Special Issue 5
2022

https://www.theghmethod.com

The GH-Method

Viscoelastic or Viscoplastic Glucose Theory (VGT #160): A Summary Report of Energy Analysis Results for 150 Different Biomedical Studies, 6 Economics Studies, and 3 Corporate Business Management Studies Using Time-Domain, Space-Domain, and Frequency-Domain Energy Analysis Tools Based on the GH-Method: Math-Physical Medicine (No. 753)

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Keywords: Viscoelastic; Viscoplastic; Frequency domain; Space domain; Time domain

Abbreviations: FFT: fast Fourier transform; FD: frequency domain; SD: space domain; TD: time domain; MPM: math-physical medicine

1. INTRODUCTION

The author was a professional engineer in the Navy, Space, and Nuclear power, an entrepreneur in both hardware and software, NASDAQ semiconductor corporate executive, a psychotherapy philanthropist for abandoned children and abused women, and a self-learned medical research scientist for the past 50 years. After he presented his first medical paper at the IDF/WHO (International Diabetes Forum of the World Health Organization) in Abu Dhabi, UAE, on December 7, 2017, he has written and published 750+ papers in 100+ professional journals. Most of them (740+) are related to biomedical subjects, where he utilized approximately 30 different research methods mainly based on disciplines of mathematics, physics, and engineering. All of these methodologies originated from his academic knowledge of applied mathematics, physics, and engineering. Readers who have an interest to learn his different research methodologies can search online for his published papers to read them. He seldom solely relied on the "statistics tools" that are popular in the fields of medical research and economics research. The terms such as "average, summation, ratios, correlation coefficient, and density" can also be considered as statistical terminologies which he uses from time to time; however, his medical research tools are mainly from his learned and defined "math-physical medicine" arena.

His industrial working experiences essentially involved hardware product design, software development, artificial intelligence applications (e.g. software robot, optical physics on glucose prediction), and big data analytics related to both cloud-computing databases and various numerical processes; therefore, computer science has become an integrated part of his execution of research methodology.

The author applied the "software robot" algorithm and product he developed during the period from 2002 to 2010 for his dedicated biomedical software, the Chronic APP on iPhone. He started self-learning internal medicine and food nutrition and collected his own health data in 2010. As a result, he established an experimental laboratory with his own computer software and continued to accumulate his experimental and personal data for 12 years. He has been enhancing and improving his software almost on weekly

Available online: 19 December 2022

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basis for the past 13 years. Thus far, he has collected and calculated more than 3 million pieces of data on his personal health and known disease conditions. In addition, he has also stored about 10 million food nutritional data from public sources on a cloud database managed by Amazon for his Chronic APP access. Although he started writing his scientific papers at the end of 2017, he continues to study, learn, enhance his software, collect his data, and contemplate biomedical subjects and medical puzzles since 2010. He works about 12 to 13 hours each day, with no break within a year, over the past 13 years. Currently, he has accumulated more than 40,000 hours of study and research on different medical subjects by reading more than 4,000 published medical papers. He has chosen the hardest way to self-educate himself on medicine by reading many medical papers. For an engineer, those Greek or Latin-based medical terminologies are the hardest things to comprehend. The above-mentioned facts explain his higher productivity in producing his medical research papers (750 papers in ~5 years).

In December of 2021, his MIT academic advisor, Professor Norman Jones, wrote to him and suggested he consider utilizing viscoelastic and viscoplastic concepts to analyze his biomedical data which are highly "time-dependent". Although he studied those courses in fluid dynamics and thermodynamics at MIT, bridge support design at Columbia University, and soil dynamics at the University of California at Berkeley, he has never applied the viscosity factor in his real-life working experience as an engineer. Therefore, he spent the entire month of December 2021 refreshing his memory by reading many engineering books and physics papers. During 1/8-14/2022, he wrote his first paper (No. 578) using his defined viscoplastic and viscoplastic glucose theory (VGT) tool on postprandial plasma glucose (PPG) of a hypothetical diabetes patient with two different viscosities (η=1 versus η=6) to see the differences on damping, stiffness, and hysteresis loop areas of a VGT problem. After that, he has written and published 159 VGT papers, including 150 medical subjects, 6 economics subjects, and 3 corporate business and finance management subjects. All of these subjects have time-dependent variables, including both outputs and inputs. Many of those medical subjects have been investigated previously using other math-physical medicine tools. However, the VGT approach indeed offers some deeper views of biophysical phenomena and/or more accurate analysis results.

