The GH-Method

Predicted HbA1C Values Using eAG/A1C Conversion Factor from Continuous Glucose Monitor Sensor Data for Three Years Based on GH-Method: Math-Physical Medicine (No. 448)

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Abstract

The author utilized his collected data of finger pierced glucose (4x per day), carbs-sugar intake amount, and post-meal walking steps for each meal over a period of 4 years, from 2017 to 2020, to calculate his predicted HbA1C values. His previously predicted A1C was conducted 9x for 9 different 5-month periods. In comparison to another set of 9 lab-tested HbA1C data, he achieved a near 100% prediction accuracy. Starting from 5/5/2018, along with the finger glucose, he also collected 96 glucose data per day for 1,095 days using a continuous glucose monitoring (CGM) sensor device for a total of ~105,120 glucose data. He noticed that from 5/5/2018 through 5/4/2019, his average daily sensor glucose (124.4 mg/dL) is 12% higher than his average daily finger glucose (110.9 mg/dL); therefore, if he uses the same formula for predicting HbA1C, it will result in a 12% higher sensor A1C (7.4%) than his finger A1C (6.6%). In this article, he uses the 90-days moving average daily glucose (eAG) data as his calculation base, which applies the following simple definition and equation of his predicted HbA1C formula with a conversion factor of CF: Predicted HbA1C = eAG / CF, where the CF values are 18.9 as the upper bound of the eAG/A1C CF value and 16.6 as the best-fitted CF value via a trial-and-error approach. In summary, comparing his predicted HbA1C values using an equation with a simple eAG/A1C CF against the lab-tested HbA1C values have the following four key observations: (1) Using the same equation and CF value, the average sensor glucose and A1C are 12% higher than his average finger glucose and A1C. However, his finger A1C is remarkably close to the lab-tested A1C with a prediction accuracy of 99%. This observation explains his 9 published A1C variance papers using finger glucose, carbs/sugar, and post-meal walking steps. (2) In terms of time-scale based on 9 lab-tested dates, applying the simple equation of Predicted HbA1C = eAG / CF, the predicted Sensor A1C would be 7.6 (13% higher than the lab A1C with 86% accuracy) if using 16.6 as the CF value; and 6.7 (same as lab A1C with 99% accuracy) if using 18.9 as the CF value. (3) The case of CF=16.6 and predicted sensor A1C=7.6 has a correlation of 51% in comparison with the 9 lab-tested A1C data curve. In the case of CF=18.9 and predicted sensor A1C=6.7 has a higher correlation of 61% in comparison with the 9 lab-tested A1C data curve. (4) In conclusion, by using 18.9 eAG/A1C CF, it generated the best predicted sensor HbA1C with 99% prediction accuracy and 61% correlation with lab-tested A1C data and curve.

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1. INTRODUCTION

The author utilized his collected data of finger pierced glucose (4x per day), carbs-sugar intake amount, and post-meal walking steps for each meal over a period of 4 years, from 2017 to 2020, to calculate his predicted HbA1C values. His previously predicted A1C was conducted 9x for 9 different 5-month periods. In comparison to another set of 9 lab-tested HbA1C data, he achieved a near 100% prediction accuracy[1,2].

Starting from 5/5/2018, along with the finger glucose, he also collected 96 glucose data per day for 1,095 days using a continuous glucose monitoring (CGM) sensor device for a total of ~105,120 glucose data. He noticed that from 5/5/2018 through 5/4/2019, his average daily sensor glucose (124.4 mg/dL) is 12% higher than his average daily finger glucose (110.9 mg/dL); therefore, if he uses the same formula for predicting HbA1C, it will result in a 12% higher sensor A1C (7.4%) than his finger A1C (6.6%)[3,4].

In this article, he uses the 90-days moving average daily glucose (eAG) data as his calculation base, which applies the following simple definition and equation of his predicted HbA1C formula with a conversion factor of CF:

Predicted HbA1C = eAG / CF

Where the CF values are 18.9 as the upper bound of the eAG/A1C CF value and 16.6 as the best-fitted CF value via a trial-and-error approach.

