materials don’t flow easily. For example, warm syrup flows more easily than cold.

What is viscoelastic?

Viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Synthetic polymers, wood, and human tissue, as well as metals at high temperature, display significant viscoelastic effects. In some applications, even a small viscoelastic response can be significant.

Medical analogy: Viscoelastic behavior means material has “time-dependent” characters. Biomedical data, i.e. biomarkers,

are time-dependent due to body cells are organic which changes with time constantly.

Elastic behavior versus viscoelastic behavior

The difference between elastic materials and viscoelastic materials is that viscoelastic materials have a viscosity factor and the elastic ones don’t. Because viscoelastic materials have the viscosity factor, they have a strain rate dependent on time. Purely elastic materials do not dissipate energy (heat) when a load is applied, then removed; however, a viscoelastic substance does.

Medical analogy: Most of the biomarkers display time-dependency; therefore, they have both change-rate of time and viscosity factor behaviors. Viscoelastic biomarkers do dissipate energy when a causing force is applied to them.

The following brief introductions are excerpts from Wikipedia:

“Elasticity (physics):

The physical property is when materials or objects return to their original shape after deformation.

In physics and materials science, elasticity is the ability of a body to resist a distorting influence and to return to its original size and shape when that influence or force is removed. Solid objects will deform when adequate loads are applied to them; if the material is elastic, the object will return to its initial shape and size after removal. This is in contrast to plasticity, in which the object fails to do so and instead remains in its deformed state.

Hooke's law states that the force required to deform elastic objects should be directly proportional to the distance of deformation, regardless of how large that distance becomes. This is known as perfect elasticity, in which a given object will return to its original shape no matter how strongly it is deformed. This is an ideal concept only; most materials that possess elasticity in practice remain purely elastic only up to very small deformations, after which plastic (permanent) deformation occurs.

In engineering, the elasticity of a material is quantified by the elastic modulus such as the

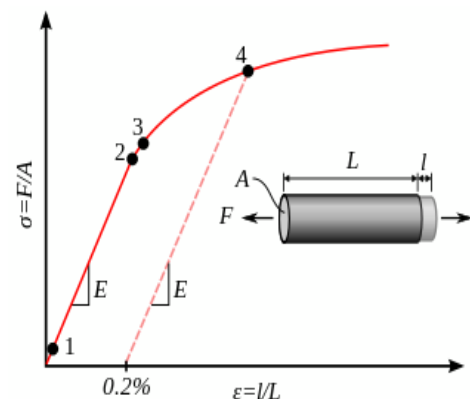
Young's modulus, bulk modulus or shear modulus which measure the amount of stress needed to achieve a unit of strain; a higher modulus indicates that the material is harder to deform. The material's elastic limit or yield strength is the maximum stress that can arise before the onset of plastic deformation.

Medical analogy: The elastic behavior analogy in medicine can be expressed by the metal rod analogy for the postprandial plasma glucose (PPG). Consuming carbohydrates and/or sugar acts like a tensile force to stretch a metal rod longer, while post-meal exercise acts like a compressive force to suppress a metal rod shorter. If lacking food consumption and exercise, the metal rod (analogy of PPG) will remain its original length, for a non-diabetes or less severe type 2 diabetes (T2D) patient.

Plasticity (physics):

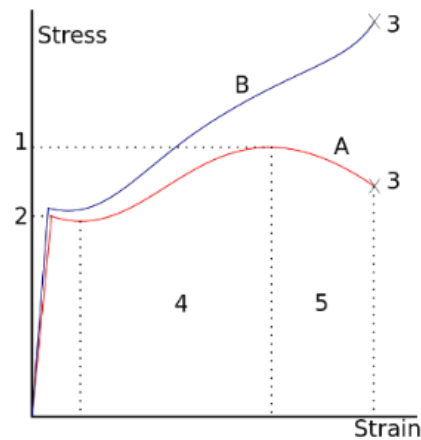
Deformation of a solid material undergoing non-reversible changes of shape in response to applied forces.

