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Research Article

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Using a Modified Candlestick Charting Technique (OHCA) and the Synthesized PPG Waveform to Develop Two Simple Formulas for PPG Prediction (GH-Method: Math-Physical Medicine)

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Introduction

This paper describes development of simple formulas for postprandial plasma glucose (PPG) prediction based on sensor-monitored data using a modified candlestick charting technique. The GH-Method: Math-physical medicine (MPM) starts with the observation of the human body's physical phenomena not biological or chemical characteristics, collecting elements of the disease related data (preferring big data), utilizing applicable engineering modeling techniques, developing appropriate mathematical equations not just statistical analysis, and finally predicting the direction of the development and control mechanism of the disease.

Method

A Japanese merchant, who traded in the rice market in Osaka, Japan, started the candlestick charting around 1850. An American, Steve Nison brought the candlestick patterns to the Western world in 1991. These techniques are largely used in today's stock market to predict the stock price trends.

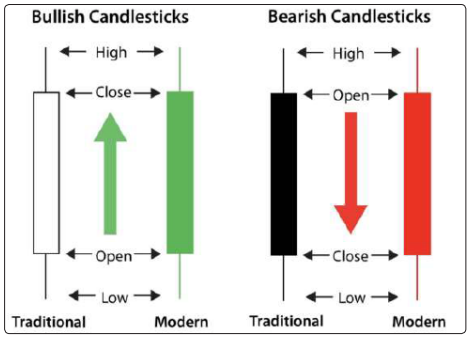


Figure 1: Candlestick Charts in Stock Market

For a period of 401 days from 5/5/2018-6/10/2019, the author collected ~29,300 glucose data via a sensor placed on his upper left arm.

He named this new glucose model as "OHCA" (open-high-close-average) using a synthesized PPG waveform from a total of 1,203 individual PPG waveforms associated with various meals and exercise.

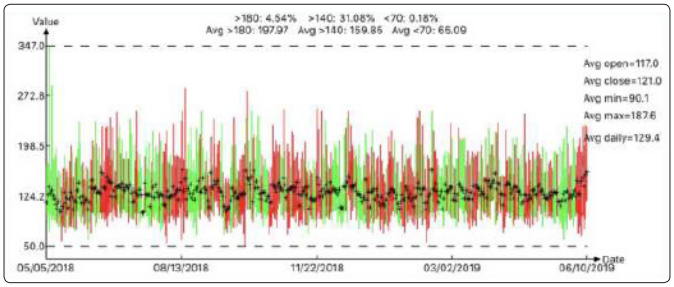


Figure 2: Candlestick chart of daily sensor-based glucose data (5/5/2018-6/10/2019)

Results

Listed below are OHCA values of the synthesized PPG curve:

Open at 0 minutes: 126 mg/dL
High at 60 minutes: 147 mg/dL
Close at 180 minutes: 132 mg/dL
Average Sensor: 136 mg/dL
Average Finger: 116 mg/dL

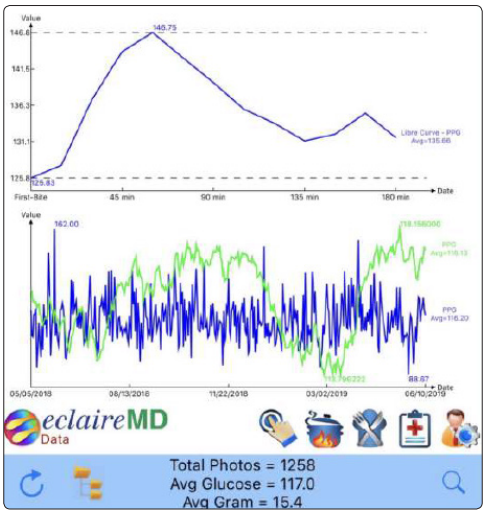
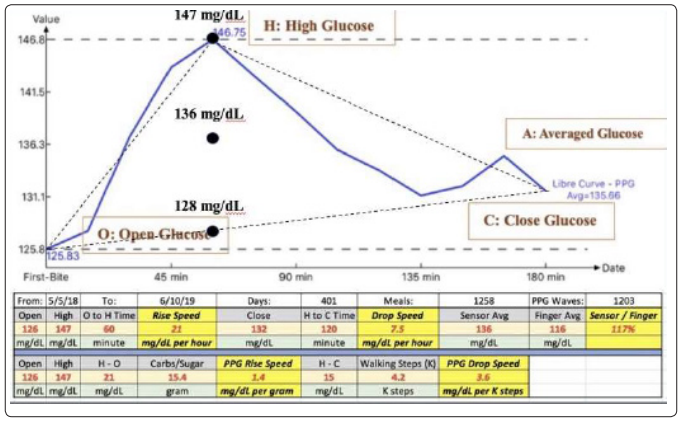


Figure 3: Sensor and Finger PPG with Carbs/Sugar Intake

Two major inputs, carbs/sugar intake and post-meal walking draw the following four conclusions regarding the predicted PPG output.

1. Average carbs/sugar intake per meal is 15.4 grams (Figure 3). This food input provides PPG rising speed at 1.4 mg/dL per gram until it reaches to its peak value at the "High" point around 60 minutes after the first bite of food.
2. Average post-meal walking steps is 4.2K (4,200) steps. This exercise input provides PPG dropping speed at 3.6 mg/dL per K steps until it reaches to its lower closing value at the "Close" point at 180 minutes after the first bite of food.
3. The average sensor-monitor data is 136 mg/dL while the average Finger-piercing data is 116 mg/dL. This 17% difference of two PPG measurements is due to the existing finger piercing testing time at approximately two hours after the first bite. This recommended time frame for finger-testing does not capture the many spikes of the actual glucose fluctuation. Unfortunately, those PPG spikes would then eventually cause many diabetes complications.
4. As shown in Figure 4,



From:	5/5/18	To:	6/10/19	Days:	401	Meals:	1258	PPG Waves:	1203
Open	High	O to H Time	Rise Speed	Close	H to C Time	Drop Speed	Sensor Avg	Finger Avg	Sensor / Finger
126	147	60	21	132	120	7.5	136	116	117%
mg/dL	mg/dL	minute	mg/dL per hour	mg/dL	minute	mg/dL per hour	mg/dL	mg/dL	

Open	High	H - O	Carbs/Sugar	PPG Rise Speed	H - C	Walking Steps (K)	PPG Drop Speed
126	147	21	15.4	1.4	15	4.2	3.6
mg/dL	mg/dL	mg/dL	gram	mg/dL per gram	mg/dL	K steps	mg/dL per K steps

Figure 4: Synthesized Sensor PPG Waveform and Calculation Table

Triangular Base point (TB)
= O + (C - O) / 3 = 128 mg/dL
Triangular Peak point (TP)
= H = 147 mg/dL
Mid-point between Peak and Base (TM) = (TB + TP) / 2 = 137 mg/dL
= ~ A: 136 mg/dL

5. The two simple formulas that provide practical guidance for diabetes patients to follow are: (a) +1.4 mg/dL of PPG increase per carbs/sugar gram and (b) -3.6 mg/dL of PPG decrease per thousand walking steps.

Conclusion

This paper has further demonstrated the power of observation for the glucose's physical phenomena, derivation of suitable mathematical equations, application of various computational tools, including big data analytics, and finally combined with real-life biomedical knowledge and experiences for further medical interpretations. This GH-Method: math-physical medicine can be used to discover many hidden biomedical facts with high precision regarding the human body. More practically, those two simple quantitative formulas with the triangular geometry application can indeed help T2D patients to predict their PPG values and then control their diabetes effectively.

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