For the author, this 10-month journey of utilizing the VGT tool is also a self-awakening and continuously improving experience. Not only has he applied VGT to explore more and deeper biomedical challenges but also improve some detailed operations of the VGT tool's application on biomedical problems. For example, after using the Excel tool manually by typing in every single step of calculation with a large amount of input data for about 100 research projects, he finally decided to develop a software program for his Chronic APP on the iPhone. Resulted of this automation, he has reduced his data-processing time from 5 to 6 hours per problem down to less than 1 minute. Therefore, he can spend these 5 to 6 hours of saved time investigating his observed biophysical phenomena in more detail and delving deeper to dig out more truth to improve the quality of his research findings.

After 159 actual experiments using the VGT tool, he has finally learned many in-depth details regarding applications using time-domain (TD), space-domain (SD), and frequency-domain (FD) energies. For example, the importance of normalization factors (NF) associated with input variables; the convenience of combining a time-zone analysis inside of the space domain (by definition, SD should contain strain X versus stress Y only, without the timescale), the way to handle m multiple outputs versus n multiple inputs, two different ways to quickly estimate TD energies (both squared average of input TD 1 and summation of inputs TD 2), various ways to link TD with SD and SD with FD, the linkage of wave theory and energy theory, and the importance of energy concept, etc.

In the methods section, the author describes three different energy models regarding this model of single output versus multiple inputs. The following paragraph offers a very simple description of these three energy domain approaches.

The first TD model uses a rudimentary physics definition of energy associated with a wave that is directly proportional to the square of wave amplitude. He calls it the TD-SQ model (TD 1). He has further identified another TD energy approach by comparing the summation of input values of each input variable which he calls the TD-SUM model (TD 2). The second SD model utilizes the hysteresis loop area of the time-dependent strain-stress curve with viscoelastic and viscoplastic engineering material behaviors. He calls it the SD-VGT model. The third FD model uses his defined new variable of strain (output) multiplied with stress (stress input is the strain change rate multiplied by the normalized viscosity input) and then goes through the fast Fourier transform (FFT) operation of wave theory in physics to get the area underneath the FD curve. He calls it the FD-FFT model.

There is only one summarized table in this article and no other graphic diagrams. However, this table provides a grand view of 30 symptoms (30 outputs) with their associated causes (30*n inputs, n = 2 or 3) with their individual degree of influence or contribution (i.e. energy) and the ranking of influences or contributions.

2. METHODS

2.1 Brief introduction of math-physical medicine (MPM) research

The author has collected 3+ million data regarding his health condition and lifestyle details over the past 13 years. He spent the entire year of 2014 developing a metabolism index (MI) model using a topology concept, nonlinear algebra, algebraic geometry, and finite element method. This MI model contains various measured biomarkers and recorded lifestyle details along with their induced new biomedical variables for an additional ~1.5 million data. Detailed data of his body weight, glucose, blood pressure, heart rate, blood lipids, body temperature, and blood oxygen level, along with important lifestyle details, including diet, exercise, sleep, stress, water intake, and daily life routines are included in the MI database. In addition, these lifestyle details also include some lifetime bad habits and certain environmental exposures. Fortunately, the author has none of these lifetime bad habits and an extremely low degree of exposure to environmental factors. The developed MI model has a total of 10 categories covering approximately 500 detailed elements that constitute his defined “metabolism index model” which are the building blocks or root causes for diabetes and other chronic disease-induced complications, including but not limited to cardiovascular disease (CVD), chronic heart disease (CHD), stroke, chronic kidney disease (CKD), diabetic retinopathy (DR), neuropathy, foot ulcer, hypothyroidism, dementia, and various cancers. The end result of the MI development work is a combined MI value within any selected period with 73.5% as its dividing line between a healthy and unhealthy state. The MI serves as the foundation for many of his follow-up medical research work.

