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Research Article

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A Comparison of the Combined HbA1C values from Two Predicted HbA1C Results Against 13 Lab-Tested HbA1C Results Within a 41-Month Period Based on GH-Method: Math-Physical Medicine (No. 522)

Gerald C Hsu

EclaireMD Foundation, USA

*Corresponding author
Gerald C Hsu, EclaireMD Foundation, USA

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Abstract

Since 1/3/2012, the author utilized his collected data of finger pierced glucose readings 4 times each day to estimate the predicted daily HbA1C value also known as the "Daily finger A1C" by ***dividing the daily average finger glucose value by a factor of 18.7.***

Starting from 5/5/2018, along with his finger glucoses, he has been collecting 96 glucoses each day using a continuous glucose monitoring (CGM) sensor device until present day. Based on the collected CGM sensor glucoses, he further estimated another predicted HbA1C value known as the "daily sensor A1C" by ***dividing the daily average sensor glucose value by a factor of 16.7.***

Finally, in this article, he merges the above-mentioned two HbA1C values into a "Combined HbA1C" with different assigned weighting factors for each A1C value.

His simple equation of the combination is as follows:

Combined A1C= 0.4*Finger A1C + 0.6*Sensor A1C

Although his initial dates for his finger glucoses and CGM sensor glucose are different, he has chosen an overlapping period of 1,233 days, 41 months, or 3.4 years from 5/8/2018 to 9/22/2021.

In addition, he accumulated his 13 lab-tested HbA1C values within the same period approximately 3.2 months with one lab-test done quarterly. He then compares his combined A1C waveform against the lab-tested A1C waveform to check the suitability of the developed equation for the combined HbA1C.

Finally, he calculates one additional set of his A1C values using the American Diabetes Association (ADA) defined formula for the HbA1C as follows:

HbA1C= (average glucose + 46.7) / 28.7

He then evaluates the ADA A1C against the lab-tested A1C.

In conclusion, the 5 average A1C values over 3.4-years are listed:

Finger A1C: ***6.5% (6.5107%)***
Sensor A1C: ***6.7% (6.6582%)***
Combined A1C: 6.6% (6.5992%)
Lab-tested A1C: 6.6% (6.5993%)
ADA formula: ***5.7% (5.7405%)***

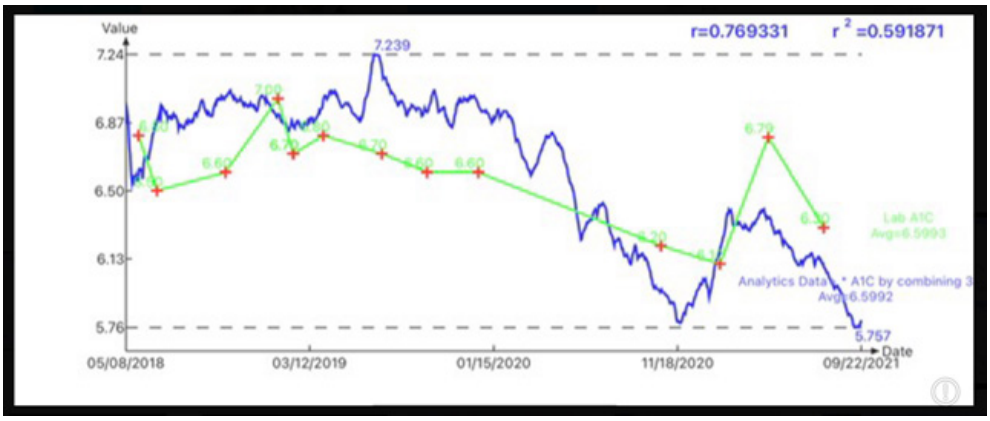
It is evident that ***the combined A1C and lab-rested A1C are almost 100% identical, up to the 4th decimal.*** *On the contrary,* ***the ADA defined HbA1C formula and lab-tested A1C have a 13% difference (87% accuracy).***

In addition, a high correlation of 77% existed between the combined A1C curve (with 1,233 data points) and the lab-tested curve (with 13 data points only). Similarly, a high correlation of 78% also existed between the ADA defined formula's A1C curve (with 1,233 data points) and the lab-tested curve (with 13 data points only). ***This comparison of almost-equal and high correlation coefficients has proven the moving trend and pattern as being extremely similar among the Lab-tested, Combined, and ADA defined.***

