Postprandial Glucose and Sense of Satiety following white rice and rice porridge

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Abstract

Postprandial Glucose and Sense of Satiety following of white rice and rice porridge

Aim The purpose of this study is to clarify the difference in the increase in blood glucose and satiety when white rice and porridge were ingested under the controlled conditions. **Methods** Nine healthy students ate glucose solution, white rice, and porridge on separate days. Blood glucose levels and satiety levels were measured every 30 minutes. The sugar content, total number of chews, and water content were controlled between white rice and porridge. Blood glucose levels were measured by a continuous blood glucose monitoring device. **Results** There was no significant difference in the increase in blood glucose among the three conditions ($p>0.05$), and satiety between white rice and porridge ($p>0.05$). Glucose was significantly less satiating than rice porridge at 30 minutes after consumption ($p<0.05$) **Conclusion** From these results, we suggested that the blood glucose level and satiety level are the same following eating of white rice and rice porridge when ingested under the sugar and water amounts and chews-controlled conditions.

白米と粥の食後血糖値変動と満腹度

目的 本研究の目的は、糖質量や咀嚼回数、水分量を統一した条件下で白米と粥の血糖値上昇と満腹度の差を明らかにすることである。**方法** 学生 9 名を対象とし、ブドウ糖溶液、白米、粥をそれぞれ別日に摂取させ、30 分ごとに血糖値および満腹度を計測した。白米と粥は糖質量と合計の咀嚼回数、水分量を統一し、ブドウ糖と白米、粥は糖質量と水分量を統一した。血糖値は、腕に装着された持続血糖測定装置によって測定した。**結果** ブドウ糖溶液と白米と粥の間で血糖値上昇に有意な差は無かった（p>0.05）。また、白米と粥の間で満腹度に有意な差は無かった（p>0.05）。一方、ブドウ糖は粥よりも摂取 30 分後で満腹度が有意に低かった（p<0.05）。**結論** これらの結果から、白米と粥は同じ条件下で摂取した場合、血糖値の上がりやすさや満腹度は同じであることが示唆された。

白米饭和粥的餐后血糖变化和饱腹感

目标 本研究的目的是研究在相同糖量，咀嚼次数和含水量下的白米和粥之间的血糖水平和饱腹感的差异。**方法** 参加这项研究的有 9 名健康的学生。他们在不同的日子里摄取葡萄糖溶液、白米饭和粥，每 30 分钟测量一次他们的血糖水平, 并将饱腹感水平。白米和粥的含糖量、总咀嚼次数和含水量都是相同, 而葡萄糖、白米和粥的含糖量和含水量都是相同。血糖水平是用戴在手臂上的连续血糖仪测量的。**结果** 葡萄糖溶液, 白米和粥之间的血糖增加没有显着差异（P>0.05）。白米和粥之间的饱腹感也没有显着差异（P>0.05）。另一方面，在摄取 30 分钟后，葡萄糖的饱腹感明显低于粥（P<0.05）。**结论** 研究结果表明，在相同条件下摄取白米和粥，其血糖水平和饱腹感水平是相同的。

Abbreviations:

GI: Glycemic Index.

iAUC: incremental area under the curve.

Introduction

Recently, aging population has been remarkable in Japan. In 2019, the average life expectancy is 81.41years for men and 87.45years for women (Ministry of Health, Labor and Welfare, 2019). In the same year, the population over 65 years old accounted for 28.4% of the total population (Cabinet office, Government of Japan, 2020). In this super-aging society, increasing medical costs and low nutrition among the older adults are becoming broad social issues (Ministry of Health, Labor and Welfare, 2020). In particular, low BMI and low nutrition in older adults linked to sarcopenia due to muscle weakness and decreased muscle volume (Dhillon, & Hasni, 2017), and frail due to reduced motor and cognitive functions (María Elena Gómez-Gómez & Sara C.Zapico, 2019). Causes of care include dementia, stroke, weakness, and fractures and falls, which are due to muscle weakness, loss of cognitive and motor functions (Momose, et al., 2021). Therefore, both exercise and nutrition are necessary to prevent care due to sarcopenia and frail. However, the older adult experiences a decrease in appetite and food intake due to age-related anorexia (Wysokiński, et al., 2015). The percentage of people aged 65 and over who have an exercise habit in 2019 is 41,9 % for men and 33,9 % for women, which is higher than that of people in 20s to 50s (Ministry of Health, Labor and Welfare, 2020). However, in the same year, the energy intake of people aged 65-74 years was 2168 kcal for men and 1798 kcal for women (Ministry of Health, Labor and Welfare, 2020), which does not reach the energy requirement of 2400 kcal for men and 1850 kcal for women at a physical activity level of II (Ministry of Health, Labor and Welfare, 2019).

Of all the nutrients we get from our diet, carbohydrates account for the majority of the energy in the diet.

