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# A Step-by-Step Explanation on How to Apply the Distributional Data Analysis Tool of the Glucose Density (GD%) with Collected Finger-Piercing Daily Glucose Data over 8.5 Months for Two Type 2 Diabetes Patients Based on GH-Method: Math-Physical Medicine (No. 517)

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## Abstract

*Recently, the author conducted a series of medical research projects by applying a distributional data density analysis tool on his weight, glucose, blood pressure (BP), and heart conditions, while using his collected big data regarding certain biomarker's density distribution for certain selected years.*

*In this particular article, he explains the step-by-step procedures on how to apply the Biomarker Density % (BMD%) tool, especially the glucose density % (GD%) to help with the type 2 diabetes (T2D) diagnosis and treatment using two T2D patients finger-piercing daily glucose (eAG) data as an illustrative example. There is no need to introduce the background of these patients since their glucose data comparison is the focus.*

*In summary, the author outlines the step-by-step process on how to apply the GD% concept and tool using two T2D clinical cases. Patient A has a higher hyperglycemic risk, while Patient B has a lower risk of hypoglycemia. Overall, Patient B, with a mean glucose of 105 mg/dL, has better diabetes control compared Patient A, with a mean glucose of 124 mg/dL. Once the readers learn the concept and method of these BMD tools, they can apply them to patients with different chronic diseases. Those who have an interest in learning more can visit the author's website: (www.eclairemd.com) and search for articles with the key word "density".*

As long as patients have collected a sizable amount of data for their glucoses, their medical doctors can use the author's developed APP software on the iPhone or iPad to display and plot out the following useful information:

1. Time-domain data and curves, i.e. glucose curves over a selected timeframe, similar to an EKG chart, or any common medical charts.
2. Density-domain data and curves, i.e. percentage of the total data associated with one particular glucose level. The doctor should always look for the "lump of the curve" where the majority of the patient's glucose concentrate.
3. The APP software will then calculate the percentages of glucose data located within time-between-range or TBR range (< 70 mg/dL), time-in-range or TIR range (70 mg/dL to 140 mg/dL or 70 mg/dL to 180 mg/dL), and time-above-range or TAR range (> 140 mg/dL or > 180 mg/dL). These 3 TxR percentages can provide useful information regarding hypoglycemia, normal condition, or hyperglycemia in patients.
4. With more experience on interpreting the GD% results and graphic diagram, the doctor will eventually be able to explore more hidden information from the available glucose waveforms, such as glucose wave associated with relative energy level which causes different degrees of damage to internal organs. The extra detailed information and findings belong to the category in the more advanced features.

## Introduction

Recently, the author conducted a series of medical research projects by applying a distributional data density analysis tool on his weight, glucose, blood pressure (BP), and heart conditions, while using his collected big data regarding certain biomarker's density distribution for certain selected years.

In this particular article, he explains the step-by-step procedures on how to apply the ***Biomarker Density % (BMD%) tool***, especially the ***glucose density % (GD%)*** to help with the type 2 diabetes (T2D) diagnosis and treatment using two T2D patients finger-piercing daily glucose (eAG) data as an illustrative example. There is no need to introduce the background of these patients since their glucose data comparison is the focus.

## Methods

### *MPM Background*

To learn more about his developed GH-Method: math-physical medicine (MPM) methodology, readers can read the following papers selected from his 500+ published medical papers.

The first paper, No. 386 describes his MPM methodology in a general conceptual format. The second paper, No. 387 outlines the history of his personalized diabetes research, various application tools, and the differences between biochemical medicine (BCM) approach versus the MPM approach. The third paper, No. 397 depicts a general flow diagram containing ~10 key MPM research methods and different tools.

In particular, his paper No. 453 illustrates his GH-Method: math-physical medicine in great details, "Using Topology concept of mathematics and Finite Element method of engineering to develop a mathematical model of Metabolism in medicine in order to control various chronic diseases and their complications via overall health conditions improvement".

### *Glucose Density (GD)*

In the past, when people researched certain biomarkers and their relationships with other influential factors, they were mostly using the averaged values of those biomarkers. However, we know that most of biomarkers, including body weight glucoses, heart rate, and blood pressure, etc. would fluctuate along the time scale in a form of "wave". Of course, each wave has its unique amplitude and specific measuring unit which are associated with this particular biomarker. However, there are two other key factors, frequency and wavelength needed to be considered as well. Particularly, the frequency component is associate with relative energy carry by this wave, especially the excessive glucose energy which causes damages to our internal organs. Therefore, without paying much attention on waveform of a biomarker and only depending upon its mean value, we would miss out lots of vital, interesting and useful hidden information. This kind of mean values, such as HbA1C, or sparsely collected finger-pierced glucose, or quarterly available lab-tested blood lipid results, which can only provide partial views of our overall health conditions. Those biomarkers still have some missing information which carried certain hidden internal turmoil or vital sign, e.g. biomarker variation or its severe stimulation due to all kinds of external and/or internal stimulators. Therefore, applying this basic knowledge of distributional data analysis by defining another term known as the "***general biomarker density%" (i.e. BMD%),*** the medical professionals can explore some more, different, deeper and useful hidden information from their collected biomarker data and associated waveforms.

