Special Issue 2
2021

The GH-Method

Creating a Formula for Estimated HbA1C Value Using the Average Daily Glucose, Daily Glucose Fluctuation, and A1C Conversion Factor Along with the Comparison of Lab-Tested HbA1C for 10 Periods Over 3 Years Based on GH-Method: Math-Physical Medicine (No. 441)

Gerald C. Hsu*

eclaireMD Foundation, USA

Abstract

In this case study, the author analyzed, predicted, and interpreted his own hemoglobin A1C (HbA1c) variance between the estimated and lab-tested A1C values. They consisted of 10 time periods with 3 months each for over the past 3 years utilizing his developed GH-method: math-physical medicine (MPM) approach. Since 1/1/2014, he applied a set of formulas with different input data, including body weight, finger-pierced glucose levels, carbs/sugar intake in grams, and post-meal walking steps. He wrote 9 articles based on the results created by this method. Since 5/5/2018, he also collected his glucose data via a continuous glucose monitoring (CGM) device on his arm at every 15-minute time interval. As a result, he could collect 96 glucose values each day; therefore, he decided to develop a new formula for his estimated HbA1C values using the daily average glucose, glucose fluctuation (GF) (GF equals to maximum glucose minus minimum glucose), and A1C conversion factor to replace the previous formula. The CGM sensor device has the capability to provide him more accurate daily glucose and GF values than the finger-piercing method. This study provides two ways for estimation: Method A: Estimated A1C = ((daily glucose * weight factor 1) + (GF * weight factor 2)) / (A1C conversion factor); Method B: Estimated A1C = (daily glucose) / (A1C conversion factor). Here is a summary of what he has learned from previous research work: (1) The most important month which contributes to the A1C is the month prior to the lab test. (2) Postprandial plasma glucose (PPG) contributes > 2/3 of HbA1C. (3) Bodyweight controls ~77% or more of the fasting plasma glucose (FPG) which provides <1/3 of HbA1C; therefore, it is important to keep the BMI below 25. (4) Carbs/sugar amount contributes ~39% to PPG. For type 2 diabetes (T2D) patients, it is safe to keep carbs/sugar intake amount below 15 grams per meal. (5) Post-meal walking steps affect ~41% of PPG. It is recommended to maintain post-meal walking exercise around 4,000 steps after each meal. (6) A combined effort of diet and exercise controls ~80% of PPG formation. The specific conclusions drawn from this study are: (1) Estimated HbA1C data from both Methods A and B provide high correlations (68%-71%) with lab-tested HbA1C data. (2) For Method A, in order to achieve a 100% match with the average HbA1C for the entire 10 periods, the daily glucose weight is 55% and GF weight is 45%. However, to accomplish a 100% match with the average HbA1C for both periods H and J, the daily glucose weight is 85% and GF weight is 15%. (3) For Method B, in order to achieve a 100% match with the average HbA1C for the entire 10 periods, the A1C conversion factor is 19.0. However, to obtain a 100% match with the average HbA1C for both periods H and J, the A1C conversion factor is 17.5. This study demonstrates a reasonably high degree of accuracy range for the calculation and prediction of the patient's forthcoming HbA1C value by using the GH-method: MPM approach. In this article, the author also utilized the CGM sensor glucose data with AI-tuned conversion factor between glucose and lab-tested HbA1C. Once the healthcare professionals and T2D patients understand his HbA1C mathematical prediction method, then the overall diabetes condition for the patient can be easier to control. The purpose of this research paper is to help people with T2D to prevent further damage to their internal organs caused by elevated A1C values prior to laboratory testing. Once the lab-tested HbA1C results are provided, it is already too late to modify your lifestyle.

Keywords: Glucose; Glucose fluctuation; Postprandial plasma glucose; Fasting plasma glucose; Diabetes

Abbreviations: HbA1C: hemoglobin A1C; MPM: math-physical medicine; CGM: continuous glucose monitoring; GF: glucose fluctuation; PPG: postprandial plasma glucose; FPG: fasting plasma glucose; T2D: type 2 diabetes

Received: 11 August 2021, Accepted: 17 September 2021, Available online: 21 September 2021

*Corresponding author: Gerald C. Hsu, eclaireMD Foundation, USA

1. INTRODUCTION

In this case study, the author analyzed, predicted, and interpreted his own hemoglobin A1C (HbA1C) variance between the estimated and lab-tested A1C values. They consisted of 10 time periods with 3 months each for over the past 3 years utilizing his developed GH-method: math-physical medicine (MPM) approach[1].

Since 1/1/2014, he applied a set of formulas with different input data, including body weight, finger-pierced glucose levels, carbs/sugar intake in grams, and post-meal walking steps. He wrote 9 articles based on the results created by this method. Since 5/5/2018, he also collected his glucose data via a continuous glucose monitoring (CGM) device on his arm at every 15-minute time interval. As a result, he could collect 96 glucose values each day; therefore, he decided to develop a new formula for his estimated HbA1C values using the daily average glucose, glucose fluctuation (GF) (GF equals to maximum glucose minus minimum glucose), and A1C conversion factor to replace the previous formula. The CGM sensor device has the capability to provide him more accurate daily glucose and GF values than the finger-piercing method[2,3].

This study provides two ways for estimation:

Method A:
Estimated A1C = ((daily glucose * weight factor 1) + (GF * weight factor 2)) / (A1C conversion factor)

Method B:
Estimated A1C = (daily glucose) / (A1C conversion factor)

2. METHODS

The author conducted his glucose research by applying the developed GH-method: MPM approach along with the following seven contribution factors of HbA1C:

(1) A1C variances contributed by fasting plasma glucose (FPG) between 15% to 35%, where he used 25% in his calculation for this article.

(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) A1C variances contributed by postprandial plasma glucose (PPG) between 65% to 85%, where he used 75% in his calculation for this article.

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

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

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

It should be noted that in the HbA1C prediction model research, he utilized his CGM collected glucose from the previous 3-months prior to the day of the lab test. 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.

In this study, he included GF as one of the influential factors of his estimated HbA1C. Furthermore, he applied different weighted factors for the daily average glucose and GF. Therefore, there are two formulas that use two different equations to estimate his forthcoming HbA1C value which are listed below:

Method A:
Estimated A1C = ((daily glucose * weight factor 1) + (GF * weight factor 2)) / (A1C conversion factor)

Method B:
Estimated A1C = (daily glucose) / (A1C conversion factor)

In this study, he attempted two sets of weight factors in Method A, 55% vs. 45% and 85% vs. 15% for daily glucose vs. GF. Similarly, he also tried two different A1C conversion factors in Method B, 19.0 and 17.5 for

converting daily average glucose value into HbA1C value[4,5].

3. RESULTS

Figure 1 shows a sample input data from his CGM collected data waveform of daily average glucose, daily GF (GF = max. glucose - min. glucose), max glucose, and min glucose.

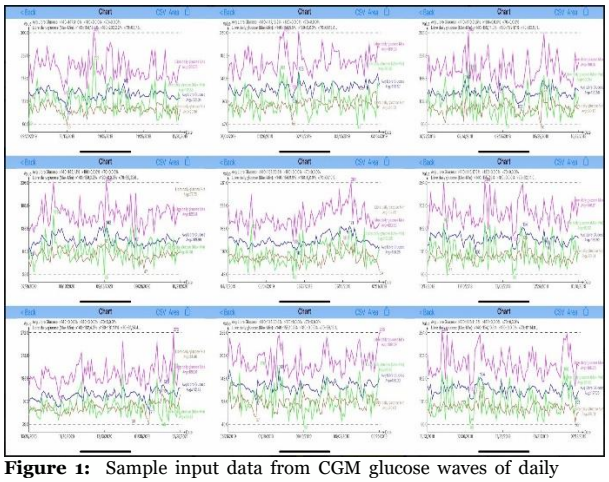

Figure 1: Sample input data from CGM glucose waves of daily glucose, GF, maximum glucose and minimum glucose for 9 periods.

Figure 2 depicts his collected HbA1C values and summarized data from figure 1 for the predicted HbA1C using Method A for the 10 periods.

