ORIGINAL ARTICLE

Effects of Decreasing the Amount of Cooked White Rice Stepwise using Agar on Postprandial Blood Glucose Levels in Japanese Patients with Type 2 Diabetes

Yuji Aoki

Matsumoto University Graduate School of Health Science, Matsumoto, Japan

ABSTRACT

Background: A large cohort study of Japanese people demonstrated that increased intake of white rice was associated with an increased risk of type 2 diabetes in women. Changes in postprandial blood glucose levels were observed while decreasing the amount of cooked white rice stepwise. **Methods:** In 12 patients with type 2 diabetes in hospital, their blood glucose levels before and 2 and 4 h after breakfast were measured in 3 consecutive days: Cooked rice for breakfast was 170 ± 38 g on the 1st day, 117 ± 24 g on the 2nd day, and 50 g as rice gruel with agar on the 3rd day. **Results:** Decreasing the amount of cooked white rice by about 30% could not cause suppressive effects on postprandial hyperglycemia measured 2 h after breakfast. The decrease in its amount by about 70% substantially suppressed postprandial hyperglycemia. **Conclusions:** Decreasing the amount of cooked white rice would be effective and feasible for Japanese people to restrict carbohydrates. To decrease a large amount of white rice, rice gruel with agar may be useful, especially for obese patients with type 2 diabetes.

Key words: Agar, postprandial blood glucose, type 2 diabetes, white rice

INTRODUCTION

Rice is the staple food for most countries in Asia. In Japan, rice and processed rice contribute 46.4% of total carbohydrate intake (The National Health and Nutrition Survey Japan, 2011). Japanese people would prefer white rice to brown rice with respect to taste and palatability. Brown rice is drier due to inclusion of bran, which contains dietary fiber and micronutrients.[1] A large cohort study of Japanese people demonstrated that increased intake of white rice was associated with an increased risk of type 2 diabetes in women and probably in men who were not engaged in strenuous physical activity.[2] Thereafter, it was demonstrated that low-carbohydrate diet was associated with decreased risk of type 2 diabetes in Japanese women, which was partly attributed to high intake of white rice.[3]

A meta-analysis of cohort studies suggests that a high whole-grain intake, but not refined grains, is associated with reduced type 2 diabetes risk (a non-linear association).[4] Replacement of white rice with whole grains or legume was found to have beneficial effects on metabolic disease risk in Western people[5] and in Korean men,[6] whereas its replacement with brown rice for 16 weeks had no substantial effects in Chinese people.[7] In Japanese patients with type 2 diabetes, no changes in blood glucose levels after breakfast were observed on the day when brown rice was substituted for white rice.[1] In this short communication, changes in postprandial blood glucose levels were observed while decreasing the amount of cooked white rice stepwise using agar instead of substitution of brown rice.

Address for correspondence:
Yuji Aoki, Matsumoto University Graduate School of Health Science, 2095-1 Niimura, Matsumoto, Nagano 390-1295, Japan. Fax: +81 0263 48 7290. Tel.: +81 0263 48 7200. E-mail: yaoki55@t.matsu.ac.jp

METHODS

In 17 patients with type 2 diabetes in hospital, their blood glucose levels before and after breakfast were measured in 3 consecutive days, while the amount of cooked rice for breakfast was decreased stepwise. They were admitted to the hospital due to hyperglycemia or diabetic complications and were studied several days after admission. Three patients with their fasting glucose levels more than 160 mg/dl and two patients treated with α-glucosidase inhibitors were excluded from the study. Then, 12 patients were included for analysis and their clinical characteristics are shown in Table 1.

The amount of cooked rice in the 3 consecutive days was as follows: On the 1^{st} day, 170 ± 38 g of cooked rice for breakfast were served according to their doctor's instructions; on the 2^{nd} day, the amount of cooked rice was decreased to 117 ± 24 g (32 ± 3% reduction from the 1^{st} day); and on the 3^{rd} day, 50 g of cooked rice (69 ± 7% reduction from the 1^{st} day) were equally served as rice gruel containing rice-mimicking agar (kindly provided by Ina Food Industry Co. Ltd.) to give a feeling of satiety. Blood glucose levels before and 2 and 4 h after breakfast were measured by nurses with a glucometer using finger-stick blood samples. Their diabetic medication as shown in Table 1 was not changed during the 3 days.

Statistical analysis

The data are expressed as the mean ± standard deviation. Statistical analysis was performed using a one-way ANOVA followed by a *post hoc* Wilcoxon *t*-test with Bonferroni's correction, considering a statistically significant level at $P < 0.05$.

RESULTS

Figure 1 shows the effect of decreasing the amount of cooked rice on blood glucose levels after breakfast. Total energy, carbohydrate, its percentage energy, and dietary fiber of breakfast in the 3 consecutive days are shown in Table 2. The mean value of blood glucose levels 2 h after breakfast was significantly lower in the 3^{rd} day than in the 1^{st} and 2^{nd} days. There was no significant difference between the 1^{st} and 2^{nd} days. The mean value of blood glucose levels 4 h after breakfast was significantly lower in the 2^{nd} and 3^{rd} days than in the 1^{st} day. There was no significant difference between the 2^{nd} and 3^{rd} days. Thus, the rise in blood glucose levels after breakfast was most suppressed in the 3^{rd} day.

For comparison, only the mean values in the five patients excluded from the above analysis are shown in Figure 2. Three patients with fasting glucose level more than 160 mg/dl in the upper panel were treated with sulfonylurea and dipeptidyl peptide-4 inhibitors (+metformin in two). Two patients treated with α-glucosidase inhibitors in the lower panel were in addition treated with sulfonylurea and dipeptidyl peptide-4 inhibitors. It is of interest that about 30% reduction in the amount of cooked rice seemed to have no effects on blood glucose levels 2 and 4 h after breakfast in all five patients. About 70% reduction of cooked rice seemed to have the greatest effects on blood glucose levels after breakfast except for 2-h glucose levels when treated with α-glucosidase inhibitors.

Table 1: Clinical characteristics of type 2 diabetic patients included

n	12
Male/Female	5/7
Age (years)	66.5±10.5 (43–83)
Body height (cm)	156.2±11.7 (144–175.5)
Body mass index (kg/m²)	26.5±4.5 (19.9–35.4)
Duration of diabetes (years)	9.9±9.1 (1–31)
HbA1c level (%)	9.8±2.6 (6.0–15.5)
Diabetic therapy (n)	
Insulin+DPP4i+Met/GLP-1 analog/SU	1/1/1
SU+DPP4i/SU+DPP4i+Met/ DPP4i+Met	6/2/1

Mean±SD (range), DPP4i: Dipeptidyl peptide-4 inhibitor, Met: Metformin, GLP-1: Glucagon-like peptide-1, SU: Sulfonylurea

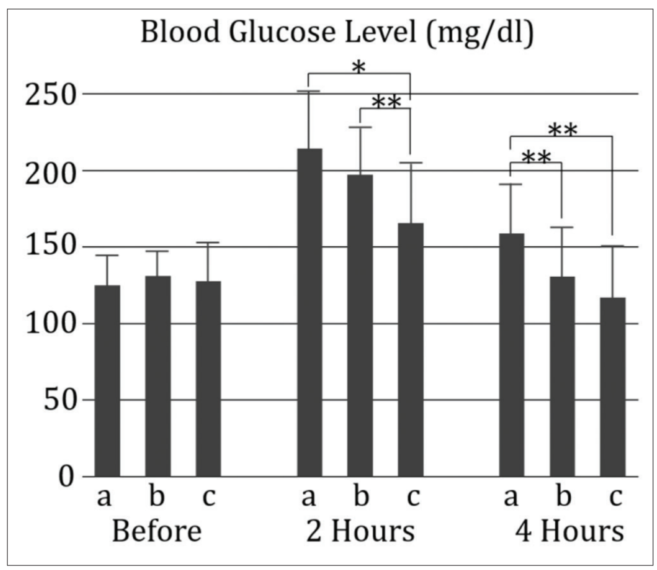

Figure 1: Blood glucose levels (mean ± standard deviation, mg/dl) before and 2 and 4 h after breakfast on the 3 consecutive days are shown. The amount of cooked rice was as instructed by doctors on the 1^{st} day (a), 32 ± 3% reduction on the 2^{nd} day (b), and 50 g with agar on the 3^{rd} day (c). The mean values of blood glucose levels 2 and 4 h after breakfast were the lowest on the 3^{rd} day. *$P < 0.05$, **$P < 0.01$ by ANOVA with Bonferroni's correction

Table 2: Contents of breakfast in 3 consecutive days

Breakfast	a	b	c
Energy (kcal)	513±76	447±50	393±31
Carbohydrate (g)	77±18	62±12	47±3
% Energy of carbohydrate	60±7	55±7	48±7
Dietary fiber (g)	5.7±2.5	3.3±1.2	8.2±1.5

