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Viscoelastic or Viscoplastic Glucose Theory (VGT #60): A Summary Report on Four Complication Risk Probability Percentages with Their Two Selective Causes and Using Both VGT Energy and Frequency Energy Methods to Estimate the Relative Energy Associated with Each Complication over Two 5-Year or 6-Year Periods Based on GH-Method: Math-Physical Medicine (No. 648)

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Abstract

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

Relationships Between Causes and Symptoms

In engineering and medicine, he discovered that people frequently seek 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 x 1, 1 x n, m x 1, or m x 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, which is a symptom of certain causes that can become a cause of another different symptom. This phenomenon is a complex scenario with "chain effects". In fact, both 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 or more amounts of causes (or input variables) and symptoms (or 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 (CVD), chronic kidney disease (CKD), or diabetic retinopathy (DR). Furthermore, obesity and diabetes are also linked with various cancers. In another example, he has applied a signal processing technique to separate 19 components from the combined postprandial plasma glucose (PPG) wave. He identified the carbs/sugar intake amount (around 60% of contribution) and post-meal exercise (around 40% of contribution) 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 intake grams, and post-meal walking k-steps as three major input components of predicted PPG formation. Let us go back to the beginning point, body weight (BW) is easily measured by using a bathroom weight scale. Weight in the early morning is highly correlated with the patient's fasting plasma glucose (FPG). His data shows a ~90% correlation existed between his body weight in the early morning and his FPG level. The FPG value can

also serve as the baseline for his postprandial plasma glucose (PPG) and contributes around 25% to 29% to the daily estimated average glucose (eAG). From a clinical viewpoint, the eAG value can be easily converted into a quarterly HbA1C value which is the averaged glucose value over the past 90-115 days divided by a conversion factor (17-18 in the author's case). A1C can then be used to determine the severity of diabetes conditions. Diabetes is one of the critical chronic diseases that may increase certain risk factors for other complications, including DR (micro-vessel leakage issues), neuropathy, heart diseases such as CVD (artery blockage or rupture problems), or CKD (micro-vessel leakage problems). Diabetes is also related to many types of cancers. Diabetes and cancers share many common root causes, but their symptoms are quite different.

Talking about research methodology, furthermore, he took a specific PPG waveform in the time domain (TD) and applied the fast Fourier transform (FFT) technique to convert it into a waveform in the frequency domain (FD). The y-axis value of this frequency diagram indicates the magnitude of energy corresponding to a certain frequency component on the x-axis, while the total area underneath the frequency vs. energy (x vs. y) curve is the total relative energy associated with this specific PPG wave. He calls this relative energy the ***"frequency energy".***

Since December 2021, the author applied theories of viscoelasticity and viscoplasticity (VGT) from physics and engineering disciplines to investigate around 60 sets of input/output biomarkers. The purpose is to identify certain hidden relationships between certain output biomarkers, DR risk, CKD risk, CVD risk, or Cancer risk, and their corresponding input biomarkers, such as HbA1C, ACR, eAG, BW, FPG, etc. In these studies, the hidden biophysical behaviors and possible inter-relationships among the multiple biomarkers are "time-dependent" which change from time to time. This important time-dependency characteristic provides insight on the complication risk's moving pattern. It also controls the curve shape, the associated energy created, stored, or burned inside during the process of stress up-loading (moving upward or increasing) and stress down-loading (moving downward or decreasing) of the input biomarkers with the output biomarker of complication risk %. This VGT application 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 (known as a* ***"hysteresis loop"*** *in physics), in which area size can also be used to estimate the relative energy created or burned during the process of uploading (digesting carbs/sugar) and unloading (walking exercise) over the timespan of a biomarker's wave, such as body weight, glucose or one specific complication risk %.* ***He calls this relative energy the "VGT energy".***

It should be emphasized here that both frequency energy and VGT energy are estimated relative energy, not "absolute" energy level, they are quite useful for comparison studies between diseases, biomarkers, or time-spans. Similar to energy level, his estimated complication risk probability % is also a relative number, not an absolute number.

"Metabolism Index (MI) Model"

This model was developed in Y2014 by the author using the topology concept, nonlinear algebra, geometric algebra, and engineering finite element method. In summary, the human body metabolism is a complex mathematical problem with a matrix format of m causes by n symptoms.