During the period from 2015 to 2017, he focused his research on type 2 diabetes (T2D), especially glucose, including fasting plasma glucose (FPG), PPG, estimated average glucose (eAG), and hemoglobin A1C (HbA1C). During the following period from 2018 to 2022, he concentrated on researching medical complications resulting from diabetes, chronic diseases, and metabolic disorders which include heart problems, stroke, kidney problems, retinopathy, neuropathy, foot ulcer, diabetic skin fungal infection, hypothyroidism, diabetic constipation, dementia, and various cancers. He also developed a few mathematical risk models to calculate the probability percentages of developing various diabetic complications based on this MI model. From his previous medical research work with 700+ published papers, he has identified and learned that the associated energy of hyperglycemic conditions is the primary source of causing many diabetic complications which lead to death. Therefore, a thorough knowledge of these energies is important for achieving a better understanding of the dangerous complications.

2.2 TD, SD, and FD analysis tools

This section has brief descriptions of TD correlation analysis with other observational results, SD VGT analysis with hysteresis loop area’s energy results, and FD analysis with frequency curve area’s energy results.

First of all, by using a TD analysis tool, we can examine the curves’ moving trend and pattern visually along with their correlation numerically. We can also study the extremely high or low data values in the dataset. The visual observation or calculation-derived interpretations are a part of statistical analysis results which can indeed provide some useful hints or even derive some accurate conclusions. However, we must be aware of the limitations of the selected data size and time window and also be cautious of the appropriate statistics tool we choose.

Regarding the TD energy, we can apply the rudimentary definition of physics that "the wave carried energy is directly proportional to the square of wave's amplitude". However, the data quantity % of each wave category should be considered and included to obtain a more accurate TD energy value.

The author would like to describe the essence of his developed "hybrid model" that combines both the SD viscoelastic/plastic VGT analysis method and FD FFT analysis method with a comparison against the traditional time-domain statistical correlation analysis. It is described in 10 steps in the English language instead of using mathematical equations to explain it. In this article, he has applied both the SD-VGT operations (steps 1-7) and the FD-FFT operations (steps 8-10). As a result, it is aimed at readers who do not have an extensive background in the academic subjects of engineering, physics & mathematics.

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 (dε/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 dε/dt and η together. The "time-dependent input or cause equation" of "stress σ = strain change rate of dε/dt * viscosity η" is the essential part of this "time dependency". The fifth step is to plot the input-output (i.e. stress-strain or cause-symptom) curve in a two-dimensional 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), which is also an indicator of associated energies (either created energy or dissipated energy) of this input and output dataset. These energy values can also be considered as the degrees of influence on output by inputs. The seventh step is the assembly of the area values of the selected periods to compare the "historical progression and contribution of medical condition" over certain periods. For the frequency domain, the eighth step is to define a "hybrid input variable" by using "strain*stress" which yields another accurate estimation of the energy ratio similar to the SD-VGT energy ratio associated with the hysteresis loop. The ninth step is to present these hybrid models' results of (strain*stress) in TD and then perform the FFT operation to convert them into FD. The enclosed area of the frequency curve (where the x-axis is the frequency and the y-axis is the amplitude of energy) can be used to estimate the total FD-FFT energy. The tenth step is to compare these FD energy results against the SD-VGT energy results, or even TD energy results.

