The Effect of Breakfast With Low Glycemic Index on Cognitive Ability in Indonesian High School Students

by Taufiqur Rahman

The Effect of Breakfast With Low Glycemic Index on Cognitive Ability in Indonesian High School Students

A Pilot Study of Locally Based Foods Approach

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Numerous studies have investigated the importance of low-glycemic-index (GI) breakfast on cognitive performance. However, until recently, none has used rice and noodles, which are staple foods in Indonesia. This pilot study examined the effect of a low-GI breakfast on cognitive ability of an arithmetic task using locally based food approach. This randomized, crossover study involved 64 high school students (32 male and 32 female students) aged 12 to 15 years. They were provided with a low-GI breakfast or placebo with high GI, which were matched by ±10% for energy amount, serving size, and macronutrient composition. The arithmetic ability Uchida-Kraepelin test was performed 2 hours after breakfast. Paired *t* test was used to analyze the difference between meals on the outcome. Students consuming the low-GI breakfast had higher scores than those on the high-GI breakfast (80.7 ± 15.9 vs 73.7 ± 17.1), a significant difference (P = .008). The low-GI breakfast was beneficial on these scores, suggesting that further investigations are warranted and that locally based food sources with lower GIs at breakfast might be in order. More tests of cognitive ability are needed to ensure findings are valid, with careful consideration on the issues appearing in this study. Nutr Today. 2020;55(6):328–332

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Breakfast is recognized as the most important meal of the day for many reasons. Among schoolchildren, there is evidence of its beneficial effect on cognitive and academic performance.[1–4] Breakfast supplies energy and essential nutrients, which are needed by the brain to function at full capacity. Despite the many benefits of breakfast, an Indonesian national health survey in 2015 reported that 39% of male and 50% of female high school students did not eat it.[5] Indonesian students still lag behind other countries (ranked 62 out of 70) in terms of average math, science, and reading scores in the International Student Assessment Program 2015,[6] and the results also showed positive relationship between breakfast and students' science performance across countries. Boys and girls who ate breakfast scored, respectively, 10 and 6 points higher than those skipping it.[7]

The effects of breakfast on cognitive development are ongoing, but it is clear that the nutritional characteristics of breakfast fed may affect outcomes. Some studies found that adequate energy intake[8,9] and macronutrient composition[10,11] of breakfast have effects on cognition and academic output. Other studies suggested an effect of low-GI breakfast on cognitive ability.[12–14] Cereal, cornflakes, and oatmeal were predominantly used in aforementioned studies, but these foods are unfamiliar to Indonesians. Therefore, it seems to be impractical to implement because Indonesian staple foods are rice and noodles (98% and 23% of population, respectively).[15] This pilot study examined the effect of low-GI breakfast on cognitive performance of an arithmetic task, using locally based foods.

MATERIALS AND METHODS

Participants

Sixty-four high school students (32 male and 32 female students) aged 12 to 15 years (mean, 13.6 ± 0.7 years) were used.

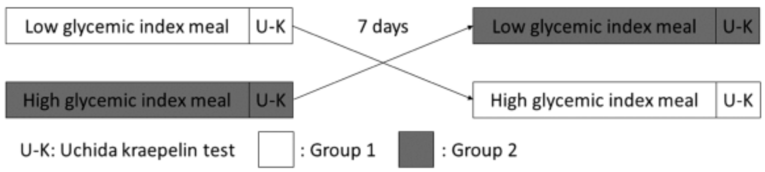

FIGURE 1. Study design.

They were recruited from Pondok Pesantren Tebuireng (an Islamic Boarding School) and SMPN 1 Ploso (a high school) in Jombang. The inclusion criteria were students who rank between 1 and 10 in their latest semester report in each class. Participants with diabetes, anemia, and food allergies were excluded. The study was approved by the Health Research Ethics Committee of Politeknik Kesehatan Kemenkes Surabaya (002/S/KEPK/VI/2016) and conducted in accordance with the Declaration of Helsinki. The procedures were registered at Thai Clinical Trials Registry as TCTR20200425002. Informed consent had been signed by both students and parents prior to the commencement of the study.

Treatment and Design

The study used a randomized, crossover design (Figure 1). Therefore, participants acted as their own controls so that the effect of the different breakfast could be evaluated. They were randomly assigned into 2 groups to receive low GI or placebo (high GI) breakfast. All participants in both groups received both meals within a predetermined schedule at 7-day interval. Blinding was not possible because the menu variation was clearly obvious. However, participants were not informed about the purpose of the different meals to limit any potential bias.

