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*Original article*

# Comparison test of the old and new FreeStyle Libre

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## Abstract

The main cause of glycative stress is an excess of aldehydes, and it is particularly important to suppress postprandial hyperglycemia, which is involved in the production of aldehydes. This is because many types of aldehydes are produced in a chain reaction following postprandial hyperglycemia. In order to understand the conditions for the occurrence of postprandial hyperglycemia, we have performed many blood glucose tests. Initially, we measured blood glucose via fingertip punctures, but in 2019, we introduced a method of monitoring blood glucose levels for two consecutive weeks using the FreeStyle Libre (Abbott). This has dramatically reduced the burden and pain of subjects by eliminating frequent pain and bleeding in the fingertips. In recent years, the model has been changed from Libre Pro to Libre 2, and the measurement interval has been shortened from the conventional 15 minutes to 1 minute. In this study, we compared the difference in the "postprandial blood glucose change curve" between the new and old models. As a result, it was shown that changes in blood glucose levels can be detected with high sensitivity even when sugar-containing sweetened beverages are consumed during meals. In our laboratory, we plan to conduct blood glucose level tests using the new model (Libre 2) in the future.

**KEY WORDS:** FreeStyle Libre 2, blood glucose test, postprandial hyperglycemia, the maximum blood glucose concentration (Cmax)

## Introduction

The main cause of glycative stress is an excess of aldehydes, and postprandial hyperglycemia is a major trigger. More than 99 % of blood glucose is in a cyclic structure, and 0.02 % is in a chain structure, maintaining an equilibrium state (***Fig. 1***). In blood with 100 mg/dL (5.6 mmol/L) of glucose, there is 1.1 nmol/L of chain glucose [1,2]. Chain glucose is highly reactive because the aldehyde group is exposed, and is inactivated through reactions with surrounding amino acids, but some of it reacts with other monosaccharides to generate new short-chain aldehydes. Therefore, aldehydes in equilibrium are detected in the blood of healthy individuals when they are fasting. According to reports, the fasting blood aldehyde concentrations are as follows: glyoxal (GO) 1,000-1,100 nmol/L, methylglucosone (MGO) 330-370 nmol/L, 3-deoxyglucosone (3DG) 950-1,050 nmol/L [3], and formaldehyde 0.01-0.08 mmol/L [4]. When blood glucose levels rise from 100 mg/dL (5.6 mmol/L) to 180 mg/dL (10.1 mmol/L), new linear glucose is produced to maintain equilibrium, generating aldehydes. It is surprising that, when postprandial blood glucose rises (from 100 mg/dL to 180 mg/dL), a mere increase of about 1 nmol/L in chain glucose (from 1 nmo/L to 2 nmol/L) leads to an increase in glyoxal of about 200 nmol/L, methylglucosal of about 100 nmol/L, and 3-deoxyglucosone of about 500 nmol/L [3]. We have named this chain reaction, which simultaneously produces many types of aldehydes, an aldehyde spark. The detailed mechanism of the chain reaction is unknown and further investigation is awaited. We have experimentally shown that not only GO, MGO, and 3DG, but also short-chain aldehydes such as acetaldehyde and glyceraldehyde increase [5,6]. Aldehyde sparks cause damage to vascular endothelial cells and modify intracellular and extracellular proteins in the body, converting them into advanced glycation end products (AGEs), which pose a risk of causing various degenerative changes, diseases, and the onset and progression of diabetic complications [7,8]. Therefore, it can be said that suppressing postprandial hyperglycemia is extremely important in preventing aldehyde sparks.

Initially, according to the unified protocol [9], finger-prick self-measurement of blood glucose was the mainstream

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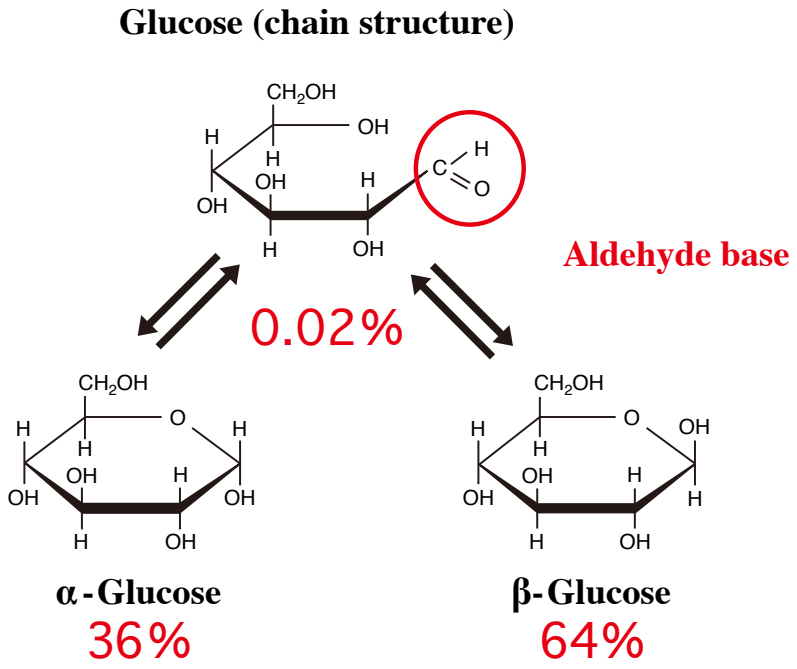


***Fig. 1.*** **Glucose structure in the blood.**

method for blood glucose testing[10-18], but since 2019, the FreeStyle Libre (Abbott) has been used[19-22]. This has dramatically reduced the burden and pain on subjects, such as pain and bleeding at the fingertip. Recently, the model was changed from the Libre Pro to the Libre 2, shortening the measurement interval from the previous 15 min to 1 min. In the present study, we compared the old and new models to examine the differences in the characteristics of the blood glucose curves obtained.

## *Methods*

### *Subjects*

Six subjects who met the following inclusion criteria were included in the study (***Table 1***). At the time of obtaining consent to participate in the study, they were 20 years of age or older, of either sex, healthy, and free of chronic physical illnesses. They were fully informed of the purpose and content of the study, had the capacity to consent, understood the study well, and volunteered to participate and agreed to participate in the study in writing. They were deemed appropriate for participation in the study by the principal investigator.

### *Contents of the study*

Subjects filled out a questionnaire to investigate their background, including their age, medical history, and the presence or absence of food allergies, and also underwent a blood test (***Table 2***). The study was conducted using Libro Pro and Libre 2 (Abbott Japan LLC, Chiba Prefecture), and the glucose concentration in the tissue interstitial fluid measured during the study period was used as the blood glucose level.

The new Libre 2 has two measurement modes with measurement intervals of 1 min and 15 min. In the comparative study of Libre Pro and Libre 2, both devices were compared on both arms (n = 5). The Libre 2 measurement mode comparison study compared different measurement interval modes (n = 6).

***Table 1. Subject profile.***

| Items | Unit | Total | Male | Female |
|---|---|---|---|---|
| Number of subjects | | 6 | 1 | 5 |
| Age | years | 22.3 ± 1.1 | 21 | 22.6 ± 1.0 |
| Body height | cm | 158.1 ± 9.5 | 175.9 | 154.5 ± 5.6 |
| Body weight | kg | 44.8 ± 8.0 | 60.3 | 41.7 ± 4.4 |
| BMI | | 17.8 ± 1.7 | 19.5 | 17.5 ± 1.7 |

Results are expressed as mean ± standard deviation. BMI, body mass index.

***Table 2. Result of the blood chemistry test.***

| Test item | Unit | Measured value | Reference range Male | Reference range Female |
|---|---|---|---|---|
| FBG | mg/dL | 81.8 ± 8.6 | 70 - 109 | |
| HbA1c | % | 5.3 ± 0.2 | 4.6 - 6.2 | |
| IRI | μU/mL | 3.6 ± 1.3 | 1.7 - 10.4 | |
| Total cholesterol | mg/dL | 175.5 ± 24.3 | 120 - 219 | |
| HDL - C | mg/dL | 69.7 ± 8.4 | 40 - 85 | 40 - 95 |
| LDL - C | mg/dL | 93.2 ± 17.2 | 65 - 139 | |
| TG | mg/dL | 51.0 ± 17.9 | 30 - 149 | |
| AST | U/L | 16.3 ± 1.9 | 10 - 40 | |
| ALT | U/L | 11.3 ± 3.0 | 5 - 45 | |
| γ - GT | U/L | 17.0 ± 5.8 | ≦ 80 | ≦ 30 |

Results are expressed as mean ± standard deviation, n = 6, FBG, fasting blood glucose; IRI, immunoreactive insulin; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG, triglyceride; AST, aspartate transaminase; ALT, alanine transaminase; γ - GTP, γ - glutamyltranspeptidase.

## *Study Protocol*

**Subjects were instructed to observe the following during the study:**

Avoid irregular lifestyles such as lack of sleep and overeating and drinking, and maintain a normal routine. Maintain the same quantity and quality of food, exercise, and sleep as before participating in the study. No new intake of supplements, health foods, etc. was permitted. Subjects were instructed to observe the following guidelines on the day before and on the day of the study: Do not exercise excessively during the pre-test or on the day of the study; Get at least 6 hours of sleep the day before the study; Do not drink alcohol the day before the study; avoid fatty foods for dinner; and consume only water after 10 p.m. During the study, subjects were to wait quietly in a seated position, and were prohibited from making phone calls, sleeping, excessive mental activity (such as working on a computer), and physical activity (such as exercise). After ingesting the test food, subjects were to fast until the end of the study.

Subjects attached the Libre 2 sensor and Libre Pro sensor to the outer side of their upper arms on both sides by themselves at least 2 days before the study. In test A, subjects consumed rice over 10 min at 10:00, and in tests B and D, sugar solution were consumed over 5 min. In tests C-1 and E-1, rice was eaten at the start of the test, followed by sugar solution 35 min later. In tests C-2 and E-2, rice was consumed at the start of the test, and sugar solution were consumed 5 min later. After that, the subjects watched a video in a seated position, and were allowed to remain relaxed until the end of the test.

The test food was chewed at least 30 times and then swallowed. In tests A and C, the blood glucose values were measured every minute starting before the test food was intake and continuing up to 165 min after. The blood glucose values measured every 15 min were taken at the following time points: before test food intake, and then at 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, and 165 minutes after the start of intake. In test B, the blood glucose values were measured every minute from before the start of the intake of the test food to 120 min afterward. Blood glucose levels were measured every 15 min at the following time points: before ingesting the test food, and at 15, 30, 45, 60, 75, 90, 105, and 120 minutes afterward.

## *Test foods*

In the test with Libre Pro and Libre 2 worn on both arms, the test foods consisted of rice, sugar solutions (glucose solution, sucrose solution), and a combination of the two. The rice used was "Sato's Rice Niigata Prefecture Koshihikari 200 g" (Sato Foods, Niigata Prefecture), the glucose solution was glucose (Marugo Corporation, Saitama Prefecture), and the sucrose solution was "Granulated Sugar" (Pearl Ace, Osaka Prefecture). For the test food that combined rice and sugar solution, the rice was consumed for 10 mins, and then the sugar solution was consumed after a 5-min and 35-min rest period.

The nutritional content of the test foods used in the comparison test between the Libre 2 1-min mode and the 15-min mode was calculated using the values displayed on each food, and the carbohydrate intake was set at 50 g for rice, and 13 g for glucose and sucrose in the solution (***Table3***). The rice and glucose solution were the same as above. The test foods were A to E, and the intake amounts were as follows:

A: 150 g cooked rice (total carbohydrate: 50 g)
B: Glucose solution (14.2 g glucose dissolved in 100 mL water) (total carbohydrate: 13 g)
C: 150 g cooked rice + glucose solution (14.2 g glucose dissolved in 100 mL water) (total carbohydrate: 63 g)
D: Sucrose solution (13 g glucose dissolved in 100 mL water) (total carbohydrate: 13 g)
E: 150 g cooked rice + sucrose solution (13 g glucose dissolved in 100 mL water) (total carbohydrate: 63 g)

Test food A was ingested 10 min after the start of the test. Test food B was ingested 5 min after the start of the test. Test foods C-1 and E-1 were ingested 10 min after the start of the test, followed by resting for 35 min and ingesting the sugar solution for 5 min. For test foods C-2 and E-2, subjects ingested cooked rice 10 min after the start of the test, then rested for 5 min, and ingested the sugar solution for 5 min.

***Table 3. Nutritional composition of the test food A to E.***

| Test food | Serving unit (g) | Energy (kcal) | Protein (g) | Fat (g) | Carbohydrate (g) | Sodium choloride amount (g) |
|---|---|---|---|---|---|---|
| A | 150 | 220.5 | 3.2 | 0 | 50.9 | 0 |
| B | 14.2 | 47.7 | 0 | 0 | 13.0 | 0 |
| C | 164.2 | 268.2 | 3.2 | 0 | 63.9 | 0 |
| D | 13.0 | 50.3 | 0 | 0 | 13.0 | 0 |
| E | 163.0 | 270.8 | 3.2 | 0 | 63.9 | 0 |

A, rice 150 g; B, Glucose solution 100 mL; C, rice 150 g + Glucose solution 100 mL; D, Sucrose solution 100 mL; E, rice 150 g + Sucrose solution 100 mL.

### *Selection of subjects for comparative analysis*

Comparative analysis subjects included those who completed the prescribed test schedule and all test contents, and those who met the following exclusion criteria were excluded from the comparative analysis: Those who engaged in behavior that significantly impaired the reliability of the test results and those who met the exclusion criteria or were found to be unable to comply with the restrictions after starting intake.

In this study, no subjects were excluded due to non-compliance.