In physics and materials science, plasticity, also known as plastic deformation, is the ability of a solid material to undergo permanent deformation, a non-reversible change of shape in response to applied forces. For example, a solid piece of metal being bent or pounded into a new shape displays plasticity as permanent changes occur within the material itself. In engineering, the transition from elastic behavior to plastic behavior is known as yielding. Plastic deformation is observed in most materials, particularly metals, soils, rocks, concrete, and foams.



A stress-strain curve showing typical yield behavior for nonferrous alloys.

1. True elastic limit
2. Proportionality limit
3. Elastic limit
4. Offset yield strength



A stress-strain is typical of structural steel.

- 1: Ultimate strength
- 2: Yield strength (yield point)
- 3: Rupture
- 4: Strain hardening region
- 5: Necking region
- A: Apparent stress (F/A)
- B: Actual stress (F/A)

For many ductile metals, tensile loading applied to a sample will cause it to behave in an elastic manner. Each increment of load is accompanied by a proportional increment in extension. When the load is removed, the piece returns to its original size. However, once the load exceeds a threshold – the yield strength – the extension increases more rapidly than in the elastic region; now when the load is removed, some degree of the extension will remain.

Medical analogy: A plastic behavior analogy in medicine is the PPG level of a severe T2D patient. Even consuming a smaller amount of carbs/sugar, the patient's PPG will rise sharply which cannot be totally brought down to a healthy PPG level even with a significant amount of exercise. This means the PPG level has exceeded its "elastic limit" and entering into a "plastic range".

Viscoelasticity:

Property of materials with both viscous and elastic characteristics under deformation.

In materials science and continuum mechanics, viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Viscous materials, like water, resist shear flow and strain linearly with time when a stress is applied. Elastic materials strain when stretched and immediately return to their original state once the stress is removed.

Viscoelastic materials have elements of both of these properties and, as such, exhibit time-dependent strain. Whereas elasticity is usually the result of bond stretching along crystallographic planes in an ordered solid, viscosity is the result of the diffusion of atoms or molecules inside an amorphous material.

In the nineteenth century, physicists such as Maxwell, Boltzmann, and Kelvin researched and experimented with creep and recovery of glasses, metals, and rubbers. Viscoelasticity was further examined in the late twentieth century when synthetic polymers were engineered and used in a variety of applications. Viscoelasticity calculations depend heavily on the viscosity variable, η . The inverse of η is also known as fluidity, ϕ . The value of either can be derived as a function of temperature or as a given value (i.e. for a dashpot).

Depending on the change of strain rate versus stress inside a material, the viscosity can be categorized as having a linear, non-linear, or plastic response. In addition, when the stress is independent of this strain rate, the material exhibits plastic deformation. Many viscoelastic materials exhibit rubber-like behaviors explained by the thermodynamic theory of polymer elasticity.

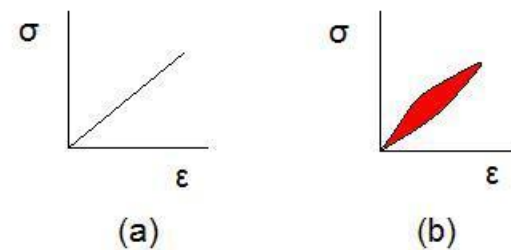
Cracking occurs when the strain is applied quickly and outside of the elastic limit. Ligaments and tendons are viscoelastic, so the extent of the potential damage to them depends both on the rate of the change of their length as well as on the force applied.

A viscoelastic material has the following properties:

- hysteresis is seen in the stress-strain
- stress relaxation occurs: step constant strain causes decreasing stress

- creep occurs: step constant stress causes increasing strain
- its stiffness depends on the strain rate or the stress rate.