During 2010 and 2011, the author collected sparse biomarker data, but from the beginning of 2012, he has been gathering body weight and finger-piercing glucose values each day. In addition, he accumulates medical conditions data including blood pressure (BP), heart rate (HR), and blood lipids along with lifestyle details (LD). Since 2020, he has added the daily body temperature and blood oxygen level due to his concerns about being exposed to COVID-19. Based on the collected big data of biomarkers, he further organized them into two main groups. The first is the medical conditions group (MC) with 4 categories: weight, glucose, BP, and blood lipids. The second is the lifestyle details group (LD) with 6 categories: food & diet, exercise, water intake, sleep, stress, and daily routines. At first, he calculated a unique combined daily score for each of the 10 categories within the MC and LD groups. The combined scores of the 2 groups, 10 categories, and 500+ detailed elements constitute an overall "metabolism index (MI) model". It includes the root causes of 6 major lifestyle inputs and symptoms from 4 rudimentary chronic diseases: obesity, diabetes, hypertension, and hyperlipidemia. Therefore, the MI model, especially its 4 chronic disease conditions, can be used as the foundation and building block for his additional research work that can expand into various complications associated with different organs, such as this article's scope of CVD, CKD, DR, and various cancers (Cancer). Of course, the same methodology can be extended to study many other complications, such as various heart problems (CVD & CHD), stroke, neuropathy, hypothyroidism, diabetic constipation, diabetic skin fungal infection, cancers, and dementia.

Some genetic conditions and lifetime unhealthy habits, which include smoking, alcohol consumption, and illicit drug use, account for approximately 15% to 25% of the root cause of chronic diseases and their complications, as well as cancers and dementia. His calculated risk probability % for CKD, CVD, DR, stroke, and various cancers have some differences in their root-cause variables, their associated weighting factors for each key cause, and certain biomedical assumptions. Specifically, the CVD/Stroke risk includes two major scenarios that combine *emphasized weighting factors, blood vessel blockage due to blood glucose and blood lipids, and blood vessel rupture caused by blood glucose and blood pressure. Some recent research work has identified the relationship between pancreatic cancer with hyperglycemia and insulin resistance phenomena of type 2 diabetes (T2D) and inflammation. There is also evidence of a relationship between BP and DR (Reference: BP control and DR, by R. Klein and BEK Klein from British Journal of Ophthalmology). The CKD risks include hyperglycemic damage to micro-blood vessels and nerves which causes protein leakage found in urine and waste deposit within the kidneys; therefore, it requires dialysis to remove waste products and excess fluids from the body. However, the cancer risk also consists of additional influences from environmental conditions, such as improper medications, viral infections, food pollution or poison, toxic chemical, radiation, air and water pollution, hormonal treatment, etc.*

All of the above-mentioned diseases fall into the category of "symptoms" which are the outcomes of "root causes" of poor living environments and unhealthy lifestyles.

This Particular Article (No. 648)

This article is a summary report of 4 sets of inter-relationships between each complication risk with its two related key influential inputs over two adjacent periods of 5 to 6 years each. In this study, he selects 4 complications, CVD, CKD, DR, and Cancer. The specific findings from 4 papers, No. 647 for CVD risk, No. 645 for CKD risk, No. 646 for DR risk, and No. 644 for Cancer risk, have utilized the VGT energy model and the frequency energy model to estimate the associated relative energy for the complication risk probability percentages. In these 4 articles, he selects 10 or 12 years of collected data and then groups them into 5-year or 6-years periods based on their annual data. The chosen dataset contains 3 key biomarkers, one complication risk % as the symptom biomarker (output) along with two individual cause biomarkers (inputs), to conduct his VGT analysis. He can apply VGT specifically to construct 2 stress-strain diagrams with 2 hysteresis loop areas that correspond to the energy status from two causes (input variables). Initially, he obtains the calculated relative energy levels in each period using the VGT energy approach. Then, he converts these two CVD risk % waveforms from a time domain into a frequency domain using the fast Fourier transform (FFT) technique. He then calculates the total area underneath the frequency curve as his frequency energies. Finally, he compares this frequency energy against those two calculated VGT energies.

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)
= η * (dε/dt)
= η * (d-strain/d-time)
= (viscosity factor η using normalized cause at present time) * (symptom at present time - symptom at a previous time)

Where the strain is the chosen complication risk percentage and the stress is his complication risk change rate multiplied by two preferred input biomarkers as the two viscosity factors. In the VGT studies, he utilizes the carefully selected normalization factors for two separate input biomarkers, respectively. The normalization factors are the dividing lines between a healthy state and an unhealthy state. For example, 170 lbs. is for body weight, 120 mg/dL for glucose, and 73.5% for MI.

To offer a simple explanation to readers who do not have a physics or engineering background, the author includes a brief excerpt from Wikipedia regarding the description of basic concepts for elasticity and plasticity theories, viscoelasticity and viscoplasticity theories from the disciplines of engineering and physics; as well as time-frequency analysis via FTT from the disciplines of mathematics and engineering in the Method section.
The following paragraph is a brief health history of the author for the past 30 years. This particular study is based on his collected biomarker data from 2010 to 2022 which includes the continuous influences from his 30-years long personal health history.