### *Statistical analysis*

Comparative analysis of the test results was performed on comparative analysis subjects, and the blood glucose change (ΔBG; Δblood glucose) was calculated by subtracting the blood glucose value before taking the test food (0 min) from the subsequent measures taken over time, and the maximum blood glucose change (ΔCmax; maximum blood glucose concentration) was calculated as the maximum blood glucose change up to 165 min after the start of the test. The incremental area under the curve (iAUC) for blood glucose increase was calculated according to the unified protocol of the Japanese Glycemic Index (GI) Study Group). Blood glucose values were expressed as mean ± standard deviation (SD). Statistical analysis was performed using the statistical analysis software BellCurve for Excel (Corporate Information Services, Tokyo, Japan). Comparison of the test results between two groups was performed using a test of the difference in the population means (paired), and comparison between groups was performed using the Bonferroni multiple test. A two-sided test with a risk level of less than 5 % ($p < 0.05$) was considered significant, and $0.05 \leqq p < 0.1$ was considered to indicate a significant tendency.

### *Ethical standards*

This study was conducted in compliance with the Declaration of Helsinki (amended at the 2013 WMA General Assembly in Fortaleza) and the ethical guidelines for medical research involving human subjects (notification of the Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Health, Labour and Welfare). The content of the study was fully explained to the subjects in advance, and the subjects were required to participate in the study and submit a voluntary consent form. This study was conducted with the approval of the Doshisha University Ethics Committee for Research Involving Human Subjects (application number #24020).

## *Results*

### *Safety evaluation*

No adverse events were reported in this study.

**Pilot test: comparative analysis of models**

A pilot test was conducted to compare models using Libre Pro and Libre 2 worn on both arms.

The results of the pilot test (n = 1) when ingesting sucrose solution (carbohydrate content 13 g) are shown in ***Fig. 2***. The blood glucose change curve was more sensitive for Libre 2 (1-min mode) than for Libre Pro and Libre 2 (15-min mode), and more sensitively reflected the fluctuation in blood glucose level after ingesting sucrose solution. In Libre Pro and Libre 2 (15-min mode), the peak curve around ΔCmax completely disappeared, and ΔCmax showed a low value. The iAUC showed almost the same value.

**Model comparison test: Measurement on a different day**

***Fig. 3*** shows the results when rice was consumed over 10 min, followed by resting for 35 min and then ingesting sucrose liquid. The same test was performed twice on different days. Libre 2 (measured at 1-min intervals) captured ΔCmax sensitively and showed two peak curves, one after rice ingestion and one after sucrose liquid ingestion, but these peaks could not be confirmed with Libre Pro and Libre 2 (15-min mode). No difference was observed in iAUC among the three conditions.

Comparing the two measurements, the blood glucose rise was more pronounced in the second measurement, but the two peak curves could be confirmed, although they were slight. They could not be confirmed at all with Libre Pro and Libre 2 (15-min mode). This demonstrates that blood glucose fluctuates greatly depending on the physical condition on a given day, even when the same meal is consumed.

***Fig. 4*** shows the results when rice was consumed over 10 min, followed by resting for 5 min and then ingesting sucrose liquid. The same test was performed twice on separate days. With Libre 2 (measured at 1-min intervals), the blood glucose peak after rice ingestion and the blood glucose peak after sucrose liquid ingestion overlapped and were observed as a single peak curve. Insulin secretion

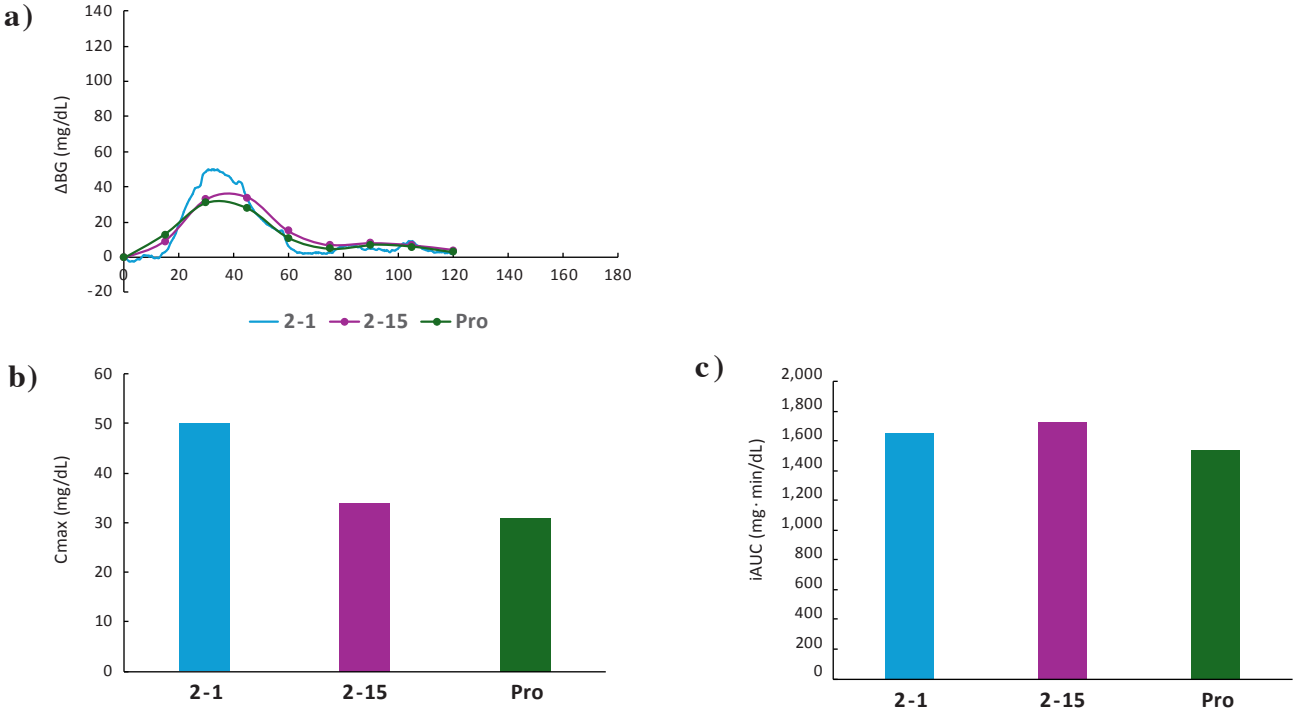


***Fig. 2.*** **Pilot test: Ingestion of sucrose solution (Test food D).**

**a)** ΔBG, **b)** ΔCmax, **c)** iAUC. ■, measurements every minute with Libre 2 (2-1); ■, measurements every 15 min with Libre 2 (2-15); ■, measurements every 15 min with Libre Pro (Pro), n = 1, details of the Test food D are shown in **Table 3**.