2. METHODS

Using signal processing techniques, the author identified approximately 20 influential factors of physical behavior for glucose. From these 20 factors, he further outlined the following six most prominent conclusions for his glucose and HbA1C values:

(1) The CGM sensor based A1C variances have the following contributions: 29% from fasting plasma glucose (FPG), 38% from postprandial plasma glucose (PPG), and 33% from between meals and pre-bedtime periods.

Therefore, all of the three segments contributed to HbA1C value almost equally.

(2) FPG variance due to weight change with ~77% contribution.

(3) Colder weather impact on FPG with a decrease of each Fahrenheit degree caused 0.3 mg/dL decrease of FPG.

(4) PPG variance due to carbs/sugar intake with ~39% weighted contribution on PPG.

(5) PPG variance due to post-meal walking with ~41% weighted contribution on PPG.

(6) Warm weather impact on PPG with an increase of each Fahrenheit degree caused 0.9 mg/dL increase of PPG.

It is common knowledge that HbA1C is closely connected to the average glucose for the past 90 days. Actually, the average human red blood cells (RBC), after differentiating from erythroblasts in the bone marrow, are released into the blood and survive in circulation for approximately 115 days. He has adopted the 120-days model in his previous sensor HbA1C studies, but he uses the 90-days model in this particular study. It should also be pointed out that, he has used the CGM collected sensor glucose and calculated HbA1C to compare against his collected nine lab-tested HbA1C data, while the lab A1C data contained a large margin of error due to various reasons[5,6].

In this study, he applied the following procedures to calculate and analyze his predicted HbA1C:

(1) He collects his daily average CGM sensor glucose and calculates where he uses the abbreviation eAG and average glucose fluctuation (maximum glucose minus minimum glucose) with the abbreviation GF. The role and influence of GF on HbA1C will be further discussed in his next article, No. 449.

(2) As a reference, he also accumulates his customized software calculated finger A1C based on finger-pierced glucose and sensor A1C based on CGM sensor collected glucose.

(3) He defines an equation for his predicted HbA1C with two different CF. Predicted

HbA1C = eAG / CF where eAG/A1C conversion factor=16.6 and 18.9 for a 3-year period.

(4) Finally, he calculates the HbA1C prediction accuracy and correlation coefficients (R) of two predicted HbA1C values using two different CF values to compare against the lab-tested HbA1C dataset[7-9].

3. RESULTS

Figure 1 shows the comparison of sensor glucose vs. finger glucose (both daily and 90-days moving average) with sensor A1C vs. finger A1C (red cross points are the lab-tested A1C in figure 1). Over a 3-year period from 5/5/2018 through 5/4/2019, his average daily sensor glucose (124.4 mg/dL) is 12% higher than his average daily finger glucose (110.9 mg/dL). Therefore, if he utilizes the same formula for predicting the HbA1C formula, it will provide the same result of 12% higher sensor A1C (7.4) than his finger A1C (6.6).
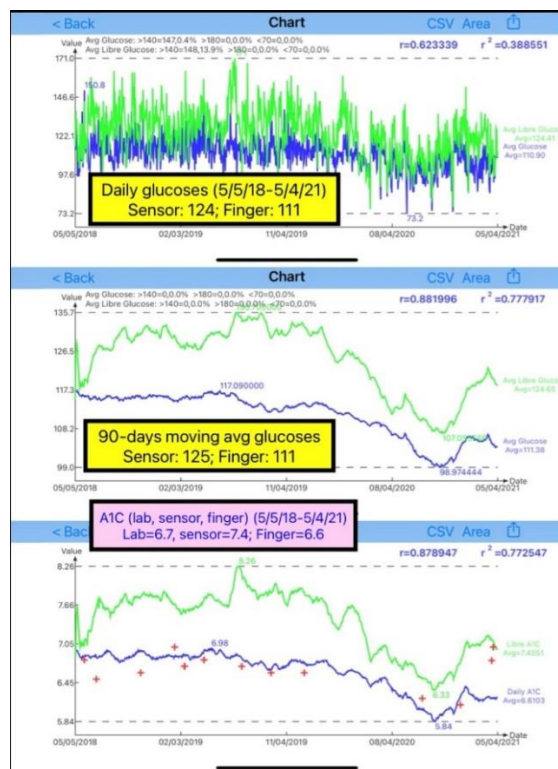

Figure 1: Comparison of sensor glucose vs. finger glucose (both daily and 90-days moving average) with sensor A1C vs. finger A1C (red cross points are lab-tested A1C).