The author was diagnosed with type two diabetes (T2D) in 1997 with a random glucose check at a 300 mg/dL level; however, his T2D condition most likely began earlier. He suffered his first two chest pain episodes in 1993-1994, along with three more heart episodes until 2007. His primary physician informed him that he had diabetic kidney issues in 2010. He then consulted with two more clinical doctors who advised him to start insulin injections and kidney dialysis immediately. This was his wake-up call. He then decided to save his life by conducting his study and research on food nutrition and chronic diseases that same year. His health profile in 2010 was: body weight

at 220 lbs., average glucose at 280 mg/dL, lab-tested A1C at 10%, triglycerides at 1160, and his ACR at 116.

During the past 13 years, he has made significant lifestyle changes. For example, he consumes less than 20 grams of carbohydrates and sugar per meal, reduces his food quantity by 50%, walks 6-7 miles or 10-11 kilometers daily, sleeps 7-8 hours each night, and avoids stress as much as possible.

As of April 10, 2022, his health profile for the first 3 months of 2022 is body weight at 169 lbs., daily average glucose at 106 mg/dL, and lab-tested A1C at 5.8%. triglycerides at 108, and ACR at 16. A significant accomplishment is that he has ceased taking 3 different kinds of diabetes medications since 12/8/2015. Fortunately, he has not detected any sign of cancer to date.
The following described biophysical characteristics have demonstrated certain key behaviors of these 4 complication risks using the approaches of both VGT energy and the frequency energy:

(1) The first step is to review the concluding numbers of the complication risk percentages. These 4 complication risks based on his developed MI model in a time domain are expressed as earlier period versus recent period: ***CVD (83% vs. 55%), CKD (79% vs. 54%), DR (74% vs. 54%), and Cancer (50% vs. 41%).*** *These 4 earlier period's complication risks are 20% to 50% higher than their corresponding recent period's complication risks.*
(2) The risks of having CVD, CKD, and DR ***in the earlier period were higher than 70%,*** *which matches his health diagnoses.* ***The Cancer risk in the earlier period was only 50% and verifies his "cancer-free" situation. All 4 complications in the recent period are lower than 55%,*** *which confirms his health status in the recent period.*
(3) All 5 input biomarkers between the two time periods have been ***improved within a range from 5% to 70 %,*** *except for ACR with an improvement of almost 300%. This indicates* ***his CKD issues are no longer a concern.*** *In summary, body weight impacts eAG (estimated average glucose) and changes HbA1C (both finger A1C and lab A1C); therefore, it affects both ACR and the overall MI score.* ***The listed data clearly shows a strong relationship existing between the 6 input biomarker improvements and the lower risk percentages of the 4 output complication risks.***
(4)The relative energy picture is similar to the above-described findings in the complication risk improvements in the time domain, except that ***relative energy offers an "amplified" picture*** *of the improvement degree of the earlier period versus the recent period. The calculated VGT energy improvement ratios are in the range of 37 to 108. The Cancer risk VGT energy improvement ratio is only 7 since his cancer risks have always been lower than the other 3 complications during the entire period.* ***The frequency energy improvement ratios are in the range of 36 to 109 which is highly comparable with the VGT energy results of 37 to 108.*** *The Cancer risk's frequency energy improvement ratio is 47.* ***The findings from the energy study deduce that both VGT energy and frequency energy methods are useful in conducting a disease comparison study.***

This article provides a summary of four different complication risk observations through either the VGT energy approach or the frequency energy approach of math-physical medicine (MPM) methodology. ***The key finding on the similar energy ranges for risks of having CVD, CKD, or DR between the earlier period and the recent period are 36-109 from using the VGT energy approach and 37-108 from using the frequency energy approach. This finding is extremely exciting to the author. However, it still warrants a more thorough and deeper investigation regarding these two energy methods to identify some additional characteristics of this methodology.***

Introduction

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Methods

Elasticity, Plasticity, Viscoelasticity, and Viscoplasticity

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.

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.

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.

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.*

The physical reasons for elastic behavior can be quite different for different materials. In metals, the atomic lattice changes size and shape when forces are applied (energy is added to the system). When forces are removed, the lattice goes back to the original lower energy state. For rubbers and other polymers, elasticity is caused by the stretching of polymer chains when forces are applied.