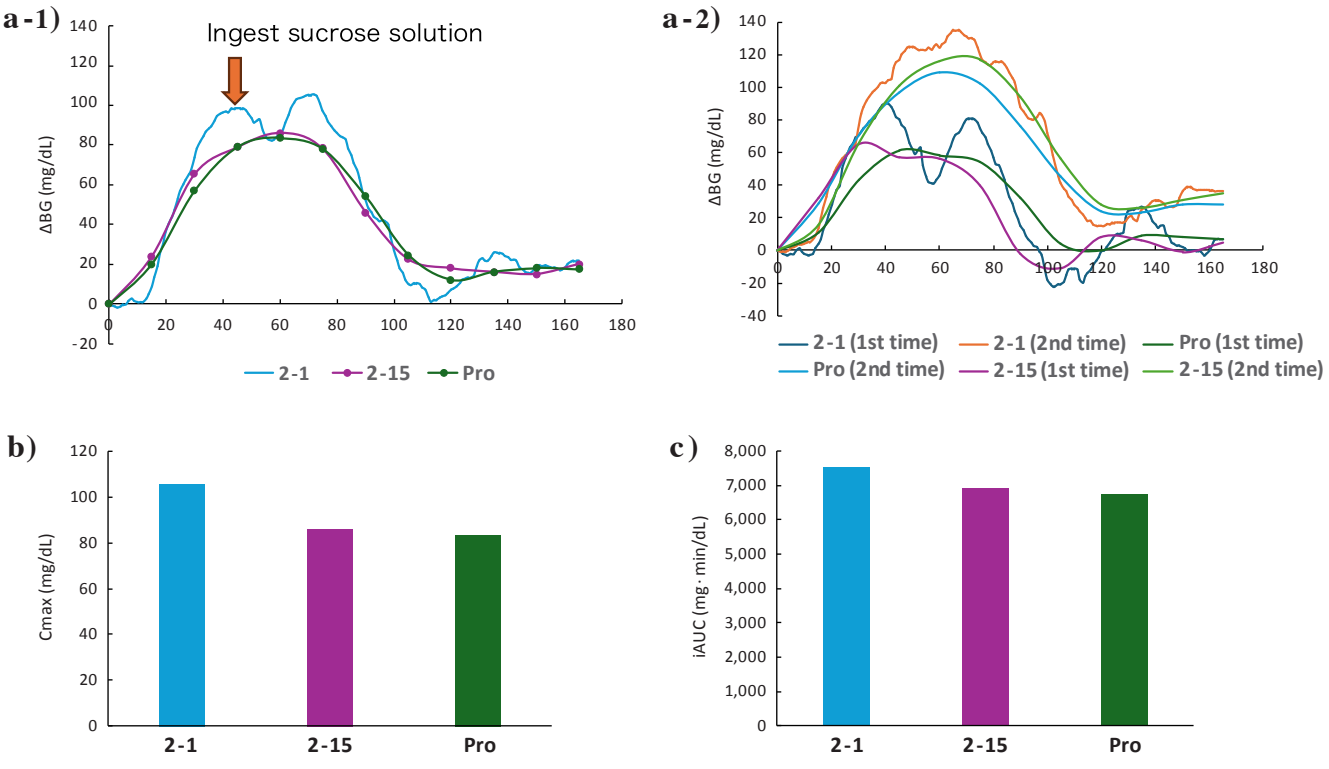


***Fig. 3.*** **Pilot test: After ingesting rice, rest for 35 min, then ingest sucrose solution (Test food E-1).**

**a)** ΔBG, **b)** ΔCmax, **c)** iAUC. ■, measurements every minute with Libre 2 (2-1); ■, measurements every 15 min with Libre 2 (2-15); ■, measurements every 15 min with Libre Pro (Pro), n = 1, details of the Test food E-1 are shown in **Table 3**.

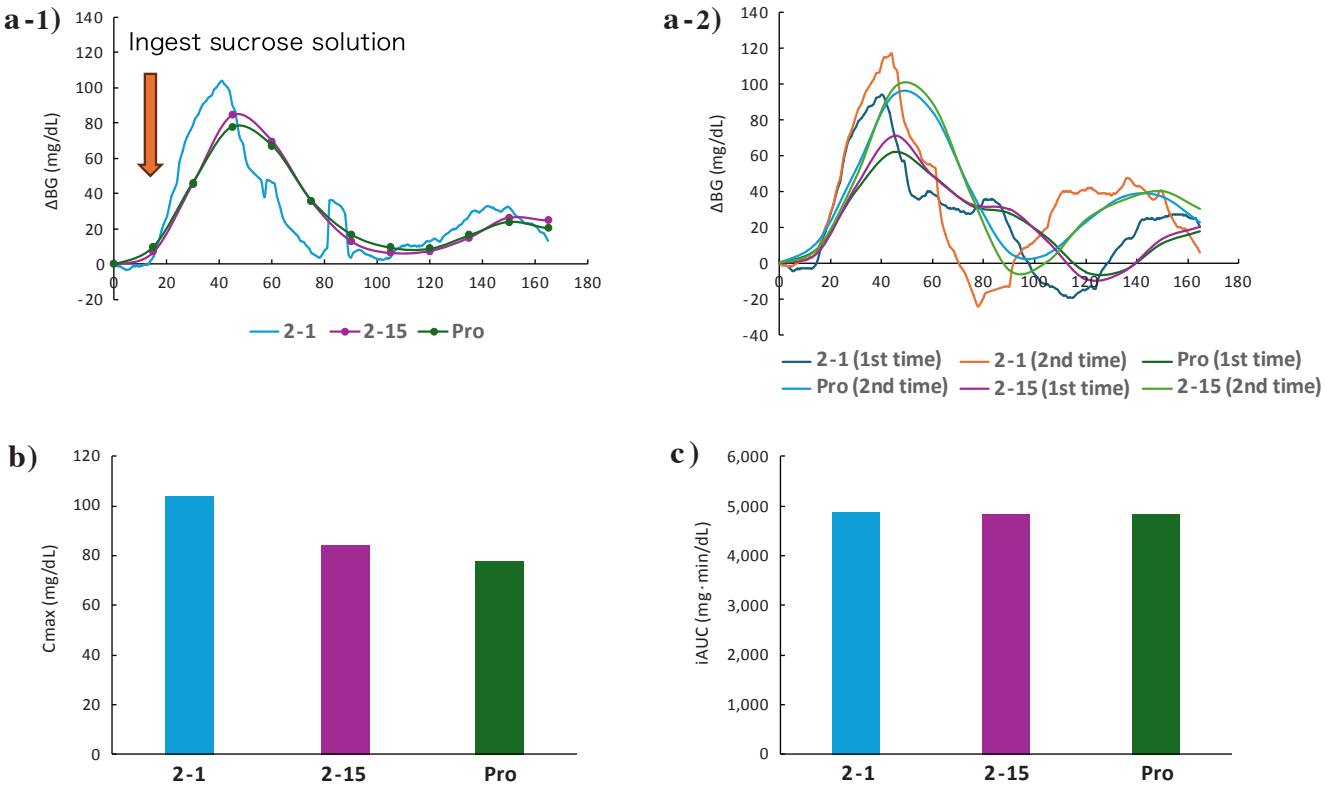


***Fig. 4.*** **Pilot test: After ingesting rice, rest for 5 min, then ingest sucrose solution (Test food E-2).**

**a)** ΔBG, **b)** ΔCmax, **c)** iAUC. ■, measurements every minute with Libre 2 (2-1); ■, measurements every 15 min with Libre 2 (2-15); ■, measurements every 15 min with Libre Pro (Pro), n = 1, details of the Test food E-2 are shown in **Table 3**.

increased in response to the steep rise in blood glucose, and a steep drop in blood glucose was observed. A small blood glucose rise curve was observed around 80 min, and a gradual blood glucose rise from 130 min onwards. This is thought to be due to transient hypoglycemia caused by the steep drop in blood glucose, which resulted in a reactive secretion of blood glucose-elevating hormones. The peak at 80 min may have been due to an adrenaline release via the sympathetic nervous system, and the rise from 130 min may have been due to glucocorticoid and glucagon secretion. With Libre Pro and Libre 2 (15-min mode), the steep rise and fall in blood glucose,, and rise in blood glucose around 80 min were not observed. ΔCmax was high only for Libre 2 (1-min mode), and no difference was observed in iAUC among the three conditions.