Elastic versus viscoelastic behavior:



Stress-strain curves for a purely elastic material (a) and a viscoelastic material (b). The red area is a hysteresis loop and shows the amount of energy lost (as heat) in a loading and unloading cycle. It is equal to $\oint \sigma d\epsilon$ where σ is stress and ϵ is strain. In other words, the hysteresis loop area represents the amount of energy during the loading and unloading process.

Unlike purely elastic substances, a viscoelastic substance has an elastic component and a viscous component. The viscosity of a viscoelastic substance gives the substance a strain rate dependence on time. Purely elastic materials do not dissipate energy (heat) when a load is applied, then removed. However, a viscoelastic substance dissipates energy when a load is applied, then removed. Hysteresis is observed in the stress-strain curve, with the area of the loop being equal to the energy lost during the loading cycle. Since viscosity is the resistance to thermally activated plastic deformation, a viscous material will lose energy through a loading cycle. Plastic deformation results in lost energy, which is uncharacteristic of a purely elastic material's reaction to a loading cycle.

Viscoplasticity:

Viscoplasticity is a theory in continuum mechanics that describes the rate-dependent inelastic behavior of solids. Rate-dependence in this context means that the deformation of the material depends on the rate at which loads are applied. The inelastic behavior that is the subject of viscoplasticity is plastic deformation which means that the material undergoes unrecoverable deformations when

a load level is reached. Rate-dependent plasticity is important for transient plasticity calculations. The main difference between rate-independent plastic and viscoplastic material models is that the latter exhibit not only permanent deformations after the application of loads but continue to undergo a creep flow as a function of time under the influence of the applied load.

Medical analogy: In viscoelastic or viscoplastic analysis, the stress component equals the strain change rate of time multiplying with the viscosity factor, or

$$\text{Stress } (\sigma) = \text{strain } (\epsilon) \text{ change rate} * \text{viscosity factor } (\eta) = d\epsilon/dt * \eta$$

The hysteresis loop area = the integrated area of stress (σ) and strain (ϵ) curve = $\oint \sigma d\epsilon$

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 displays the data table.

