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Comparison of Glucose Results from Finger-Piercing and Sensor-Collected Data Using GH-Method: Math-Physical Medicine

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Introduction

This paper addresses the varying glucose results between Finger-piercing and test strip (*Finger*) and a continuous monitored blood glucose (CMBG) device (*Sensor*). It covers mainly postprandial plasma glucose (PPG) but also deals with fasting plasma glucose (FPG). The author uses his own type 2 diabetes (T2D) metabolic conditions control as a case study for some detailed illustration and explanation of this methodology.

Math-physical medicine 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.

Methods

The glucose data are collected during the period of 483 days (5/5/2018 through 8/30/2019). Sensor data are collected at 74 times per day with a total of 35,842 sensor data. Finger data are collected at four times per day with a total of 1,932 finger data.

Each day has one sensor FPG waveform from 00:30 midnight to 7:45 am and three sensor PPG waveforms covering a three-hour period. There are a total of 483 FPG waveforms and 1,449 PPG waveforms.

Each PPG waveform has five key data points:

Open glucose at 0 minute

Maximum glucose (usually around 60 minutes)

Minimum glucose

Close glucose (at 180 minutes)

Average glucose

Results

Table 1 (summarized from Figure 1 through 6) are self-explanatory. The key findings are re-stated below:

(1) The max sensor PPG is 41% higher than max finger PPG.

(2) The averaged sensor PPG is 13% higher than averaged Finger PPG.

(3) The averaged Sensor PPG at 120 minutes is 18% higher than Finger PPG at 120 minutes (Figure 4).

(4) 32% of total sensor PPG values belong to the "high-glucose" segments (both >140 mg/dL and >180 mg/dL) which have separated higher percentages (26% and 4%), than Finger PPG values. These high-glucose segments must be controlled tightly in order to reduce their damages on internal organs via their associated energies.

(5) 0.2% of total sensor PPG values belongs to the "low-glucose" segment (<70 mg/dL) which is slightly lower than Finger's low-glucose segment percentage (0.3%). These two extremely low glucoses (averaged 65 mg/dL for sensor and 68 mg/dL for finger) can cause insulin shock and be life-threatening.

(6) PPG wave rises at 58 mg/dL per hour to reach to its maximum point and then decays at 28 mg/dL per hour until reach to its waveform's close point.

(7) Glucoses of different categories within Sensor database have high correlation among them. However, there are low correlations between Finger and Sensor, except sensor's 120 minutes and finger's two-hour have a 50% correlation.

Table1: *Comparison of Sensor and Finger Glucoses*

(5/5/2018-8/30/2019)	Finger Glucose mg/dL	Sensor PPG mg/dL	Sensor vs. Finger
FPG	111	113	102%
Avg Open (PPG Waveform)	111	128	115%
Avg Close (PPG Waveform)	111	131	118%
Avg Max (PPG Waveform)		145	
Min	99	93	94%
Max (Avg PPG Peak)	162	186	115%
Max (Peak Time-Series PPG Peak)	162	225	139%
AVG Daily	115	130	113%
Avg 2 Hours post-meal	116	134	115%
PPG Rising Speed (mg/dL / hour)			58
PPG decaying Speed (mg/dL / hour)			28
% of >180 mg/dL	1%	5%	4.0%
Avg mg/dL of >180	204	198	97%
% of >140 mg/dL	6%	32%	26%
Avg mg/dL of >140	161	160	99%
% o<70 mg/dL	0.3%	0.2%	-0.1%
Avg mg/dL of <70	68	65	96%
Correlation Coefficients:	(6/5/18-8/30/18)	R	
FPG vs. PPG (Time-Series)		66%	
FPG vs. PPG (Sensor Waveform)		-87%	
Open vs. Close (sensor)		81%	
Pre-Meals vs. Pre-Bed (Sensor)		63%	
Sensor FPG vs. Fnger FPG		14%	
Sensor PPG vs. Fnger PPG		41%	
Finger vs. Sensor: No correlation	Within Sensor: Correlation		

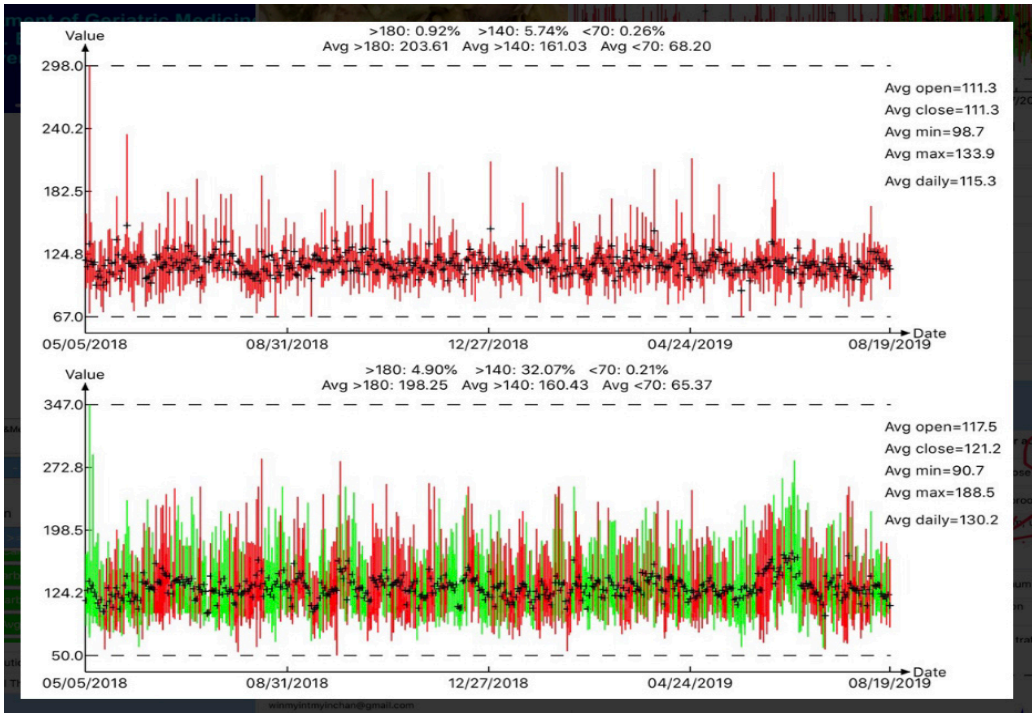

Figure 1: *Comparison of Sensor and Finger Glucoses*

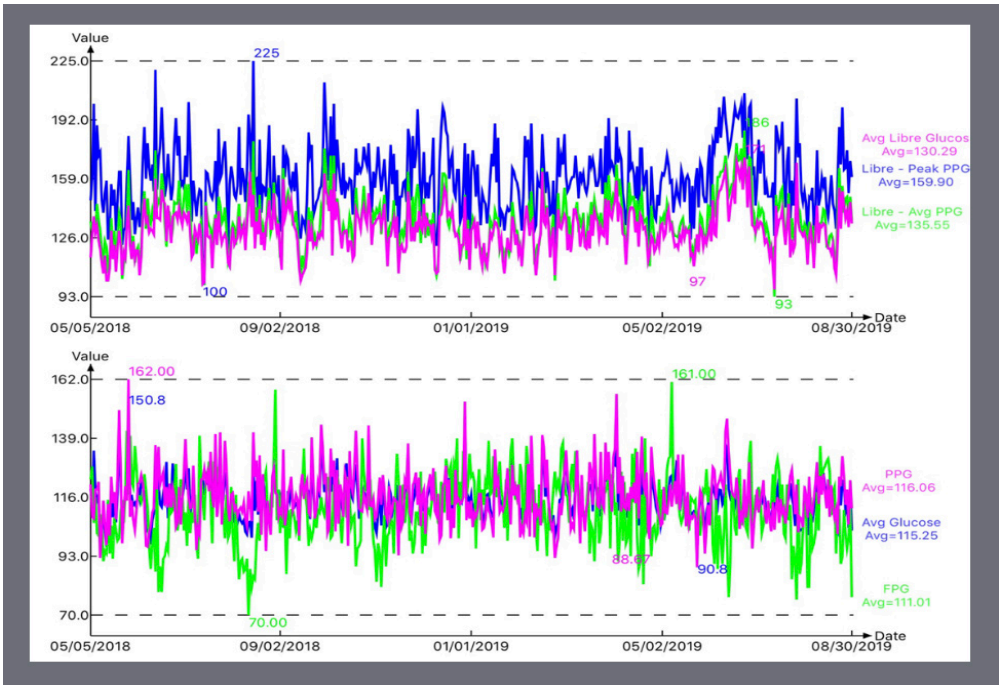

Figure 2: *Detailed Glucoses of Sensor and Finger*

