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Research Article

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Comparison of HbA1C values among Lab-tested, Finger-piercing, CGM-collected (GH-Method: math-physical medicine)

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Introduction

This paper describes the research results of his mathematically predicted HbA1C values from both finger-piercing data and a continuous glucose monitoring device (CGM) sensor collected data. He then compared these two sets of HbA1C against lab-tested data.

Methods

Since 1/1/2012, the author has measured his glucose values using finger-piercing method: once for FPG and three times for PPG each day. On 5/5/2018, he applied a CGM device on his upper arm and checked his glucose measurements ~80 times each day (every 15 minutes during awaken hours).

He has maintained the dual glucose testing for 717 days, almost 20 months from 5/5/2018 to 4/22/2020, for his in-depth glucose research and mathematical predictions of HbA1C by using these two different PPG measurement datasets.

Between the period of 2015-2017, he developed a mathematical equation of "Daily A1C N-2 Model", with a distribution weight of 10%, 15%, 25%, and 50% for each month with a conversion factor between glucose versus HbA1C of 17.19. He applied the same mathematic model as the finger A1C prediction to conduct his calculation of the CGM sensor HbA1C prediction. It should be noted that the initial stage for the dataset, in this case, the first 4-months may encounter some degree of prediction accuracy issues due to unavailable and insufficient data at the beginning stage of this analysis.

Results

Before calculating the predicted HbA1C, we should first look into the picture of the daily average glucoses. The author has noticed that two curves of both finger and CGM sensor glucose data have some inherent issues related to the device reliability and data accuracy. The author was a professionally trained mathematician, physicist, and engineer such that sometimes, he wonders how the medical community could tolerate and accept such high levels of inaccuracy (ranging from +/- 20% to +/- 30%) on the glucose measurement devices.

In Figure 1, there are no strong correlation observed (R = 19% for daily curves and 36% for 90-days moving averaged curves) between his finger curve and his sensor curve for the past 20-month period. This finding does not surprise the author since they came from two different measuring devices by the same manufacturer.

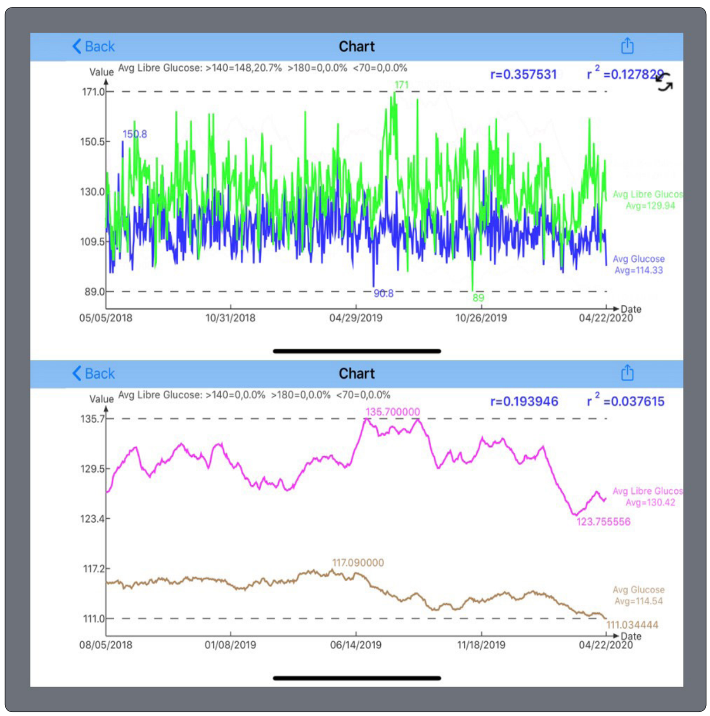


Figure 1: Correlation R between Finger and CGM Sensor (daily data with R of 36% and 90-days moving average with R of 19%)

In Figure 2, we can observe the comparison among the lab-tested A1C (Red Cross), daily finger A1C (Blue Curve), and daily CGM sensor A1C (Green Curve). It should be noted that the initial dip of the curve around May and June of 2018 in the CGM sensor is due to the "initial condition error" from unavailable or insufficient data by using his A1C N-2 Model. However, there is no similar phenomenon of curve dip for the finger A1C since he has collected his finger glucose data and then predicted his finger A1C values since 1/1/2012 (see Figure 3).

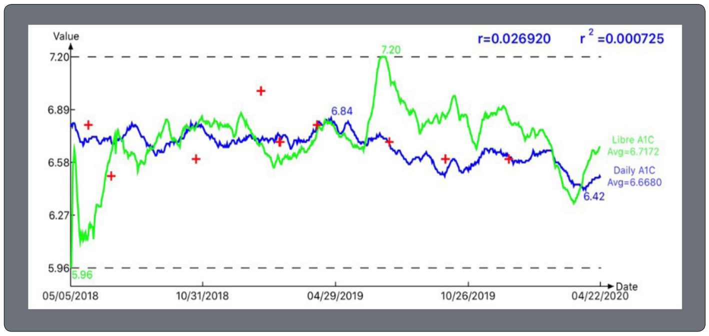


Figure 2: Comparison among lab-tested A1C (Red Cross), daily finger A1C (Blue Curve), daily CGM sensor A1C (Green Curve)