After providing the above 10-step description, the author would still like to use the following set of VGT stress-strain mathematical equations in a two-dimensional SD to address the selected medical variables:

Strain
= ε (time-dependency characteristics of individual strain value at the present time duration)

Stress
= σ (based on the change rate of strain multiplying with a chosen viscosity factor η)
= η * (dε/dt)
= η * (d-strain/d-time)
= (viscosity factor η using individual viscosity factor at present time duration) * (strain at present time duration - strain at previous time duration)

Some of these inputs (causes or viscosity factors) are further normalized by dividing them or being divided by a normalization factor using certain established health standards or medical pieces of knowledge. Some examples of normalization factors are 6.0 for HbA1C, 120 mg/dL for glucose, 25 for body mass index (BMI), 4,000 steps after each meal, 10,000 or 12,000 steps for daily walking exercise depending on time-period selection, 13 grams to 20 grams of carbs/sugar intake amount per meal depends on time-period selection. If using the originally collected data, i.e. the non-normalized data, it would distort the numerical comparison of the hysteresis loop areas. Using this "normalization process", we can remove the dependency of the individual unit or certain unique characteristics associated with each viscosity factor. This process allows us to convert the originally collected variables into a set of "dimensionless variables" for easier numerical comparison and result interpretation.

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 containing 30 cases. This table provides a grand view of 30 symptoms (30 outputs) with their associated causes (30*n inputs, n = 2 or 3) with their individual degree of influence or contribution (i.e. energy) and the ranking of influences or contributions.

Figure 1: Data table containing 30 cases (the bigger percentage of input means the larger influence or contribution on output).

4. CONCLUSION

In summary, there are 5 conclusive findings regarding the results of using these 4 energy models.

(1) Overview: There are 30 cases in this study. Each case has displayed 4 energy results, i.e. TD 1 (TD-SQ) versus FD-FFT, TD 2 (TD-SUM) versus SD-VGT. The total 30 cases include 25 medical cases (83%), 2 economic cases (7%), and 3 business cases (10%). For the simplicity of table design, he has excluded his research paper results containing more than 3 inputs. Each case table inside this master table is arranged as: "comparison of TD 1 against FD using red color and comparison of TD 2 against SD using blue color". Each case table has shown its paper name, date, and simple title of "single output versus multiple inputs".

(2) Comparison criteria: Each case table using different energy analysis method have resulted in a certain specific energy ratio pattern, i.e. "the ranking order from the highest energy level to the lowest energy level" with a numerical percentage indicating each input's influence or contribution, i.e. energy, on the output. By comparing this ranking order and each energy method's specific numerical value inside, we can examine the similarities or differences between two different energy method results. For example, the TD-squared amplitude energy ranking (1 output with 5 inputs) for longevity (age difference of health age minus real age) is: Obesity = 24%; T2D = 16%; Beta-cell health = 28%; Insulin Resistance = 24%, NAFLD (fatty liver) = 7%. The TD energy ranking order from high to low is Beta-cell > Obesity = IR > T2D > NAFLD.

(3) The similarity of results from TD 1 and FD (red colored data): Among those 30 cases, there is only 1 problem case showing a disagreement of energy % patterns.

(4) The similarity of results from TD 2 and SD (blue colored data): Among those 30 cases, all of them have shown a high similarity of energy % patterns, with no disagreements.

(5) Conclusions: The extremely high similarities of the energy % pattern and comparable numerical values have demonstrated the FD method results are very close to the TD squared input amplitude (TD 1) results, while the SD stress-strain method results are very close to the TD input amplitude summation (TD 2) results. It should be noted that both the TD 1 and FD results have a sort of "amplification" effect, i.e. the large amount becomes larger and the small amount becomes smaller. This is due to the numerical process of "squared" input amplitude in TD 1 and the variable definition of "strain multiplying stress" in FD. It should also be mentioned here that there are some small numerical deviations between the two associated methods which are resulted from

the initialized strain rate of zero to at initial time instant.

Note: The SD-VGT stress-strain diagram's hysteresis loop area is:

Area
= Sum of trapezoidal areas
= Sum of (x*(y1+y2)/2)
= Sum of ((strain rate)*(stress2+stress1)/2)
$= \Sigma ((\varepsilon 2-\varepsilon 1)*(\sigma 2+\sigma 1) / 2)$
$= \Sigma ((\varepsilon 2-\varepsilon 1)*((\varepsilon 2-\varepsilon 1)*\eta 2+(\varepsilon 1-\varepsilon 0)*\eta 2))/2$

Where Σ from i = 1 to n

This total SD area's value is very close to the summation of the square of strain rate (change rate of output) multiplied by the summation of viscosity (normalized input). This explains the reason behind the proximity between TD-SUM (TD 2) numerical values and SD-VGT (SD) numerical values.