For example, the dietary reference intakes sets the carbohydrate target at 50-65% of energy (Ministry of Health, Labor and Welfare, 2014). Carbohydrates can be broadly divided into two categories: saccharinity which are absorbed by the body and become a source of energy, and dietary fiber, which is not digested and absorbed and does not provide energy. Of these, saccharinity produces about 4 kcal of energy, and plays an essential role in sustaining life (Ministry of Health, Labor and Welfare, 2014). In particular, the brain consumes 20% of the total basal metabolism, and carbohydrates provide glucose that is the brain's only source of energy (Ministry of Health, Labor and Welfare, 2014). Staple foods in Japan generally consist of rice, wheat, and buckwheat as the major source of carbohydrate (Zheng, et al., 2015). In particular, it is known that the masticatory function of older adults is declining (Ministry of Health, Labor and Welfare, 2020), and most older adults have eaten rice porridge; 76% of people over the age of 60 have eaten rice porridge and 93% of these people have eaten it as a staple food (Ministry of Health, Labor and Welfare, 2017).

However, rice porridge has the problem that it tends to raise blood glucose levels according to the glycemic index (GI), which is a measure of how easily a person's blood glucose level rises (Jenkins, et al., 1981). Rice porridge has a GI value of 92.5 or 78, compared to 69.9 or 73 for white rice (Kim, et al, 2019; Atkinson, et al., 2008). It has also been found that the older adults also have reduced glucose metabolic function (Kishimoto, et al., 2006), and porridge is a risk for the older adults. However, since the chewing and digestive functions have decreased in older adults, it is thought that rice porridge would be useful foods for older adults.

The GI value was first used in 1981 and represents the degree of increase in blood glucose level when consuming 50g of carbohydrates contained in a certain food, with glucose being 100 (Jenkins, et al., 1981). However, this study did not take into account the number of chews, and there are other studies which do not know the number of chews or water content (Kim, et al., 2019; Atkinson., et al., 2008; Sugiyama, et. al., 2003). The difference in the number of chews also affects postprandial blood glucose levels. In one study, when white rice is chewed more often, the increase in blood sugar is greater (Ranawana, et al., 2014). On the other hand, in the experiment using nuts, blood glucose levels were lower when the number of chewing was increased (Madhu, et al., 2016). Furthermore, there is a study shows that differences in water intake and beverages also affect postprandial blood glucose levels (Torsdottir & Andersson, 1989). In addition, glucose is often used as a standard for GI and has a higher GI than white rice or porridge, but the difference in water content between the foods being compared is not taken into account (Kim, et al., 2019; Atkinson, et al., 2008). This chewing frequency and water content are not taken into account when the GI values are created, and the sugar content varies from study to study. Therefore, it can not be said that the GI value reflects the actual postprandial blood glucose variation between white rice and porridge. There are no studies that have examined blood glucose fluctuations under the control of conditions for sugar content, chewing frequency, and water content. In addition, studies have shown that a higher GI value results in a lower satiety level (Makris, et al., 2011; Niwano, et al., 2009; Holt, et al., 1992), and a higher number of chews results in a higher satiety level (Cassady, et al., Zhu, et al., 2009; 2013; Komai, et al., 2016). Rice porridge is considered less satiating than white rice because it has a higher GI value, but the GI value does not take into account the number of times it is chewed or the amount of water it contains, as discussed in the blood sugar section above. Therefore, the satiety of white rice and rice porridge cannot be measured by GI value. In addition, glucose has a high GI value, and glucose solution is more satiating than water (Steinert, et al., 2011), but no studies have compared it to food.

The purpose of this study was to compare the variation and range of increase in blood glucose levels and satiety level when white rice and rice porridge were ingested with the same sugar content, number of chews, and water content, which are factors related to postprandial blood glucose levels. It is also to examine the fluctuation and rise in blood glucose levels and the satiety level when glucose, white rice and porridge are ingested with a same amount of water. Glucose solution has been used for testing blood glucose responses (Brouns, et al., 2005; Kim,et al., 2019; WHO, 1999). This is because glucose is digested quickly, and causes a faster rise in blood glucose levels (Clemens, et al., 2016). There is also a relationship between the rise in blood sugar and the level of satiety (Makris, et al., 2011; Niwano, et al., 2009; Holt, et al., 1992). Therefore, this study added glucose solution to compare the results provided from white rice or rice porridge as the widely-accepted test meal.

We hypothesized that there are no significant differences in the variation and increase in blood glucose levels, because it unifies the factors related to postprandial blood sugar levels: sugar content, number of chews, and water content (Jenkins, et al., 1981; Izumi, et al., 2012; Madhu, et.,al., 2016; Torsdottir & Andersson, 1989). Furthermore, the number of chews, which is related to satiety (Cassady, et al., Zhu, et al., 2009; 2013; Komai, et al., 2016), was controlled, and blood glucose was assumed to be the same in this study, so there is also no difference in satiety between white rice and rice porridge. When focusing on glucose solution, white rice, and porridge, we assumed that glucose would cause a faster rise in blood glucose levels than white rice or porridge, and that satiety would be higher at earlier points. This is because glucose is a monosaccharide and is digested quickly, unlike rice which is a polysaccharide (Clemens, et al., 2016), and because there is a relationship between the rise in blood sugar and the level of satiety (Makris, et al., 2011; Niwano, et al., 2009; Holt, et al., 1992).

Materials and Methods

Participants

The participants are 6 healthy females and 3 healthy males (Age: 21.3±0.5 ys, Weight: 51.6±5.1 kg, BMI: 20.0±1.4 kg/m^2). All participants did not smoke and had no abnormalities in glucose metabolism function. The participants were received a detail explanation of the purposes and risks associated with participation in this study.

Experimental design

Participants performed three experiments on the days at least 24h. All experiments were conducted in the morning. The experimental protocol is shown in Fig.1. First day, the participants ingested a glucose solution. The specified amount of glucose was dissolved in water. On the second or third days, the participants ate white rice or rice porridge. Order of white rice or rice porridge was randomized. In the case of white rice, water was ingested to match the water content with the rice porridge. Blood glucose levels were measured before consumption (0 minute) and 30, 60, 90, 120 minutes thereafter. Satiety levels were measured before consumption (0 minute) and postprandial, and 30, 60, 90, 120 minutes thereafter. Participants did not consume any additional food or liquids other than water for 12 hours prior to the experiment and until finish the day’s experiment. They were instructed to rest during the experiment. They also had prohibited from alcohol intake, intense exercise, medication intake the day before the experiment, and instructed to lead a regular life.

The amount of carbohydrates used in the oral glucose tolerance test, and in the calculation of GI is 50 g. However, the amount when converted to porridge was so large that it was expected that the participants would not be able to finish the meal. In addition, since there was a difference in the energy requirements of the participants (1675-2160 kcal) calculated from basal metabolic rate and physical activity level (Ministry of Health, Labor and Welfare, 2014), they were divided into groups that ingested approximately 30g and 40g of carbohydrates. Then, the amount of glucose, white rice, and rice porridge corresponding to the amount of carbohydrates in each group was calculated. Furthermore, the amounts were determined by taking into account that the total number of chews of white rice and rice porridge should be the same (Table 1).

White rice and rice porridge were divided into cups, with each cup containing 10 grams (Fig. 2). Participants were asked to consume one cup per mouthful. In previous study, the average number of times when white rice was chewed per 10g bite was 35 times (Yanagisawa & Wakabayashi, 1991), and when thin rice porridge was chewed per 5 or 10 g bite was approximately 8 times and 16 times, respectively (Nakayama & Kohyama 2004; Takahashi, at el., 2013). In preliminary experiments, the average number of chews for 10g of white rice was 35 times, and for rice porridge was 25 times. In order to controll the total number of chews, the number of chews per mouthful of rice porridge was set to 15, which is the number of times it is possible to swallow in preliminary experiments. Therefore, each mouthful of white rice was chewed 35 times, and for rice porridge was chewed 15 times. The total number of chews was 315 times in Group 1, and 420 times in Group 2. The total number of chews of white rice and rice porridge was same in the group. We measured the chewing speed of white rice and porridge beforehand, and found no difference. Therefore, the participants chewed food at a rate of 75 bpm in time with a metronome. In order to unify the water content of white rice and rice porridge, Group 1 and Group 2 were asked to drink 120 ml and 160 ml of water, respectively after consuming white rice.

Measuring methods

Blood glucose

The participants' blood glucose levels were measured using self-glucose monitoring system (Abbott Japan LLC, The FreeStyle Libre Flash glucose monitoring system, Tokyo, Japan). It is consist of two parts: a reading device and a disposable sensor (Fig. 3). The participants wore the censor on the back of upper arm until all the experiments were completed. The sensor measures glucose levels in the subcutaneous interstitial fluid, which is a reliable indicator of blood glucose levels. When the reader scans the sensor, the glucose level recorded on the sensor is wirelessly transmitted to the reader, and the glucose level is displayed on the screen. Blood glucose levels were measured before consumption (0 minute) and 30, 60, 90, 120 minutes thereafter.

Satiety level

The satiating capacity following eating of the test meals was assessed by interview. The participants were asked to number their satiety on a scale of 1 to 9 as shown below (Fig 4). These scores were recorded before each meal, immediately after having it and at 30, 60, 90, 120 minutes after having it.

