The GH-Method

Viscoelastic and Viscoplastic Glucose Theory (VGT #131): The Fifth Sensitivity Study of Normalization Factors Using Three Different Energy Methods, Time Domain, Space Domain, and Frequency Domain, to Calculate Energies or Degrees of Influence on the Total 4,731 Postprandial Plasma Glucose (PPG) versus 1,565 Low-Carbs Meals (33%), 1,669 Medium-Carbs Meals (35%), and 1,497 High-Carbs Meals (32%) Over a Period of 4+ Years from 5/8/2018 to 8/16/2022 Based on Math-Physical Medicine Methodology (No. 722)

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Keywords: Viscoelastic; Viscoplastic; Postprandial plasma glucose; Fasting plasma glucose; Type 2 diabetes; Fast Fourier transform

Abbreviations: FFT: fast Fourier transform; T2D: type 2 diabetes; PPG: postprandial plasma glucose; FPG: fasting plasma glucose; FD: frequency domain; SD: space domain; TD: time domain; MPM: math-physical medicine

1. INTRODUCTION

The author has conducted medical research work using viscoelastic or viscoplastic glucose theory (VGT) starting on 1/8/2022 with Paper No. 578. During this research period, he has written 130 papers with different medical symptoms and various biomarkers where he learned in depth the subtlety and things to watch out for by applying this specific VGT medical research tool.

In the beginning, he selected multiple input viscosities, i.e. causes, without using any normalization factors (NF); therefore, he obtained some enlarged or dwindled stress components due to differences in their originally inherited measurement units. Afterward, he learned that some meaningful NF values should be used before calculating the hysteresis loop areas of the stress-strain diagram, i.e. diagram of input causes versus output symptoms for the biomedical studies. Sometimes, NF values are used in reverse, such as applying 120 mg/dL divided by glucose values or utilizing 4,000 steps divided by the post-meal walking steps. This is due to the glucose unit following the pattern of "lower the better" whereas exercise is "more the better."

In this research article, he studies the contribution of energy (or degree of influence) of the total PPG associated with 4,731 meals from the low-PPG (0-7.0 grams) from 1,565 meals, medium-PPG (7.1-14 grams) from 1,669 meals, and high-PPG (14.1-200 grams) from 1,497 meals. The day or meal number ratio of these 3 meal groups is "33% : 35% : 32%" for "high : medium : low" levels of carbohydrates & sugar intake amount per meal (carbs). The author deliberately select these three carbs ranges in order to have an almost equal size of day numbers or meal numbers for each carbs group.

At the beginning, he thought about only using 120 mg/dL (break-even line of diabetes)

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to divide the PPG values which would provide the energy contribution results from each type of meal, such as "low-carbs energy of 28% to 31% < medium-carbs energy of 33% to 36% < high-carbs energy of 36% to 38%". These calculated energies revealed the PPG biophysical characteristics resulting from each meal "type" or each average "carbs level."

However, these types of calculated energy contributions are missing the "overall impact on the total PPG from each PPG group by including influences from day number count (or meal number at 3 meals per day)". Therefore, he inserted another set of energy calculations using another modified NF value of "NF = (input/120) * (day number count %)" to conduct the same energy analyses via both SD-VGT and FD-FFT. Under this additional "influence of day number count %", the newly calculated energy contribution results are: "low-PPG energy of 28% to 31% < high-PPG energy of 34% to 36%" < medium-PPG energy of 35% to 38%. This set of calculated energies uncovered the specific influences from "day number count %".

Based on the above-described comparison, it is obvious that "no day number count %" and "with day number count %" have yielded a similar range and data pattern of results from the 3 carbs groups. This finding has resulted from the author's deliberate selection of his 3 carbs ranges from three "almost equal day counts groups", where he has chosen each day number count group around 1/3 of the total data group. His purpose in doing so is to see whether it would create a homogenous result pattern and energy ranges between the "no-day number count %" group and the "with day number count %" group.

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 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.