***The term of "biomarker density percentage" (BMD%) is defined as the occurrence frequency at a specific person's biomarker value.*** In this way, we can then calculate and examine each biomarker's occurrence rate within certain range over his selected timespan. This selected timespan is depending on the specific study which is suitable to certain specific patients (for this case, these two selected T2D patients). By watching out for the changes of the peak biomarker value with their associated BMD% from year to year, we can easily observe patients biomarker moving trend and understand their actual health problems or necessary health improvement program (e.g. treatment) clearly.

Above description provides the reason behind why the author keeps on search for more applicable tools to analyze collected big data of any biomarker. If this kind of biomarker examination method accepted by the medical community, it could be an extremely beneficial tool for doctors to quickly study the health conditions of their patients. Furthermore, the author has also programmed this algorithm into an iPhone APP software. Through the combination of his publishes papers and medical books along with a widely distributed APP for patient's use in the future, he believes that worldwide chronic diseases patients can benefit from his research work. Hopefully, in this way, his research papers would not be limited within the scope of a "descriptive style using 26 alphabets" but instead as a "quantitative style using 10 digits". Numbers do not lie as long as we don't use fake, and/or uncleaned data. Statistics is a tricky tool to use for any research work because it has the obvious characteristics of "garbage in and garbage out (GIGO)". It is also important to know that by using statistics with different selected time-windows for certain studies will result into varying conclusions.

For the case of one particular patient i, the collected biomarker data can be expressed by pairs of data in the format of (t ij, X ij), j = 1 … T, where the t ij represent recording times and X ij is the biomarker level at time instant t ij, and T is the overall observation length of weight.

***For the case in this article, the total T is 182 (e.g. from 51 mg/dL to 233 mg/dL with an equal interval of 1 mg/dL between two finger glucose end-points).***

Therefore, he can describe the above mathematical problem into a more simplified equation for one patient only. The ***glucose density% (GD%) for one patient can be defined in terms of a continuous format*** as follows:

$$GD(x) = \frac{1}{T}\int_{1}^{T} Y(t)\,dt$$

***with x1 < Y(t) < x2***
***where x1 and x2 are ∫ boundaries of his selected glucose range.***

The ***glucose density % (GD%) equation for*** one patient, such as himself, can also be defined in terms of a discrete format as follows:

$$GD(x) = \frac{1}{T}\sum_{j=1}^{T} Y(tj)$$

***with x1 < Y(t) < x2***

***where x1 and x2 are boundaries of his selected glucose range.***

He then develop his APP software program using the above-described algorithm.

## Procedures and Example Results

For the first step, doctors should ask their diabetes patients to collect their glucose data either via finger-pierced method or CGM sensor device on a daily basis or a regular pattern. Nevertheless, the glucose data size must be big enough for a meaningful analysis and useful results finding. If the patient's data only covers one or two weeks' time period, then it is recommended to use the CGM sensor collected glucoses. Sparse or insufficient glucose data have no merit for this type of statistical analysis. The data can be manually entered or collected by a device, but they must have a Microsoft Excel compatible format (CSV format) in order to transfer them into the author's APP software on iPhone or iPad. The APP software will then conduct a time-domain analysis which is similar to an EKG chart. Figure 1 shows the time-domain glucose analysis of these two patients. These two glucose waves are demonstrated through the daily curve and 90-days moving average curve of the finger-piercing glucoses.