Even under these conditions, the degree of rise in blood glucose was greater in the second test.

***Fig. 5*** shows the results when subjects ingested cooked rice over 10 min, rested for 5 min, and then ingested glucose solution. With Libre 2 (1-min mode), blood glucose rose steeply, reached its peak quickly, and the ΔCmax value was high. Blood glucose fell slowly for about an hour after the peak, but at around 124 min, blood glucose fell sharply, followed by a rise in blood glucose of nearly 50 mg/dL. It is assumed that a brief period of hypoglycemia occurred at around 124 min, followed by a rebound rise in blood glucose due to the responsive secretion of blood glucose-elevating hormones.

With Libre Pro and Libre 2 (15-min mode), blood glucose rose and gradually increased. Compared to Libre 2 (1-min mode), ΔCmax was slightly lower and iAUC was significantly lower.

**Model comparison test: simultaneous measurement**

Based on the results of the pilot test, we set conditions for rice ingestion, glucose solution ingestion, and rice + glucose solution ingestion, and compared the models (n = 5) by simultaneously wearing the Libre 2 on the left arm and the Libre Pro on the right arm.

When rice was consumed, the Libre 2 (1-min mode) detected a steeper rise in blood glucose than the Libre Pro (***Fig. 6-a***) and had a higher ΔCmax value (***Fig. 6-b***, $p < 0.1$). There was no difference in iAUC (***Fig. 6-c***). No significant difference was observed between the Libre 2 (15-min mode) and the Libre Pro.

When glucose solution was consumed, the Libre 2 (1-min mode) detected a steep rise in blood glucose, which peaked at 42 min, entered the hypoglycemic range from 67 min, reached the hypoglycemic peak at 82 min, and then gradually returned to baseline (***Fig. 7-a***). The Libre Pro was unable to detect such detailed movements. Libre 2 had a significantly higher ΔCmax value (***Fig. 7-b***, $p < 0.1$), but there was no difference in iAUC (***Fig. 7-c***). There was no significant difference between Libre 2 (15-min mode) and Libre Pro.

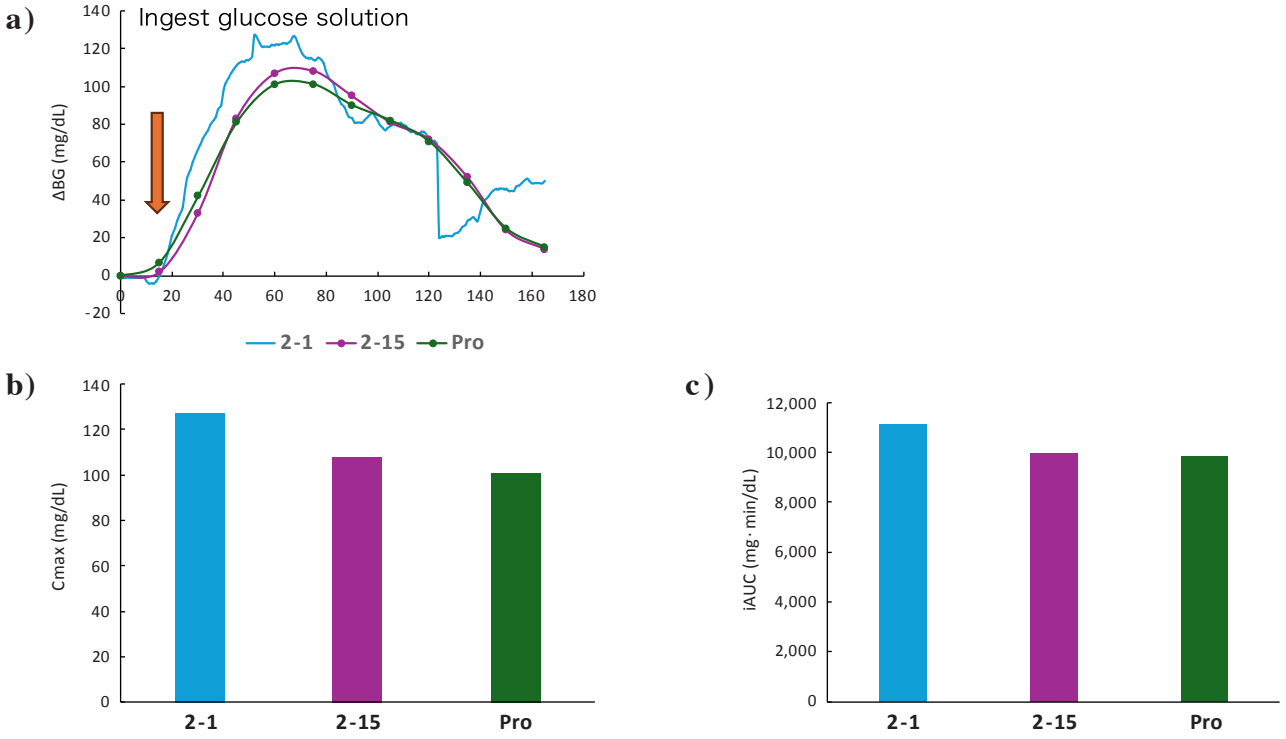


***Fig. 5.*** **Pilot test: After ingesting rice, rest for 5 min, then ingest glucose solution (Test food C-2).**
**a)** ΔBG, **b)** ΔCmax, **c)** iAUC. ■, measurements every minute with Libre 2 (2-1); ■, measurements every 15 min with Libre 2 (2-15); ■, measurements every 15 min with Libre Pro (Pro), n = 1, details of the Test food C-2 are shown in **Table 3**.

