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A case study of the relationship between weight and glucose using math-physics medicine

Background & Aim: During a period of 2,245 days (1/1/2012 - 2/24/2018), the author, who has type 2 diabetes for approximately twenty years, collected and processed about 1.5 million biomedical data regarding his health and lifestyle conditions, including 13,470 data for weight and glucose. This dataset includes medication, weight (measured after waking up and at bedtime), FPG, PPG (3 times a day), carbs and sugar intake, exercise, stress, sleep, travel, weather, glucose measurement time delay, water intake, bowel movement, night time urination, etc. All of the above factors are interrelated with each other to a different degree since the human body is a highly nonlinear, dynamic, and sophisticated "analog" system. In this article, the author will discuss the direct relationship between weight and glucose, both FPG and PPG.

Material & Method: Weight is one of the outputs as well as one of the inputs of human metabolism system. Its main contribution factors are food consumption quantity, food quality (fat, protein, carbs, sugar), exercise amount, bowel and urine elimination, sleep quality, emotional stress, etc. Glucose (A1C, daily average glucose, FPG, PPG) involves about 20 direct and indirect input factors with 4 major factors, including medication, weight, carbs/sugar, and exercise. Prior to 2012, he did not keep a complete daily record of his health and lifestyle data. However, he weighed 210 lbs. / 95.5kg (BMI 31, obese), his peak PPG was 380 mg/dL, average daily glucose was 280 mg/dL, and A1C above 10.0%. After 2012, he has kept a complete record. His weight bounced between 166.9 lbs. / 75.9 kg (BMI 24.65) and 193.8 lbs. / 88.1 kg (BMI 28.65); therefore, his averaged weight was 178 lbs. / 81 kg (BMI 26.28). His glucose level varied from 52 mg/dL to 280 mg/dL, average daily glucose was 126.5 mg/dL, and A1C around 6.5%. The author utilized advanced mathematics to develop various governing equations. He applied finite element engineering concept to convert a human analog system into a digitized system to get approximate solutions. He also decomposed a complicated glucose wave into many single-sourced waveforms and then recombine them to a predicted glucose wave signal for comparison between measured vs. predicted glucose. Each single-sourced waveform is further studied for its intensity and importance level of contribution to glucose formation. Finally, he applied many statistical techniques to analyze these massive data, including linear accuracy, correlation and determination coefficients, spatial analysis, time series, frequency-based analysis via Fourier and Hilbert Transforms, etc. He has spent 4 years researching and interpreting the outcomes from his numerical simulation work.

Results: There are approximately 10 direct influential factors and about another 10 indirect factors for determining our glucose level. For FPG, weight is the most dominant factor contributing 80% to 90% to its value. In the time series analysis, results show that, between weight and FPG, their correlation is 84% (high). In spatial analysis, results show 93% of the total collected data are covered by a +/- 20% band. This "relationship band" stretched from point A (24.5, 95) to point B (27.2, 150) on a spatial map with coordinates of x=BMI, y=glucose. However, for PPG, weight is not the dominating factor any more. Instead, combined carbs and sugar intake with exercise occupied about 81% of the contribution and importance level of PPG. Weather and measurement time delay count about 14% and the other factors count about 5%. In the time series analysis, results show that, between weight and PPG, their correlation is between 9% to 36% (low). In spatial analysis, results show 86% of total collected data are covered by a +/- 20% "horizontal" band which is centered around a "constant" PPG value of 127 mg/dL. A stacking spatial analysis graphics over 6 years from 1/2012 through 2/2018 shows that his BMI moved toward the lower range, while his PPG kept at a relative constant level around 127 mg/dL.

Conclusion: Based on the case study of this overweight but not obese (BMI < 30) patient's data analyses, results show that most of his FPG data (93%) are almost directly proportional to his weight change according to a "fixed" slope. However, most of his

PPG data (86%) have been kept within a range of 102 mg/dL and 152 mg/dL. The amplitude changes within this range are mostly determined by both carbs / sugar and exercise, but not directly by weight.

Biography

Gerald C Hsu received an honourable PhD in mathematics and majored in engineering at MIT. He attended different universities over 17 years and studied seven academic disciplines. He has spent 20,000 hours in T2D research. First, he studied six metabolic diseases and food nutrition during 2010-2013, then conducted research during 2014-2018. His approach is "math-physics and quantitative medicine" based on mathematics, physics, engineering modelling, signal processing, computer science, big data analytics, statistics, machine learning, and AI. His main focus is on preventive medicine using prediction tools. He believes that the better the prediction, the more control you have.

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