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The impact of eating methods on eating rate and glycemic response in healthy adults

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HIGHLIGHTS

- Glycemic response of consuming rice with chopstick was lower than with spoon.
- The glycemic index of rice using chopsticks (GI: 68) was lower than spoon (GI: 81).
- Little observed differences (GI) between using fingers with spoon or with chopsticks.
- Different ways of consuming white rice alter glycemic index.

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ABSTRACT

Singapore is an island state that is composed of three major ethnic groups, namely Chinese, Malay and Indian. Its inhabitants consume food either using chopsticks (Chinese), fingers (Malay and Indian) or spoon (Chinese, Malay and Indian). Previous work by our group showed that the degree of mastication significantly influenced the glycemic response. The degree of mastication in turn may depend on the eating method as the amount of food taken per mouthful and chewing time differs between eating methods. Eleven healthy volunteers came in on six non-consecutive days to the laboratory and evaluated three methods of eating white rice (spoon, chopsticks and fingers) once and the reference food (glucose solution) three times in a random order. Their glycemic response (GR) was measured for the subsequent 120 min. Mastication parameters were determined using surface electrode electromyography. The GR to white rice eating with chopsticks was significantly lower than spoon. The GI of eating rice with chopsticks was 68 which is significantly lower than eating with spoon (GI = 81). However there were no differences between fingers and spoon, and between fingers and chopsticks either in GR 120 min or GI. The inter-individual number of mouthful, number of chews per mouthful, chewing time per mouthful and the total time taken to consume the whole portion of rice were significantly different between spoon and chopsticks groups. Significant correlations between the number of mouthful to take the entire portion of rice and amount of rice per mouthful during mastication and the GR were observed for eating rice with spoon and chopsticks, but not for fingers. The results suggest that individual differences in number of mouthful and amount of rice per mouthful may be two of the causes for inter-individual differences in the GR between spoon and chopsticks. The present study suggests that eating rice with different feeding tools has different chewing times and amount of food taken per mouthful and then alters the GI of the rice.

1. Introduction

Singapore is an island state that is composed of three major ethnic groups, namely Chinese, Malay and Indian. In addition to Singaporean diverse cuisine, its inhabitants consume food either using chopsticks (Chinese), fingers (Malay and Indian) or spoon (Chinese, Malay and Indian). The major staple in Singapore and South-east Asia in particular is rice. The Asian diet is characterized as one that is high in carbohydrates, and in most regions herein rice remains the major staple. Refined grains such as white rice have been linked to type 2 diabetes and the metabolic syndrome [1–3]. The glycemic index (GI) concept was developed by Jenkins over three decades ago [4] and is useful to quantify the glycemic impact of carbohydrate foods. Understanding the GI and devising simple ways to reduce glycemic response are particularly beneficial for those with diabetes and pre-diabetes. The Asian region is showing the largest rise in diabetes and related chronic disease incidence both as a result of a large population size and changes in lifestyle and economic status. It is estimated that diabetes and impaired glucose

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tolerance incidence rates will increase by up to 60% by 2025 compared with 2007 levels [5]. The present study aims to investigate the role of eating methods of rice in glycemic response and glycemic index.

The introduction into the diet of meals that contain carbohydrates in a form that is absorbed slowly in the small intestine or not at all has been advocated as a simple means of preventing or treating diabetes or obesity [6]. Mastication, the physiological function of which is the mechanical breaking down of food into small particles suitable for gastrointestinal absorption of nutrients, influences postprandial plasma glucose concentrations [7,8]. Chewing breaks food into smaller particles, enhances salivation and mixes it with salivary enzymes initiating hydrolysis of carbohydrate in the mouth and stomach [6]. These effects would be expected to increase the glycemic and insulinemic responses. It was reported that swallowing white rice without chewing reduced the blood glucose response [6]. Thus, mastication should play a crucial role in determining the postprandial plasma glucose concentrations. In our previous studies, we found that rice elicited the greatest inter-individual variations in the glycemic response compared to spaghetti and carbohydrate drinks [9]. This suggested that difference in habitual mastication of whole grains may be a contributor to its glycemic variations. One aim of this study is to obtain more knowledge about the association of mastication on glucose metabolism. Although dietary interventions are the most effective and economical methods in diabetes management and prevention [10], limited data is currently available on the mastication (bite size, the same portion with different numbers of mouthfuls) effects on glycemic of white rice consumed in Asia [11–14].

Previous work by our group showed that the degree of mastication significantly influenced the glycemic response [15]. The degree of mastication in turn may depend on the eating method as the amount of food taken per mouthful and chewing time differs between eating methods. Therefore it may be possible that the eating method may influence the GI. The eating method may have greater effects on the GI in multi-ethnic countries like Singapore where each ethnic group has their own peculiar way of eating. Whereas ethnic groups of Chinese descent prefer chopsticks, South Asians and Malays use their fingers. Both groups also use western utensils on occasion. Therefore, determining the impact of eating method on the GI may be more important from a Singapore perspective.

