ISSN: 2689-1204

Research Article

Journal of Applied Material Science & Engineering Research

Applying the Distributional Data Analysis Tool of Blood Pressure Density Along with the Collected Daily Data of Systolic Blood Pressure & Diastolic Blood Pressure over the past 7.5 Years from a Patient with Chronic Diseases to Investigate Heart Health Conditions Based on GH-Method: Math-Physical Medicine (No. 515)

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Submitted: 09 Sep 2021; **Accepted:** 15 Sep 2021; **Published:** 28 Sep 2021

Citation: *Gerald C Hsu (2021) Applying the Distributional Data Analysis Tool of Blood Pressure Density Along with the Collected Daily Data of Systolic Blood Pressure & Diastolic Blood Pressure over the past 7.5 Years from a Patient with Chronic Diseases to Investigate Heart Health Conditions Based on GH-Method: Math-Physical Medicine (No. 515). J App Mat Sci & Engg Res, 5(3), 1-6.*

Abstract

Recently, the author conducted a series of medical research projects by applying the distributional data density analysis tool on his glucose, weight, blood pressure, and heart conditions by using his collected big data regarding certain biomarkers over the multiple years. In this article, he only utilizes the collected biomarker data of blood pressure (BP) from himself, where the data covers a long time span of 7.5 years. Moreover, he can interpret the results and explore additional and deeper information, since he is most familiar with his own health conditions. The finding regarding his own body is definitely applicable to other patients. The main purpose of writing this series of research articles is to demonstrate the applicability and power of using this specific distributional data density analysis tool.

In the past, when he researched certain biomarkers and their relationships with other influential factors, such as body weight, fast plasma glucose (FPG), food consumption quantity, he generally used the average values of those biomarkers. However, we know that most biomarkers, including body weight glucoses and blood pressure, would fluctuate along the time scale in the form of a "wave". Waves have one common key factor which is the "amplitude" of this particular biomarker, where the other two key factors are frequency and wavelength. Therefore, without focusing on waveform of the biomarker and depending on its mean value, we would lose many vital, interesting, and useful hidden information. This type of mean value, such as HbA1C, or sparsely collected finger-pierced glucose or blood lipid data from quarterly lab testing can only provide partial views of health conditions. These biomarkers still have some missing information carrying certain hidden internal turmoil or vital signs, e.g. biomarker variations or its severe stimulations due to all types of external and/or internal stimulators. Therefore, by applying this basic knowledge of distributional data analysis, he has defined a new term known as the "general biomarker density or Bio-density% (BMD%)" in order to explore additional, different, deeper and useful hidden information in the collected biomarker data and their associated waveforms.

The term blood pressure density (BPD) is defined as the occurrence frequency at a specific person's blood pressure value. For example, the author's peak SBP 5.04% occurrence rate at 106 mmHG and peak DBP 6.58% occurrence rate at 64 mmHG value. In this way, he can calculate and examine each BP's occurrence rate within a range of 41 mmHG to 150 mmHG over the past 7.5 years. The selected time span of 7.5 years is dependent on the study which is suitable to specific patients (in this case, himself). *He started to track his daily BP since the early morning of 4/1/2014.* By investigating the changes of the peak systolic blood pressure (SBP) & diastolic blood pressure (DBP) value with their associated BPD% from year to year, he can easily and clearly observe his "blood pressure" situation's moving trend and understand his actual health problems or necessary health improvement effort.

As a matter of fact, he has been aware that in general, both his SBP & DBP are lower. Through using a developed BPD analysis tool, ***he is finally able to quantify his BP by recognizing that 81% of his SBP and 90% of his DBP data are within the "normal" range (i.e. SBP < 120 mmHG and DBP < 80 mmHG) over the past 7.5 years. This numerical exercise demonstrates the power and usefulness of BP density tools***.

The above description provides the reason he keeps searching for applicable tools to analyze collected big data of any biomarker. If this type of biomarker examination method is accepted by the medical community, it can be an extremely beneficial tool for doctors to quickly study the health conditions of their patients. Furthermore, the author has 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 patients with chronic diseases can benefit from his research work. Hopefully, 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, unorganized, 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.

In summary, the author has chosen to perform his research work using the tools of Blood Pressure Density % (BPD%) with his collected ***BP data which are measured every morning when he wakes up, while still resting in bed*** from the past 7.5 years (4/1/2014 - 9/13/2021).

He has selected a consistent resting heart rate range covering 41 mmHG to 150 mmHG with an equal interval of 1 mmHG with a total of 110 BP measurements, both SBP and DBP, data points on the x-axis, in order to express his BP density % diagram and BP density % amplitude on the y-axis (between 0% and 6.58%).