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 fast Fourier transform (FFT) analysis method together 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 those 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 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), 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 time 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 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 a time domain and then perform the fast Fourier transformation (FFT) operation to convert them into a frequency domain. 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 quarter - 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 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.

In this particular study, he has used two sets of "normalization factors": (1) 120 mg/dL; (2) (specific meal number / total meal number) * 120 mg/dL.

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

3. RESULTS

Figure 1 shows 2 data tables.

8/17/22	Strain	Visc. 1	Visc. 2	Visc. 3	N.1 (/120)	N.2 (/120)	N.3 (/120)	Strain Rate	Strain	Stress 1	Stress 2	Stress 3	Area 1	Area 2	Area 3			8/17/22	SQRT 1	SQRT 2	SQRT 3
PPG Study	Total PPG	Lo Carb	Med Carb	HI Carb	Lo Carb	Med Carb	HI Carb	Total Rate	Total PPG	Lo Carb	Med Carb	HI Carb	Lo Carb	Med Carb	HI Carb	Time #	Time %		Lo Carb	Med Carb	HI Carb
0-min	121	116	123	125	0.96	1.03	1.05	0.00	121	0.00	0.00	0.00	0.0	0.0	0.0			0-min	0	0	0
15-min	124	117	125	129	0.98	1.04	1.07	2.32	124	2.27	2.42	2.49	2.6	2.8	2.9			15-min	280	300	308
30-min	128	119	130	135	0.99	1.08	1.13	4.38	128	4.34	4.74	4.94	14.5	15.7	16.3			30-min	556	608	633
45-min	131	121	133	141	1.00	1.11	1.17	3.30	131	3.32	3.66	3.87	12.6	13.9	14.5	0-60		45-min	435	481	508
60-min	132	121	133	142	1.00	1.11	1.18	0.20	132	0.20	0.22	0.24	0.4	0.4	0.4	97	53%	60-min	26	29	31
75-min	129	119	129	140	0.99	1.07	1.16	-2.68	129	-2.65	-2.88	-3.12	3.3	3.6	3.9			75-min	-342	-371	-402
90-min	126	117	126	137	0.97	1.05	1.14	-2.59	126	-2.52	-2.71	-2.96	6.7	7.2	7.9			90-min	-318	-342	-374
105-min	123	115	122	134	0.96	1.01	1.12	-3.13	123	-2.99	-3.17	-3.49	8.6	9.2	10.1	75-120		105-min	-369	-391	-430
120-min	121	113	119	131	0.94	0.99	1.09	-2.33	121	-2.20	-2.31	-2.54	6.0	6.4	7.0	80	44%	120-min	-266	-279	-307
135-min	120	114	118	129	0.95	0.98	1.08	-0.85	120	-0.80	-0.83	-0.92	1.3	1.3	1.5			135-min	-96	-100	-110
150-min	120	115	118	129	0.96	0.98	1.07	0.34	120	0.33	0.33	0.36	-0.1	-0.1	-0.1			150-min	39	40	44
165-min	121	117	119	129	0.97	0.99	1.07	0.82	121	0.80	0.81	0.88	0.5	0.5	0.5	135-180		165-min	97	98	107
180-min	121	119	119	127	0.99	0.99	1.06	0.16	121	0.16	0.16	0.17	0.1	0.1	0.1	6	3%	180-min	19	19	21
Average	124	117	124	133	0.97	1.03	1.11	-0.005	124	0.02	0.03	-0.01	56	61	65	182	100%	Sum	62	92	28
	TD-E #	13683	15377	17665								SD-E%	31%	33%	36%	FD-E #	4E+06	FD-E #	1107885	1423229	1E+06
	TD-E %	29%	33%	38%												FD-E %	100%	FD-E %	28%	36%	37%