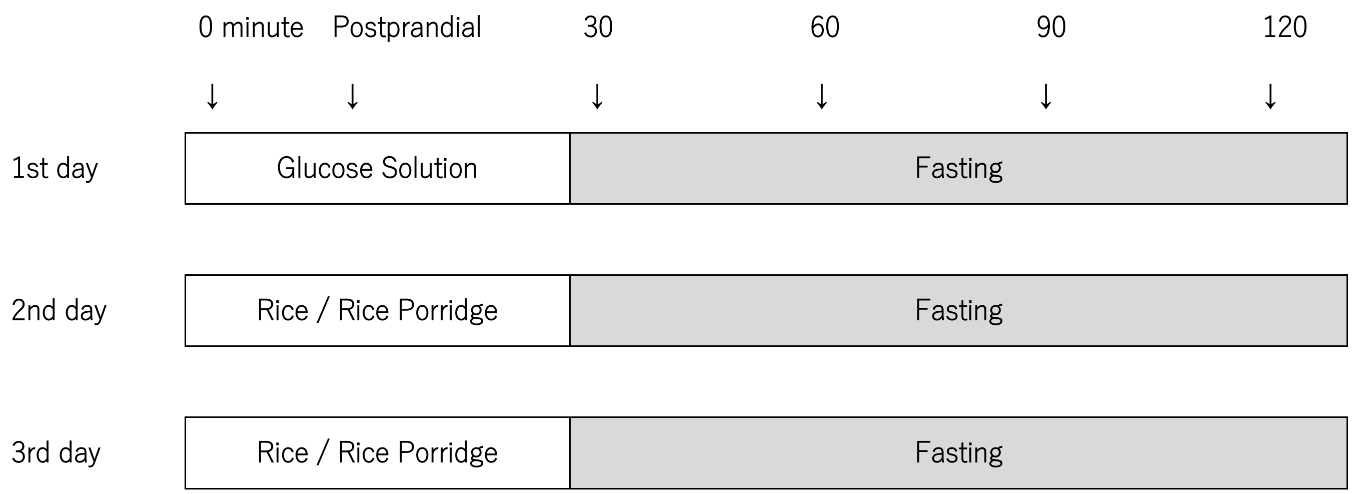

Fig. 1 The experimental protocol. Blood glucose levels were measured before consumption (0 minute) and 30, 60, 90, 120 minutes thereafter. Satiety levels were measured before consumption (0 minute) and postprandial, and 30, 60, 90, 120 minutes thereafter.

Table.1 Nutrient components of the test meals for each group (Group 1: n=6, Energy requirements=1675-1855 kcal; Group 2: n=3, Energy requirements=2099-2160 kcal). We used glucose (Marugo Corporation), and polished white rice (Aichi no kaori). White rice and rice porridge were cooked in a rice cooker.

Group		Weight (g)	Energy (kcal)	Water content (g)	Water intake (g)	Sugar (g)
1	Glucose solution	36.0	124.0	3.2	170.0	32.8
	White rice	90.0	140.0	54.0	120.0	33.1
	Rice porridge	210.0	136.0	174.3	0.0	32.8
2	Glucose solution	48.0	165.0	4.3	230.0	43.7
	White rice	120.0	187.0	72.0	160.0	44.2
	Rice porridge	280.0	182.0	232.4	0.0	43.7

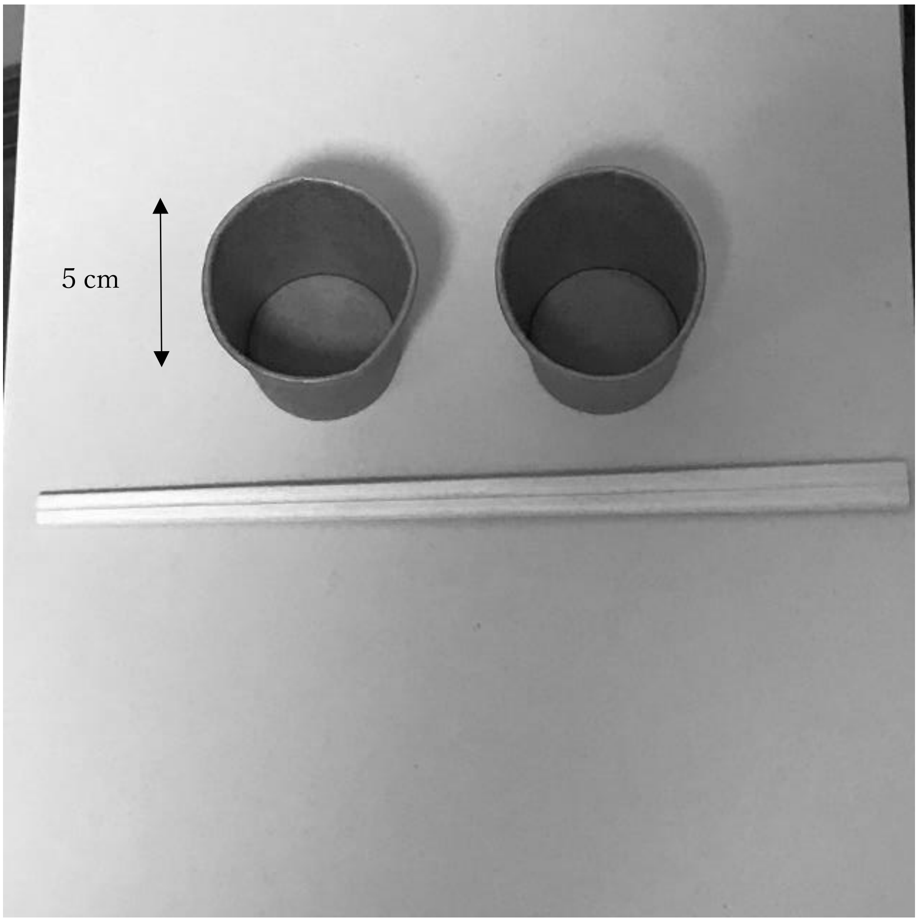

Fig.2 Cups and chopsticks for eating.

Fig. 3 A reading device and a disposable sensor of the FreeStyle Libre Flash glucose monitoring system.

Number	Satiety level
1	Painfully hungry
2	Very hungry
3	Hungry want to eat
4	Not hungry, but ready to eat
5	No particular feeling
6	Partly satisfied
7	Pleasantly full
8	Unpleasantly full
9	Full to nausea

Fig. 4 Satiety scale.