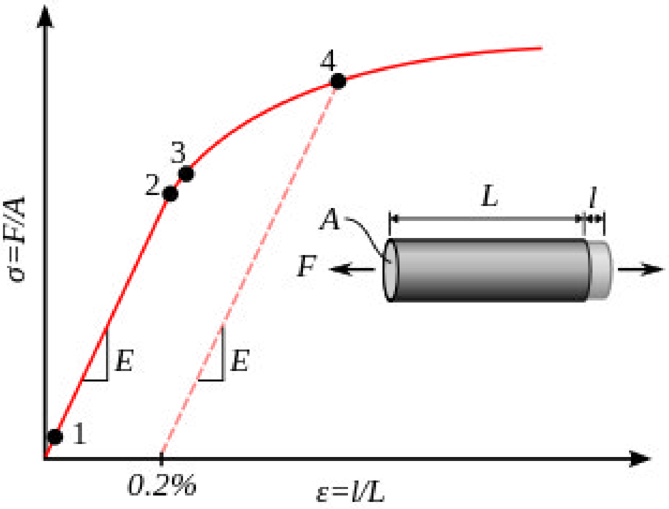
Hooke's law states that the force required to deform elastic objects should be directly proportional to the distance of deformation, regardless of how large that distance becomes. This is known as perfect elasticity, in which a given object will return to its original shape no matter how strongly it 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 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.

Plasticity (Physics)

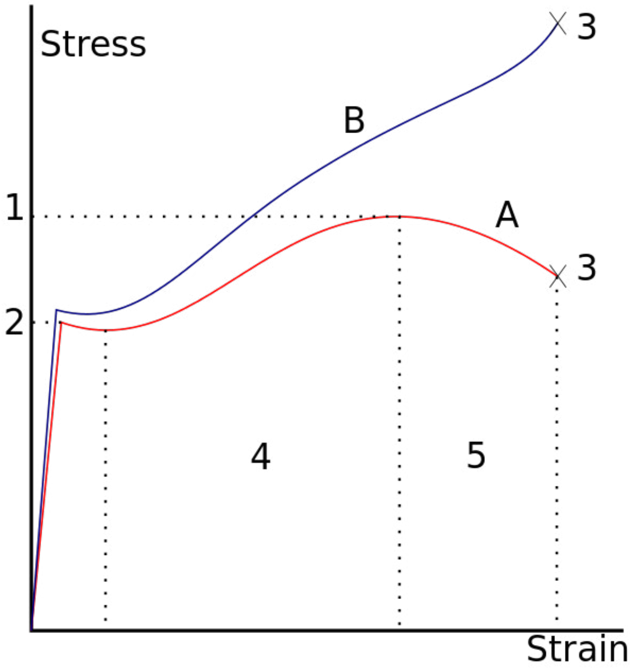
Deformation of a solid material undergoing non-reversible changes of shape in response to applied forces.

*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.*



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 curve 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/A0)*
- *B: Actual stress (F/A)*

Plastic deformation is observed in most materials, particularly metals, soils, rocks, concrete, and foams. However, the physical mechanisms that cause plastic deformation can vary widely. At a crystalline scale, plasticity in metals is usually a consequence of dislocations. Such defects are relatively rare in most crystalline materials, but are numerous in some and part of their crystal structure; in such cases, plastic crystallinity can result. In brittle materials such as rock, concrete, and bone, plasticity is caused predominantly by slip at microcracks. In cellular materials such as liquid foams or biological tissues, plasticity is mainly a consequence of bubble or cell rearrangements, notably T1 processes.

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 extension will remain.

Elastic deformation, however, is an approximation and its quality depends on the time frame considered and loading speed. If, as indicated in the graph opposite, the deformation includes elastic deformation, it is also often referred to as "elasto-plastic deformation" or "elastic-plastic deformation".

Perfect plasticity is a property of materials to undergo irreversible deformation without any increase in stresses or loads. Plastic materials that have been hardened by prior deformation, such as cold forming, may need increasingly higher stresses to deform further. Generally, plastic deformation is also dependent on the deformation speed, i.e. higher stresses usually have to be applied to increase the rate of deformation. Such materials are said to deform visco-plastically."

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).

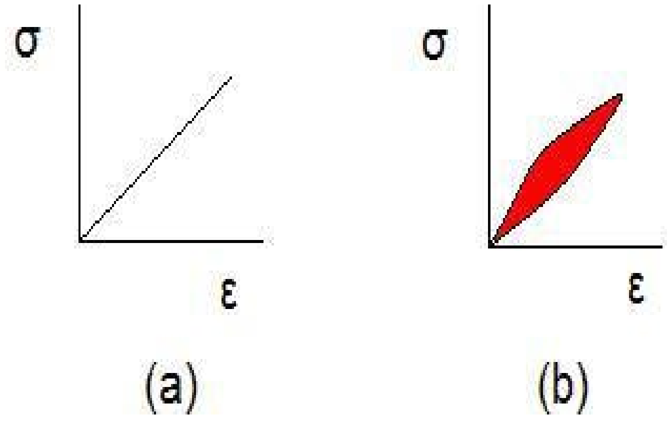
Depending on the change of strain rate versus stress inside a material, the viscosity can be categorized as having a linear, non-linear, or plastic response. When a material exhibits a linear response it is categorized as a Newtonian material. In this case, the stress is linearly proportional to the strain rate. If the material exhibits a non-linear response to the strain rate, it is categorized as Non-Newtonian fluid. There is also an interesting case where the viscosity decreases as the shear/strain rate remains constant. A material that exhibits this type of behavior is known as thixotropic. 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

$$\oint \sigma d\varepsilon$$

where σ is stress and ε is strain.