8/17/22	Strain	Visc. 1	Visc. 2	Visc. 3	N.1 with %	N.2 with %	N.3 with %	Strain Rate	Strain	Stress 1	Stress 2	Stress 3	Area 1	Area 2	Area 3			8/17/22	I/O 1	I/O 2	I/O 3
PPG Study	Total PPG	Lo Carb	Med Carb	HI Carb	Lo Carb	Med Carb	HI Carb	Total Rate	Total PPG	Lo Carb	Med Carb	HI Carb	Lo Carb	Med Carb	HI Carb	Time #	Time %		Lo Carb	Med Carb	HI Carb
0-min	121	116	123	125	0.32	0.36	0.33	0.00	121	0.00	0.00	0.00	0.0	0.0	0.0			0-min	0	0	0
15-min	124	117	125	129	0.32	0.37	0.34	2.32	124	0.75	0.86	0.79	0.9	1.0	0.9			15-min	93	106	97
30-min	128	119	130	135	0.33	0.38	0.36	4.38	128	1.44	1.67	1.56	4.8	5.5	5.1			30-min	184	214	200
45-min	131	121	133	141	0.33	0.39	0.37	3.30	131	1.10	1.29	1.22	4.2	4.9	4.6	0-60 min		45-min	144	170	161
60-min	132	121	133	142	0.33	0.39	0.37	0.20	132	0.07	0.08	0.07	0.1	0.1	0.1	32	53%	60-min	9	10	10
75-min	129	119	129	140	0.33	0.38	0.37	-2.68	129	-0.88	-1.02	-0.99	1.1	1.3	1.2			75-min	-113	-131	-127
90-min	126	117	126	137	0.32	0.37	0.36	-2.59	126	-0.83	-0.96	-0.94	2.2	2.6	2.5			90-min	-105	-121	-118
105-min	123	115	122	134	0.32	0.36	0.35	-3.13	123	-0.99	-1.12	-1.10	2.9	3.2	3.2	75-120		105-min	-122	-138	-136
120-min	121	113	119	131	0.31	0.35	0.35	-2.33	121	-0.73	-0.81	-0.81	2.0	2.3	2.2	27	44%	120-min	-88	-98	-97
135-min	120	114	118	129	0.31	0.35	0.34	-0.85	120	-0.27	-0.29	-0.29	0.4	0.5	0.5			135-min	-32	-35	-35
150-min	120	115	118	129	0.32	0.35	0.34	0.34	120	0.11	0.12	0.12	0.0	0.0	0.0			150-min	13	14	14
165-min	121	117	119	129	0.32	0.35	0.34	0.82	121	0.26	0.29	0.28	0.2	0.2	0.2	135-180		165-min	32	35	34
180-min	121	119	119	127	0.33	0.35	0.34	0.16	121	0.05	0.06	0.05	0.0	0.0	0.0	2	3%	180-min	6	7	7
Average	124	117	124	133	0.32	0.36	0.35	-0.005	124	0.01	0.01	0.00	19	22	21	61	100%	Average	21	33	1
	TD-E #	4526	5425	5590								SD-E%	31%	35%	34%	FD-E #	430151	FD-E #	121293	161518	147340
	TD-E %	29%	35%	36%												FD-E %	100%	FD-E %	28%	38%	34%

Figure 1: 2 Data tables.

Figure 2 displays the background data and the TD analysis results.

Carbs Range	0-200	0-7.0	7.1-14	14.1-200	PPG mg/dL	0-120	121-150	151-400
PPG Study	Total PPG	Lo Carb	Med Carb	HI Carb	PPG Study	Lo Carb	Med Carb	HI Carb
No. of Meals	4731	1565	1669	1497	Norm %	33%	35%	32%
Ag. F. PPG	110.9	107.2	107.9	118.3	Correlation	84%	97%	92%
Avg. Carbs	13.3	2.1	10.8	27.9				
Avg. Steps	4238	4019	4297	4405				