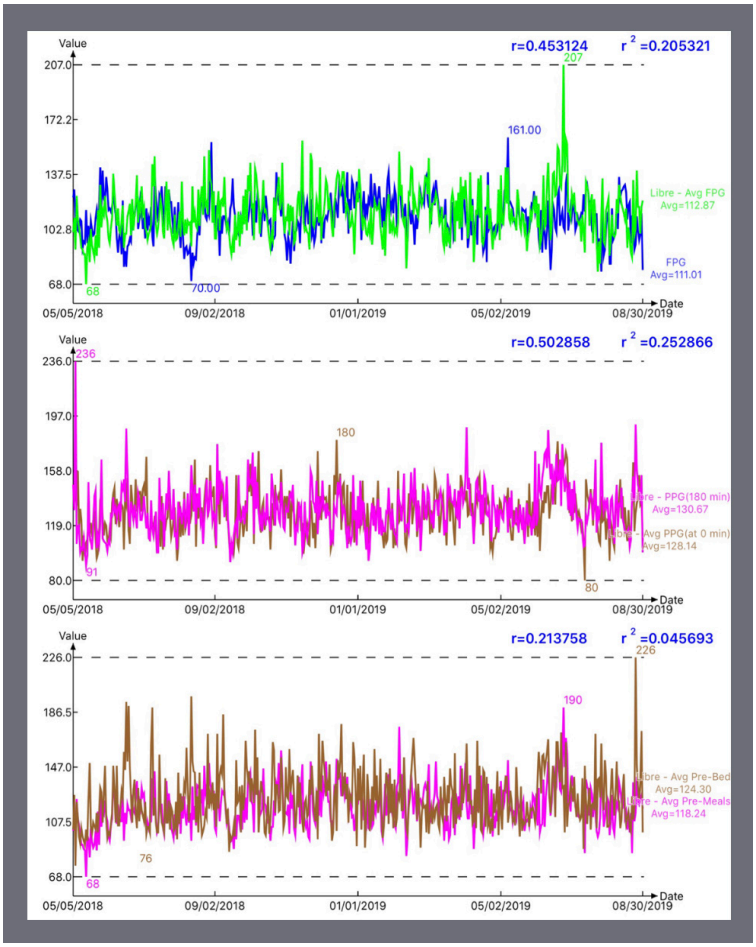

Figure 3: *Detailed Sensor data*

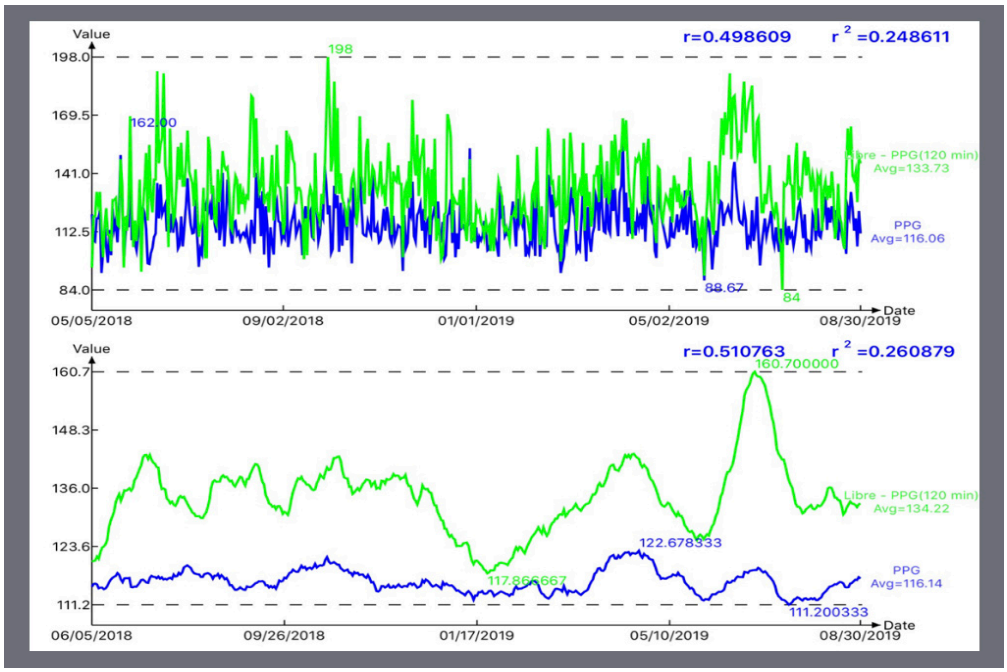

Figure 4: *Comparison between Finger PPG and Sensor PPG at 120 minutes (18% difference)*