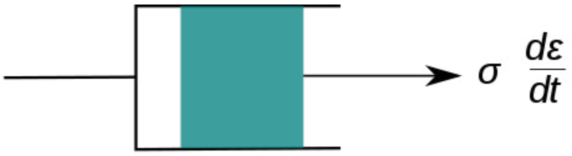
Unlike purely elastic substances, a viscoelastic substance has an elastic component and a viscous component. **The viscosity of a viscoelastic substance gives the substance a strain rate dependence on time.** Purely elastic materials do not dissipate energy (heat) when a load is applied, then removed. 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.

Specifically, viscoelasticity is a molecular rearrangement. When a stress is applied to a viscoelastic material such as a polymer, parts of the long polymer chain change positions. This movement or rearrangement is called "**creep**". Polymers remain a solid material even when these parts of their chains are rearranging in order to accompany the stress, and as this occurs, it creates a back stress in the material. When the back stress is the same magnitude as the applied stress, the material no longer creeps. When the original stress is taken away, the accumulated back stresses will cause the polymer to return to its original form. **The material creeps, which gives the prefix visco-, and the material fully recovers, which gives the suffix -elasticity.**

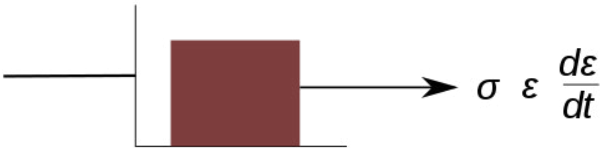
Viscoplasticity

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.



(a) Dashpot Element (λ,N)

(b) Spring Element (E)



(c) Sliding Frictional Element (σy)

Figure 1. Elements used in one-dimensional models of viscoplastic materials.

The elastic response of viscoplastic materials can be represented in one dimension by Hookean spring elements. Rate-dependence can be represented by nonlinear dashpot elements in a manner similar to viscoelasticity. Plasticity can be accounted for by adding sliding frictional elements as shown in Figure 1. In Figure E is the modulus of elasticity, λ is the viscosity parameter and N is a power-law type parameter that represents non-linear dashpot $[\sigma(d\varepsilon/dt)= \sigma = \lambda(d\varepsilon/dt)(1/N)]$. The sliding element can have a yield stress (σy) that is strain rate dependent, or even constant, as shown in Figure 1c.

Viscoplasticity is usually modeled in three dimensions using overstress models of the Perzyna or Duvaut-Lions types. In these models, the stress is allowed to increase beyond the rate-independent yield surface upon application of a load and then allowed to relax back to the yield surface over time. The yield surface is usually assumed not to be rate-dependent in such models. An alternative approach is to add a strain rate dependence to the yield stress and use the techniques of rate-independent plasticity to calculate the response of a material

For metals and alloys, viscoplasticity is the macroscopic behavior caused by a mechanism linked to the movement of dislocations in grains, with superposed effects of inter-crystalline gliding. The mechanism usually becomes dominant at temperatures greater than approximately one-third of the absolute melting temperature. However, certain alloys exhibit viscoplasticity at room temperature (300K). For polymers, wood, and bitumen, the theory of viscoplasticity is required to describe behavior beyond the limit of elasticity or viscoelasticity.

In general, viscoplasticity theories are useful in areas such as

- the calculation of permanent deformations,
- the prediction of the plastic collapse of structures,
- the investigation of stability,
- crash simulations,
- systems exposed to high temperatures such as turbines in engines, e.g. a power plant,
- dynamic problems and systems exposed to high strain rates.
-

Phenomenology

For qualitative analysis, several characteristic tests are performed to describe the phenomenology of viscoplastic materials. Some examples of these tests are
1. hardening tests at constant stress or strain rate,
2. creep tests at constant force, and
3. stress relaxation at constant elongation.

Strain Hardening Test

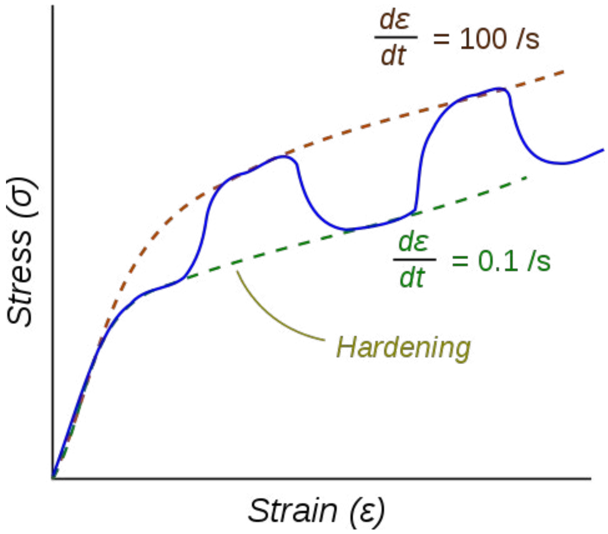


Figure 2. *Stress-strain response of a viscoplastic material at different strain rates.*

The dotted lines show the response if the strain rate is held constant. The blue line shows the response when the strain rate is changed suddenly.

One consequence of yielding is that as plastic deformation proceeds, an increase in stress is required to produce additional strain. This phenomenon is known as Strain/Work hardening. For a viscoplastic material, the hardening curves are not significantly different from those of rate-independent plastic material. Nevertheless, three essential differences can be observed.

1. At the same strain, the higher the rate of strain the higher the stress

2. A change in the rate of strain during the test results in an immediate change in the stress-strain curve.

3. The concept of a plastic yield limit is no longer strictly applicable.

The hypothesis of partitioning the strains by decoupling the elastic and plastic parts is still applicable where the strains are small, i.e.,

$\varepsilon = \varepsilon e + \varepsilon vp$

where εe is the elastic strain and εvp is the viscoplastic strain.

To obtain the stress-strain behavior shown in blue in the figure, the material is initially loaded at a strain rate of 0.1/s. The strain rate is then instantaneously raised to 100/s and held constant at that value for some time. At the end of that period, the strain rate is dropped instantaneously back to 0.1/s and the cycle is continued for increasing values of strain. There is clearly a lag between the strain-rate change and the stress response. This lag is modeled quite accurately by overstress models (such as the Perzyna model) but not by models of rate-independent plasticity that have a rate-dependent yield stress."

Time-Frequency Analysis via fast Fourier Transform

Time and Frequency Domain Analysis of Signals
A Review by Getachew Admassie Ambaye
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The time domain is the analysis of mathematical functions, and physical signals with respect to time. In the time domain, the signal or function's value is known for all real numbers, in the case of continuous-time, or at various separate instants in the case of discrete-time. An oscilloscope is a tool commonly used to visualize real-world signals in the time domain. A time-domain graph shows how a signal changes with time, whereas a frequency-domain graph shows how much of the signal lies within each given frequency band over a range of frequencies. The frequency-domain refers to the analysis of mathematical functions or signals with respect to frequency, rather than time. Put simply, a time-domain graph shows how a signal changes over time, whereas a frequency-domain graph shows how much of the signal lies within each given frequency band over a range of frequencies. A frequency-domain representation can also include information on the phase shift that must be applied to each sinusoid to be able to recombine the frequency components to recover the original time signal. And finally, the time-frequency signal analysis introduced, it's a new method in which the problem that had on the frequency signal analysis will be solved.

Time-Frequency Analysis
***Techniques and methods in signal processing** (from Wikipedia)*

In signal processing, the time-frequency analysis comprises those techniques that study a signal in both the time and frequency domains simultaneously, using various time-frequency. Rather than viewing a 1-dimensional signal (a function, real or complex-valued, whose domain is the real line) and some transform (another function whose domain is the real line, obtained from the original via some transform), time-frequency analysis studies a two-dimensional signal – a function whose domain is the two-dimensional real plane, obtained from the signal via a time-frequency transform.

***Fourier Transform** (from Wikipedia):*
Mathematical transform that expresses a function of time as a function of frequency

A Fourier transform (FT) is a mathematical transform that decomposes functions depending on space or time into functions depending on the spatial frequency or temporal frequency. An example application would be decomposing the waveform of a musical chord in terms of the intensity of its constituent pitches. The term Fourier transform refers to both the frequency domain representation and the mathematical operation that associates the frequency domain representation to a function of space or time.

Results

Figure 1 shows 4 complication risks of both time-domain waveforms and frequency energies.