Mean±SD, a: On the 1st day, b: 2nd day, c: 3rd day

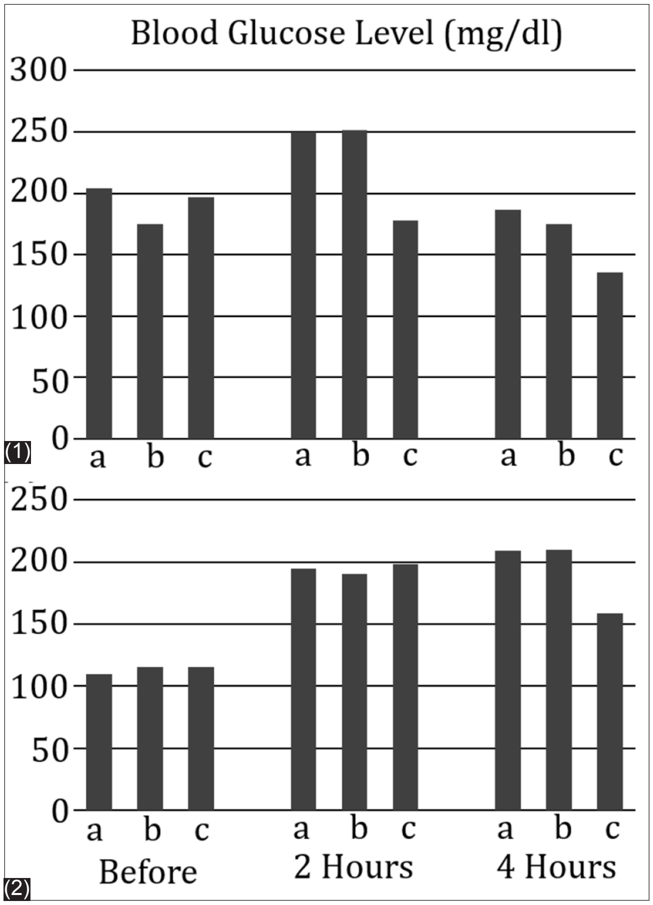

Figure 2: Only mean values of blood glucose levels (mg/dl) before and 2 and 4 h after breakfast are shown in three cases with fasting glucose level more than 160 mg/dl (1) and in two cases treated with α-glucosidase inhibitors (2). About 30% reduction in the amount of cooked rice seemed to have no effects on blood glucose levels 2 and 4 h after breakfast. About 70% reduction of cooked rice seemed to have the greatest effects except for 2-h glucose levels when treated with α-glucosidase inhibitors. a, b, and c are similar to those in Figure 1.

DISCUSSION

The present study showed that decreasing the amount of cooked white rice by about 30% could not cause substantial suppressive effects on postprandial hyperglycemia measured 2 h after breakfast. The decrease in its amount by about 70% substantially suppressed postprandial hyperglycemia. In this case, the total energy of breakfast was reduced to about 70–80% of, respectively, instructed calories because nothing but agar, which is high in dietary fiber,[8] was added. Since an acute effect of dietary fiber on postprandial blood glucose profile was not expected,[1,8] the suppression of postprandial hyperglycemia was considered to be attributed to a large decrease in the amount of cooked white rice. The percentage of energy from carbohydrate was 48 ± 7% in the rice gruel with agar for breakfast. It is of note that a prospective cohort study and meta-analysis indicated the association between 50-55% carbohydrate intake and minimal mortality risk.[9] Considering that rice gruel with agar can result in calorie restriction but give a feeling of satiety, having such breakfast may be a useful choice for obese patients with type 2 diabetes.

The glycemic index is a measure of the postprandial glucose response to various carbohydrate-containing foods.[10] The glycemic index of brown rice is lower than that of white rice,[11] but the acute effect of brown rice on postprandial blood glucose levels seems to be small, if any, in a mixed meal.[1,12,13] Umbrella review of meta-analyses of prospective observational studies revealed an inverse association for type 2 diabetes incidence with increased intake of whole grains and the association for increased incidence of type 2 diabetes with higher intake of sugar-sweetened beverages.[14] There is a report that higher carbohydrate intake was associated with higher risk of diabetes in obese men, but not in non-obese men in Japan.[15] In a recent systematic review and meta-analysis, it was concluded that higher white rice consumption has not been shown to be associated with increased risk of coronary heart disease, stroke, and type 2 diabetes but may be associated with increased risk of metabolic syndrome.[16]

Carbohydrate or simple carbohydrate restriction seems to be effective in diabetes treatment,[17] and decreasing the amount of cooked white rice is simple and feasible for Japanese people to restrict carbohydrates. To decrease a large amount of white rice, rice gruel with agar may be useful, especially for obese patients with type 2 diabetes.

CONCLUSIONS

The present study and the literature indicate that removing white rice is more effective on a short-term glycemic control, compared with replacing white rice with brown rice in Japanese patients with type 2 diabetes. Decreasing the amount of cooked white rice would be effective and feasible for Japanese people to restrict carbohydrates. To decrease a large amount of white rice, rice gruel with agar may be useful, especially for obese patients with type 2 diabetes.

COMPETING INTERESTS

The author declares that they have no conflicts of interest.

ACKNOWLEDGMENT

I am grateful to Megumi Onzuka, R.D. and the staff of the Department of Nutrition Management, National Hospital Organization Matsumoto Medical Center, Matsumoto, Japan, for their assistance.