7/12/22	Strain	Norm. Strain	Eta	Strain Rate	Strain	Stress	Height	Area	Sub-Period	Sub-Period	Strain*Stress
BW vs. SH	BW	Norm. BW/170	Sleep Hours	BW Rate	BW	Sleep Hours	Sleep Hours	BW vs. Sleep	Area	Energy %	FPG*SH
Y2015	175	1.032	6.2	0.0	175	0.0	0.0	0			0
Y2016	173	1.017	6.1	-1.4	173	-8.8	-4.4	6			-1322
Y2017	174	1.025	6.2	0.8	174	4.9	-1.9	-2			861
Y2018	171	1.006	5.9	-1.9	171	-11.2	-3.1	6			-1913
Y2019	173	1.015	5.9	0.0	173	5.1	-3.0	-3	8	47%	886
Y2020	170	1.000	6.3	-1.5	170	-9.5	-2.2	3			-1614
Y2021	169	0.992	6.5	-0.8	169	-5.5	-7.5	6			-1204
Y2022	170	0.998	7.0	0.6	170	4.2	-0.6	0	9	53%	709
Avg	172	1.01	6.3	-0.4	172	-2.8	-2.8	17			17
6/2/22	Strain	Norm. Strain	Eta	Strain Rate	Strain	Stress	Height	Area	Sub-Period	Sub-Period	Strain*Stress
FPG vs. SH	FPG	Norm. FPG/120	Sleep Hours	FPG Rate	FPG	Sleep Hours	Sleep Hours	FPG vs. Sleep	Area	Energy %	FPG*SH
Y2015	121	1.005	6.2	0.0	121	0.0	0.0	0			0
Y2016	117	0.975	6.1	-2.9	117	-17.9	-9.0	26			-2099
Y2017	120	0.998	6.2	2.3	120	14.1	-1.9	-4			1688
Y2018	114	0.948	5.9	-5.0	114	-29.8	-7.9	40			-3395
Y2019	115	0.955	5.9	0.7	115	4.0	-12.9	-9	53	7%	463
Y2020	101	0.841	6.3	-11.3	101	-71.6	-33.8	382			-7233
Y2021	94	0.781	6.5	-6.0	94	-38.9	-55.3	332			-3645
Y2022	93	0.773	7.0	-0.9	93	-5.9	-22.4	19	734	93%	549
Avg	100	0.91	6.3	-2.9	100	-18	-18	736	788		549
R of BW vs. SH		-49%	Squared BW	1.02	TD Energy BW	55%	SD: BW Ratio	2%	BW Reduction	3%	SH Increase
R of FPG vs. SH		-76%	Squared FPG	0.83	TD Energy FPG	45%	SD: FPG Ratio	38%	FPG Reduction	23%	15%
6/2/22	Strain	Norm. Strain	Eta	Strain Rate	Strain	Stress	Height	Area	Sub-Period	Sub-Period	Strain*Stress
FPG Rate	FPG	Norm. FPG/120	Sleep Hours	FPG Rate	FPG	Sleep Hours	Sleep Hours	FPG vs. Sleep	Area	Energy %	FPG*SH
Y2015	121	1.005	6.2	0.0	121	0.0	0.0	0			0
Y2016	117	0.975	6.1	-2.9	117	-17.9	-9.0	26			-2099
Y2017	120	0.998	6.2	2.3	120	14.1	-1.9	-4			1688
Y2018	114	0.948	5.9	-5.0	114	-29.8	-7.9	40			-3395
Y2019	115	0.955	5.9	0.7	115	4.0	-12.9	-9	53	7%	463
Y2020	101	0.841	6.3	-11.3	101	-71.6	-33.8	382			-7233
Y2021	94	0.781	6.5	-6.0	94	-38.9	-55.3	332			-3645
Y2022	93	0.773	7.0	-0.9	93	-5.9	-22.4	19	734	93%	549
Avg	100	0.91	6.3	-2.9	100	-18	-18	736	788		549
6/2/22	Strain	Norm. Strain	Eta	Strain Rate	Strain	Stress	Height	Area	Sub-Period	Sub-Period	Strain*Stress
FPG Rate	Sleep Hours	Norm. FPG/77	FPG	FPG Rate	FPG	Sleep Hours	Sleep Hours	FPG vs. SH	Area	Energy %	FPG*SH
Y2015	6.2	0.890	121	0.0	6.2	0.0	0.0	0			0
Y2016	6.1	0.869	117	-2.1	6.1	-25.1	-125.4	269			-1325
Y2017	6.2	0.889	120	2.0	6.2	240	-5.6	-11			1490
Y2018	5.9	0.849	114	-4.0	5.9	-455	-107.7	431			-2702
Y2019	5.9	0.844	115	-0.4	5.9	-49	-252.0	188	796	13%	296
Y2020	6.3	0.904	101	6.0	6.3	606	278.4	1670			3835
Y2021	6.5	0.924	94	2.0	6.5	188	396.7	793			1213
Y2022	7.0	0.996	93	-1.1	7.0	662	425.0	3036	5499	87%	4617
Avg	6.3	0.90	105.1	1.3	6.3	117.6	36.2	4086	6296		4617

Figure 1: Data table.

Figure 2 shows the TD-correlation analysis results.