By comparing the data and curves of the 5 HbA1C curves, including finger A1C, CGM sensor A1C, combined A1C, ADA defined A1C, and lab-tested A1C, we can see that ***the combined A1C equation provides the most accurate and more reliable HbA1C prediction values within the selected time period of 3.4-years.***

The author spends his time and efforts on developing several highly accurate HbA1C prediction models in order to provide an ***"early and preventive warning"*** to diabetes patients on a daily basis. Therefore, they do not have to wait until the actual lab-test day to ascertain their HbA1C value. By that time, it will be too late to make any modifications for past behaviors in order to control their diabetes. Of course, both glucose and HbA1C involve many influential factors. ***Until now, the medical community still lacks a precise and accurate definition for the term of HbA1C.*** It is loosely defined as the 90-days average glucose value; however, the actual life-span of red blood cells (RBC) range between 90 to 120 days, where some documents even stated as 115 days. In reality, a lab-tested HbA1C is also affected by many other non-biomedical influential factors, including but not limited to its operational procedures, possible human errors, testing environment differences (even the altitude of the laboratory), etc. Therefore, the variance range of A1C values are evident.

Nevertheless, the objective of this article is to provide some simple yet useful A1C prediction tool to other patients for their diabetes control. If we can predict the future outcomes of HbA1C on a daily basis, then diabetes control will not be such a difficult task. The author strongly believes that an accurate prediction offers a better chance in preventing the disease, which is always superior to disease treatments, including medications, injections, surgeries, chemotherapy, or radiation which have different side-effects on the human bodies.



Introduction

Since 1/3/2012, the author utilized his collected data of finger pierced glucose readings 4 times each day to estimate the predicted daily HbA1C value also known as the "Daily finger A1C" by dividing the daily average finger glucose value by a factor of 18.7.

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Finally, he calculates one additional set of his A1C values using the American Diabetes Association (ADA) defined formula for the HbA1C as follows:

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He then evaluates the ADA A1C against the lab-tested A1C.

Method

By using signal processing techniques, the author identified more than 20 influential factors of physical behaviors for glucose. From the 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 three segments contributed to the HbA1C value almost equally (approximately one-third each).***
(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 (RBCs), after differentiating from erythroblasts in the bone marrow, are released into the blood and survive in circulation for approximately 115 days. The author has adopted the 120-days finger glucose model with different weight-factor for each month. In addition, he uses the CGM collected daily average sensor glucose (eAG) data for this HbA1C study. ***It should be reemphasized that the lab-tested HbA1C value should not be considered as the "golden standard" since it contains a large margin of error due to various possible causes. However, given the fact with the lack of golden rules, he still uses his Lab-tested A1C data as the baseline for the comparison study because most clinical doctors have confidence in the lab-tested HbA1C values.***

He lists his three arithmetic equations to be used for the predicted HbA1C of this study period. These three predicted HbA1C formulas with three associated conversion factors (CF) are as follows:

Finger A1C= (finger eAG) / (CF=18.7)
Sensor A1C= (sensor eAG) / (CF=16.7)

The CF values are selected to achieve high accuracy and can vary from patient to patient or from one time period to another. This CF value can be different for a specific patient dependent on significant changes occurring in a certain time period or with special health conditions. However, for a general case, they do not vary too much.

His simple equation of the combination for finger A1C and sensor A1C is listed as follows:

Combined A1C= 0.4*Finger A1C + 0.6*Sensor A1C

The ADA defined formula for HbA1C is:

ADA HbA1C= (average glucose + 46.7) / 28.7

Results

This paper is a simple demonstration of 3 predicted A1C models that achieved ~100% prediction accuracy with 12 lab-tested results over a long period of 38 months from 5/29/18 to 7/22/2021.