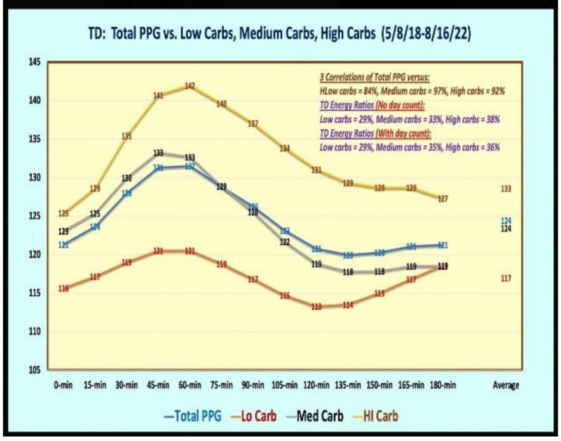


Figure 2: Background data and the TD analysis results.

Figure 3 depicts 2 SD-VGT analysis results.

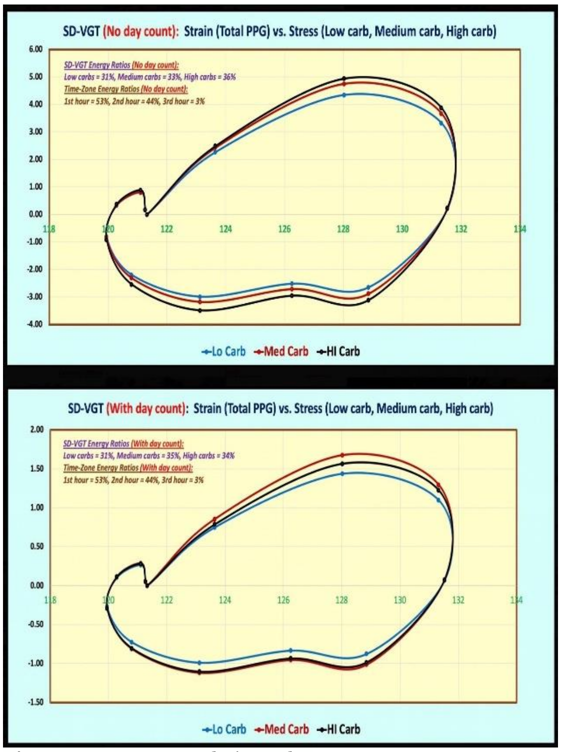
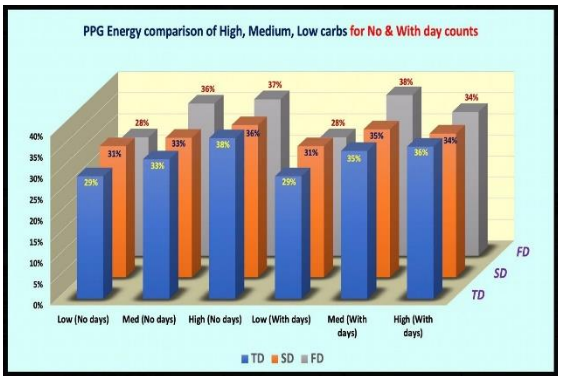


Figure 3: 2 SD-VGT analysis results.

Figure 4 reflects 2 FD-FFT analysis results.

Figure 5 illustrates the energy comparison of using three research tools with both no day number counts and with day number counts.

Figure 4: 2 FD-FFT analysis results.



No & With days	TD	SD	FD
Low (No days)	29%	31%	28%
Med (No days)	33%	33%	36%
High (No days)	38%	36%	37%
Low (With days)	29%	31%	28%
Med (With days)	35%	35%	38%
High (With days)	36%	34%	34%

Figure 5: Energy ratio comparison for both excluding and including day number count in the normalization factors.

4. CONCLUSION

In summary, there are 5 key findings from this fifth special sensitivity study of normalization factor in the biomedical energy analysis with similar day or meal count size of each carbs group:

(1) From the TD diagram, the average PPG values are 124 mg/dL for the total PPG, 117 mg/dL for the low-carbs group, 124 mg/dL for the medium-carbs group, and 133 mg/dL for the high-carbs group. Each carbs group occupies approximately 1/3 of the total PPG data group.