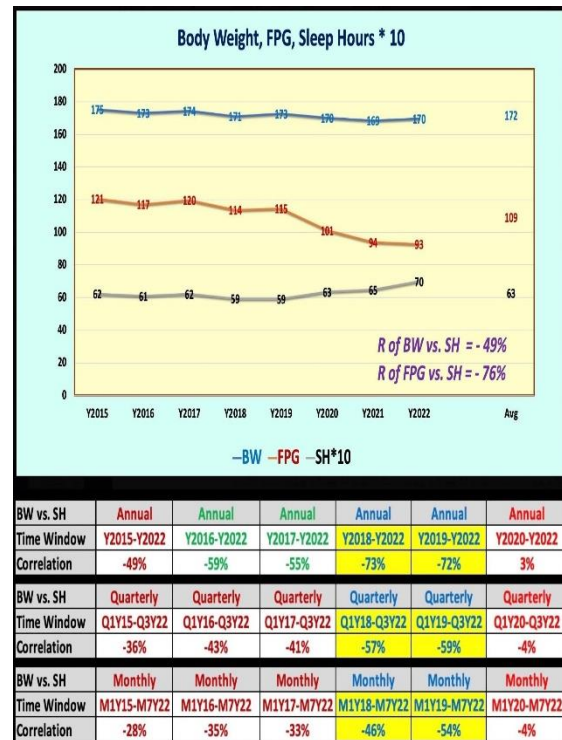


Figure 2: TD-correlation analysis results.

Figure 3 reflects the SD-VGT analysis results of BW Vs. SH and FPG vs. SH.

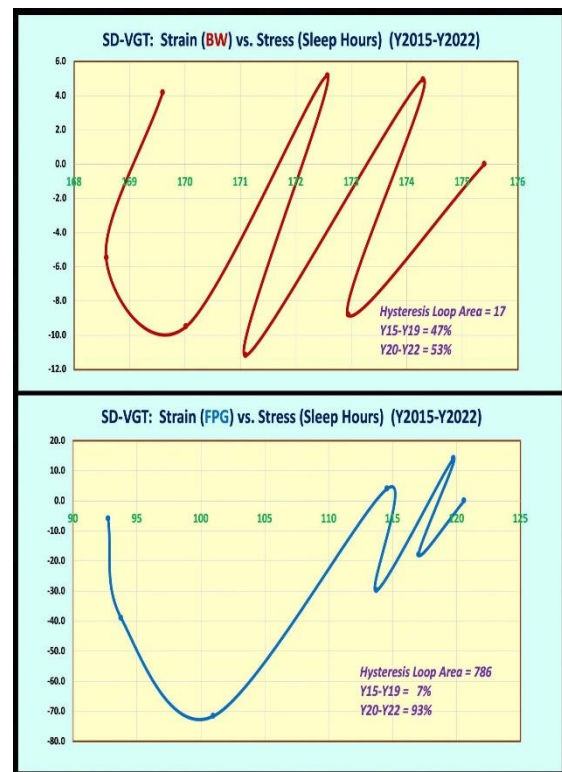


Figure 3: SD-VGT analysis results of BW vs. SH & FPG vs. SH.

Figure 4 depicts the VGT results comparison between SH influences FPG and FPG influences SH.

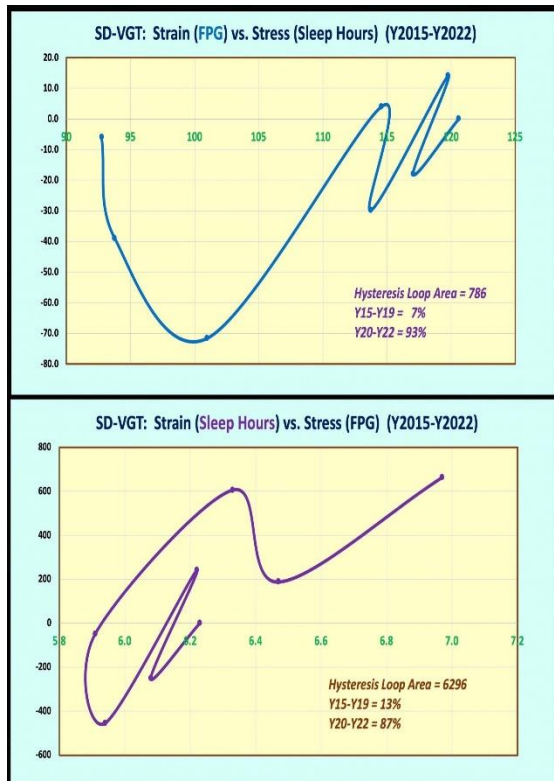


Figure 4: SD-VGT analysis results of FPG vs. SH & SH vs. FPG.