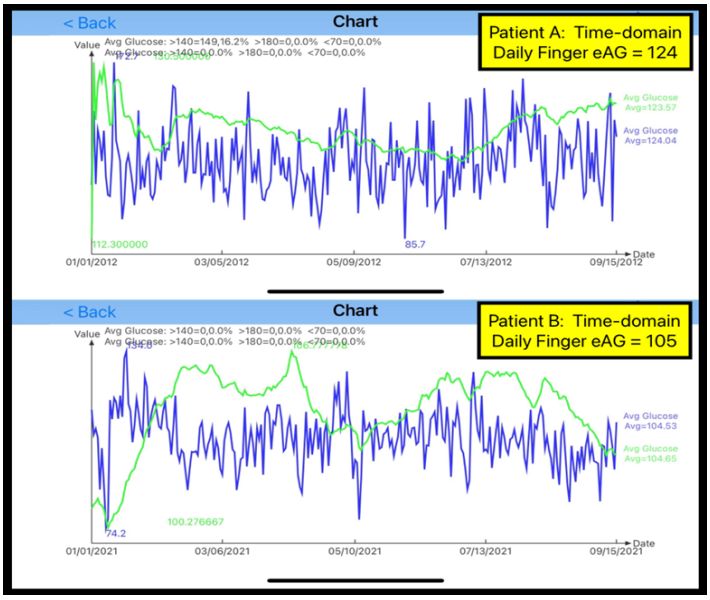


**Figure 1:** Time-domain analysis results of two T2D patients over a period of 8.5 months

For the second step, doctors can conduct a density-domain analysis via the APP software. Figure 2 reflects two separate APP generated glucose density % charts with two different glucose ranges. They can examine each GD% diagram to study each patient's specific glucose density distribution. Doctors should always focus on the curve's "lump area" where the majority of the patient's glucose concentrate. For example, in Figure 2, Patient A has a GD% peak of 3.08% around 110 mg/dL but the lump area covers between 92 mg/dL and 150 mg/dL which means higher glucoses are concentrated within this "wider" lump. On the contrary, Patient B's GD% peak of 3.30% located around 110 mg/dL but the lump area covers a "narrower" area between 100 mg/dL and 120 mg/dL which indicates lesser amount of glucose data are concentrated within this narrower lump.

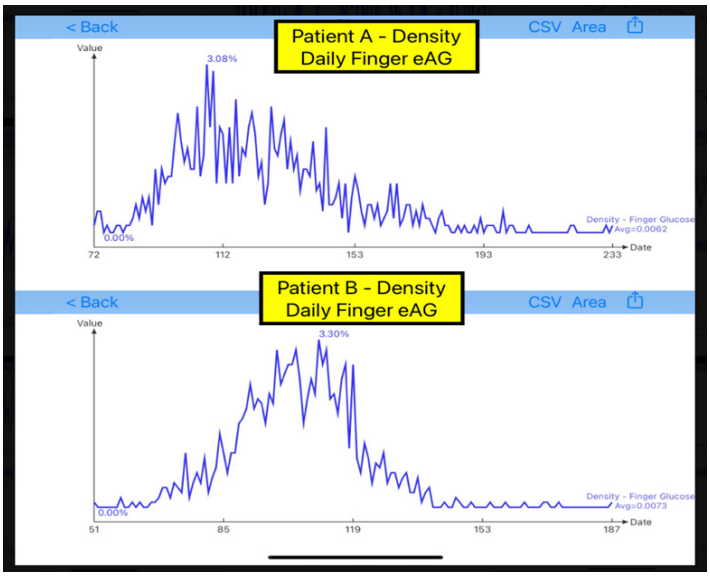


**Figure 2:** Separated Glucose Density % distribution analysis results of two T2D patients over a period of 8.5 months (using APP with different glucose ranges)

For the third step, doctors can combine these two separate GD% curves into a single diagram with the same glucose range. This step is useful for comparison of two patients or comparison of two different timespan of one patient. The above-described lumps situation in Figure 2 can be observed more clearer in Figure 3. The lump area of Patient A (blue curve) covers a bigger area with higher glucose summation values compared to Patient B (red curve). This wider lump area located on the higher glucose range signifies that the excessive glucose energy is carried in Patient A's blood which would cause more damage to the internal organs of Patient A.

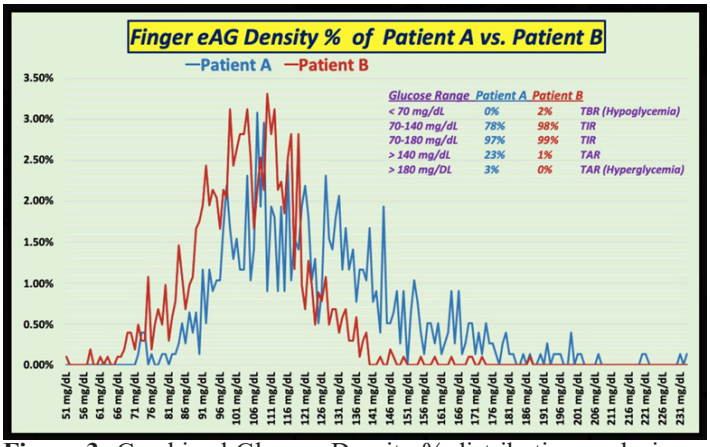


**Figure 3:** Combined Glucose Density % distribution analysis results of two T2D patients over a period of 8.5 months (using Excel with same glucose ranges)