(2) From the TD diagram, the three correlation coefficients are: Total vs. Low = 84%; Total vs. Medium = 97%; and Total vs. High = 92%. All of the three correlations are high.

(3) TD squared-amplitude energy analysis results of "no day number count" and "with day number count" are: For the "no day number count % in normalization factors" case: The TD squared amplitude energy ratios are: Low-carbs = 29%; Medium-carbs = 33%; and High-carbs = 38%. But, for the "with day number count in normalization factors" case: The TD squared amplitude energy ratios are: Low-carbs = 29%; Medium-carbs = 35%; and High-carbs = 36%. These two cases have derived similar TD energy results regardless of excluding or including day number count %. This has resulted from the author's deliberate selection of equal day numbers for 3 carbs group.

(4) From the SD-VGT analysis results, there are two energy ratios from "no day number count" and "with day number count" which are: For the "no day number count in normalization factors" case: The SD-VGT energy ratios are: Low-carbs = 31%; Medium-carbs = 33%; and High-carbs = 36%. But, for the "with day number count in normalization factors" case: The SD-VGT energy ratios are: Low-carbs = 31%; Medium-carbs = 35%; and High-carbs = 34%. Again, these two cases have derived similar TD energy results regardless of excluding or including day number count %. This resulted from the author's deliberate selection of equal day numbers for 3 carbs group. From the SD-VGT analysis results, the author has further analyzed the energy's time-zone process from "energy generation through energy dissipation to the state of left-over energy". Again, there are two energy ratios from "no day number count" and "with day number count" which are: For the "no day number count in normalization factors" case: The SD-VGT energy ratios are: 1st hour = 53%; 2nd hour = 44%; and 3rd hour = 3%. However, for the "with day number count in normalization

factors" case: The SD-VGT energy ratios are: 1st hour = 53%; 2nd hour = 44%; and 3rd hour = 3%. It is interesting to discover that, regardless of the inclusion or exclusion of meal numbers inside the normalization factors, these two time-zone energy ratios are identical to each other. In other words, generated energy via food consumption during the first hour contributes 53% of total energy, dissipated energy via exercise during the second hour contributes 44% of total energy, and left-over energy within the third hour is 3% of total energy, regardless inclusion or exclusion of day number count % in the normalization factors. Another way to look at this observation is that the energy infusion from his food is almost completely depleted via post-meal exercise. As a result, this energy process leaves a small amount of energy (3%) inside his body. This description fits the definition of elastic behavior according to engineering theory. Furthermore, by observing the stress-strain diagram, especially the hysteresis loop, it has a "nearly-complete closed loop"; therefore, according to engineering theory, his total PPG also has a viscoelastic behavior.

(5) From the FD-FFT analysis results, there are two energy ratios from "no day number count" and "with day number count" which are: For the "no day number count in normalization factors" case: The FD-FFT energy ratios are: Low-carbs = 28%; Medium-carbs = 36%; and High-carbs = 37%. However, for the "with day number count in normalization factors" case: The FD-FFT energy ratios are: Low-carbs = 28%; Medium-carbs = 38%; and High-carbs = 34%. These two FD-FFT analysis results are very similar to each other. Again, these two cases have derived similar TD energy results regardless of excluding or including day number count %. This has resulted from the author's deliberate selection of equal day numbers for the 3 carbs group.

In summary, this fifth special NF sensitivity study has yielded either similar or identical results between excluding and including day number count %. This finding has shown the importance of selecting the normalization factor in using three different energy analysis tools. It is especially important for using the SD-VGT tool since the other two tools, TD with number count % modification on squared-amplitude values and FD's newly defined variables based on (strain*stress) from SD results, are closely related to the SD energy concept or its derived variables.

This fifth sensitivity study of the normalization process has indeed offered a deeper understanding of biophysical behaviors of various biomedical variables, i.e. biomarkers. This article has also further proven the usefulness of math-physical medicine research methodology in biomedical research.