Statistics

All data are provided as mean and SD. The non-parametric analysis was used in this study since the sample size was small. The incremental areas under the curve (iAUC) were calculated for the blood glucose concentrations during tests. The area was calculated using the trapezoidal method. The iAUCs of glucose solution, white rice, and rice porridge were compared using Friedman test. Blood glucose levels at 0 minute and other times (30, 60, 90, 120 minutes) and satiety levels at 0 minute and other times (postprandial, 30, 60, 90, 120 minutes) among glucose solution, white rice, and rice porridge were compared using the Friedman test. Wilcoxon with Bonferroni collection was performed as a post hoc test for the pairs between 0 minute and other times of blood glucose and satiety. The level of statistical significance was set at $p < 0.05$. Statistical analyses were performed using SPSS software (version 25.0; SPSS, Tokyo, Japan).

Results

There were no significant differences between the iAUCs for blood glucose of glucose solution, white rice and rice porridge ($p > 0.05$) (Figure 5). The changes of the blood glucose levels are shown in Fig. 6. There was a significant differences between 3 groups at 90 minutes ($p < 0.05$), and were no differences between 3 groups at 0, 30, 60, and 120 minutes. However, there were no significant differences between glucose solution and white rice, glucose solution and rice porridge, white rice and rice porridge at 90 minutes ($p > 0.05$). The blood glucose level of glucose solution at 60 minutes after taking was significantly higher than at 0 minute ($p < 0.05$). The blood glucose levels of

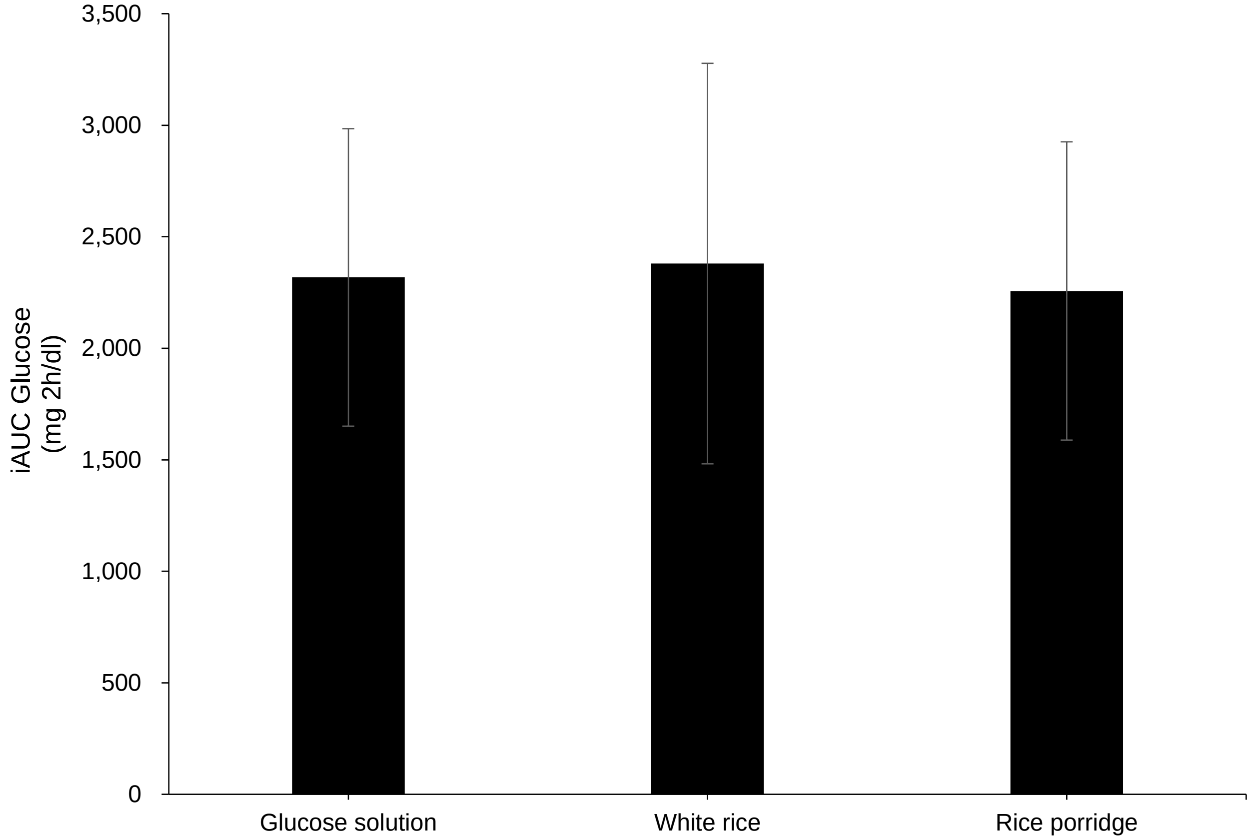

Fig.5 The iAUC for Glucose solution, white rice, and rice porridge.