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.

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).

Special Issue | Issue No. 5

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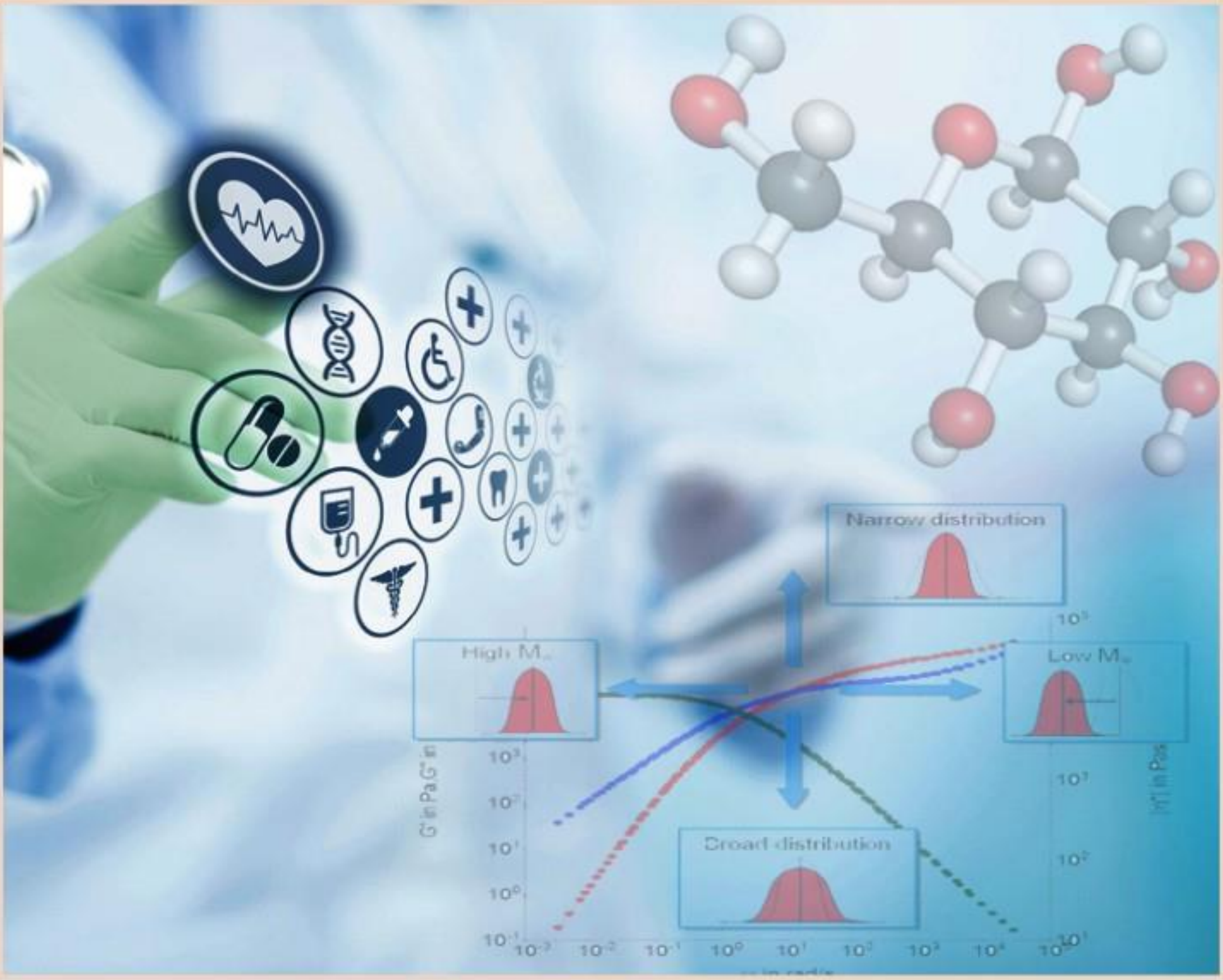

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