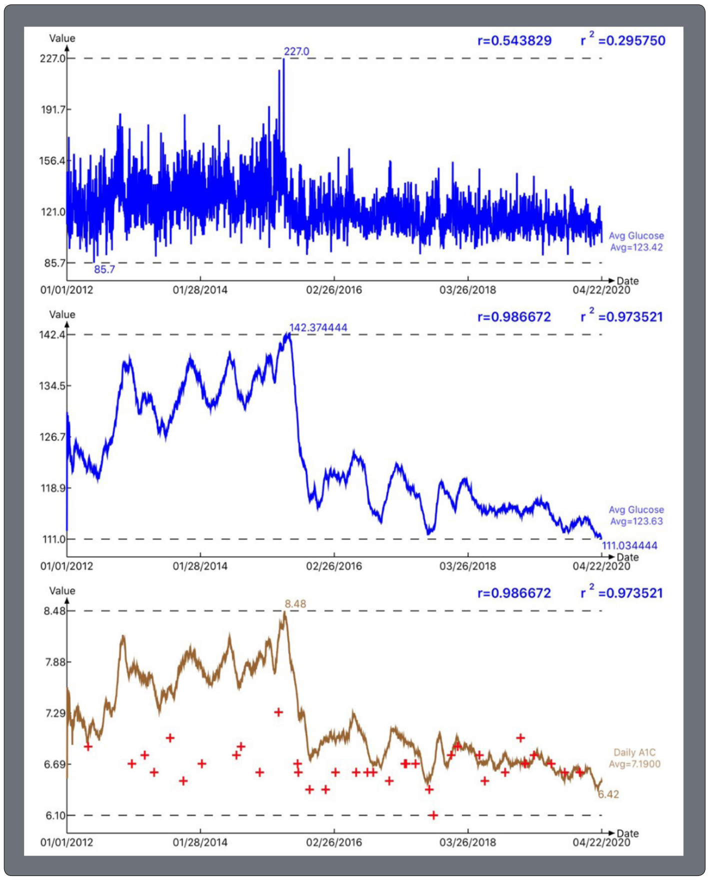
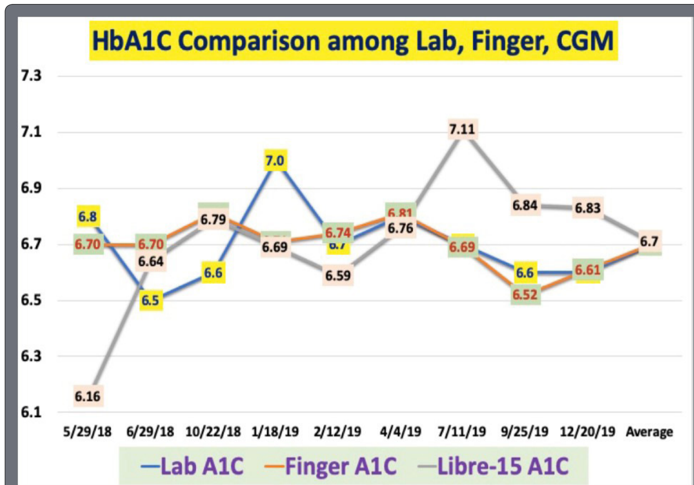


Figure 3: Finger data comparison among daily glucose, 90-days moving average glucose, & HbA1C

The author used his lab-tested A1C values as the "base" and then extracted their corresponding A1C values, on exactly the same dates, from both the daily finger and daily CGM sensor databases for a predicted data accuracy comparison (Figure 4). The range of accuracy for the finger A1C is between 96% to 103%, while the range of accuracy for the CGM sensor A1C is between 96% to 106%. Please note that he omitted the first accuracy number of 91% on the CGM sensor A1C table in his above conclusive statements due to the mathematical inaccuracy introduced by the "initial condition". Nevertheless, from the table in Figure 4, we can see the overall average accuracies are ~100% for both finger A1C and sensor A1C.



Date	Lab A1C	Finger A1C	accuracy %	Libre-15 A1C	accuracy %
5/29/18	6.8	6.70	99%	6.16	91%
6/29/18	6.5	6.70	103%	6.64	102%
10/22/18	6.6	6.81	103%	6.79	103%
1/18/19	7.0	6.71	96%	6.69	96%
2/12/19	6.7	6.74	101%	6.59	98%
4/4/19	6.8	6.81	100%	6.76	99%
7/11/19	6.7	6.69	100%	7.11	106%
9/25/19	6.6	6.52	99%	6.84	104%
12/20/19	6.6	6.61	100%	6.83	103%
Average	6.7	6.7	100%	6.7	100%

Figure 4: Lab A1C, Finger A1C, and CGM sensor A1C on the same lab-testing dates (both curves and data table)

It is important to mention that the author has stopped taking his diabetes medications since 12/8/2015.

Conclusion

Most diabetes patients usually have their quarterly or annual A1C test done at a hospital or medical lab. When patients receive the lab-test results of their elevated HbA1C, it is too late to change what has happened during the previous 3 to 4 months. Therefore, if patients use the author's predicted HbA1C, they will receive an immediate information regarding their status of diabetes. The daily A1C values provide an instant warning and continuous monitoring to them on a daily basis.

This special analysis of predicted CGM sensor A1C is "almost" as accurate as his 8-year long predicted finger A1C. Both predicted results are quite close to his lab-tested A1C. As a result, the author can stop performing his "dual" daily glucose data collection tasks. This would save a lot of his data collection time and effort, which can be better used on his higher value-added medical research work.

The proven accuracy of his predicted CGM sensor A1C provides him reassurance regarding his continuous diabetes control.

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