Both menus were calorically matched and had similar serving size, as well as macronutrient component (protein, fat, and carbohydrate) with a 10% tolerance. The energy and nutrient contents were analyzed using Nutrisurvey 2007 (EBISpro). The low-GI breakfast value was 46 and consisted of 150 g noodles, 30 g caisims, 25 g chicken sausage, 60 g fried eggs, and 25 g shredded chicken (Table 1). The high-GI breakfast value was 86 and consisted of 175 g rice, 25 g carrots, 25 g beans, 25 g tempeh, 10 g soy sauce, 25 g fried chicken, and cooking oil (Table 2). The total energy values of the low and high GI were 508 and 481 kcal, respectively. The GIs of food items were obtained from the international glycemic index table and glycemic load values.[16] In addition, GI estimation of mixed meals was calculated using the formula[17] shown in Figure 2.

Procedure

The sequence of GI breakfasts was provided in a random manner. All participants ate both GI breakfasts and performed the arithmetic test twice, separated by 7 days. Half of the participants received the low-GI breakfast first, whereas the other half had a high-GI breakfast first. Participants were instructed not to eat after 10:00 PM the night before intervention and to go to school on the test day without breakfast. In the morning at 7:00 AM, they were asked to eat the entire administered meal within 10 minutes. Additional food consumption such as snacks or sugary drinks was not permitted except ad libitum mineral water. The arithmetic tasks were measured 2 hours after eating breakfast (9:00 AM).

Assessment Test

The Uchida-Kraepelin test is a shortened, 30-minute modification of Kraepelin's arithmetic test[18] containing 25 column lines of 115 random and single-digit number. Participants were instructed to sum each sequence of 2 overlapping vertical numbers, with the second of each pair becoming the

TABLE 1 The Low Glycemic Index (GI) Breakfast

Food	GI	Serving Size, g	Energy, kcal	Protein, g	Fat, g	CHO, g	GI × CHO	Meal GI
Noodles	47	150	246.8	8.4	1.2	49.5	2326.5	45.9
Caisims	0	30	4.5	0.7	0.1	0.6	0	
Chicken sausage	0	25	71.3	2.9	6.7	0	0	
Fried egg	0	60	114.6	7.2	9.1	0.6	0	
Shredded chicken	0	25	71.2	6.7	4.7	0	0	
Total			508.4	25.9	21.8	50.7	2326.5	

Abbreviation: CHO, Carbohydrate.

TABLE 2 The High Glycemic Index (GI) Breakfast

Food	GI	Serving Size, g	Energy, kcal	Protein, g	Fat, g	CHO, g	GI × CHO	Meal GI
Rice	98	150	195	3.6	0.3	42.9	4204.2	85.6
Carrots	49	30	4.5	0.2	0.1	1.2	58.8	
Beans	32	25	71.3	0.5	0.1	2	64	
Tempeh	21	25	49.8	4.8	4.3	4.3	90.3	
Soy sauce	0	10	6	1.0	06	0.6	0	
Chicken (skinless)	0	55	85.3	16.9	0	0.6	0	
Cooking oil	0	15	129.3	0	15	0	0	
Total			480.6	27.0	19.3	51.6	4417.3	

Abbreviation: CHO, Carbohydrate.

first number of the next pair. Only the answer unit is written down in a space between the pair. They were asked to change to a new line each minute following the examiner's signal regardless of their current line position. The test was taken for 15 minutes for the first 15 lines and rest for 5 minutes, followed by 10 minutes to work on the remaining 10 lines. Because the test was performed twice for each participant, the final score analyzed was the average of those 2 scores.

Statistical Analysis

Statistical analyses were performed using SPSS statistics 20 (IBM Corp, Armonk, New York), and values were reported as mean ± SD. Paired *t* test was used to analyze the arithmetic test scores difference between the low and high GI groups. The statistical significance level was determined at $P < .05$.

RESULTS

Figure 3 illustrates that students achieved higher average arithmetic test scores after consuming the low-GI breakfast (80.7 ± 15.9) compared with those who ate the high-GI breakfast (73.7 ± 17.1). In addition, Table 3 reveals that better scores consistently persisted in the low-GI-breakfast group, regardless of the GI breakfast sequence. Furthermore, Table 4 shows a statistically significant difference in the arithmetic test scores between interventions ($P = .008$).

DISCUSSION

These preliminary findings indicated that a low-GI breakfast enhanced cognitive performance of an arithmetic task, as opposed to a high-GI breakfast. A low-GI breakfast has also been reported to be associated with attention in a positive manner.[19] In the present study, rice and noodles were used for high- and low-GI breakfast interventions, respectively, which are the main staple for Indonesians. To the best of our knowledge, there have been no experimental studies using rice and noodles, staple Indonesian breakfast foods, providing such interventions until recently. Compared with earlier studies across countries in 3 systematic reviews, it was found that most breakfast comprised cereals, cornflakes, and bread, as well as oatmeal, and none of the studies used rice or noodles as interventions.[1,19,20]

