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Original article

Effect of breakfast on lunch time postprandial blood glucose

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Abstract

Purpose: Recently, the relationship between skipping breakfast and glycolipid metabolism-related lifestyle diseases is paid attention. The authors verified the effects of presence or skipping of breakfast on postprandial blood glucose (PBG) level after lunch.

Method: The subjects were 11 healthy persons (4 males and 7 females aged 22.5 ± 3.7) who participated in the following 4 blood glucose tests. They had steamed rice (200 g, 294 kcal), convenience store food (624 kcal) or gyudon, rice bowl (630 kcal) for breakfast or skipped breakfast on the day of the test and had steamed rice at lunch time, and their blood glucose levels were tested. The PFC balance of each test food (protein : fat : carbohydrate) was 6 : 0 : 94, 7 : 45 : 48, and 11 : 41 : 48, and the content of dietary fiber were 1.0 g, 2.4 g and 1.5 g. The subjects measured their blood glucose level 15, 30, 45, 60, 90 and 120 min after the start of intake of the test food using a blood glucose self-measuring device. The correlation between these blood glucose levels and the fasting serum glucagon levels measured in the early morning on another day was analyzed.

Results: The elevation in PBG after the intake of lunch (steamed rice) was significant when the subjects skipped breakfast compared with that when they had breakfast (steamed rice), and the maximum blood glucose change (ΔCmax, $p < 0.001$) and the area under the curve (AUC, $p = 0.003$) were significantly higher. As for the comparison of the kind of breakfast, when they had convenience store food, gyudon or steamed rice as breakfast, the fasting blood glucose before the intake of lunch was 80.5 ± 2.6 mg/dL, 93.1 ± 1.9 mg/dL or 82.6 ± 3.1 mg/dL, and ΔCmax and AUC after the intake of lunch (steamed rice) tended to easily elevate in the order of convenience store food, steamed rice and gyudon as breakfast. The serum glucagon in the morning had a positive correlation with the PBG elevation after breakfast (ΔCmax, $r = 0.51$, $p = 0.050$; AUC: $r = 0.57$, $p = 0.026$), however, had no correlation with PBG after lunch.

Conclusion: It was suggested that having a well-balanced and filling breakfast is possibly effective for the prevention of postprandial hyperglycemia after lunch.

KEY WORDS: postprandial blood glucose, breakfast, gyudon (rice bowl), glucagon

Introduction

Glycation reaction means the reducing of sugars including glucose non-enzymatically bound to protein which become glycated protein, eventually forming advanced glycation end products (AGEs), and the stress caused by reducing sugars and aldehyde loading on the body protein are referred to as "glycative stress [1, 2]. Glycative stress is one of the risk factors accelerating aging and plays a role in progressing skin aging, diabetic complications or others. There are various methods to alleviate glycative stress, such as inhibition of postprandial blood glucose (PBG) level, inhibition of glycative reaction thus preventing AGE formation, and decomposition and excretion of AGEs. For the purpose of reducing PBG, several methods were pointed out in this research, such as selecting low Glycemic Index (GI)-food that moderately elevates PBG, as staple diet, taking in the food rich in dietary fibers, such as vegetables, before taking in high carbohydrate contents and restricting the intake of carbohydrates. According to "Outline of 2015 National Health and Nutrition Survey" by the Ministry of Health, Labour and Welfare, the breakfast-skipping rate of male adults was 14.3% and that of female adults was 10.1% [3], and these rates were highest both for males and females in their 20s. Although these rates tend to decrease as they get older, the breakfast skipping rate has been a rising trend

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for more than 20 years. Skipping breakfast becomes a risk factor for various diseases including cardiovascular disease,[4, 5], obesity[6, 7], diabetes and glucose metabolic disorder[8], lipid metabolism abnormality[9] and bone mineral loss[10]. Facing these facts, the government of Japan is implementing efforts to decrease the rate of Japanese skipping breakfast as one of the secondary basic plans for the promotion of food education[3]. Therefore, this research verified the impact of skipping breakfast on the PBG elevation after lunch in the young males and females.

Methods

Subjects

The subjects were recruited among those who were involved in Doshisha University Graduate School Faculty of Life and Medical Science and Advanced Course. The selection criteria of the subjects was that they should be healthy, 20 years old or older and not meet the following exclusion criteria: having food allergy or drug allergy, being pregnant, breastfeeding, being treated with drugs, having a disease follow-up, having been diagnosed with diabetes, showing a significant disorder in cardio-pulmonary functions, taking medication to treat high blood pressure, having received surgery on a digestive organ and being suspected of having an infectious disease. The subjects were fully explained about the research and presented written consent forms.

The number of subjects were 15 (6 males and 9 females, 23.1 ± 3.3 years, 163.5 ± 6.3 cm in height, 53.8 ± 7.2 kg in body weight and 20.1 ± 1.8 kg/m^2 in body mass index; BMI). However, 4 subjects out of the 15 subjects could not participate in the test after lunch. The 11 subjects participated in both tests after breakfast and lunch (4 males and 7 females, 22.5 ± 3.7 years, 161.6 ± 4.6 cm in height, 52.5 ± 6.5 kg in body weight and 20.1 ± 2.1 kg/m^2 in BMI).

Protocol for the blood glucose test

The unified protocol by the Japanese Association of the Study for Glycemic Index (GI)[11, 12] was used as a reference.

The subjects complied with the following promises on the day before the test: refraining from strenuous exercise, not eating food after 22 : 00, not eating or drinking to excess and avoid staying up late.

In the case when the subjects became ill on the previous day of the test, before the test or during test, the test was postponed or aborted.

The subjects were asked to measure their own fasting blood glucose level using a blood glucose self-measuring device. They measured it twice, and the average level was used. When the difference between the two measurements was more than 10%, they were asked to measure it once more and the average level of the two levels with less difference was used. The subjects consumed control food or test food within 10 min and chewed each bite of food about 30 times. The blood glucose was measured 15 min after the start of intake (the second time), 30 min after the start (the third time), 45 min after the start (the fourth time), 60 min after the start (the fifth time), 90 min after the start (the sixth time) and 120 min after the start (the seventh time). The area under curve (AUC) was calculated using a figure showing PBG. A blood glucose self-measuring device (Glucose measuring device for self-measurement, Glucocard G Black: GT-1830, Arkray, Inc., Kyoto, Japan) was used for measurement.

Serum glucagon was measured in LSI Medience Corporation (Tokyo, Japan).

Test design

Steamed rice 200 g (Sato-no-gohan, Koshihikari (the brand name of the rice) produced in Niigata Prefecture, Sato Foods Industries Co., Ltd., Niigata, Japan) was used for the control test food.

A test was conducted where the subjects had steamed rice as lunch 4 hours and 30 min after they had steamed rice as breakfast, and another test was conducted where they had steamed rice as lunch after they had had nothing as breakfast.

They had steamed rice together with 2.5 g of *furikake*, seasoned power for sprinkling over rice (Noritama™, Marumiya Shokuhin Kogyou Co. Ltd., Tokyo, Japan).

In the test of comparison by the kind of breakfast, gyudon, known as rice bowl (toppings of gyudon and steamed rice, 200 g) and convenience store food were added to the steamed rice described above as breakfast. They had steamed rice as lunch 4 hours and 30 min after they had breakfast, and blood glucose level was measured. The toppings of gyudon provided by Yoshinoya Holdings (Tokyo, Japan) were used, which were the same as reported before. The two items of "Tsunamayo (tuna and mayonnaise) rice ball of University Co-operative Association" (Myojin Delica, Izumiotsu, Osaka, Japan) and "Chocolate Danish" (Yamazaki Baking Co., Ltd., Tokyo, Japan) were used as convenience store food because they were the most commonly sold (***Fig. 1***) in convenience stores. The food composition data are shown in ***Table 1***.

Statistical analysis

The PBG levels by the time passing after the intake of the test food deducted by fasting blood glucose level were regarded as the amounts of change Δ and the AUC from the start of intake to 120 min were calculated. The maximum blood glucose level was expressed as Cmax and the maximum amount of change as ΔCmax. The results were expressed as average ± standard error mean (SEM).

As the statistical analysis, a paired t-test was used for the comparison between the two groups and a Bonferroni test (IBM SPSS Statistics 24, IBM Japan, Tokyo, Japan) was used for multiple comparisons. A risk rate less than 5% by a two-sided test was regarded as having a significant difference.