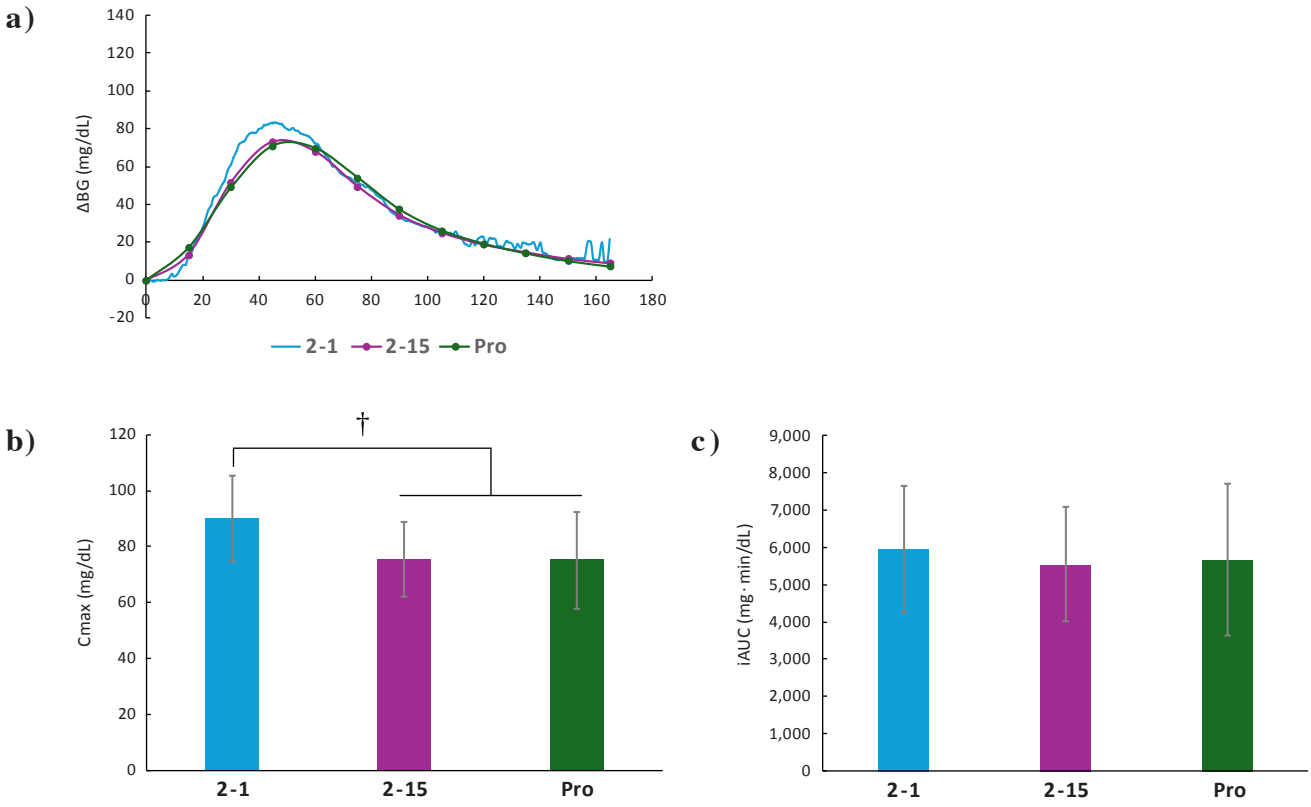


***Fig. 6.*** **Comparison between Libre 2 and Libre Pro: Ingestion of rice (Test food A).**
**a)** ΔBG, **b)** ΔCmax, **c)** iAUC. ■, measurements every minute with Libre 2 (2-1); ■, measurements every 15 min with Libre 2 (2-15); ■, measurements every 15 min with Libre Pro (Pro), results are expressed as mean ± standard deviation, n = 5, † $p < 0.1$, Bonferroni test. details of the Test food A are shown in **Table 3**.

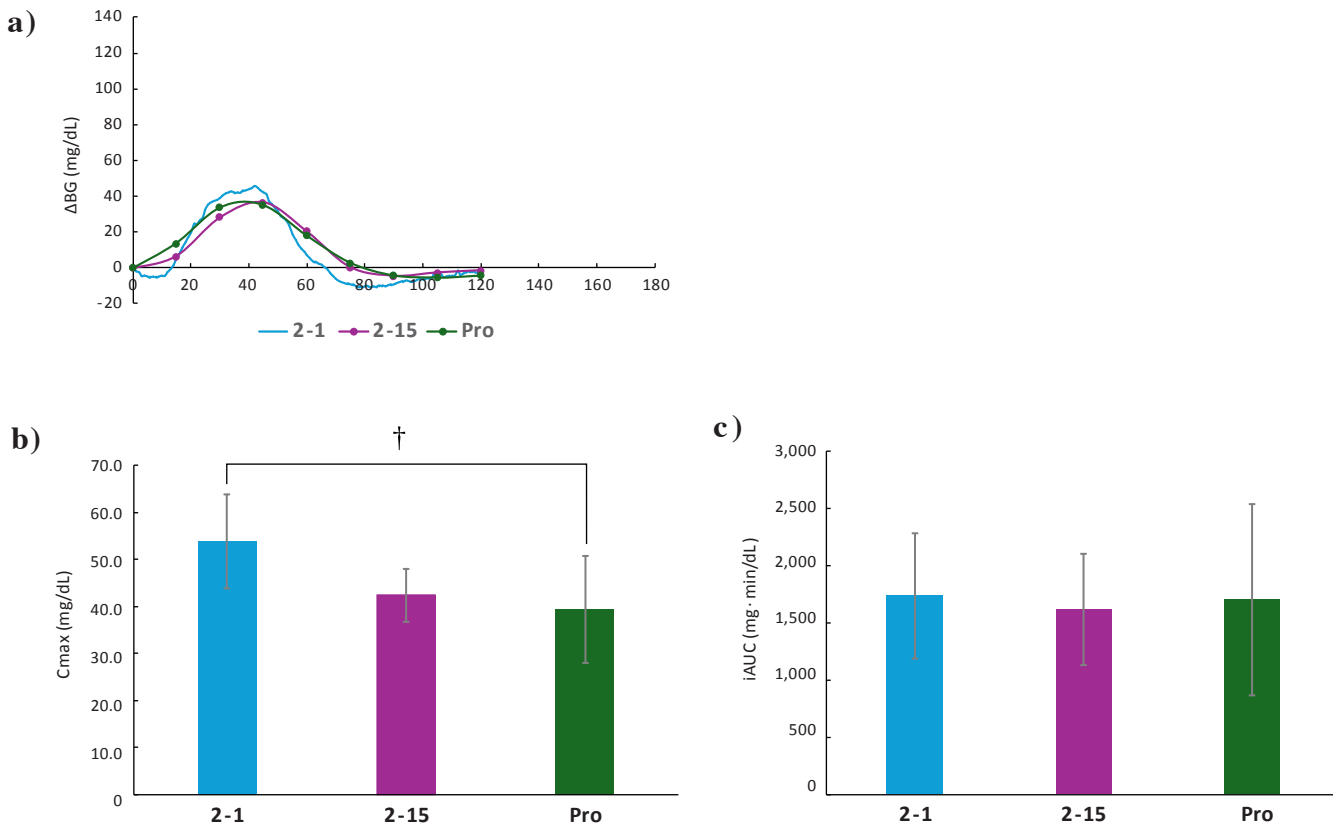


***Fig. 7.*** **Comparison between Libre 2 and Libre Pro: Ingestion of glucose solution (Test food B).**
**a)** ΔBG, **b)** ΔCmax, **c)** iAUC. ■, measurements every minute with Libre 2 (2-1); ■, measurements every 15 min with Libre 2 (2-15); ■, measurements every 15 min with Libre Pro (Pro), results are expressed as mean ± standard deviation, n = 5, †p < 0.1, Bonferroni test. details of the Test food B are shown in **Table 3**.