For the fourth step, doctors can draw bar charts to compare TBR (<70 mg/dL, TIR (70-140 or 180 mg/dL), TAR (> 140 or 180 mg/

dL) of Patient A and Patient B. The 180 mg/dL boundary between TIR and TAR is more applicable for "severe T2D" patients while the 140 mg/dL boundary between TIR and TAR is more applicable for "improved T2D" patients. Figure 4 reveals that Patient A has no risk on hypoglycemia (insulin shock) while Patient B has little risk of having hypoglycemia (~2% of risk). This is due to Patient B's better T2D control (resulted in a lower mean glucose value) but still carries damaged Pancreatic beta cells. Regarding hyperglycemia, Patient B has no risk at all (>180 mg/dL) while Patient A has a low risk (3%) due to higher mean glucose value and wider glucose lump area. Regarding TIR, by using either 140 boundary or 180 boundary, Patient B is higher compared to Patient A which indicates that overall speaking, Patient B has better diabetes control than Patient A.

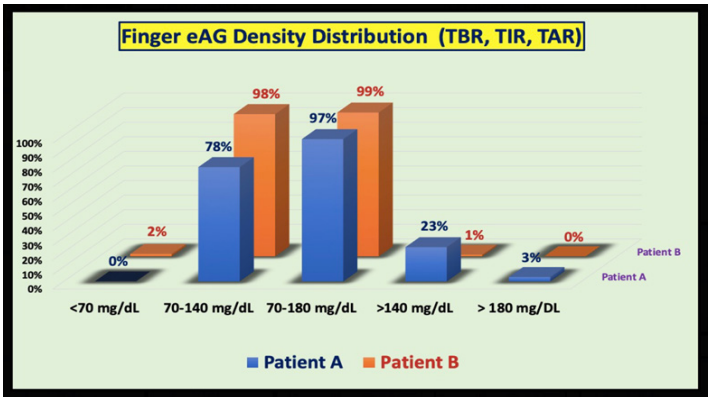


**Figure 4:** Finger-piercing glucose density % of two T2D patients over a period of 8.5 months (TBR, TIR, TAR)

In this article, the author's objective is to demonstrate the basic usage of the biomarker density concept and practice. He will reserve other more advanced research results in his forthcoming medical papers. Actually, quite a few of those advanced studies have been reported through his published medical papers already.

In addition, Figure 5 displays a combined biomarker density % (BMD%) distribution diagram of five selected biomarkers, weight, glucose, HR, SBP, DBP, of one particular patient with long-term chronic diseases. This diagram uses the same data range on x-axis within a longer period of 7.5 years (4/1/2014 - 9/13/2021). The purpose of inserting this figure in the study is to validate the broader applicability for the density distribution on other biomarkers.

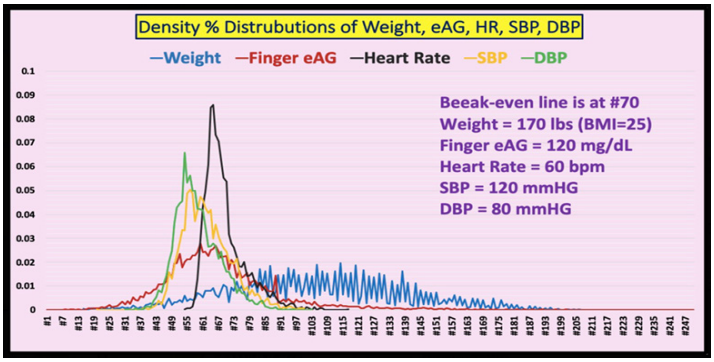


**Figure 5:** Combined density % distribution diagram of 5 selected biomarkers of one particular chronic diseases patient based on a consistent data range within a period of 7.5 years (4/1/2014 - 9/13/2021)

## Conclusions

In summary, the author outlines the step-by-step process on how to apply the GD% concept and tool using two T2D clinical cases. ***Patient A has a higher hyperglycemic risk, while Patient B has a lower risk of hypoglycemia. Overall, Patient B, with a mean glucose of 105 mg/dL, has better diabetes control compared Patient A, with a mean glucose of 124 mg/dL.*** Once the readers learn the concept and method of these ***BMD*** tools, they can apply them to patients with different chronic diseases. Those who have an interest in learning more can visit the author's website: (**www.eclairemd.com**)
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## References

For editing purposes, 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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