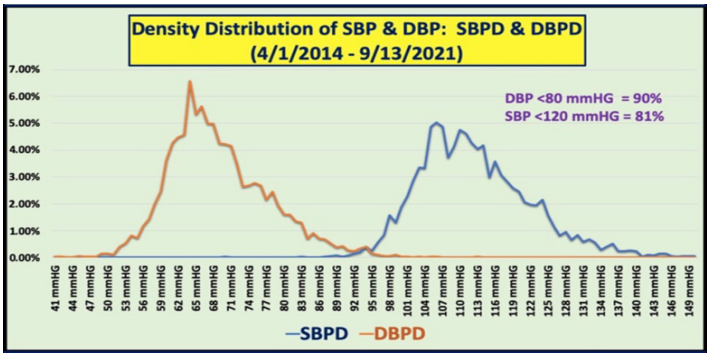
By using his developed APP software program on the iPhone, he can generate and display these heart rate density data and heart rate density curves.

Through a closer examination of each diagram in this article, he can provide the following conclusive statements:

From the density-domain analysis of BP (Figure 2), his normal SBP data occupy 81% of the time (less than 120 mmHG), while his normal DBP data dominates 90% of the time (less than 80 mmHG) over the past 7.5 years. However, it should be noted that these BP data are measured once he wakes up which are usually tilting toward lower blood pressures. During the day with some activities, his BP values would be higher than these collected data. Nevertheless, they still offer some frameworks and views regarding his BP conditions.

From the time-domain analysis of BP (Figure 1), he can identify a "hypertensive" condition in 2014, which was not severe, when his stress level was high.

By combining these two different analysis methods, time-domain and density-domain, he can investigate additional insights associated with his BP conditions.



Introduction

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The above description provides the reason he keeps searching for applicable tools to analyze collected big data of any biomarker. If this type of biomarker examination method is accepted by the medical community, it can be an extremely beneficial tool for doctors to quickly study the health conditions of their patients. Furthermore, the author has 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 patients with chronic diseases can benefit from his research work. Hopefully, 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, unorganized, 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.

Methods

MPM Background

To learn more about his developed GH-Method: math-physical medicine (MPM) methodology, readers can read the following three 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".

The Author'S Case of Diabetes and Complications

The author has been a severe T2D patient since 1996. He weighed 220 lb. (100 kg, BMI 32.5) at that time. By 2010, he still weighed 198 lb. (BMI 29.2) with an average daily glucose of 250 mg/dL (HbA1C of 10%). During that year, his triglycerides reached to 1161 (diabetic retinopathy or DR) and albumin-creatinine ratio (ACR) at 116 (chronic kidney disease or CKD). He also suffered from five cardiac episodes within a decade. In 2010, three independent physicians warned him regarding his needs of kidney dialysis treatment and future high risk of dying from severe diabetic complications. Other than cerebrovascular disease (stroke), he has suffered most known diabetic complications, including both macro-vascular and micro-vascular complications.

In 2010, he decided to launch his self-study on endocrinology, diabetes, and food nutrition in order to save his own life. During 2015 and 2016, he developed four prediction models related to diabetes conditions: weight, PPG, fasting plasma glucose (FPG), and A1C. As a result, from using his developed mathematical metabolism index (MI) model in 2014 and the four prediction tools, by end of 2016, his weight was reduced from 220 lbs. (100 kg, BMI 32.5) to 176 lbs. (89 kg, BMI 26.0), waistline from 44 inches (112 cm, nonalcoholic fatty liver disease /NAFLD) to 33 inches (84 cm), average finger glucose reading from 250 mg/dL to 120 mg/dL, and lab-tested A1C from 10% to ~6.5%. One of his major accomplishments is that ***he no longer takes any diabetes medications since*** 12/8/2015.

In 2017, he has achieved excellent results on all fronts, especially his glucose control. However, during the pre-COVID period of 2018 and 2019, he traveled to approximately 50+ international cities to attend 65+ medical conferences and made ~120 oral presentations. This hectic schedule inflicted damage to his diabetes control, through dinning out frequently, post-meal exercise disruption, jet lag, and along with the overall metabolism impact due to his irregular life patterns through a busy travel schedule; therefore, his glucose control and overall metabolism state were somewhat affected during this two-year heavier traveling period.

During 2020 with a COVID-19 quarantined lifestyle, not only has he published ~400 medical papers in 100+ journals, but he has also reached his best health conditions for the past 26 years. By the beginning of 2021, his weight was further reduced to 165 lbs. (BMI 24.4) along with a 6.1% A1C value (daily average glucose at 105 mg/dL), without having any medication interventions or insulin injections. These good results are due to his non-traveling, low-stress, and regular daily life routines. Due to his knowledge of chronic diseases, practical lifestyle management experiences, and developed various high-tech tools contribute to his excellent health status since 1/19/2020, which is the start date of being self-quarantined.