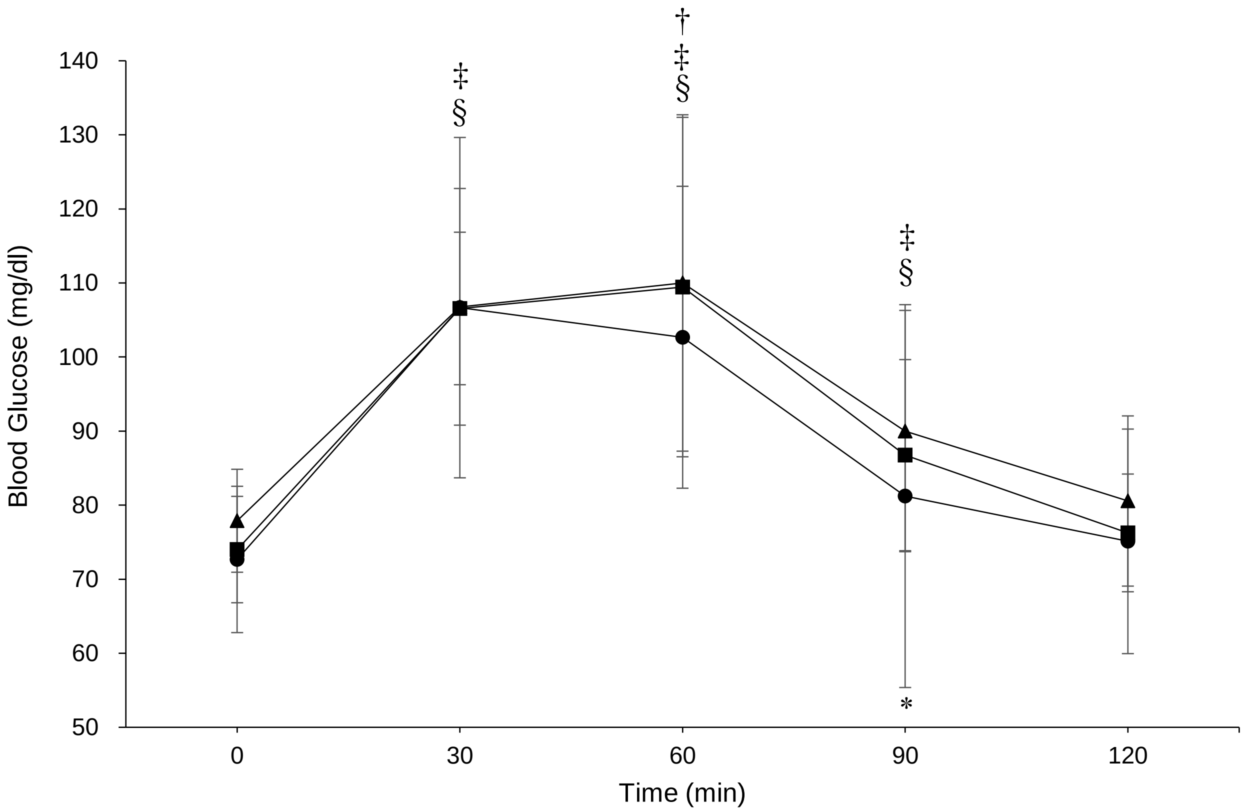

Fig.6 Mean(±SD) Blood glucose levels after taking glucose solution (-●-), white rice (-▲-), and rice porridge (-■-). (*$p < 0.05$ among the three meals analyzed using Friedman test. †$p < 0.05$ vs 0min in glucose solution, ‡$p < 0.05$ vs 0min in white rice, §$p < 0.05$ vs 0min in rice porridge analyzed using Wilcoxon with post hoc Bonferroni correction.)

