

Viscoelastic or Viscoplastic Glucose Theory (VGT#53) Applying VGT for Selecting an Appropriate Conversion Factor from Finger-Pierced Daily Estimated Average Glucose (eAG) to a Predicted Finger A1C (F.A1C) and using Collected Annual Average Data from Y2012 to Y2022 to Study the Inter-Relationships Among Lab-Tested A1C, Calculated Finger A1C, and Finger-Pierced eAG Based on the GH-Method: Math-Physical Medicine (No. 640)

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Abstract

The author was a professional engineer working in the fields of the space shuttle, naval battleships, nuclear power plant, computer hardware and software, artificial intelligence, and semiconductor chips. After retiring from his work, he initiated self-study and research on internal medicine with an emphasis on biomarker relationship exploration and disease prevention. Since 2010, he has utilized these disciplines learned from 7 different universities along with various work experiences to formulate his current medical research work during the past 13 years.

One thing he has learned is that in engineering or medicine, we are frequently seeking answers, illustrations, or explanations for the relationships between the input variable (force applied on a structure or cause of a disease) and output variable (deformation of a structure or symptom of a disease). However, the multiple relationships between input and output could be expressed with many different matrix formats of 1×1 , $1 \times n$, $m \times 1$, or $m \times n$ (m or n means different multiple variables). In addition to these described mathematical complications, the output resulting from one or more inputs can also become an input of another output, i.e. a symptom of certain causes can become a cause of another different symptom. This phenomenon is a complex scenario with "chain effects". In fact, engineering and biomedical complications are fundamentally mathematical problems that correlate or conform with many inherent physical laws or principles.

Over the past 13 years, in his medical research work, he has encountered more than 100 different sets of biomarkers with almost equal amounts of cause/input variables versus symptom/output variables. For example, food and exercise influence both body weight and glucose level, where persistent high glucose can result in diabetes. When diabetes combines with hypertension (high blood pressure) and hyperlipidemia (high blood lipids), it can cause cardiovascular diseases. Furthermore, obesity and diabetes are also linked with various kinds of cancers. These multiple sets of biomedical input versus output have been researched by the author using different tools he has learned from academic fields of mathematics, physics, computer science, and engineering.

Previously, he has applied signal processing techniques to separate 19 components from the combined postprandial plasma glucose (PPG) wave. He identified the carbs/sugar intake amount and post-meal exercise as the two most important contributing factors to PPG formation. Based on these findings, he then applied the theory of elasticity to develop a linear elastic glucose theory (LEGT) to predict PPG value with high prediction accuracy, using fasting plasma glucose (FPG), carbs/sugar grams, and post-meal walking k -steps as three major input components of predicted PPG formation.

Furthermore, he took a specific PPG waveform in the time domain (TD) and applied Fourier transform technique to convert it into a waveform in the frequency domain (FD). The y-axis value in the frequency diagram indicates the magnitude of energy corresponding to a certain frequency component on the x-axis, while the total area underneath the frequency-energy curve is the total relative energy associated with the specific PPG wave.

Recently, he has applied theories of viscoelasticity and viscoplasticity (VGT) in physics and engineering to various biomedical problems and has written more than 50 biomedical research papers. This VGT technique emphasizes the time-dependency characteristics of certain variables. In the medical field, most biomarkers are time-dependent since body organ cells are organic in nature and change all of the time. Incidentally, VGT can generate a stress-strain curve or cause-symptom curve (in physics, it is called the “hysteresis loop”), in which area size can be used to estimate the relative energy created during the uploading (digesting carbs/sugar) and unloading (walking exercise) process over the timespan of a PPG wave.

In this article, he selects a dataset containing 3 key biomarkers, lab-tested HbA1C as the symptom (output) and daily calculated finger A1C (F. A1C), daily estimated average glucose (eAG) as two causes (inputs) to conduct his VGT analysis. Now, he applies VGT specifically to construct stress-strain diagrams with two hysteresis loop areas which are corresponding to the energy status from these two input variables. The purpose of this study is to identify an appropriate numerical factor for converting his eAG values into F.A1C values easily and with high prediction accuracy. In this way, he would be able to quickly calculate his HbA1C value using his daily collected finger-pierced glucose values.