On 5/5/2018, he applied a CGM sensor device on his upper arm and checks glucose measurements every 5 minutes for a total of ~288 times each day. He has maintained the same measurement pattern to present day. In his research work, he uses the CGM

sensor glucose at time-interval of 15 minutes (96 data per day). By the way, the difference of average sensor glucoses between 5-minute intervals and 15-minute intervals is only 0.4% *(average glucose of 114.81 mg/dL for 5-minutes and average glucose of 114.35 mg/dL for 15-minutes with a correlation of 93% between these two sensor glucose curves) during the period from 2/19/20- to 8/13/21.*

Therefore, over the past 11 years, he could study and analyze the collected 2+ million data regarding his health status, medical conditions, and lifestyle details. He applies his knowledge, models, and tools from mathematics, physics, engineering, and computer science to conduct his medical research work. His medical research work is based on the aims of achieving both "high precision" with "quantitative proof" in the medical findings.

The following timetable provides a rough sketch of the emphasis of his medical research during each stage:

• 2000-2013: Self-study diabetes and food nutrition, developing a data collection and analysis software.
• 2014: Develop a mathematical model of metabolism, using engineering modeling and advanced mathematics.
• 2015: Weight & FPG prediction models, using neuroscience.
• 2016: PPG & HbA1C prediction models, using optical physics, artificial intelligence (AI), and neuroscience.
• 2017: Complications due to macro-vascular research such as cardiovascular disease (CVD), coronary heart disease (CHD) and stroke, using pattern analysis and segmentation analysis.
• 2018: Complications due to micro-vascular research such as chronic kidney disease (CKD), bladder, foot, and eye issues such as diabetic retinopathy (DR).
• 2019: CGM big data analysis, using wave theory, energy theory, frequency domain analysis, quantum mechanics, and AI.
• 2020: Cancer, dementia, longevity, geriatrics, DR, hypothyroidism, diabetic foot, diabetic fungal infection, linkage between metabolism and immunity, and learning about certain infectious diseases such as COVID-19.
• 2021: Applications of linear elastic glucose theory (LEGT) and perturbation theory from quantum mechanics on medical research subjects, such as chronic diseases and their complications, cancer, and dementia. Using metabolism and immunity.it's as the base, he expands his research into cancers, semantic, and COVID-19.

To date, he has collected more than two million data regarding his medical conditions and lifestyle details. In addition, he has written 498 medical papers and published 400+ articles in 100+ various medical journals, including 6 special editions with selected 20-25 papers for each edition. Moreover, he has given ~120 presentations at ~65 international medical conferences. He has continuously dedicated time and effort on medical research work and shared his findings and learnings with other patients worldwide.

Blood Pressure Density (BPD)

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 110 (e.g. from 41 mmHG to 150 mmHG with an equal interval of 1 mmHG between two blood pressure end-points).*

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

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

with $x1 < Y(t) < x2$
where x1 and x2 are $\int$ ***boundaries of his selected blood pressure range.***

The ***blood pressure density % (BPD% or D%) equation for*** one patient, such as himself, can also be defined in terms of ***a discrete format*** as follows:

$$D(x) = \left(\sum_{j=1}^{T} Y(tj)\right) / T$$

with $x1 < Y(t) < x2$
where x1 and x2 are boundaries of his selected blood pressure range.

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

Results

Figure 1 shows his SBP, DBP, and heart rate measured each morning once he wakes up, while in bed, over a period of 7.5 years (from 4/1/2014 to 9/13/2021). This time-domain figure contains the combination of SBP, DBP, and heart rate with a separated daily data chart and 90-days moving average data chart. The averaged SBP values is 110 mmHG, averaged DBP values is 67 mmHG, averaged heart rate is 58 bpm. If we only observe the numbers, we will lose some vital information hidden inside the BP waveform and its fluctuation.

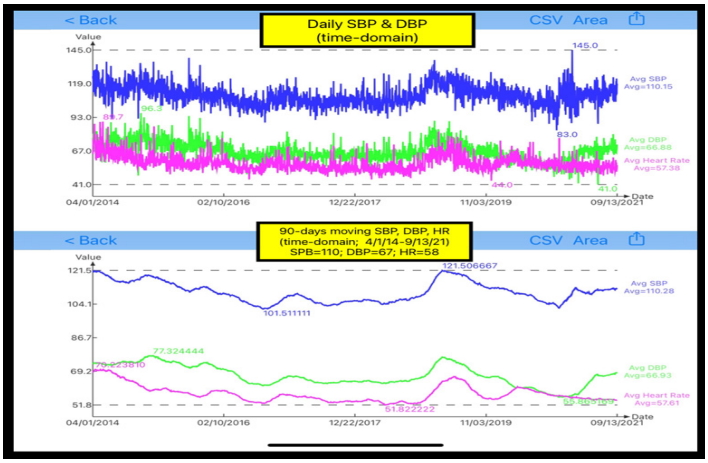

Figure 1: Time-domain of blood pressure and heart rate of 7.5 years (4/1/2014 - 9/13/2021)