When rice and glucose solution were consumed in combination, a steep rise in blood glucose was detected in Libre 2 (1-min mode), with the first peak at 45 min and a higher second peak at 72 min, after which blood glucose levels declined (***Fig. 8-a***). In Libre Pro, blood glucose rose slowly and did not show two peaks. There were no significant difference between Libre Pro and Libre 2 in ΔCmax (***Fig. 8-b***) and iAUC (***Fig. 8-c***). When comparing Libre 2 (15-min mode) and Libre Pro, there was a difference in the blood glucose curve, but there was no significant difference in ΔCmax and iAUC.

**Comparison between Libre2 1-min and 15-min modes**

Using the results of the test on the same day as the model comparison test, a comparative analysis was performed between Libre 2 1-min and 15-min modes, with the number of subjects that could be analyzed set at n = 6.

In test A (rice intake), the maximum value was reached at 46 min after the start of the test when measured every min, and at 45 min after the start of the test when measured every 15 min, and then decreased (***Fig. 9-a***). In test B (glucose solution intake), the maximum value was reached at 42 min after the start of the test when measured every min, and at 45 min after the start of the test when measured every 15 min, and then decreased (***Fig. 9-b***). In test C (rice + glucose solution intake), the maximum value was reached once at 48 min after the start of the test when measured every min, then decreased for 9 min, then increased again, reached the maximum value 83 min later, and then decreased. When measured every 15 min, the maximum value was reached 75 min after the start of the test, and then it decreased (***Fig. 9-c***).

In Studies A, B, and C, ΔCmax measured every 15 min was lower than that measured every minute (Study A: p = 0.005, Study B: p = 0.015, Study C: p < 0.001, ***Fig. 10-a***). No difference in iAUC was observed in Studies A, B, and C (***Fig. 10-b***).

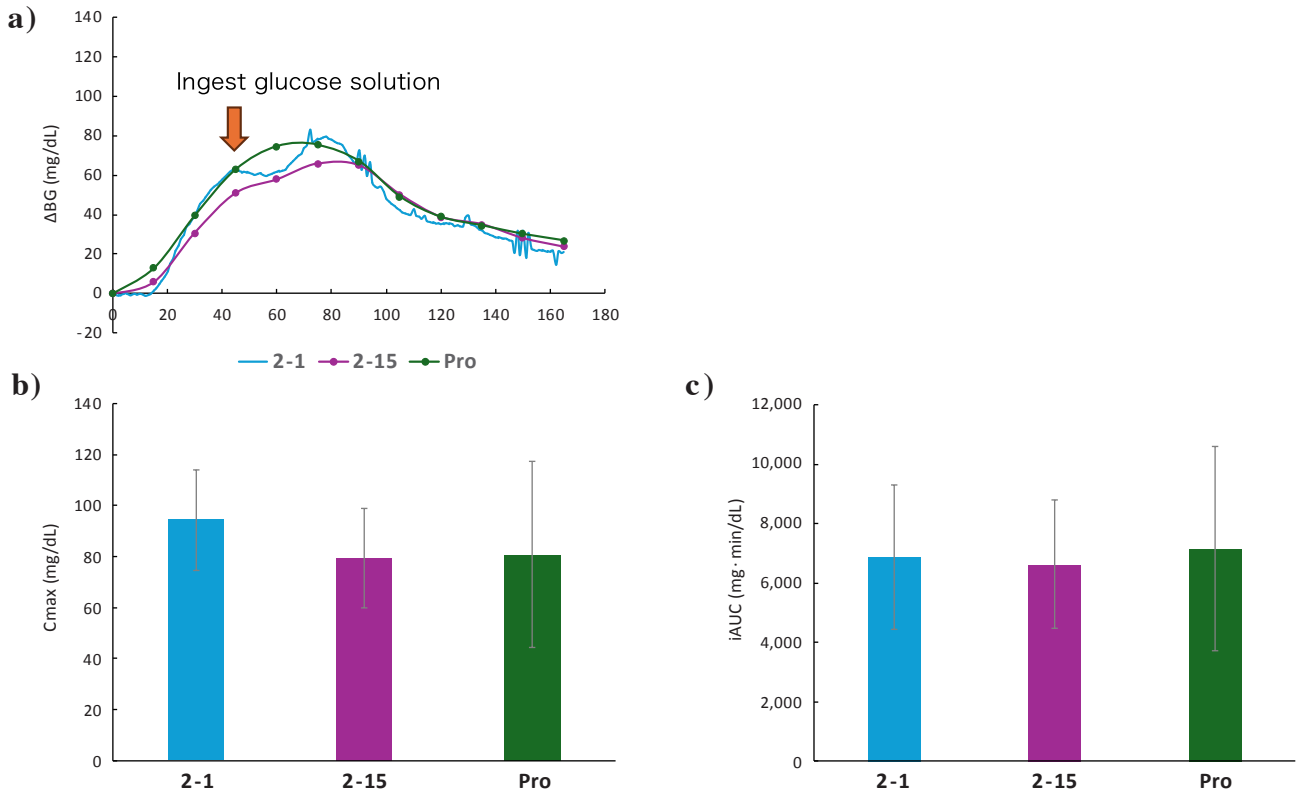


***Fig. 8.*** **Comparison between Libre 2 and Libre Pro: After ingesting rice, rest for 35 min, then ingest glucose solution (Test food C-1)**

**a)** ΔBG, **b)** ΔCmax, **c)** iAUC. ■, measurements every minute with Libre 2 (2-1); ■, measurements every 15 min with Libre 2 (2-15); ■, measurements every 15 min with Libre Pro (Pro), results are expressed as mean ± standard deviation, n = 5, †p < 0.1, One-way Analysis of Variance. Details of the Test food C-1 are shown in **Table 3**.