The GI has become a widely used tool in the selection of foods suitable for glycemic control. However, wide variations in the GI value to any single food are a consistent observation. A clear understanding of all the factors affecting the GI and thereby contributing to its variations is imperative if it is to be effectively used as a clinical tool. The results of this study will investigate whether the eating method has any bearing on the GI of rice. The findings of this study are especially important for Singapore as it is home to a multi-ethnic population who consumed rice extensively.

2. Experimental methods

2.1. Subjects

Eleven healthy participants (4 females and 7 males) were recruited for the study by means of advertisements, flyers, and personal communications and consisted entirely of staff and students of University of Singapore. Before inclusion in the study, potential participants were briefed on all aspects of the experiment and were given the opportunity to ask questions. Following the securing of consent, a health assessment was performed which included anthropometric measurements (Table 1) and a health questionnaire (giving details of food allergies/intolerance, metabolic diseases, special dietary needs, and smoking habits). Those who fulfilled all the inclusion criteria (body mass index, 18.5–24.9 kg/m^2; blood pressure (BP)–systolic BP between 110 and 120 mm Hg and diastolic BP between 75 and 85 mm Hg; age 21–50 years; fasting blood glucose, 4–6 mmol/L; not on prescription medication; non-smoking; no genetic or metabolic diseases, full set of natural teeth and the subjects were chosen on their abilities to eat with fingers, chopsticks or spoon comfortably) were enrolled in to the study. Physical activity was quantified using the questionnaire of Baecke et al. [16], and only those not partaking in competitive sports and endurance events were included. Participants were informed that the purpose of the study was to investigate the effect of different eating methods on plasma glucose. When the participants completed the study, they were given the option to withdraw their data from the study. The study was conducted at the Clinical Nutrition Research Centre (CNRC), Singapore Institute for Clinical Sciences (SICS). All participants gave written informed consent before starting, and the study was initiated after ethical approval by the Domain Specific Review Board (DSRB) of National Healthcare Group.

Table 1
Mean (±SE) baseline measurements of participants.

	Males	Females
Number (n)	7	4
Age (y)	23.0 ± 0.3	24.8 ± 1.5
Height (m)	1.8 ± 0.02	1.6 ± 0.02
Weight (kg)	68.8 ± 3.09	49.1 ± 2.6
BMI (kg/m^2)	21.8 ± 0.92	19.0 ± 0.7
Body fat content (%)	18.8 ± 1.7	24.8 ± 1.7
Fasting blood glucose (mmol/L)	4.6 ± 0.2	4.6 ± 0.1
Blood pressure		
Systolic (mm Hg)	119.7 ± 2.15	104.3 ± 2.3
Diastolic (mm Hg)	68.8 ± 2.38	68.8 ± 1.7
Physical activity score	7.6 ± 0.2	7.5 ± 0.3

2.2. Study design

Randomized, within-subjects, non-blind design was adopted in this study. Each participant returned for six test sessions on 6 non-consecutive days. At three random sessions subjects tested the glucose reference and on the remaining three random days tested the white rice with different eating methods (spoon, chopsticks and fingers). While the participants tested the in vivo GR (as described in measurement of glucose response section) on all 6 days, oral processing parameter data were collected on 3 random days for white rice eating with different methods. At each session, subjects came to the CNRC laboratory between 7:30 and 8:30 am following a 12-h overnight fast. Upon arrival at the laboratory, the participants were first allowed to rest for 10 min before testing began. Following a brief rest, two baseline finger prick blood samples were taken 5 min apart to measure fasting glucose levels. During the white rice test sessions where oral processing parameters were measured, electromyogram (EMG) electrodes were attached to the participant's cheeks just before they begin to consume the white rice. The test or reference food was given to consume within 15 min. Further blood samples for glucose were taken for the subsequent 120 min (every 15 min in the first hour and every 30 min for the subsequent hours).

2.3. Test foods

The subjects were given white rice and glucose. The rice and the reference food were given in portions containing 50 g of available carbohydrates. White rice amounted to 63.6 g of uncooked rice. The glucose reference drink was made using 50 g of anhydrous glucose dissolved in 250 mL of room temperature water. The white rice used was Thai Hom Mali fragrant rice (NTUC Fairprice, Singapore). All of the rice was from a single cultivated batch. Compositional information (per 100 g) was obtained from the supplier (total carbohydrate 79 g, fiber 0.4 g, protein 7.1 g, fat 0.5 g). The percentage increase in weight after cooking was 156% for rice.

For cooking, the rice ratio to water was maintained at 1:8. Each white rice portion was cooked individually. The water was brought to