Ethical standard

This test was implemented in compliance with ethical principles and personal information protection law based on Helsinki Declaration (comments were added in the 2004 Annual Meeting in Tokyo) and referring to "the Ministerial Ordinance for Good Clinical Practice (GCP)" (Ordinance of the Ministry of Labor and Welfare No. 28 of March 27, 1997) and "Ethical Guidelines for Epidemiological Study" by the Ministry of Health, Labour and Welfare and the Ministry of Education, Culture, Sports, Science and Technology. An ethical review board concerning "the research targeting people" of Doshisha University was held, the morality and appropriateness of this research were discussed, the research was implemented based on the approval (Application No. 16029), and the clinical test was previously registered (Registration No. UMIN000023814).

(a) (b)

Fig. 1. **1. Pictures of the convenient food.**
a) Tunamayo rice ball, **b)** Chocolate Denish.

Table 1. Nutrition component of the breakfast.

	Energy (kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Dietary fiber (g)	P：F：C
Gyudon	630	17.2	28.1	75.6	1.3	11：41：48
Gyudon toping (135 g)	336	13	28.1	7.8	0.7	
Steamed rice (200 g)	294	4.2	0	67.8	0.6	
Convenient	624	10.5	30.8	74.7	4.1	7：45：48
Tunamayo rice ball	219	3.8	5.7	36.6	2.1	
Chocolate Denish	405	6.7	25.1	38.1	2.0	
Gyudon	294	4.2	0	67.8	0.6	6：0：94

P, protein; F, fat; C, carbohydrate.

Results

Change in PBG after lunch: Effect of skipping breakfast

The amounts of changes of PBG level (ΔPBG) after lunch when the subjects had breakfast and that when they skipped it were compared. The ΔPBG data are presented in ***Fig. 2-a*** and AUC in ***Fig. 2-b***.

The blood glucose level before lunch was 86.4 ± 3.1 mg/dL when breakfast was skipped and was 83.1 ± 4.1 mg/dL when they had had breakfast, and no significant difference was observed. However, ΔPBG at 30 min, 45 min, 60 min and 90 min when they had skipped breakfast were significantly higher than when they had breakfast.

AUC was 7,488.4 ± 629.5 mg･min/dL when they had skipped breakfast and was 4,991.7 ± 689.9 mg･min/dL with breakfast; the former was significantly higher than the latter ($p = 0.003$). ΔCmax was 96.3 ± 7.7 mg/dL when they had skipped breakfast and was 71.3 ± 9.4 mg/dL with breakfast; the former was significantly higher than the latter ($p = 0.004$).

Changes of blood glucose levels: Effect by the kind of breakfast

The curves in blood glucose when they had steamed rice as lunch and when they ate convenience store food, gyudon or steamed rice (200 g) as breakfast are shown in ***Fig. 3-a***.

The fasting blood glucose levels immediately before lunch when they ate convenience store food, gyudon or steamed rice for breakfast were 80.5 ± 2.6 mg/dL, 93.1 ± 1.9 mg/dL or 82.6 ± 3.1 mg/dL, respectively. Compared with gyudon, significantly low blood glucose trends were shown when they had any of the other two kinds of breakfast. The curves in blood glucose level after lunch showed a tendency that it was the highest after eating convenience store food for breakfast, followed by steamed rice, and it was the lowest when they ate gyudon for breakfast. AUCs were 6,231.5 ± 485.8 mg･min/dL for convenience store food, 5,201.6 ± 523.3 mg･min/dl for steamed rice and 4,281.2. ± 635.0 mg･min/dL for gyudon in descending order (***Fig. 3-b***). ΔCmax were 87.2 ± 7.2 mg/dL for convenience store food, 72.5 ± 6.9 mg/dL for steamed rice and 60.1 ± 8.2 mg/dL for gyudon in descending order, and that of convenience store food was significantly higher than that of gyudon ($p = 0.040$).

The blood glucose curves in the morning when they had convenience store food, gyudon or steamed rice for breakfast are shown in ***Fig. 4-a***. The blood glucose curves after breakfast show that PBG levels were the highest 30 min to 90 min after they had steamed rice, and the curves of the levels after they had gyudon or convenience store food showed similar transitions. AUCs were 3,573.2 ± 402.6 mg･min/dl for convenience store food, 4,816.1 ± 393.5 mg･min/dL for steamed rice and 3,029.9 ± 353.1 mg･min/dL for gyudon. It was the highest after the steamed rice intake (***Fig. 4-b***). ΔCmax after the steamed rice intake (76.0 ± 5.0 mg/dL) was significantly higher than after the intake of convenience store food intake (53.8 ± 5.1 mg/dL, $p = 0.007$) and gyudon (51.9 ± 4.3 mg/dL, $p = 0.003$).