Figure 2 depicts the separated density-domain diagrams of his BP (4/1/2014 - 9/13/2021) which are generated through the developed APP on the iPhone. ***The top diagram is his SBP with a peak value of 5.04% at 106 mmHG. The bottom diagram is his DBP with a peak value of 6.58% at 64 mmHG.*** It should be noted that these two density-domain diagrams have ***two different x-axis scales, i.e. their BP covered ranges are different*** due to the built-in auto-selection function for the data range.

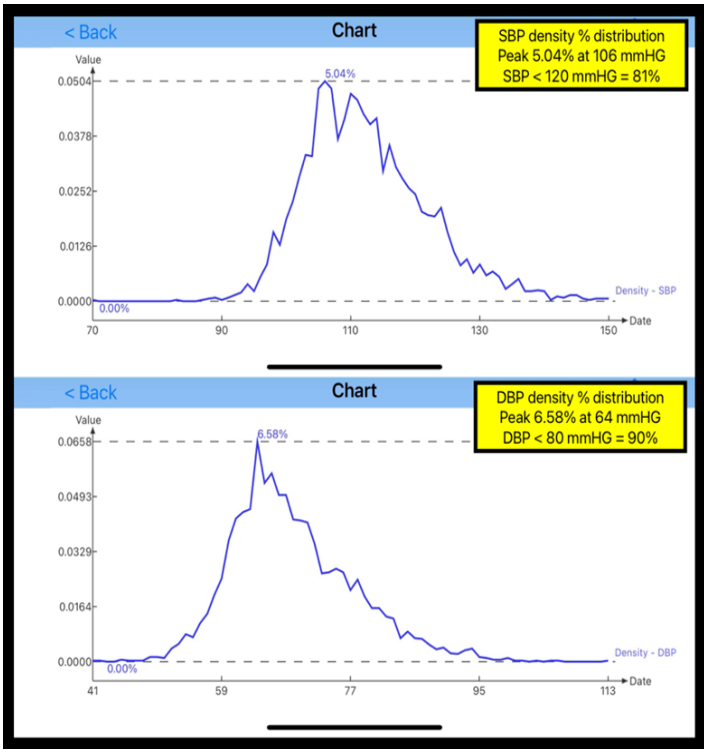

Figure 2: Density-domain of two separated SBP and DBP diagrams via APP (4/1/2014 - 9/13/2021)

Figure 3 illustrates the combined SBP and DBP density-domain diagrams ***with one identical x-axis scales, i.e. their BP covered ranges between 41 mmHG and 150 mmHG with a total of 110 blood pressure data points***. Therefore, these two peaks of SBP and DBP are located at different mmHG numbers on x-axis scale. From Figure 3, it is evident that the author has no "hypertensive" issues over the past 7.5 years. However, if we examine his BP data using the time-domain curve, he can identify his "hypertensive" situation existing only in 2014.

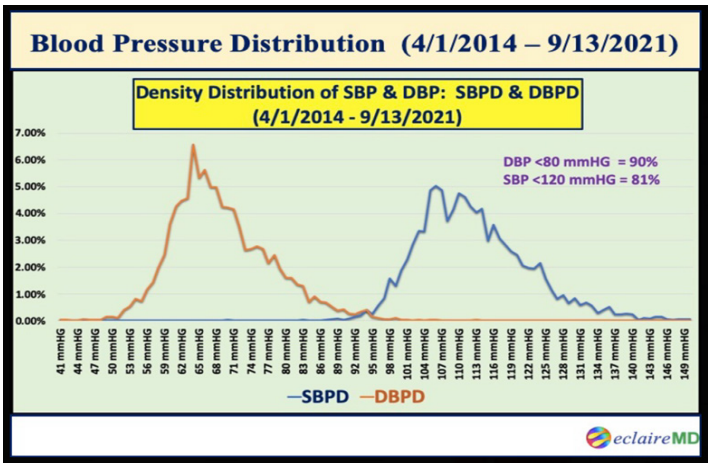

Figure 3: Density-domain of one combined diagram of SBP & DBP via Excel (4/1/2014 - 9/13/2021)

Conclusions

In summary, the author has chosen to perform his research work using the tools of ***Blood Pressure Density % (BPD%) with his collected BP data which are measured every morning when he wakes up, while still resting in bed*** from the past 7.5 years (4/1/2014 - 9/13/2021).

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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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