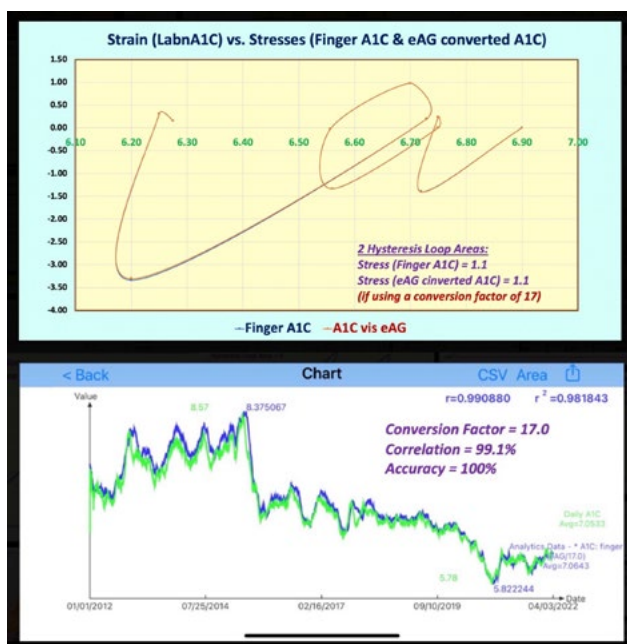
The following defined stress and strain equations are used to establish the VGT stress-strain diagram in a space domain (SD):

VGT strain
 = ϵ (symptom)
 = individual symptom at the present time

VGT Stress
 = σ (based on the change rate of strain, symptom, multiplying with one or more viscosity factors or causes)
 = $\eta * (d\epsilon/dt)$
 = $\eta * (d\text{-strain}/d\text{-time})$
 = (viscosity factor η using normalized cause at present time) * (symptom at present time - symptom at a previous time)

To control the word size of this article, he omits the repetitive background introduction regarding LEGT, VGT, Fourier transformation, frequency domain analysis, and energy theory in the Research Method section.

In summary, the following statement contains the key discovery from this simple VGT analysis: From the VGT analysis of lab-tested A1C (symptom) versus both calculated F.A1C and finger eAG (causes), he has identified that the hysteresis loop area ratio between F.A1C and eAG using the conversion factor of 17.0 is 1.0 (both areas are 1.1), i.e. they match 100% with each other. This means that the conversion factor of 17 is a perfect choice for converting his finger eAG values into finger A1C values for this dataset from 1/1/2012 to 3/31/2022.



Introduction

The author was a professional engineer working in the fields of the space shuttle, naval battleships, nuclear power plant, computer hardware and software, artificial intelligence, and semiconductor chips. After retiring from his work, he initiated self-study and research on internal medicine with an emphasis on biomarker relationship exploration and disease prevention. Since 2010, he has utilized these disciplines learned from 7 different universities along with various work experiences to formulate his current medical research work during the past 13 years.

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one or more inputs can also become an input of another output, i.e. a symptom of certain causes can become a cause of another different symptom. This phenomenon is a complex scenario with “chain effects”. In fact, engineering and biomedical complications are fundamentally mathematical problems that correlate or conform with many inherent physical laws or principles.

Over the past 13 years, in his medical research work, he has encountered more than 100 different sets of biomarkers with almost equal amounts of cause/input variables versus symptom/output variables. For example, food and exercise influence both body weight and glucose level, where persistent high glucose can result in diabetes. When diabetes combines with hypertension (high blood pressure) and hyperlipidemia (high blood lipids), it can cause cardiovascular diseases. Furthermore, obesity and diabetes are also linked with various kinds of cancers. These multiple sets of biomedical input versus output have been researched by the author using different tools he has learned from academic fields of mathematics, physics, computer science, and engineering.