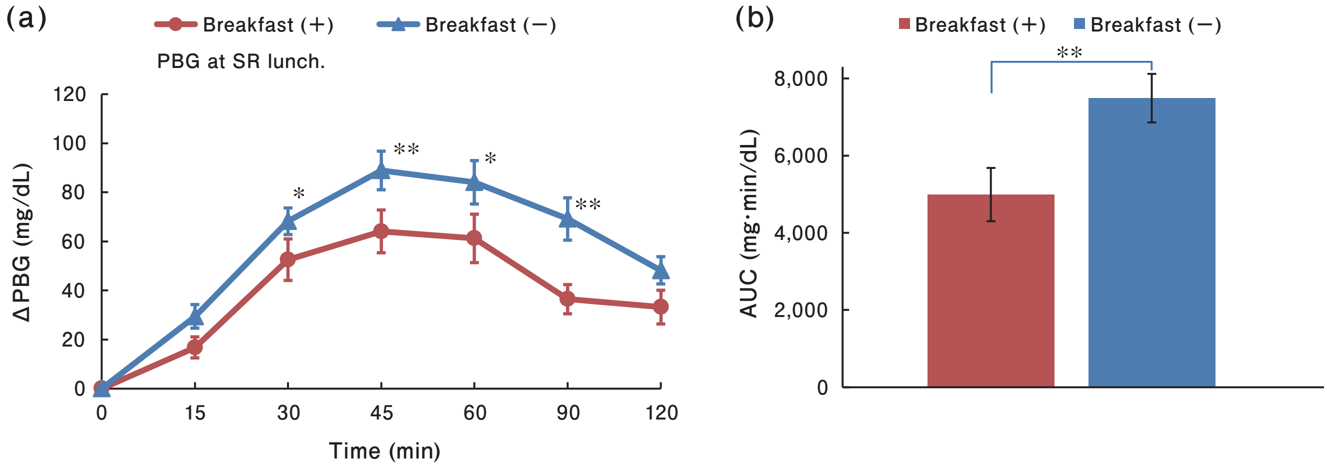

Fig. 2. **Comparison of lunch time PBG between cases with or without SR breakfast.**

a) ΔPBG curve after SR intake, **b)** AUC. SR alone was taken at breakfast, then PBG examined at lunch time. Results are expressed as mean ± SEM. *p < 0.05, **p < 0.01 vs Breakfast (+) by paired t test (n = 15). PBG, postprandial blood glucose; ΔPBG, difference of glucose level from 0-min value; AUC, area under curve; SR, steamed rice; SEM, standard error mean.

