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Dietary glycemic index and glycemic load and their relationship with cardiovascular risk factors in Chinese children

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Abstract: The purpose of this study is to examine the cross-sectional associations of dietary glycemic index (GI) and glycemic load (GL) with cardiovascular disease (CVD) risk factors in Chinese children. A total of 234 Chinese schoolchildren in Guangdong aged 8–11 years participated in the study. Dietary intake was assessed via a three-day dietary record. Seven established cardiovascular indicators were analyzed in this study: fasting plasma glucose (FPG), fasting triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), systolic blood pressure (SBP), and diastolic blood pressure (DBP). Higher dietary GI was significantly associated with higher TG ($P = 0.037$) levels and lower HDL-C levels ($P = 0.005$) after adjusting for age, gender, nutritional intake, physical activity, and BMI-Z score. LDL-C was found to differ across tertiles of dietary GL. The middle tertile tended to show the highest level of LDL-C. TC, FPG, and blood pressure were independent of both dietary GI and GL. Our findings suggest that higher dietary GI is differentially associated with some CVD risk factors, including lower HDL-C and higher TG, in school-aged children from South China.

Keywords: Glycemic index, Glycemic load, Children, Cardiovascular risk factors

Introduction

According to the 2011 World Health Organization report, non-communicable diseases are responsible for 63% of all deaths worldwide. In particular, deaths from cardiovascular disease (CVD) account for nearly 50% of the global mortality, resulting in 17 million deaths annually (Mendis and Alwan 2011). