Metabolism Open 22 (2024) 100282

Contents lists available at ScienceDirect

Metabolism Open

journal homepage: www.sciencedirect.com/journal/metabolism-open

# Differences in glucose readings between the continuous glucose monitoring calibration free interstitial sensors versus capillary blood glucose monitoring by glucometer: An analysis of two cases

Phaik Ling Quah [a,b,*], Sally Mun Hua Chai [a], Kok Hian Tan [a,b]

[a] Division of Obstetrics & Gynaecology, KK Women's and Children's Hospital, Singapore
[b] Duke-NUS Medical School, National University of Singapore, Singapore

ABSTRACT

*Aim:* To assess the differences in glucose readings between the continuous glucose monitoring calibration-free interstitial sensors versus capillary blood glucose monitoring by glucometer.

*Study design:* Two healthy non-pregnant volunteers participated in the study, and wore simultaneously both the calibration-free Freestyle Libre and the Dexcom G6 sensor. Glucose values were recorded before and after meals during breakfast, lunch, and dinner on three separate days by either scanning the Freestyle Libre CGM sensor with a smartphone, or obtaining glucose readings real-time through the Dexcom G6 CLARITY mobile application. Blood glucose values were recorded using the Accu-Chek Active glucose meter. The Wilcoxon signed-rank test was used for paired non-parametric data to compare glucose readings between groups.

*Results:* The average glucose values obtained from the Dexcom G6 CGM consistently registered higher ($6.54 \pm 0.80$ mmol/L) and those from the Freestyle Libre ($5.49 \pm 0.65$ mmol/L) consistently lower, from the glucometer ($6.17 \pm 0.55$ mmol/L), with p-value $<0.05$ between groups. In the three-way comparison, the Dexcom G6 CGM sensor yielded the highest values, followed by the glucose meter, and finally the Freestyle Libre CGM sensor

*Conclusion:* Both CGM systems exhibited discrepancies from blood glucose (BG) measurements, and variations were observed among the different CGM systems themselves.

## 1. Introduction

Continuous glucose monitoring (CGM) is increasingly used in obstetrics and gynaecology [1]. The conventional method for monitoring glucose levels in patients involves frequent capillary blood sampling to ensure close monitoring. However, self-monitoring of blood glucose does not provide a complete daily glucose profile due to long intervals (i.e. nighttime sleep) between finger pricking and relies heavily on a patients' compliance [2]. The CGM system offers a promising alternative by continuously providing a greater number of glucose readings, thus offering a more comprehensive understanding of glucose control. They enable the detection of trends and patterns, facilitating the development of personalized glucose monitoring management strategies [1].

The measurement performance of various commercially accessible CGM systems have been explored [3–6], including the differences in the performance of these CGM sensors with and without calibration [7]. However, these studies were all conducted in patients with Type I diabetes, and in inpatient or controlled settings [3–7] and were utilizing the older generation of Dexcom sensors [3–6]. There is a scarcity of studies investigating variations in glucose readings from CGM sensors used in clinical practice, versus glucose readings from the traditional glucose meter in non-diabetics and free-living conditions. This study is designed to assess the differences in glucose readings between the Freestyle Libre and Dexcom G6 CGM sensors, compared to the blood glucose meter.

## 2. Study design

Two healthy non-pregnant volunteers participated in the study, and wore simultaneously both the calibration-free Freestyle Libre (Abbott Diabetes Care, Alameda, California, USA) and the Dexcom G6 sensor (Dexcom, Inc., San Diego, CA, USA) on the upper arm, either left or right, for a maximum of 14 days for the Freestyle Libre, and up to 10 days for the Dexcom G6. The Freestyle Libre recorded interstitial glucose readings every 15 min, [2] while the Dexcom G6 recorded interstitial glucose readings every 5 min [3] Glucose values were recorded before and after meals during breakfast, lunch, and dinner on three separate days by either scanning the Freestyle Libre CGM sensor with a smartphone, or obtaining glucose readings real-time through the Dexcom G6 CLARITY mobile application. Blood glucose values were recorded using the Accu-Chek Active glucose meter (Roche Diagnostics GmbH, Mannheim,

* Corresponding author. Division of Obstetrics and Gynaecology, KK Women's and Children's Hospital (KKH), 100 Bukit Timah Rd, 229899, Singapore.
*E-mail address:* quah.phaik.ling@kkh.com.sg (P.L. Quah).

https://doi.org/10.1016/j.metop.2024.100282
Received 26 March 2024; Received in revised form 16 April 2024; Accepted 17 April 2024
Available online 18 April 2024
2589-9368/

Germany). This study, exempted from an ethics review under institutional policy, was conducted in accordance with the ethical standards outlined by the responsible institution for human subjects, as well as the principles set forth in the Helsinki Declaration. The description of the glucose values was presented as mean and standard deviation averaged over three days for both individuals. The Wilcoxon signed-rank test was used for paired non-parametric data to compare glucose readings between groups and statistical analyses were performed using STATA software version 13.1 (Statacorp LP, College Station, TX, USA).

## 3. Results

The analysis of glucose readings reveals a consistent pattern: the average glucose values obtained from the Dexcom G6 CGM consistently registered higher (6.54 ± 0.80 mmol/L) and those from the Freestyle Libre (5.49 ± 0.65 mmol/L) consistently lower, from the glucometer (6.17 ± 0.55 mmol/L), with p-value <0.05 between groups. Across all recorded data points, the Dexcom G6 CGM sensor yielded the highest values, followed by the glucose meter, and finally the Freestyle Libre CGM sensor (Table 1).

## 4. Discussion

In this study, we observed deviations in glucose readings between the Freestyle Libre and the Dexcom G6 CGM sensors in the measurement of interstitial glucose levels compared with capillary blood glucose values assessed by the glucometer. Across the averaged glucose readings, the Dexcom G6 CGM sensor yielded the highest values, followed by the glucose meter, and finally the Freestyle Libre CGM sensor. Making direct comparisons between our study findings and previously published ones is challenging due to differences in parameters measured. While we present our findings using simple mean and standard deviation, other studies have explored the accuracy of the CGM systems using the Mean Absolute Relative Difference (MARD) [3–6,8].

While the parameters measured may not align directly with our study, two other studies have assessed the performance of these commercially available CGM systems in free-living settings, and have similarly observed deviations in the accuracy of the two systems from blood glucose measurements [5,8]. One study conducted by Hanson *et al.* compared the latest CGM devices, specifically the Dexcom G7 and FreeStyle Libre 3 systems [8]. This single-arm study focused on adults diagnosed with either type 1 diabetes (T1D) or type 2 diabetes (T2D). Hanson *et al.* reported that the Dexcom G7 exhibited a significantly higher MARD compared to the FreeStyle Libre 3 sensor, along with a higher bias and lower agreement with capillary blood glucose measurements [8]. Another study by Freckmann *et al.* had similar observations and reported deviations of the Dexcom G5 and Freestyle Libre from blood glucose measurements [5].

The strength in our study is the direct impact on how these two CGM sensors will be used in the clinical and home setting. This work emphasizes the importance of considering CGM characteristics when prescribing these devices, and the consideration of prior calibration even for calibration-free devices. The limitations to our study need to be acknowledged. Firstly, comparisons to any other previous studies are difficult due to the utilization of older Dexcom sensor generations, such as G4 or G5 [3,4,6] and because of the lack of standardized protocols and metrics used for reporting the differences in the CGM values. Secondly, we only have two cases based on a very small amount of data collected over three days.

## 5. Conclusion

This study highlights the considerable variations in glucose readings provided by different CGM systems. It underscores the need for more extensive studies to validate the impact of each 'calibration-free' CGM system on glycaemic control.

**Table 1**
The comparisons of interstitial glucose values measured using the Freestyle Libre CGM and the Dexcom G6 CGM and blood glucose values measured using a glucometer.

| Timing of glucose value measurement | Glucose measurement devices | | |
|---|---|---|---|
| | Freestyle Libre | Dexcom G6 | Glucometer |
| | Mean (standard deviation) | | |
| *Morning | | | |
| Pre-meal (mmol/L), n = 6 | 5.13 (0.29) | 6.47 (0.29) | 5.80 (0.34) |
| Post-meal (mmol/L), n = 6 | 5.33 (0.28) | 5.90 (0.56) | 5.97 (0.15) |
| *Afternoon | | | |
| Pre-meal (mmol/L), n = 6 | 5.10 (0.1) | 6.25 (0.43) | 5.90 (0.48) |
| Post-meal (mmol/L), n = 6 | 5.18 (0.43) | 6.78 (0.63) | 6.15 (0.48) |
| *Dinner | | | |
| Pre-meal (mmol/L), n = 6 | 5.45 (0.83) | 5.85 (0.48) | 5.83 (1.01) |
| Post-meal (mmol/L), n = 6 | 6.80 (0.66) | 8.02 (1.34) | 7.38 (1.42) |
| Average glucose values (mmol/L), n = 36 | [a]5.49 (0.65) | [b]6.54 (0.80) | [c]6.17 (0.55) |