4/24/21	Correlation =	71%		eAG weight	GF weight	Max. eAG weight	A1C Conversion			
	Estimated A1C = (eAG*weight+GF*weight)/A1C conversion			55%	45%	0%	17.13			
Period	Lab A1C	Estimated A1C	A1C Difference	Sensor eAG	eAG GF	eAG Max.	eAG Min.	Starting Date	Ending Date	No. of Days
A	6.6	6.8	4%	131	101	131	90	7/22/18	10/22/18	93
B	7.0	6.7	-4%	130	97	187	90	10/18/18	1/18/19	93
C	6.7	6.6	-1%	127	97	185	88	11/13/18	2/13/19	93
D	6.8	6.6	-2%	129	96	186	91	1/4/19	4/4/19	91
E	6.7	7.0	4%	134	101	194	93	4/11/19	7/11/19	92
F	6.6	6.8	3%	130	99	189	91	6/25/19	9/25/19	93
G	6.6	7.2	9%	132	113	204	91	9/20/19	12/20/19	92
H	6.2	5.8	-6%	110	87	165	78	7/21/20	10/21/20	93
I	6.1	5.8	-4%	112	85	166	81	10/28/20	1/28/21	93
J	6.9	6.7	-4%	120	106	188	81	1/20/21	4/20/21	91
Average	6.6	6.6	0%	126	98	179	87			92
4/24/21	Correlation =	70%		eAG weight	GF weight	Max. eAG weight	A1C Conversion			
	Estimated A1C = (eAG*weight+GF*weight)/A1C conversion			85%	15%	0%	17.13			
Period	Lab A1C	Estimated A1C	A1C Difference	Sensor eAG	eAG GF	eAG Max.	eAG Min.	Starting Date	Ending Date	No. of Days
A	6.6	7.4	11%	131	101	131	90	7/22/18	10/22/18	93
B	7.0	7.3	4%	130	97	187	90	10/18/18	1/18/19	93
C	6.7	7.2	7%	127	97	185	88	11/13/18	2/13/19	93
D	6.8	7.2	6%	129	96	186	91	1/4/19	4/4/19	91
E	6.7	7.5	13%	134	101	194	93	4/11/19	7/11/19	92
F	6.6	7.3	11%	130	99	189	91	6/25/19	9/25/19	93
G	6.6	7.6	14%	132	113	204	91	9/20/19	12/20/19	92
H	6.2	6.2	0%	110	87	165	78	7/21/20	10/21/20	93
I	6.1	6.3	4%	112	85	166	81	10/28/20	1/28/21	93
J	6.9	6.9	0%	120	106	188	81	1/20/21	4/20/21	91
Average	6.6	7.1	7%	126	98	179	87			92

Figure 2: Input data of lab-tested HbA1C values and calculation using equation with both eAG and GF (Method A) for 10 HbA1C periods.

Figure 3 reveals the results using Method A.

The curves in the top diagram used the weighting factor of 55% for daily glucose and 45% for GF. Therefore, the equation is:

Estimated HbA1C = (daily glucose * 0.55 + GF * 0.45) / 17.13

Where the A1C conversion factor of 17.13 is the number he utilized over the past 9 years for his predicted A1C based on finger-piercing glucose levels.

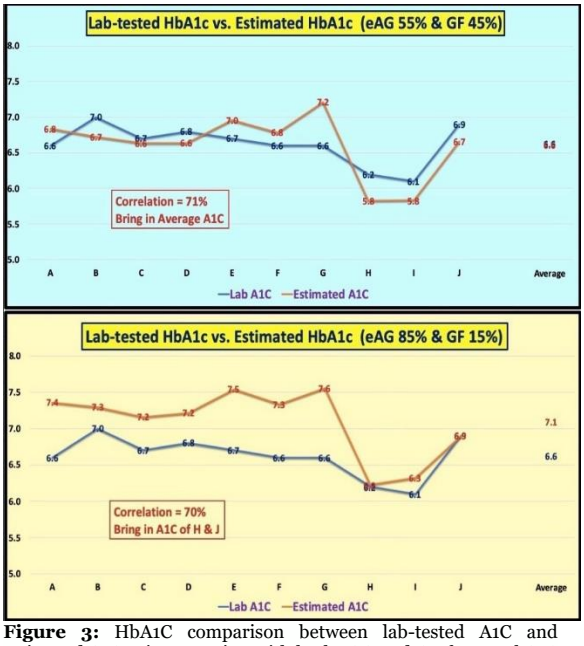

Figure 3: HbA1C comparison between lab-tested A1C and estimated A1C using equation with both eAG and GF for 10 HbA1C periods (Method A).

The results using 55% vs. 45% show that the average HbA1C over the 10 periods is identical between the lab-tested A1C and his estimated A1C.

The curves in the bottom diagram used the weighting factor of 85% for daily glucose and 15% for GF. Therefore, the equation is:

Estimated HbA1C = (daily glucose * 0.85 + GF * 0.15) / 17.13

Once again, where the A1C conversion factor of 17.13 is the number he used over the past 9 years for his predicted A1C based on finger-piercing glucose levels.

The results using 85% vs. 15% show the average HbA1C for periods H and J are identical between the lab-tested A1C and his estimated A1C.

Figure 4 illustrates his collected HbA1C values and summarized data from figure 1 for the predicted HbA1C using Method B for the 10 periods.

4/24/21	Correlation =	68%		eAG weight	GF weight	Max. eAG weight	A1C Conversion			
	Etimated A1C = (eAG*weight+GF*weight)/A1C conversion			100%	0%	0%	19.0			
Period	Lab A1C	Estimated A1C	A1C Difference	Sensor eAG	eAG GF	eAG Max.	eAG Min.	Starting Date	Ending Date	No. of Days
A	6.6	6.9	4%	131	101	131	90	7/22/18	10/22/18	93
B	7.0	6.8	-2%	130	97	187	90	10/18/18	1/18/19	93
C	6.7	6.7	0%	127	97	185	88	11/13/18	2/13/19	93
D	6.8	6.8	0%	129	96	186	91	1/4/19	4/4/19	91
E	6.7	7.1	5%	134	101	194	93	4/11/19	7/11/19	92
F	6.6	6.9	4%	130	99	189	91	6/25/19	9/25/19	93
G	6.6	7.0	6%	132	113	204	91	9/20/19	12/20/19	92
H	6.2	5.8	-7%	110	87	165	78	7/21/20	10/21/20	93
I	6.1	5.9	-3%	112	85	166	81	10/26/20	1/26/21	93
J	6.9	6.3	-8%	120	106	188	81	1/20/21	4/20/21	91
Average	6.6	6.6	0%	126	98	179	87			92

4/24/21	Correlation =	68%		eAG weight	GF weight	Max. eAG weight	A1C Conversion			
	Etimated A1C = (eAG*weight+GF*weight)/A1C conversion			100%	0%	0%	17.50			
Period	Lab A1C	Estimated A1C	A1C Difference	Sensor eAG	eAG GF	eAG Max.	eAG Min.	Starting Date	Ending Date	No. of Days
A	6.6	7.5	13%	131	101	131	90	7/22/18	10/22/18	93
B	7.0	7.4	6%	130	97	187	90	10/18/18	1/18/19	93
C	6.7	7.3	9%	127	97	185	88	11/13/18	2/13/19	93
D	6.8	7.3	8%	129	96	186	91	1/4/19	4/4/19	91
E	6.7	7.7	14%	134	101	194	93	4/11/19	7/11/19	92
F	6.6	7.4	13%	130	99	189	91	6/25/19	9/25/19	93
G	6.6	7.6	15%	132	113	204	91	9/20/19	12/20/19	92
H	6.2	6.3	1%	110	87	165	78	7/21/20	10/21/20	93
I	6.1	6.4	5%	112	85	166	81	10/26/20	1/26/21	93
J	6.9	6.9	0%	120	106	188	81	1/20/21	4/20/21	91
Average	6.6	7.2	8%	126	98	179	87			92

Figure 4: Input data of lab-tested HbA1C values and calculation using equation with A1C conversion factor only (Method B) for 10 HbA1C periods.

Figure 5 reflects the results using Method B.

The curves in the top diagram used 19.0 as the A1C conversion factor. Therefore, the equation is:

Estimated HbA1C = (daily glucose) / 19.0

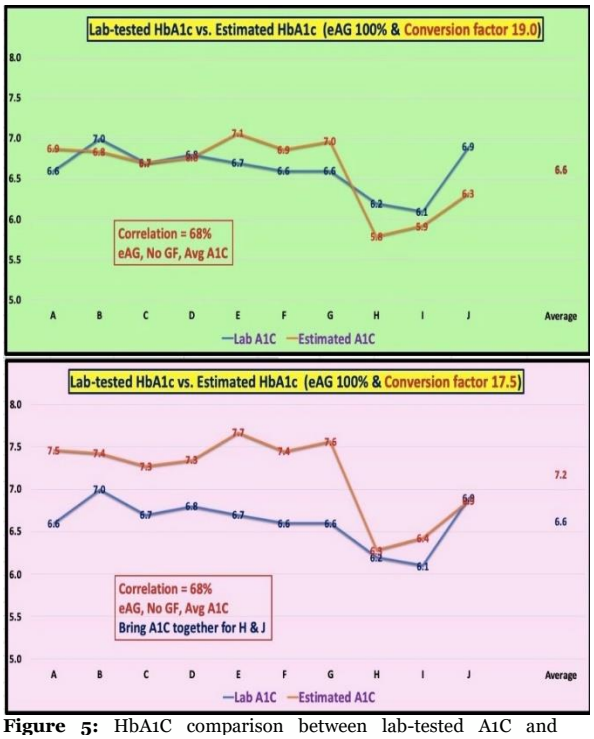

Figure 5: HbA1C comparison between lab-tested A1C and estimated A1C using equation with A1C conversion factors only for 10 HbA1C periods (Method B).

The results using 19.0 as the A1C conversion factor show the average HbA1C over the 10 periods is identical between the lab-tested A1C and his estimated A1C.

The curves in the bottom diagram utilized 17.5 as the A1C conversion factor. Therefore, the equation is:

Estimated HbA1C = (daily glucose) / 17.5

The results using 17.5 as the A1C conversion factor show the average HbA1C for periods H and J are identical between the lab-tested A1C and his estimated A1C.

All of the 4 predicted A1C curves have high correlation coefficients (68%-71%) in comparison with the lab-tested A1C curve. As a matter of fact, all of the 4 predicted A1C curves have extremely high correlation coefficients (93%-99%) in comparison with the CGM collected glucose curve for the 10 periods.

4. CONCLUSION

The author focused on nine periods over 1,299 days. It contains 3,897 meal data, including key contributing factors such as carbs/sugar intake, post-meal exercise, weather, and more. This study demonstrated a high degree of accuracy for the calculation and prediction of the patient's forthcoming HbA1C value by using the GH-method: MPM approach. In this article, the author also utilized CGM sensor glucose data with an AI-tuned conversion factor between glucose and HbA1C. Furthermore, he also implemented his developed linear elastic glucose behavior theory for his PPG calculation in order to obtain a better estimation for the final HbA1C value[6-8].

Once the healthcare professionals and type 2 diabetes (T2D) patients understand his HbA1C mathematical prediction method, then the overall diabetes condition for the patient can be easier to control. The purpose of this research paper is to help people with T2D to prevent further damage to their internal organs caused by elevated A1C values prior to laboratory testing.

If healthcare professionals and diabetes patients have the interest to delve deeper regarding the formation of tested glucose and mathematical predicted A1C, they should focus on the influential factors and their respective weighted contribution percentages described in the author's previous papers.

Here is a summary of what he has learned from previous research work:

(1) The most important month which contributes to the A1C is the month prior to the lab test.

(2) PPG contributes > 2/3 of HbA1C.

(3) Bodyweight controls ~77% or more of the FPG which provides <1/3 of HbA1C; therefore, it is important to keep the BMI below 25.

(4) Carbs/sugar amount contributes ~39% to PPG. For T2D patients, it is safe to keep carbs/sugar intake amount below 15 grams per meal.

(5) Post-meal walking steps affect ~41% of PPG. It is recommended to maintain post-meal walking exercise around 4,000 steps after each meal.

(6) A combined effort of diet and exercise controls ~80% of PPG formation.

5. REFERENCES

1) Hsu GC. Biomedical research methodology based on GH-Method: Math-Physical Medicine. eclaireMD Foundation, USA. No. 310.

2) Hsu GC. A case study on the prediction of a1c variances over seven periods with guidelines using GH-Method: Math-Physical Medicine. eclaireMD Foundation, USA. No. 262.

3) Hsu GC. A case study on the investigation and prediction of A1C variances over six periods using GH-Method: Math-Physical Medicine. eclaireMD Foundation, USA. No. 116.

4) Hsu GC. A case study of investigation and prediction of A1C variances over 5 periods using GH-Method: Math-Physical Medicine. eclaireMD Foundation, USA. No. 65.

5) Hsu GC. Segmentation and pattern analyses for three meals of postprandial plasma glucose values and associated carbs/sugar amounts using GH-Method: Math-Physical Medicine. eclaireMD Foundation, USA. No. 326.

6) Hsu GC. Using GH-Method: Math-Physical Medicine to conduct segmentation analysis to investigate the impact of both weight and weather temperatures on fasting plasma glucose (FPG). eclaireMD Foundation, USA. No. 68.

7) Hsu GC. Investigation of linear elastic glucose behavior with GH-modulus linking carbohydrates/sugar intake and incremental PPG via an analogy of Young's modulus from theory of elasticity and engineering strength of materials using GH-Method: Math-Physical Medicine (Parts 1, 2, and 3). eclaireMD Foundation, USA, No. 352.

8) Hsu GC. Applying linear elastic glucose behavior theory and AI auto-correction to predict A1C Variances over the ninth period using GH-Method: Math-Physical Medicine. eclaireMD Foundation, USA No. 354..

Special Issue | Issue No. 2

The GH-Method

Advances In Biomedical Research Using GH-Method: Math-Physical Medicine

Gerald C. Hsu

https://www.theghmethod.com

2021