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.eclairemd.com.

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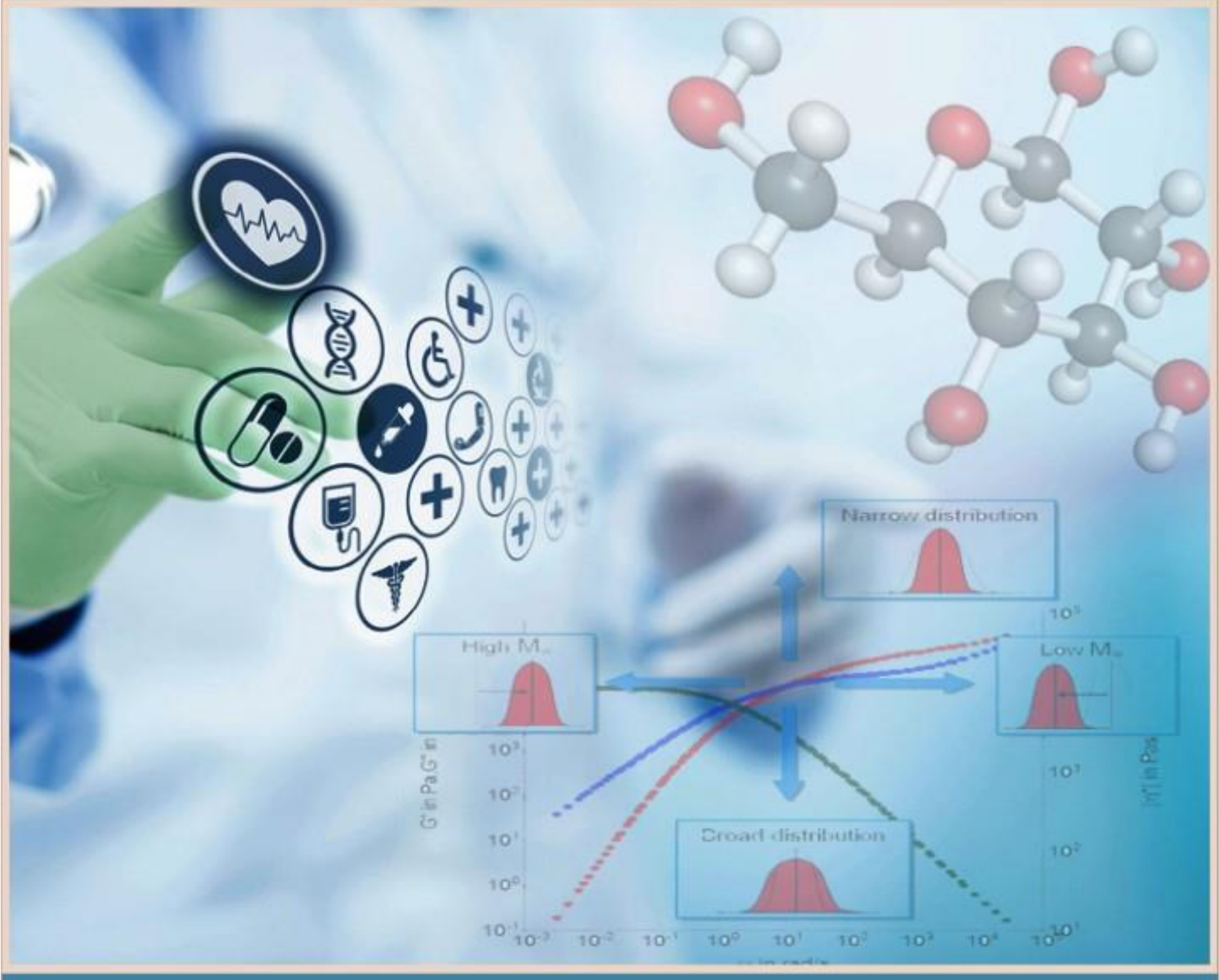

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