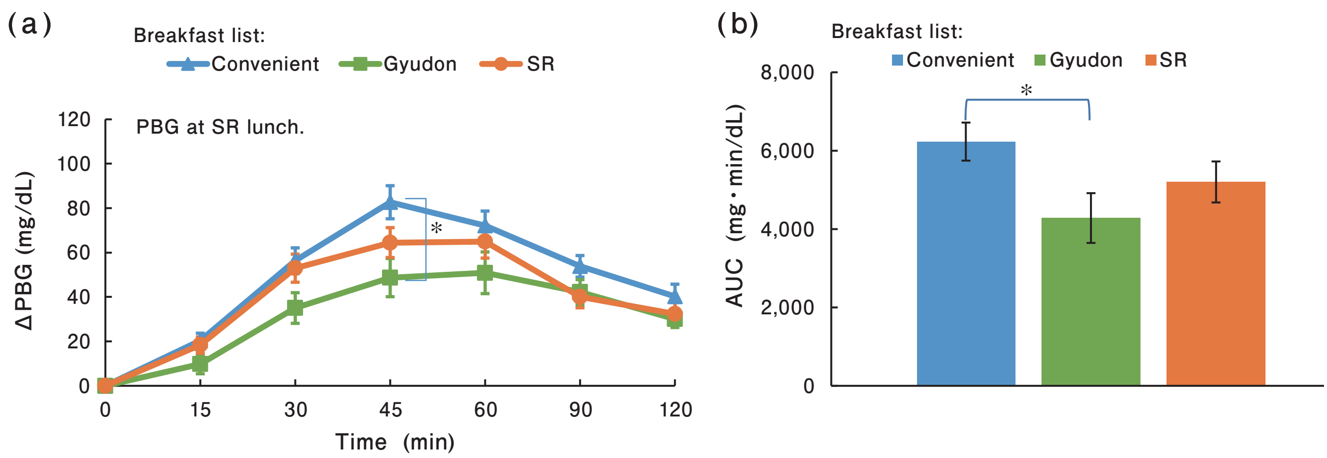

Fig. 3. **Comparison of lunch time PBG after different breakfast intake.**

a) ΔPBG curve after SR intake, **b)** AUC. Breakfast list: Convenient, rice ball and sandwich; Gyudon, beef bowl (beef with SR); SR, SR alone. Results are expressed as mean ± SEM. *p < 0.05 by Bonferroni-corrected multiple comparison analysis (n = 11). PBG, postprandial blood glucose; ΔPBG, difference of glucose level from 0-min value; AUC, area under curve; SR, steamed rice; SEM, standard error mean.

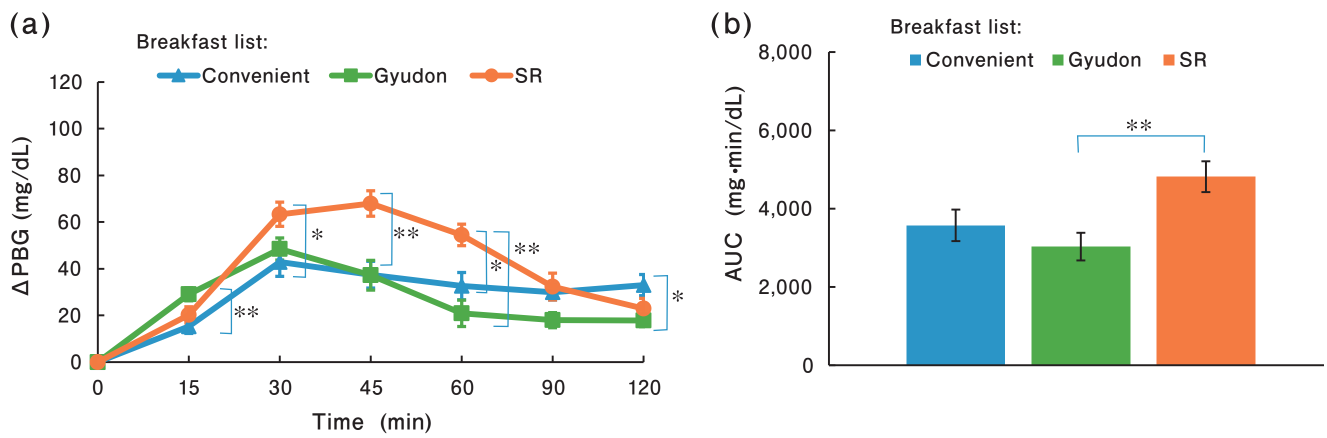

Fig. 4. **Comparison of breakfast time PBG after different breakfast intake.**

a) ΔPBG curve after each breakfast intake, **b)** AUC. Breakfast list: Convenient, rice ball and sandwich; Gyudon, beef bowl (beef with SR); SR, SR alone. Results are expressed as mean ± SEM. *p < 0.05, **p < 0.01 by Bonferroni-corrected multiple comparison analysis (n = 11). PBG, postprandial blood glucose; ΔPBG, difference of glucose level from 0-min value; AUC, area under curve; SR, steamed rice; SEM, standard error mean.

Glucagon and PBG level

The relationship between serum glucagon and the PBG after the intake of steamed rice for breakfast was analyzed. The examination for serum glucagon was performed on a day separate from the day of the blood glucose test. A positive correlation trend was observed between serum glucagon and ΔCmax (r = 0.51, p = 0.050, ***Fig. 5-a***), and a significant correlation was observed between serum glucagon and AUC (r = 0.57, p = 0.026, ***Fig. 5-b***). No significant correlation was observed between serum glucagon and the PBG curve at lunch time, disregarding whether they had breakfast or not (***Table 2***).

The correlation coefficients of ΔCmax and AUC after stemed rice breakfast were r = –0.28, r = –0.19 to insulin, r = –0.08 and r = 0.03 to HbA1c, r = –0.23 and r = –0.32 to triglyceride, r = –0.41 and r = –0.40 to low density-lipoprotein (LDL)-cholesterol, r = –0.01 and r = 0.07 to dehydroepiandrosterone-sulfate (DHEA-s), and r = 0.44, r = 0.37 to insulin-like growth factor-I (IGF-I). None of them showed significant correlation.

Discussion

This research is the record of PBG tests performed, targeting healthy persons in their 20s under various conditions, such as presence or skipping of breakfast and different kinds of breakfast. As a result, it was clarified that skipping breakfast leads to the significant elevation in lunch time PBG. The comparison by the kind of breakfast showed that the lunch time PBG was the highest by convenience store food (rice balls and sandwiches), then by steamed rice, and the lowest by gyudon.

It has been reported that eating late at night elevates blood glucose the next morning[13], and that skipping breakfast leads to a great and continued elevation in PBG after lunch[14] and that the blood glucose 30 min after the oral glucose tolerance test (OGTT) elevates[15]. The research by Qin YP *et al*. was conducted, targeting 6 adult females (42.2 ± 17.1 years), and a significant difference in blood glucose level before the food intake was observed[14]. Our results are compatible with these reports, except for having no significant difference in blood glucose level before the food intake.

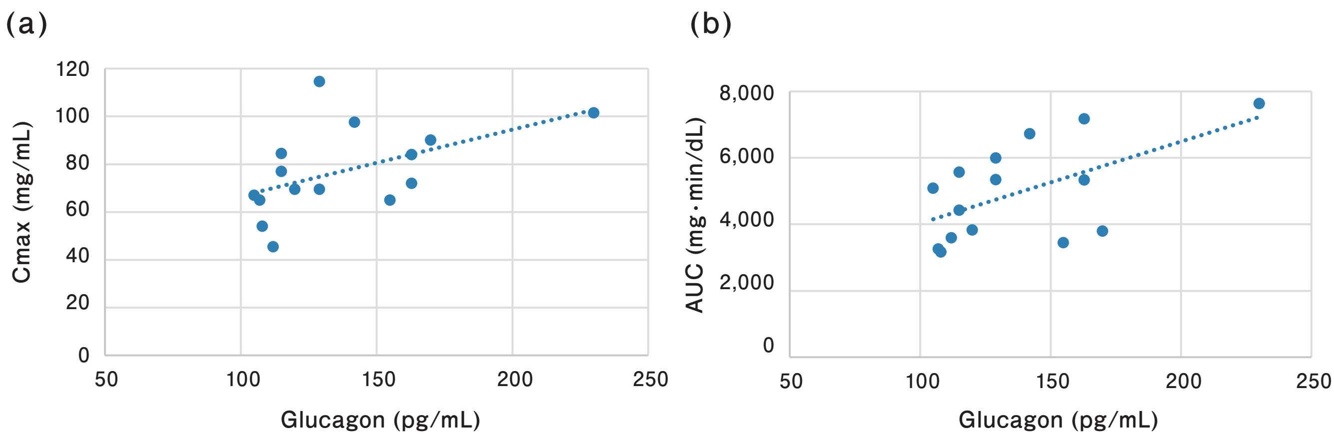

Fig. 5. **Correlation between glucagon and Cmax (a) and AUC (b) in PBG.**
Correlation is analyzed when participants ate steam rice at breakfast. Glucagon was measured at the different date. **a)** y = 0.2777 x + 38.901, r = 0.51, p = 0.050, **b)** y = 24.612 x + 1568.1, r = 0.57, p < 0.05, p = 0.026, n = 15. PBG, postprandial blood glucose; SR, steamed rice; max, the peak level of PBG; AUC, area under curve of PBG.

Table 2. Correlation between serum glucagon and PBG after SR intake.

		Glucagon vs Cmax		Glucagon vs AUC	
	n	r	p value	r	p value
PBG at SR breakfast	15	**0.47**	0.050	**0.55**	0.026
PBG at SR lunch					
Breakfast (−)	11	**0.33**	> 0.05	**0.36**	> 0.05
Breakfast (+)	11	**0.24**	> 0.05	**0.25**	> 0.05

The date of glucagon measurement is different from the PBG examination date. PBG, postprandial blood glucose; SR, steamed rice; Cmax, the peak level of PBG; AUC, area under curve of PBG; r, correlation coefficient.