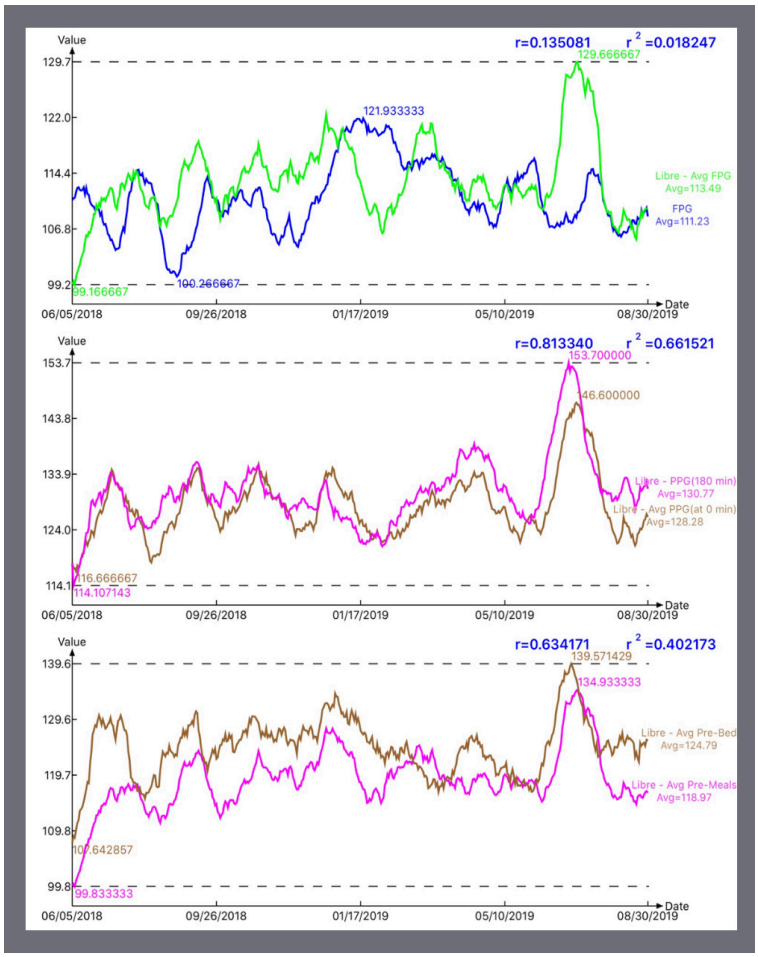

Figure 5: *30-days moving averaged glucose curves to calculate Correlations.*

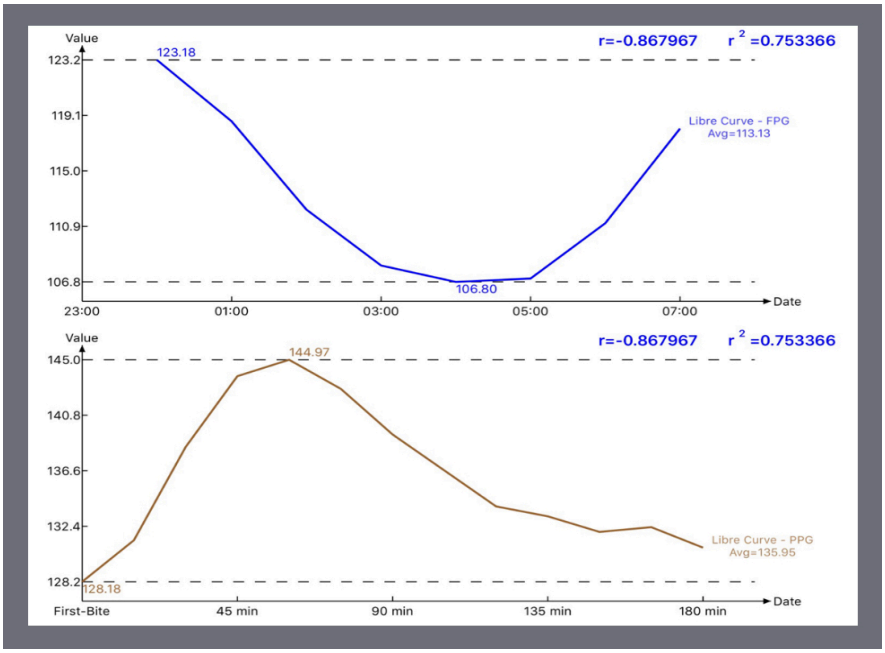

Figure 6: *Waveforms of FPG & PPG (Correlation -87%)*

Conclusions

First, observation from combined sensor and finger glucose values could offer a reasonable range (13% to 41%) of a more realistic glucose situation for a T2D patient.

Second, if healthcare professionals could study and understand glucose with such a depth and detailed manner as shown in this paper, then their knowledge and ability to assist diabetes patients to control their complications would be greatly improved.

References

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