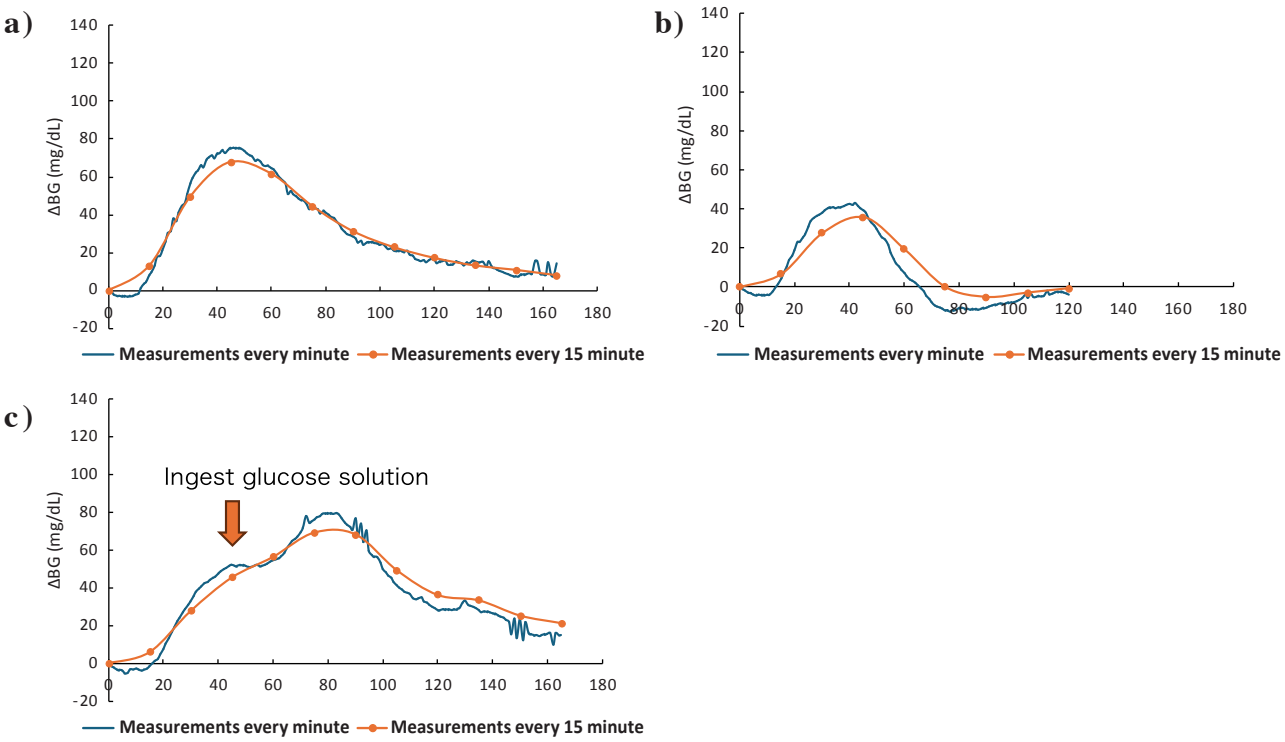


***Fig. 9.*** **Comparison between 1-min mode and 15-min mode in Libre 2: Fluctuation of the ΔBG level at the time of test food intake.**

**a)** Ingestion of rice (Test food A), **b)** Ingestion of glucose solution (Test food B), **c)** iAfter ingesting rice, rest for 35 min, then ingest glucose solution (Test food C). Results are expressed as mean, n = 6, the Test food A ~ C; details of the test food are shown in **Table 3**.

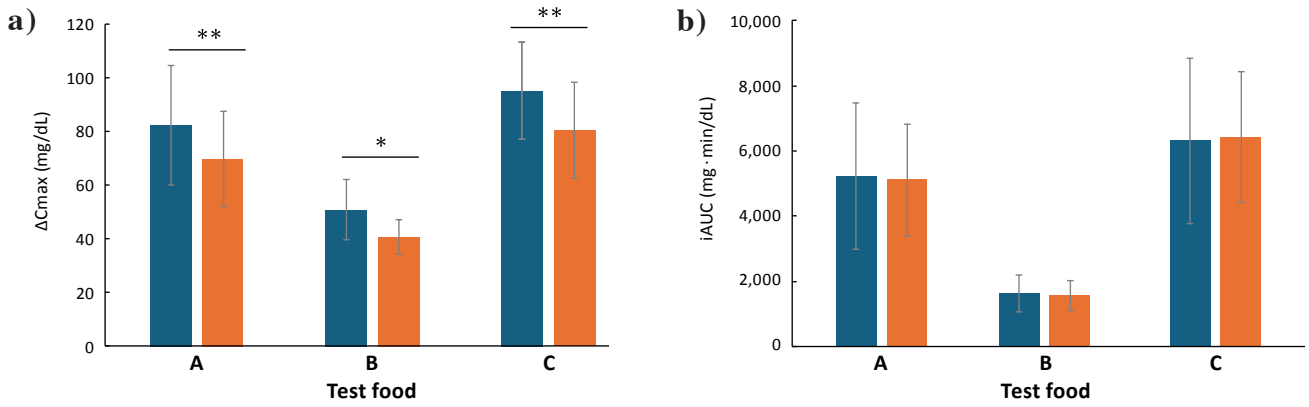


***Fig. 10.*** **Comparison between 1-min mode and 15-min mode in Libre 2: The amount of ΔCmax and iAUC after test food intake.**

**a)** ΔCmax, **b)** iAUC. ■, measurements every minute; ■, measurements every 15 min, results are expressed as mean ± standard deviation, n = 6, **p < 0.01, *p < 0.05, paired t-test. ΔCmax , maximum blood glucose change; iAUC, incremental area under the curve of blood glucose change. Test food A, ingestion of rice; Test food B, ingestion of glucose solution; Test food C, after ingesting rice, rest for 35 min, then ingest glucose solution. A～C; details of the test food are shown in **Table 3**.

## *Discussion*

Postprandial hyperglycemia is an important finding that occurs before the onset of diabetes in association with impaired glucose tolerance and increased insulin resistance. When the peak value of postprandial hyperglycemia exceeds 140 mg/dL, it is called a glucose spike, which subsequently induces the chain reaction leading to the production of various aldehydes (aldehyde sparks), and is closely related to vascular endothelial cell damage. Therefore, controlling postprandial hyperglycemia is an important issue for preventing physical disorders caused by glycative stress. Initially, we followed the method of the Japanese research group[9] and investigated the transition of postprandial blood glucose levels using fingertip blood self-measurement[10-18]. Puncturing the tip of the finger had the disadvantage of being painful and highly invasive for subjects. We used this method in publications up to 2019[10-18], but in papers published after 2020, we changed to a method using the Libre Pro[19-22]. Our report is the first of its kind in Japan. This has significantly reduced the invasiveness of blood glucose tests for subjects. In addition, this study conducted blood glucose tests using the newly developed Libre 2 and compared its differences with existing devices.

The findings obtained this time are discussed.

The measurements taken every minute with the Libre 2 are actual values, whereas the measurements taken every 15 min are values optimized by the sensor and are different from actual values. The difference in the data processing method in the sensor may have led to lower readings with the Libre Pro compared to the Libre 2. In addition, it has been reported that the measurements of the Libre Pro are lower than those of other continuous glucose monitors[23]. This also suggests that the Libre Pro may underestimate actual blood glucose levels.

Comparing the Libre 2 1-min mode and 15-min mode, the data processing algorithm for the Libre 2 15-min measurements is believed to be similar to that of the Libre Pro, which may explain why the measurements every 15 min were lower. Two peaks were seen with the Libre 2, but only one peak was seen with the Libre Pro. The difference in the measurement interval is also believed to be a contributing factor. In the 15-min measurements, blood glucose levels drop and rise between the measurement points. Therefore, we believe that the measurement every min allowed us to measure a phenomenon that was not seen in the 15-min measurements.

## *Conclusion*

We compared blood glucose fluctuation curves after ingesting a meal using a new model (measures every minute) and an old model (measures every 15 min) of a blood glucose monitoring apparatus (FreeStyle Libre), and it has shown that the new model can detect blood glucose changes with higher sensitivity. We plan to conduct blood glucose measurements using the new model in the future.

## *Conflict of interest declaration*

There are no companies with which this research has a COI relationship to disclose.

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