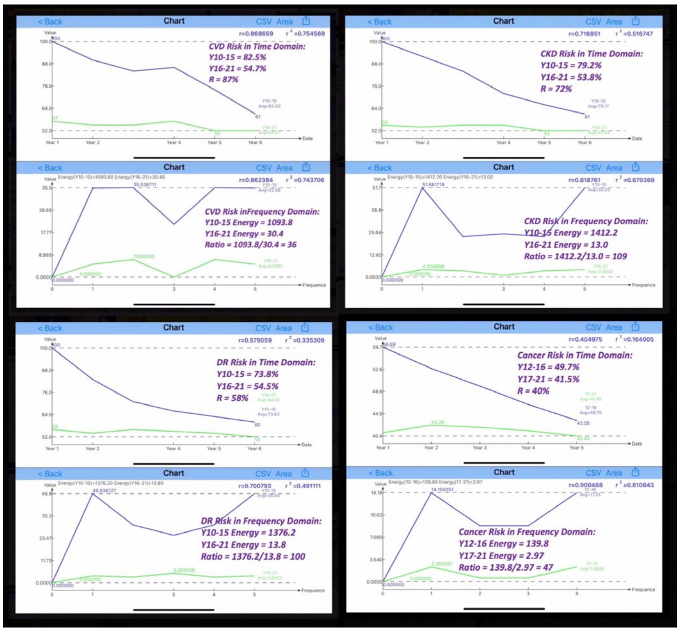
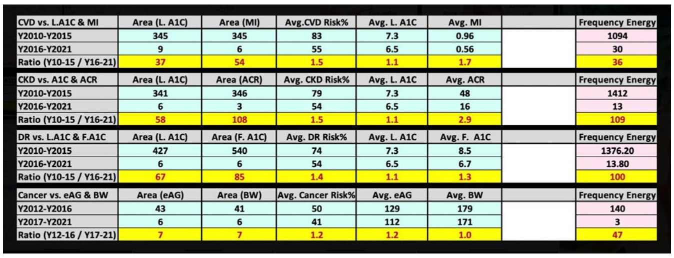


Figure 1: *4 complication risks of both time-domain waveforms and frequency energies*

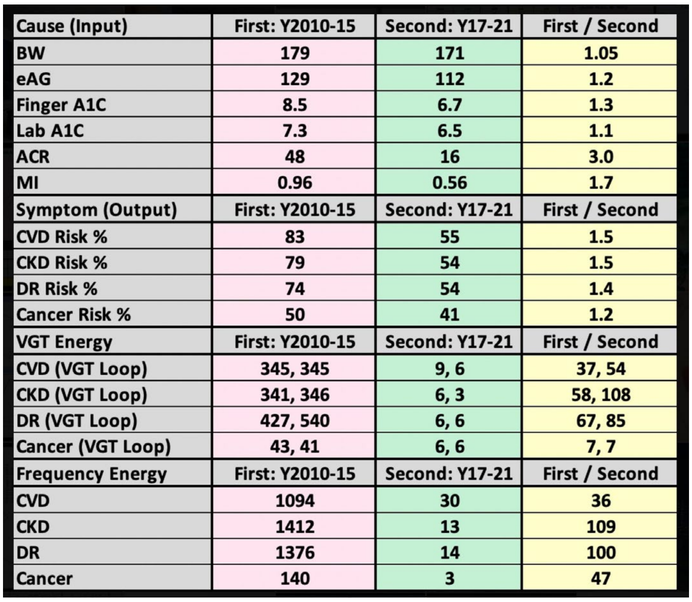
Figure 2 depicts the summary comparison Data Table One.



CVD vs. L.A1C & MI	Area (L. A1C)	Area (MI)	Avg.CVD Risk%	Avg. L. A1C	Avg. MI		Frequency Energy
Y2010-Y2015	345	345	83	7.3	0.96		1094
Y2016-Y2021	9	6	55	6.5	0.56		30
Ratio (Y10-15 / Y16-21)	37	54	1.5	1.1	1.7		36
CKD vs. A1C & ACR	Area (L. A1C)	Area (ACR)	Avg. CKD Risk%	Avg. L. A1C	Avg. ACR		Frequency Energy
Y2010-Y2015	341	346	79	7.3	48		1412
Y2016-Y2021	6	3	54	6.5	16		13
Ratio (Y10-15 / Y16-21)	58	108	1.5	1.1	2.9		109
DR vs. L.A1C & F.A1C	Area (L. A1C)	Area (F. A1C)	Avg. DR Risk%	Avg. L. A1C	Avg. F. A1C		Frequency Energy
Y2010-Y2015	427	540	74	7.3	8.5		1376.20
Y2016-Y2021	6	6	54	6.5	6.7		13.80
Ratio (Y10-15 / Y16-21)	67	85	1.4	1.1	1.3		100
Cancer vs. eAG & BW	Area (eAG)	Area (BW)	Avg. Cancer Risk%	Avg. eAG	Avg. BW		Frequency Energy
Y2012-Y2016	43	41	50	129	179		140
Y2017-Y2021	6	6	41	112	171		3
Ratio (Y12-16 / Y17-21)	7	7	1.2	1.2	1.0		47

Figure 2: Summary comparison Data Table One

Figure 3 reflects the summary comparison Data Table Two.