4. CONCLUSION

In summary, there are 4 observations from the TD-correlation results and SD-VGT analysis results, for investigating SH at night, BW in the early morning, and FPG in the early morning.

(1) From 18 time-domain correlation analyses (TD-R) results of 6 annual periods, 6 quarterly periods, and 6 monthly periods, 2/3 of their total 18 calculated correlations are below -50% which means not-so-strong and negative correlations exist. Except for only 1/3 or 6 time periods of Y2018-Y2022 have shown strong and negative correlations that are greater than -50%. These observed results have provided two important conclusions. First, the selection of a time window with different data numbers is extremely important, but not necessarily a wider time window with more included data would produce a higher correlation. Second, not only is the time window size important, the data contents within the selected time window must contain sufficient and critical data patterns and physical characteristics of

those data. Many existing medical research results are solely based on a calculated correlation coefficient from a casual or random selection of data and their associated time windows. If certain important medical conclusions are derived based on the kind of random correlation study using mixed data from different patients, similar to “mixing apples and oranges”, it should be considered an irresponsible research practice that can lead to dangerous results.

(2) In space-dimension VGT analyses of comparing BW vs. SH against FPG vs. SH, the strain rate of BW or FPG change rates ratio is 7:1. The comparison of stress (=strain rate * viscosity value of sleep hours) of BW against FPG ratio is also 7:1. Therefore, the hysteresis loop areas (degree of influences) of BW against FPG is 49 (7*7) : 1. The above statement has proven the amplification effect of hysteresis loop area (energy or influence).

(3) In space-dimension VGT analyses of comparing different periods between earlier years of Y2015-2019 and COVID years of Y2020-Y2022, the comparison results are different. For the BW case, the time-period ratio is 47% : 53% which resulted from the smaller BW change rates and a more “evenly-distributed” BW data from 175 lbs. in Y2015 to 170 lbs. in Y2022 (3% of BW variance). For the FPG case, the time-period ratio is 7% : 93% which resulted from the bigger FPG change rates and a more “violently-distributed” FPG data from 121 mg/dL in Y2015 to 93 mg/dL in Y2022 (23% of FPG variance).

(4) The author has also wondered which scenario offers more facts, sleep influences FPG or FPG influences sleep. Therefore, he has conducted two separated but reversed studies: one study uses FPG as the output versus SH as the input, and the other study utilizes SH as the output versus FPG as the input. As he expected, both curve patterns (resulting from strain change rate) and the hysteresis loop areas varied; however, the author still speculates that SH functioned as the influential input on the output of FPG as the most-likely case, not the other way around. One specific observation is consistent. For the case of FPG vs. SH, the time-period ratio between Y15-Y19 : and Y20-Y22 is 7% : 93%. For both cases of SH vs. FPG, the time-period ratio between Y15-Y19 : Y20-Y22 is 13% : 87%.

The quantitative findings from this paper have matched with the general healthcare recommendations of “maintaining sufficient sleep hours, preferably not less than 7 hours”. The SD-VGT energy tool adopted from engineering and physics has further provided some useful hints and realistic interpretations of complex biomedical results from body weight and fasting glucose resulting from sufficient sleep hours and high quality of sleep. Body weight maintenance is not a simple or easy task that is equally or more difficult than glucose control. Both weight control and glucose control require a deeper understanding of complex physical and biomedical phenomena. Not only has this study offered the same findings as in his other medical research papers, but it also provided one additional research tool for investigating complex and important biomarker behaviors.

5. REFERENCES

For editing purposes, the majority of the references in this paper, which are self-

references, have been removed for this article. Only references from other authors' published sources remain. The bibliography of the author's original self-references can be viewed at www.eclaircmd.com.

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For reading more of the author's published VGT analysis on medical research, please locate them through 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: Sonny Hazi).

Viscoelastic and Viscoplastic Glucose Theory Application in Medicine

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