The 2 supplied menus were matched by ±10% for energy amount, serving size, and macronutrient composition. The total energy was equated to prevent any potential limitations as performed by previous investigations.[21,22] The amount of energy accounted for 20% to 25% of total intake according to recommended dietary allowance (Indonesia),[23] regardless of individual needs variance. It is also in accordance with an earlier study that reported better reasoning scores for children having adequate breakfast ≥20% of daily energy, compared with those eating inadequate breakfast.[8] Furthermore, it is also important to note that compositional differences may influence cognitive performance.[10,11] Hence, the provided meals were matched in terms of macronutrient contents aiming to minimize the possibility of nutritional component differences impact on the outcome.[12]

There are important limitations to be considered. First, it was unclear whether participants had similar characteristics (such as body mass index, socioeconomic, and

$$\text{Meal GI} = \{[(\text{GI}_{\text{foodA}} \times \text{g available carbohydrate (avail CHO)}_{\text{foodA}}] + [\text{GI}_{\text{foodB}} \times \text{g avail CHO}_{\text{foodB}}] + \ldots\}/\text{total g avail CHO}$$

FIGURE 2. GI estimation formula.

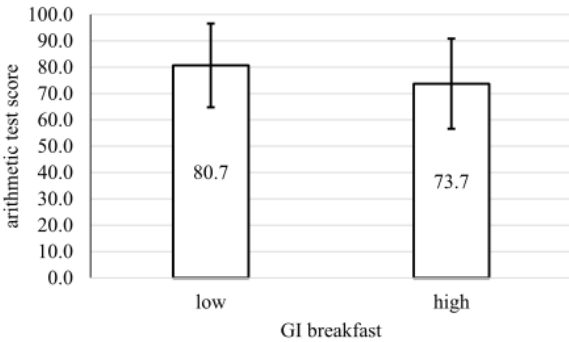

FIGURE 3. Difference of arithmetic test score between low- and high-GI breakfast.

psychological) because it was not investigated. Because portion size was held constant for all volunteers, it is possible that cognitive processes of students who were bigger or had higher energy requirements being attributed to glycemic index may partially reflect differential energy content of the high- and low-GI portions. Also, the breakfast manipulations were equal rather than ad libitum, meaning that the participants did not eat at a certain portion size based on individual preferences. Third, baseline measurement of the arithmetic test was not performed; therefore, it was not understood whether breakfast caused an improvement or a decline on the outcome. Another issue is that the arithmetic test was only one of many aspects of cognitive processes, preventing the generalizability of the results. Furthermore, food cost and palatability of the 2 breakfasts provided were not explored; thus, the affordability and practicality of the meals in real-life conditions are still questionable. Additionally, overestimation on the GI values might occur because the measurements were based only on published values and math formula.

TABLE 3 Arithmetic Test Scores of the 2 Groups in the Crossover Experiment Sequence

	Arithmetic Test Score (Mean ± SD)	
	Experiment 1	Experiment 2
Group 2	Low-GI breakfast	High-GI breakfast
Male (n = 16)	81.2 ± 16.4	76.0 ± 15.7
Female (n = 16)	77.6 ± 18.8	74.0 ± 16.5
Total (n = 32)	79.4 ± 17.4	75.0 ± 15.8
Group 1	High-GI breakfast	Low-GI breakfast
Male (n = 16)	73.6 ± 20.1	81.8 ± 12.5
Female (n = 16)	71.3 ± 17.4	82.1 ± 16.3
Total (n = 32)	72.4 ± 18.5	81.9 ± 14.3

Abbreviation: GI, glycemic index.

TABLE 4 Paired *t* Test of Arithmetic Test Score Between Low and High Glycemic Index (GI) Breakfast

Arithmetic Test Score	Mean ± SD	*P*
Low-GI breakfast	80.7 ± 15.9	0.008
High-GI breakfast	73.7 ± 17.1	

Considering the aforementioned limitations, suggestions for further research need to be followed up before findings can be translated into action. First, participants' characteristics (such as body mass index, socioeconomic, and psychological) need to be investigated to confirm whether significant results persisted, and adjustment of confounders did not attenuate the observed GI effect. It is also suggested that ad libitum meals should be provided to better reflect participants' habitual breakfast consumption rather than fixed serving. Third, more tests of cognitive function are needed (such as memory and attention), and baseline measurement should be taken into consideration. In addition, exploration of food cost and palatability are proposed in order to ensure that the meals are accessible and practical. Because the formula overestimated the GI of mixed meals, it is essential to measure continuous blood glucose during the tests to monitor postprandial glycemic responses more accurately.

In conclusion, the present pilot study found that locally based Indonesian breakfast food sources with lower GI might be beneficial for cognitive performance on an arithmetic score, just as other GI studies have found for other types of foods. Additional investigations of cognitive ability with locally based foods are needed with careful consideration of the issues noted in this study to ensure findings are valid prior to implementation in Indonesian schools.

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