[*] Values presented are averages of six readings for each device (glucose from two individuals over three days).
[a, b, c] p value < 0.05 between groups (Freestyle Libre versus glucometer, Dexcom versus glucometer, Freestyle Libre versus Dexcom G6).

## Informed consent

This was not classified as a research study and received an ethics review exemption.

## Data availability

The data of this study will be available upon reasonable request from the corresponding author

## CRediT authorship contribution statement

**Phaik Ling Quah:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Sally Mun Hua Chai:** Data curation. **Kok Hian Tan:** Writing – review & editing, Conceptualization.

## Declaration of competing interest

No authors report any potential conflict of interest.

## References

[1] Yu Q, Aris IM, Tan KH, Li LJ. Application and utility of continuous glucose monitoring in pregnancy: a Systematic review. Epub 20191011 Front Endocrinol 2019;10:697. https://doi.org/10.3389/fendo.2019.00697. PubMed PMID: 31681170; PubMed Central PMCID: PMCPMC6798167.
[2] Blum A. Freestyle Libre glucose monitoring system. Clin Diabetes 2018;36(2):203–4. https://doi.org/10.2337/cd17-0130. PubMed PMID: 29686463; PubMed Central PMCID: PMCPMC5898159.
[3] Kropff J, Bruttomesso D, Doll W, Farret A, Galasso S, Luijf YM, et al. Accuracy of two continuous glucose monitoring systems: a head-to-head comparison under clinical research centre and daily life conditions. Epub 20140910 Diabetes Obes Metabol 2015;17(4):343–9. https://doi.org/10.1111/dom.12378. PubMed PMID: 25132320; PubMed Central PMCID: PMCPMC4409843.
[4] Damiano ER, McKeon K, El-Khatib FH, Zheng H, Nathan DM, Russell SJ. A comparative effectiveness analysis of three continuous glucose monitors: the Navigator, G4 Platinum, and Enlite. Epub 20140421 J Diabetes Sci Technol 2014;8(4):699–708. https://doi.org/10.1177/1932296814532203. PubMed PMID: 24876423; PubMed Central PMCID: PMCPMC4764229.
[5] Freckmann G, Link M, Pleus S, Westhoff A, Kamecke U, Haug C. Measurement performance of two continuous tissue glucose monitoring systems intended for replacement of blood glucose monitoring. Diabetes Technol Therapeut 2018;20(8): 541–9. https://doi.org/10.1089/dia.2018.0105. PubMed PMID: 30067410; PubMed Central PMCID: PMCPMC6080122.

[6] Boscari F, Galasso S, Facchinetti A, Marescotti MC, Vallone V, Amato AML, et al. FreeStyle Libre and Dexcom G4 Platinum sensors: accuracy comparisons during two weeks of home use and use during experimentally induced glucose excursions. Epub 20171111 Nutr Metabol Cardiovasc Dis 2018;28(2):180–6. https://doi.org/10.1016/j.numecd.2017.10.023. PubMed PMID: 29258716.

[7] Leelarathna L, English SW, Thabit H, Caldwell K, Allen JM, Kumareswaran K, et al. Accuracy of subcutaneous continuous glucose monitoring in critically ill adults: improved sensor performance with enhanced calibrations. Epub 20131104 Diabetes Technol Therapeut 2014;16(2):97–101. https://doi.org/10.1089/dia.2013.0221. PubMed PMID: 24180327; PubMed Central PMCID: PMCPMC3894676.

[8] Hanson K, Kipnes M, Tran H. Comparison of point accuracy between two widely used continuous glucose monitoring systems. Epub 20240108 J Diabetes Sci Technol 2024:19322968231225676. https://doi.org/10.1177/19322968231225676. PubMed PMID: 38189290.