Gastric peristalsis and glucagon

It is known that skipping breakfast leads to low heat production for 6 hours, including 3 hours after breakfast and 3 hours after lunch, and the heart rate increases after lunch [16]. However, the mechanism that skipping breakfast increases blood glucose after lunch has not been clarified. We focus on this issue from the perspective of gastric peristalsis and hormone dynamics.

The peristalsis of digestive systems is said to be linked to the sleep quality and the lowering of the sleep quality, including late sleeping time, and lack of sleep, increases the fatigue feeling and gastrointestinal complaints; as a result, breakfast tends to be skipped [17]. The study based on electrogastrography shows that the gastric peristalsis of the persons habitually skipping breakfast is weakened and that the gastric motility correlates to feeling of hunger and appetite [18]. However, once the peristalsis of gastrointestinal tracts diminished, digestive and absorptive functions may weaken; therefore, it is considered not to be linked to the PBG elevation.

From the perspective of hormone dynamics, when the fasting state lasts excessively long due to skipping breakfast, insulin-counter-acting hormones including glucagon increase in response to hypoglycemia. Glucagon, a peptide hormone secreted from α cells of the pancreas islet, promote glycogen decomposition and glyconeogenesis in the liver, thus elevating blood glucose level, and inhibiting gastric peristalsis. It is recently paid attention to as the hormone that plays the important pathogenetic role in the development of diabetes [19-21]. In the patients with diabetes, the serum glucagon does not easily decrease, even after a meal, hepatic glycogenosis declines and inhibition of hepatic glucose production becomes insufficient. This easily leads to postprandial hyperglycemia [22]. In this study, it was recognized that glucagon levels show a correlation with Cmas and AUC of PBG after breakfast. This finding suggests that even in the case of healthy persons (non-diabetic patients), the higher the glucagon level is, the more it leads to postprandial hyperglycemia.

The serum glucagon in the morning was not correlated with the PBG elevation after lunch when they did not eat breakfast. Fasting times are different in the morning and afternoon and the glucagon level in the morning is different from that in the afternoon, so that it is natural that the serum glucagon in the morning has no correlation with the lunch time PBG.

As a result of the discussion on the glucagon action on PBG in the study performed recently, intermediate positive correlations of serum glucagon with fasting insulin ($r = 0.50$) and HOMA-IR ($r = 0.48$) were recognized [23]. This finding suggests that the higher the glucagon level is, the more the insulin resistance increases and the more easily it causes postprandial hyperglycemia.

Blood glucose fluctuation

Blood glucose level is elevated by the intake of meals, and after that, it gradually goes down by the secretion of insulin. If blood glucose levels radically rise and radically go down, it leads to increasing oxidative stress in the body and the frequency of the complications from diabetes including retinopathy and arterial sclerosis increases [24, 25]. The more blood glucose level varies, the more glycoalbumin tends to increase [26]. The blood glucose level of dialysis patients receiving insulin therapy for diabetes radically rises after dialysis one hour after the intake of lunch [27]. It is reported that the variation width of blood glucose level is related to insulin level and methylglyoxal level after the completion of dialysis and that if the blood glucose level rises after dialysis, methylglyoxal level rises. As methylglyoxal is an intermediate of the glycation reaction and glycoalbumin is an advanced glycation end products (AGEs), it is suggested that the larger the variation of blood glucose level, the larger glycative stress.

In ***Fig. 2-a*** from the test results, the straight lines connecting Δ blood glucose 45 min after the intake of lunch (peak) and Δ blood glucose 120 min after are expressed as $y = -40.682x + 129.59$ when breakfast was skipped and $y = -30.864x + 94.955$ when breakfast was consumed. From these slopes of the lines, the blood glucose level after lunch drastically declined when breakfast was skipped compared with when breakfast was consumed. This result was similar to that of the report of Qin YP *et al.* [14]. It is believed that the fluctuation of blood glucose level is larger when breakfast is skipped and the glycative stress increases after the intake of lunch.

Comparison by the kind of breakfast

The result of comparison by the kind of breakfast conducted this time showed that blood glucose level slowly rose after gyudon was eaten the same as the previous research, compared with steamed rice. Convienience store food also showed the same result. As the reason of why there was a rise in blood glucose level by gyudon is moderate, it is said to be caused by the actions of protein, lipid and dietary fiber included in gyudon [28, 29]. Protein has the function to promote the secretion of insulin by glucose-dependent insulinotropic polypeptide (GIP) being secreted [30], lipid favorably affects on the smooth movement of the stomach through gastrointestinal hormone and vagus nerve and have function to decrease gastric emptying velocity [31]. Dietary fiber delays the absorption of glucose [29]. As convenience store food also includes lipid and protein, it is supposed that the rise in blood glucose level was alleviated by convenience store food, comparing with steamed rice mostly consisting of carbohydrates. The action to alleviate the rise in postprandial blood glucose level is proportionate to the amount of protein and is said to be stronger than fat [31, 32]. The reason why convenience store food's action to inhibit the rise in blood glucose level was weaker than that of gyudon is caused by the amount of protein included in each food (17.2 g in gyudon and 10.7 g in convenience store food).

The result that the blood glucose levels after lunch differ depending upon different kind of breakfast was obtained. The effect of eating gyudon for breakfast inhibiting the rise in blood glucose level was maintained until lunch time; however, it was not recognized in convenience store food. The reason is not clear. Although the reason for this is not clear, the following reasons are considered. As the first reason, in the case of gyudon, carbohydrates were consumed as steamed rice, but in the case of convenience store food, half of the carbohydrates were consumed as bread. As the second reason, gyudon included an appropriate amount of dietary fiber. As the third reason, gyudon included more fat, and as a result, PFC balance of gyudon was nearest to 2 : 2 : 6 [33].

About the first reason, the previous research of the author et al. showed a more moderate rise in blood glucose level by bread than by steamed rice [34]. However, it may be affected by, generally speaking, steamed rice being more filling than bread.

About the second reason, the comparison of the contents of dietary fiber shows 0.6 g in steamed rice, 1.3 g in gyudon and 4.1 g in convenience store food, and convenience store food included the largest amount of dietary fiber (***Table 1***). It suggests that the difference of nutritional composition of protein and fat has larger impact on the variation of blood glucose level after lunch than the difference of about 3 g of dietary fiber for breakfast. As it is said "vegetables first," it is better to have a meal in the order of vegetable (dietary fiber), meat and fish (protein and fat) and staple food (carbohydrate), in order to inhibit a rise in postprandial blood glucose level [35]. However, when steamed rice and steamed rice with added dietary fiber (0.7 g) were compared in the previous research, there was no such difference that can be called significant [34]. The alleviation of postprandial blood glucose level is greatly affected by the eating order and dietary fiber can exert it effect whether it is eaten first or not.

About the third reason, it is known that fat decreases gastric emptying function and makes the stomach feel full longer [36]. According to the report about the comparison between the variances of blood glucose level after the intake of ordinary bread and flaxseed bread, significant decrease in postprandial blood glucose level in the group of intake of flaxseed bread is recognized [37], which is considered to be affected by lignin and alpha-linolenic acid included in flaxseed. There is a report that postprandial blood glucose level was inhibited by simultaneous intake of butter 20 g [38], so that these are common phenomenon to some extent disregard the kinds of fat. In the comparison of variety of milk by fat content, the simultaneous intakes of whole milk diet and low-fat milk diet inhibited postprandial blood glucose level more than the control food [38, 39]. However, as for the simultaneous intake of milk, it is considered that the effect of protein content contributes to the alleviation of the rise in postprandial blood glucose level than the fat content [40].

From the results of this test, the fasting blood glucose level immediately before the intake of lunch was 80.5 ± 2.6 mg/dL when the subjects had convenience store food, 93.1 ± 1.9 mg/dL when they had gyudon and 82.6 ± 3.1 mg/dl when they had steamed rice for breakfast, and the fasting blood glucose level was significantly lower when they ate convenience store food than when they ate gyudon ($p = 0.004$). It is assumed that the factors of protein and fat included in gyudon comprehensively acted in a way that the blood glucose level was maintained at lunch time without mobilization of glucagon, and the rise in postprandial blood glucose level was alleviated.

Conclusion

It was suggested that skipping breakfast leads to a rise in blood glucose level after lunch and having breakfast is effective in the prevention of postprandial hyperglycemia. It was also presumed that it is important to eat a well-balanced and high dietary fiber breakfast.

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Conflict of Interest Statement

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