Figure 1 shows the comparison between finger A1C, sensor A1C, combined A1C, and Lab-tested A1C. The following records the 4 average A1C values as 2 correlation coefficients:
Finger A1C: 6.5%
Sensor A1C: 6.7%
Correlation of Finger vs. sensor: 90%

Combined A1C: 6.6%
Lab-tested A1C: 6.6%
Correlation of Combined vs. Lab: 77%

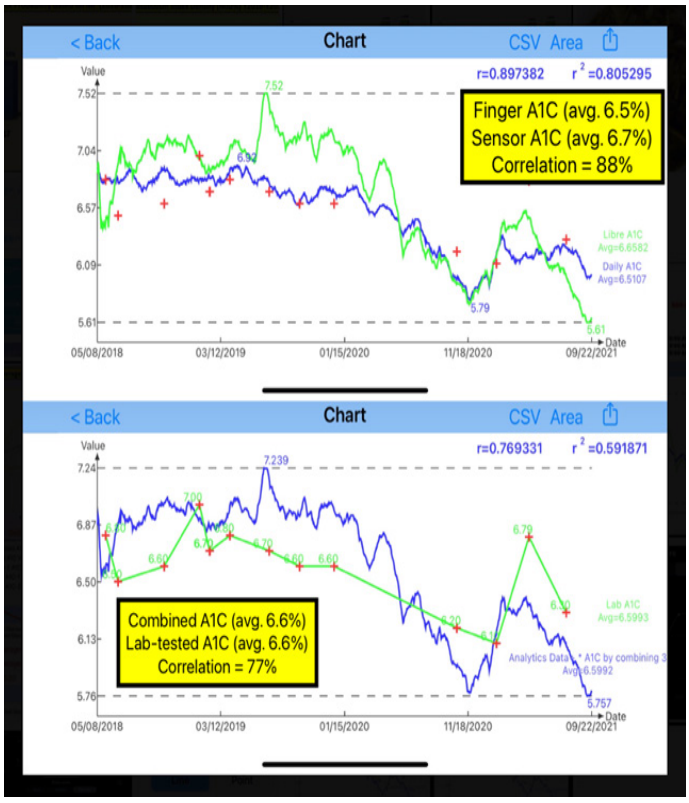

Figure 1: Finger A1C, Sensor A1C, Combined A1C and Lab-tested A1C

Figure 2 depicts the equation of the combined A1C and its comparison against the lab-tested A1C with the following results:

Combined A1C Equation= (0.4*Finger A1C + 0.6*Sensor A1C)

Combined A1C = 6.6%
Lab-tested A1C = 6.6%
Correlation of Combined vs. Lab = 77%

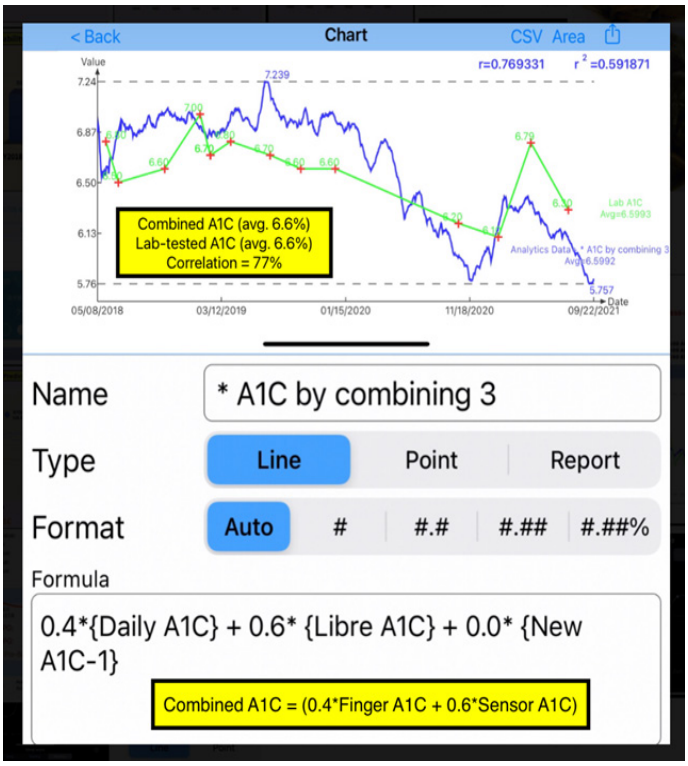

Figure 2: Combined A1C and Lab-tested A1C

Figure 3 reflects the equation of the ADA defined A1C and its comparison against the lab-tested A1C with the following results:

ADA defined A1C formula= (Finger A1C + 46.7) / 28.7

ADA defined A1C = 5.7%
Lab-tested A1C = 6.6%
Correlation of ADA vs. Lab = 78%

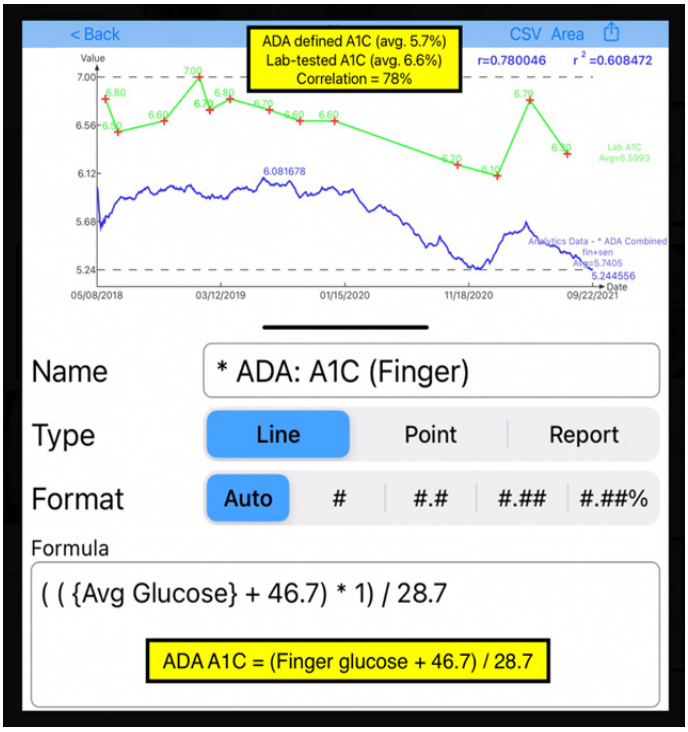

Figure 3: ADA defined A1C and Lab-tested A1C

Conclusion

In conclusion, 5 averaged A1C values over past 3.4-years are listed below:

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It is very clear that ***the combined A1C and lab-rested A1C are almost 100% identical, up to 4th decimal.*** On contrary, ***the ADA defined HbA1C formula and lab-tested A1C have a 13% difference (87% accuracy).***

In addition, a high correlation of 77% existed between the combined A1C curve (with 1,233 data points) and the lab-tested curve (with 13 data points only). Similarly, a high correlation of 78% also existed between the ADA defined formula's A1C curve (with 1,233 data points) and the lab-tested curve (with 13 data points only). ***This comparison of almost-equal and high correlation coefficients proves the moving trend and pattern are very similar among Lab-tested, Combined, and ADA defined.***

By comparing both data and curves of these 5 HbA1C curves, including finger A1C, CGM sensor A1C, combined A1C, ADA defined A1C, and lab-tested A1C, we can see that ***the combined A1C equation indeed provide the most accurate and more reliable HbA1C prediction values within the selected time period of 3.4-years.***

The author spends his time and efforts on developing several highly accurate HbA1C prediction models in order to provide an ***"early and preventive warning"*** to diabetes patients on a daily basis. Therefore, patients do not have to wait until the actual lab-test day to find out their HbA1C value. By that time, it will be too late to make any modifications for past behaviors in order to control their diabetes. Of course, both glucose and HbA1C involve many influential factors. Until now, the medical community still lacks a precise and accurate definition for the term of HbA1C. It is loosely defined as the 90-days average glucose value. However, the actual life-span of red blood cells (RBC) range between 90 to 120 days, where some documents even stated as 115 days. In reality, a lab-tested HbA1C is also affected by many other non-biomedical influential factors, including but not limited to its operational procedures, possible human errors, testing environment differences (even the altitude of the laboratory), etc. Therefore, the variance range of A1C values are evident.

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References

For editing purposes, majority of the references in this paper, which are self-references, have been removed for this article. Only references from other authors' published sources remain.

The bibliography of the author's original self-references can be viewed at www.eclairemd.com.

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