This figure depicts the high accuracy of his finger A1C. However, sensor glucose monitoring has become increasingly popular

for outpatients with diabetes. While the CGM can provide valuable information, the author would like to develop a simple yet highly accurate sensor A1C prediction equation for patients. This is the purpose of this article and articles No. 449 and No. 450.

Figure 2 illustrates the HbA1C comparison between the lab-tested A1C vs. his predicted sensor A1C using the equation of "eAG / CF". As a result, it provides an upper bound of A1C (7.6%) using a lower CF value of 16.6 (accuracy 86%) and a more accurately predicted A1C (6.7%) using a higher CF value of 18.9 (accuracy 99%). In this diagram, the curve shape results using two different CF values are quite similar to each other, R=51% with CF=16.6 and R=61% with CF=18.9. Therefore, CF=18.9 not only provides a near 100% of prediction accuracy but also 10% on A1C shape similarity with a correlation of 61%.
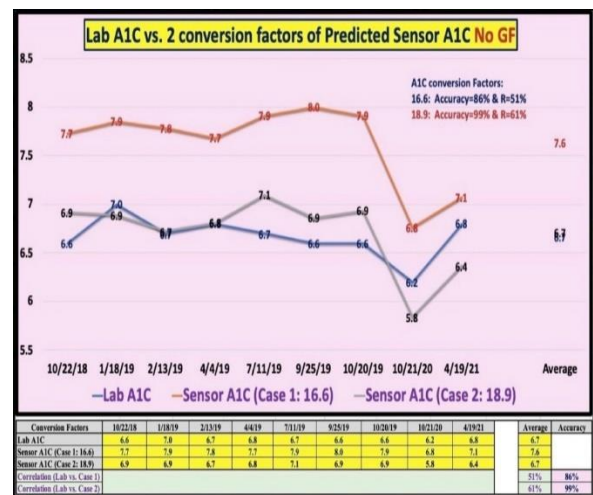

Figure 2: Three HbA1C curves (CF=16.6, CF=18.9, and lab A1C) and input data table with results of prediction accuracy and correlation coefficients.

4. CONCLUSION

In summary, comparing his predicted HbA1C values using an equation with a simple eAG/A1C CF against the lab-tested HbA1C values have the following four key observations:

(1) Using the same equation and CF value, the average sensor glucose and A1C are 12 % higher than his average finger glucose and A1C. However, his finger A1C is remarkably close to the lab-tested A1C with a prediction accuracy of 99%. This observation explains his 9 published A1C variance papers using

finger glucose, carbs/sugar, and post-meal walking steps.

(2) In terms of time-scale based on 9 lab-tested dates, applying the simple equation of "Predicted HbA1C = eAG / CF", the predicted sensor A1C would be 7.6 (13% higher than the lab A1C with 86% accuracy) if using 16.6 as the CF value; and 6.7 (same as lab A1C with 99% accuracy) if using 18.9 as the CF value.

(3) The case of CF=16.6 and predicted sensor A1C=7.6 has a correlation of 51% in comparison with the 9 lab-tested A1C data curve. In the case of CF=18.9 and predicted sensor A1C=6.7 has a higher correlation of 61% in comparison with the 9 lab-tested A1C data curve.

(4) In conclusion, by using 18.9 eAG/A1C CF, it generated the best predicted sensor HbA1C with 99% prediction accuracy and 61% correlation with lab-tested A1C data and curve[10-12].

5. REFERENCES

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