REFERENCES

1. Terashima Y, Nagai Y, Kato H, Ohta A, Tanaka Y. Eating glutinous brown rice for one day improves glycemic control in Japanese patients with type 2 diabetes assessed by continuous glucose monitoring. Asia Pac J Clin Nutr 2017;26:421-6.
2. Nanri A, Mizoue T, Noda M, Takahashi Y, Kato M, Inoue M, *et al.* Rice intake and type 2 diabetes in Japanese men and women: The Japan public health center-based prospective study. Am J Clin Nutr 2010;92:1468-77.
3. Nanri A, Mizoue T, Kurotani K, Goto A, Oba S, Noda M, *et al.* Low-carbohydrate diet and type 2 diabetes risk in Japanese men and women: The Japan public health center-based prospective study. PLoS One 2015;10:e118377.
4. Aune D, Norat T, Romundstad P, Vatten LJ. Whole grain and refined grain consumption and the risk of type 2 diabetes: A systematic review and dose-response meta-analysis of cohort studies. Eur J Epidemiol 2013;28:845-58.
5. Sun Q, Spiegelman D, van Dam RM, Holmes MD, Malik VS, Willett WC, *et al.* White rice, brown rice, and risk of type 2 diabetes in US men and women. Arch Intern Med 2010;170:961-9.
6. Jang Y, Lee JH, Kim OY, Park HY, Lee SY. Consumption of whole grain and legume powder reduces insulin demand, lipid peroxidation, and plasma homocysteine concentrations in patients with coronary artery disease: Randomized controlled clinical trial. Arterioscler Thromb Vasc Biol 2001;21:2065-71.
7. Zhang G, Pan A, Zong G, Yu Z, Wu H, Chen X, *et al.* Substituting white rice with brown rice for 16 weeks does not substantially affect metabolic risk factors in middle-aged Chinese men and women with diabetes or a high risk for diabetes. J Nutr 2011;141:1685-90.
8. Sanaka M, Yamamoto T, Anjiki H, Nagasawa K, Kuyama Y. Effects of agar and pectin on gastric emptying and post-prandial glycaemic profiles in healthy human volunteers. Clin Exp Pharmacol Physiol 2007;34:1151-5.
9. Seidelmann SB, Claggett B, Cheng S, Henglin M, Shah A, Steffen LM, *et al.* Dietary carbohydrate intake and mortality: A prospective cohort study and meta-analysis. Lancet Public Health 2018;3:e419-28.
10. Aoki Y, Onzuka M. Glycemic variations after ingestion of different carbohydrate-containing foods assessed by continuous glucose monitoring in healthy and diabetic individuals in daily life. Diabetes Res Open J 2015;1:41-7.
11. Chapagai MK, Bakar NA, Jalil RA, Muda WA, Karrila T, Ishak WR, *et al*. Glycaemic index values and physicochemical properties of five brown rice varieties cooked by different domestic cooking methods. Funct Foods Health Dis 2016;6:506-18.
12. Adebamowo SN, Eseyin O, Yilme S, Adeyemi D, Willett WC, Hu FB, *et al.* A mixed-methods study on acceptability, tolerability, and substitution of brown rice for white rice to lower blood glucose levels among Nigerian adults. Front Nutr 2017;4:33.
13. Kim JS, Nam K, Chung SJ. Effect of nutrient composition in a mixed meal on the postprandial glycemic response in healthy people: A preliminary study. Nutr Res Pract 2019;13:126-33.
14. Neuenschwander M, Ballon A, Weber KS, Norat T, Aune D, Schwingshackl L, *et al.* Role of diet in type 2 diabetes incidence: Umbrella review of meta-analyses of prospective observational studies. BMJ 2019;366:l2368.
15. Sakurai M, Nakamura K, Miura K, Takamura T, Yoshita K, Nagasawa SY, *et al.* Dietary carbohydrate intake, presence of obesity and the incident risk of type 2 diabetes in Japanese men. J Diabetes Investig 2016;7:343-51.
16. Krittanawong C, Tunhasiriwet A, Zhang H, Prokop LJ, Chirapongsathorn S, Sun T, *et al.* Is white rice consumption a risk for metabolic and cardiovascular outcomes? A systematic review and meta-analysis. Heart Asia 2017;9:e10909.
17. Aoki Y. Simple carbohydrate restriction could bring about the renoprotective effect of sodium-glucose cotransporter 2 inhibitors in diabetes treatment. Acta Sci Nutr Health 2019; 2019;3:149-51.

How to cite this article: Aoki Y. Effects of Decreasing the Amount of Cooked White Rice Stepwise using Agar on Postprandial Blood Glucose Levels in Japanese Patients with Type 2 Diabetes. Clin Res Diabetes Endocrinol 2019;2(1):1-4.