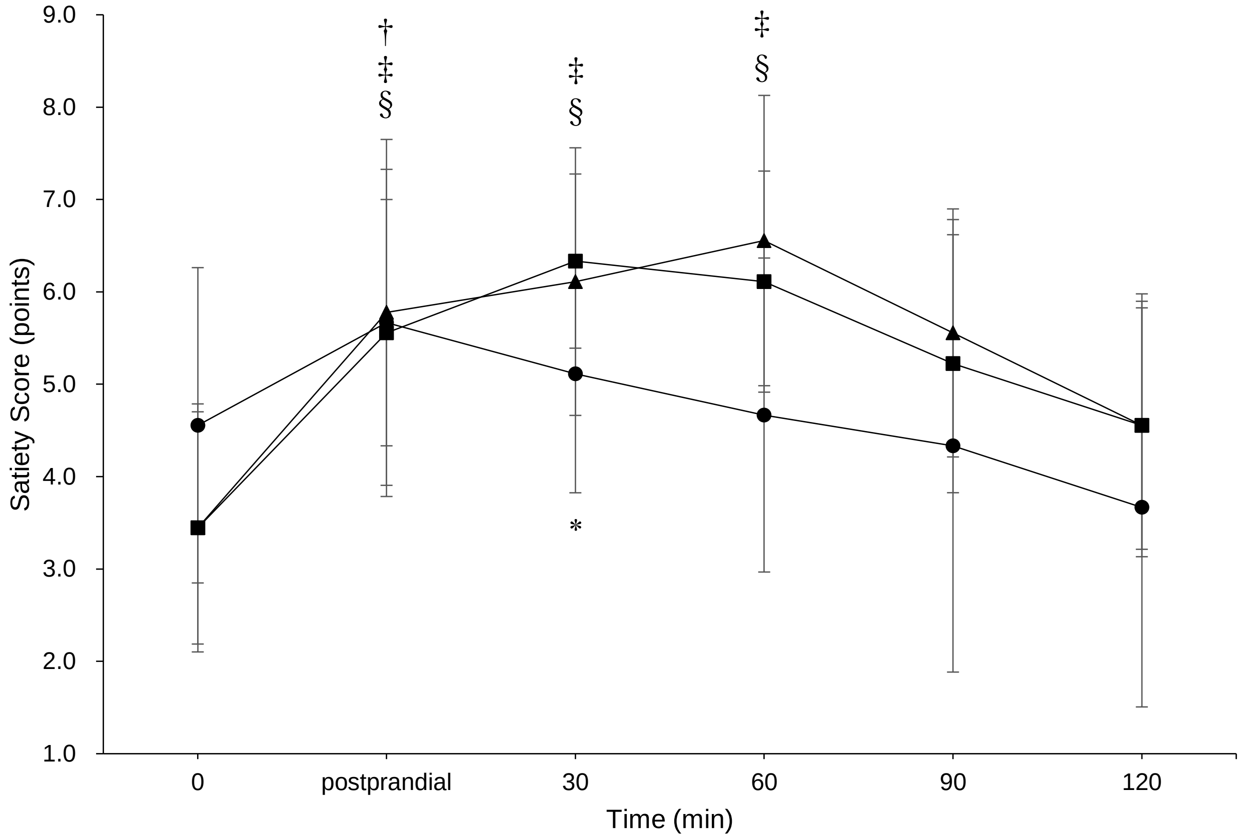

Fig.7 Mean(±SD) Satiety levels after taking glucose solution(-●-), white rice(-▲-), and rice porridge(-■-) (*$p < 0.05$ between glucose solution and rice porridge. †$p < 0.05$ vs 0min in glucose solution, ‡$p < 0.05$ vs 0min in white rice, §$p < 0.05$ vs 0min in rice porridge analyzed using Wilcoxon with post hoc Bonferroni correction.)

white rice and rice porridge 30, 60, 90 minutes after taking were significantly higher than at 0 minute ($p < 0.05$).

The changes of the satiety levels are shown in Fig. 7. There was a significant differences between 3 groups at 30 minutes ($p < 0.05$), and were no differences between 3 groups at 0, postprandial, 60, 90, and 120 minutes. The satiety level of glucose solution was significantly lower than rice porridge at 30 minutes ($p < 0.05$). The satiety level of glucose solution was significantly higher at immediately after taking than at 0 minute ($p < 0.05$). The satiety levels of white rice and rice porridge were significantly higher at immediately, 30, 60 minutes after taking than 0 minute. ($p < 0.05$).

Discussion

In this study, there were no significant differences between glucose solution, white rice and rice porridge before and after 30, 60, 90, and 120 minutes of consumption in the blood glucose levels and the iAUC of glucose ($p>0.05$). Time courses in blood glucose levels following eating of white rice and rice porridge were similar. These results support the hypothesis. This could be explained by following six factors.

The first is amount of sugar content. The amount of sugar is related to blood glucose level. For example, a cake with one-fourth the sugar content had one-fourth the maximum blood glucose level compared to a regular cake, partly due to the effect of dietary fiber (Izumi, et al., 2012). The amount of sugar in white rice and rice porridge was controlled in this study (30g in group 1, 40g in group 2). Therefore, the sugar content in this study did not affect the blood glucose levels and the iAUC of glucose. The second is number of chews. In a previous study, when white rice is chewed 30 times, the blood glucose response is greater than when it is chewed 15 times (Ranawana, et.,al., 2014).

The total number of chews for white rice and rice porridge was controlled in this study (315 times in group 1, 420 times in group 2). Therefore, the total number of chews in this study did not affect the blood glucose level and the iAUC of glucose. The third is the amount of water. In a previous study, when potatoes, a high carbohydrate food, are ingested with or without 300 ml of water, the blood glucose level rises rapidly and the glycemic response is greater when water is ingested due to rapid gastric emptying (Torsdottir & Andersson, 1989). The amount of water ingested was controlled in this study (170g in group 1, 230g in group 2). Therefore, the amount of water in this study did not affect the blood glucose level and the iAUC of glucose. The fourth is the types of sugar and varieties of rice. The absorption rate of monosaccharides and polysaccharides is supposed to be different (Clemens, et al., 2016), and monosaccharides are considered to increase blood glucose levels. In addition, high amylose rice has a lower increase in blood glucose levels than white rice because amylose reduces enzyme accessibility and results in a greater proportion of slowly digestible and resistant starch (Yamaguchi, et al., 2019). The sugars in the white rice and rice porridge were polysaccharide starch, and the rice varieties used were same in this study. Therefore, the types of sugar and varieties of rice in this study did not affect the blood glucose level and the iAUC of glucose. The fifth is the difference in temperature. In a previous study, when white rice is cooled, the range of increase in blood sugar is smaller than that before cooling due to the function of resistant starch (Sonia, et al., 2015). The Heat retention temperature of the rice cooker used in this study was 70 ± 3 degrees Celsius (Sharp, 2021), and the temperature of both white rice and porridge at the time of consumption was considered to be the same. Therefore, the temperature of both white rice and porridge did not affect the blood glucose level and the iAUC of glucose. The sixth is chewing speed. Although there are no studies showing that chewing speed or rhythm affects blood glucose levels, fast eating is associated with higher glycemic excursion (Saito, et al., 2020). In previous study, the chewing cycle of white rice was 87.9 bpm while that of porridge was 84.8 bpm (Nakayama & Kohyama, 2004). In the preliminary experiment of this study, the chewing cycle of white rice was 74.0 bpm and that of porridge was 78.9 bpm, and there was no difference between the two conditions. They were combined at 75.0 bpm, the speed of mastication and mastication rhythm were controlled in this study. Therefore, it is thought that the speed of mastication did not affect the blood glucose level and the iAUC of glucose.