Cause (Input)	First: Y2010-15	Second: Y17-21	First / Second
BW	179	171	1.05
eAG	129	112	1.2
Finger A1C	8.5	6.7	1.3
Lab A1C	7.3	6.5	1.1
ACR	48	16	3.0
MI	0.96	0.56	1.7
Symptom (Output)	First: Y2010-15	Second: Y17-21	First / Second
CVD Risk %	83	55	1.5
CKD Risk %	79	54	1.5
DR Risk %	74	54	1.4
Cancer Risk %	50	41	1.2
VGT Energy	First: Y2010-15	Second: Y17-21	First / Second
CVD (VGT Loop)	345, 345	9, 6	37, 54
CKD (VGT Loop)	341, 346	6, 3	58, 108
DR (VGT Loop)	427, 540	6, 6	67, 85
Cancer (VGT Loop)	43, 41	6, 6	7, 7
Frequency Energy	First: Y2010-15	Second: Y17-21	First / Second
CVD	1094	30	36
CKD	1412	13	109
DR	1376	14	100
Cancer	140	3	47

Figure 3: Summary comparison Data Table Two

Conclusion

The following paragraph is a brief health history of the author for the past 30 years. This particular study is based on his collected biomarker data from 2010 to 2022 which includes the continuous influences from his 30-years long personal health history.

The author was diagnosed with T2D in 1997 with a random glucose check at a 300 mg/dL level; however, his diabetes condition most likely began earlier. He suffered his first two chest pain episodes in 1993-1994, along with three more heart episodes until 2007. His primary physician informed him that he had diabetic kidney issues in 2010. He then consulted with two more clinical doctors who advised him to start insulin injections and kidney dialysis immediately. This was his wake-up call. He then decided to save his life by conducting his study and research on food nutrition and chronic diseases that same year. His health profile in 2010 was: body weight at 220 lbs., average glucose at 280 mg/dL, lab-tested A1C at 10%, triglycerides at 1160, and his ACR at 116.

During the past 13 years, he has made significant lifestyle changes. For example, he consumes less than 20 grams of carbohydrates and sugar per meal, reduces his food quantity by 50%, walks 6-7 miles or 10-11 kilometers daily, sleeps 7-8 hours each night, and avoids stress as much as possible.

As of April 10, 2022, his health profile for the first 3 months of 2022 is body weight at 169 lbs., daily average glucose at 106 mg/dL, and lab-tested A1C at 5.8%. triglycerides at 108, and ACR at 16. A significant accomplishment is that he has ceased taking 3 different kinds of diabetes medications since 12/8/2015. Fortunately, he has not detected any sign of cancer to date.

The following described biophysical characteristics have demonstrated certain key behaviors of these 4 complication risks using the approaches of both VGT energy and the frequency energy:

(1)The first step is to review the concluding numbers of the complication risk percentages. These 4 complication risks based on his developed MI model in a time domain are expressed as earlier period versus recent period: ***CVD (83% vs. 55%), CKD (79% vs. 54%), DR (74% vs. 54%), and Cancer (50% vs. 41%).*** *These 4 earlier period's complication risks are 20% to 50% higher than their corresponding recent period's complication risks.*

(2) The risks of having CVD, CKD, and DR **in the earlier period were higher than 70%,** *which matches his health diagnoses. The Cancer risk in the earlier period was only 50% and verifies his "cancer-free" situation. All 4 complications in the recent period are lower than 55%, which confirms his health status in the recent period.*

(3) All 5 input biomarkers between the two time periods have been ***improved within a range from 5% to 70 %,*** *except for ACR with an improvement of almost 300%. This indicates his* ***CKD issues are no longer a concern.*** *In summary, body weight impacts eAG (estimated average glucose) and changes HbA1C (both finger A1C and lab A1C); therefore, it affects both ACR and the overall MI score.* ***The listed data clearly shows a strong***

relationship existing between the 6 input biomarker improvements and the lower risk percentages of the 4 output complication risks.

(4)The relative energy picture is similar to the above-described findings in the complication risk improvements in the time domain, except that ***relative energy offers an "amplified" picture*** *of the improvement degree of the earlier period versus the recent period. The calculated VGT energy improvement ratios are in the range of 37 to 108. The Cancer risk VGT energy improvement ratio is only 7 since his cancer risks have always been lower than the other 3 complications during the entire period.* ***The frequency energy improvement ratios are in the range of 36 to 109 which is highly comparable with the VGT energy results of 37 to 108.*** *The Cancer risk's frequency energy improvement ratio is 47.* ***The findings from the energy study deduce that both VGT energy and frequency energy methods are useful in conducting a disease comparison study.***

This article provides a summary of four different complication risk observations through either the VGT energy approach or the frequency energy approach of math-physical medicine (MPM) methodology. ***The key finding on the similar energy ranges for risks of having CVD, CKD, or DR between the earlier period and the recent period are 36-109 from using the VGT energy approach and 37-108 from using the frequency energy approach. This finding is extremely exciting to the author. However, it still warrants a more thorough and deeper investigation regarding these two energy methods to identify some additional characteristics of this methodology.***

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.

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