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two causes (inputs) to conduct his VGT analysis. Now, he applies VGT specifically to construct stress-strain diagrams with two hysteresis loop areas which are corresponding to the energy status from these two input variables. The purpose of this study is to identify an appropriate numerical factor for converting his eAG values into F.A1C values easily and with high prediction accuracy. In this way, he would be able to quickly calculate his HbA1C value using his daily collected finger-pierced glucose values.

The following defined stress and strain equations are used to establish the VGT stress-strain diagram in a space domain (SD):

$$\begin{aligned} \text{VGT strain} &= \varepsilon \text{ (symptom)} \\ &= \text{individual symptom at the present time} \end{aligned}$$

$$\begin{aligned} \text{VGT Stress} &= \sigma \text{ (based on the change rate of strain, symptom, multiplying with one or more viscosity factors or causes)} \\ &= \eta * (d\varepsilon/dt) \\ &= \eta * (d\text{-strain}/d\text{-time}) \\ &= (\text{viscosity factor } \eta \text{ using normalized cause at present time}) * \\ &(\text{symptom at present time} - \text{symptom at a previous time}) \end{aligned}$$

To control the word size of this article, he omits the repetitive background introduction regarding LEGT, VGT, Fourier transformation, frequency domain analysis, and energy theory in the Research Method section.

Methods

Viscoelasticity/Plasticity Glucose Theory (VGT)

The following defined stress and strain equations are used to establish the VGT stress-strain diagram in a space domain (SD):

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$$\begin{aligned} \text{VGT Stress} &= \sigma \text{ (based on the change rate of strain, symptom, multiplying with one or more viscosity factors or causes)} \\ &= \eta * (d\varepsilon/dt) \\ &= \eta * (d\text{-strain}/d\text{-time}) \\ &= (\text{viscosity factor } \eta \text{ using normalized cause at present time}) * \\ &(\text{symptom at present time} - \text{symptom at a previous time}) \end{aligned}$$

Results

Figure 1 shows a stress-strain diagram of lab-tested A1C (symptom) versus calculated finger A1C and eAG (causes) and a data table.

Conclusion

In summary, the following statement contains the key discovery from this simple VGT analysis:

From VGT analysis of lab-tested A1C (symptom) versus both calculated F.A1C and finger eAG (causes), he has identified that the hysteresis loop area ratio between F.A1C and eAG using the conversion factor of 17.0 is 1.0 (both areas are 1.1), i.e. they match 100% with each other. This means that the conversion factor of 17 is a perfect choice for converting his finger eAG values into finger A1C values for this dataset from 1/1/2012 to 3/31/2022.

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.eclairmd.com.

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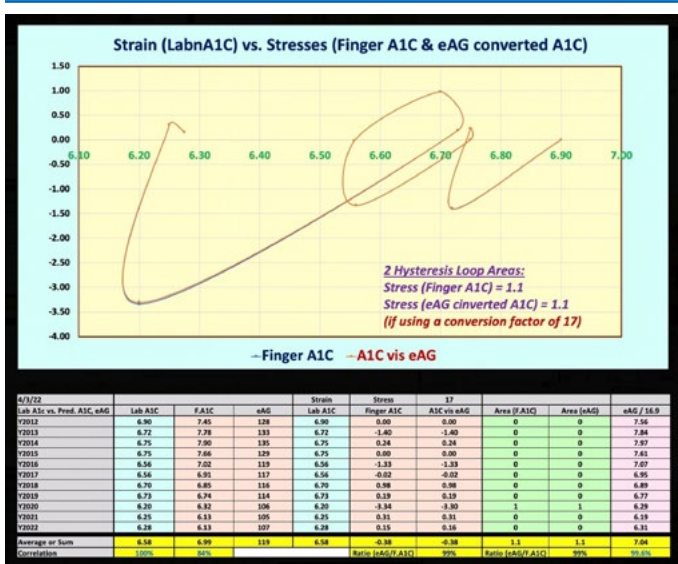


Figure 1: A stress-strain diagram of lab-tested A1C (symptom) versus calculated finger A1C and eAG (causes) and data table

Figure 2 depicts the background data and information.



Figure 2: Background data and information

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