There was no difference in satiety between glucose solution, white rice and rice porridge before, postprandial, 60, 90, and 120 minutes after consumption ($p>0.05$). Time courses in satiety levels following eating of white rice and rice porridge were similar. These results support the hypothesis. This result may be related to blood glucose levels, number of chews, and stomach fullness. Factors related to satiety include gastric fullness and hormones released from the small intestine (Maljaars, et al., 2007). Some of the peptides released from the small intestine act on the hypothalamus, and are involved in regulating eating. Among them, GLP-1 is associated with elevated blood glucose levels. GLP-1 suppresses elevated blood glucose levels by secreting insulin from islet of Langerhans b cells in the pancreas when the concentration of glucose in the blood rises (Baggio & Drucker 2007), and it also acts on the nucleus of the solitary tract to suppress food intake (Williams, 2009). Although elevated blood glucose is a factor that stimulates the satiety center, there is no difference in blood glucose fluctuations between the white rice and rice porridge in this study. Therefore, there is no difference in GLP-1, which secretes insulin in response to elevated glucose levels, and suppresses eating, resulting in no change in satiety. In addition, chewing has also been shown to increase cholecystokinin, which is considered to be related to satiety and appetite regulation

(Beglinger & Degen, 2004; Beinfeld, 2013). In a previous study, 40 chews resulted in higher plasma cholecystokinin concentration and lower hunger than 15 chews (Li, et al., 2011; Zhu, et al., 2013). Thus, the difference in the number of chews affects the level of satiety, but since the total number of chews was same in this study, we consider that it did not affect the level of satiety. Furthermore, gastric fullness is related to volume, and a study has shown that gastric dilation with a balloon decreases food intake and satiety (Oesch, et al., 2006). However, in this study, water was added after the intake of white rice to unify the water content, taking into account the inherently high water content of porridge. This suggests that the volume of white rice and porridge in the stomach was the same. Therefore, we consider that there was no difference in the level of satiety between white rice and rice porridge.

In this study, there were no significant differences between glucose solution, white rice and rice porridge before and after 30, 60, 90, and 120 minutes of consumption in the blood glucose levels and the iAUC of glucose ($p>0.05$). When focusing on glucose solution, this result does not support the hypothesis. This result suggests the influence of chewing. A study showed that when rice or potatoes were chewed for 15 seconds and ingested, or swallowed without chewing, blood glucose levels rose rapidly in both cases of chewing (Read, et al., 1986). This is considered because chewing makes the grains smaller, which facilitates the transport of food from the stomach to the small intestine, and chewing also increases the surface area of the food, making it easier for enzymes to work (Zhu, et al., 2013). For these reasons, we consider that chewed white rice and rice porridge accelerated the rise in blood glucose levels, and at the end of 30 minutes, they were equivalent to glucose solutions that had not been chewed.

The satiety level of glucose solution was significantly lower than that of rice porridge at 30 minutes after consumption ($p<0.05$). We hypothesized that the glucose solution would raise blood glucose levels more, and thus satiety would be higher earlier than rice. However, since there was no difference in blood glucose fluctuation between the two groups, we considered that the presence or absence of chewing was related to the level of satiety. Since chewing increases satiety (Cassady, et al., Zhu, et al., 2009; 2013; Komai, et al., 2016), it is thought that chewing rice porridge increases cholecystokinin, which increases satiety, while they are not released without chewing, resulting in lower satiety in glucose solution. In addition, glucose is a monosaccharide and is digested and absorbed faster than the polysaccharide starch (M, Wee & C, Henry, 2109), which may have resulted in a faster decrease in satiety.

This study was conducted as an experiment on healthy young people. In the case of older adults, if the amount of water and the number of chewing is the same, there would be no difference in blood sugar fluctuation and satiety between white rice and rice porridge. However, insulin secretion decreases due to aging, and the ability to metabolize sugar declines. Therefore, it can be expected that the elevated blood glucose level will be difficult to lower and hyperglycemia will continue. There is a data showing that hyperglycemia two hours after a meal is associated with a higher mortality rate from cardiovascular diseases (DECODE Study Group, 2001), thus blood glucose control is necessary in the older adults. Although rice porridge without 'omoyu' which is the clear liquid in top of rice porridge was used in this study, thin rice porridge has a higher water content (Ministry of Education, Culture, Sports, Science and Technology. 2015). Since blood glucose levels rise when water intake is increased (Torsdottir & Andersson 1989), blood glucose levels must be controlled when older people with reduced masticatory function consume rice porridge with high water content. When eating rice porridge as part of a meal, rather than as a stand-alone food, it is necessary to change the foods they eat together and the order in which they are eaten.

In conclusion, we compared the difference of the increase in blood glucose and satiety level between white rice and rice porridge, and between glucose solution and white rice, rice porridge with the same conditions. There are no significant difference in the increase in blood glucose among the three. However, glucose solution reduces satiety more quickly than rice porridge. From these results, we suggested that rice porridge does not necessarily raise blood glucose levels and satiety levels than white rice, and chewing may increase satiety.

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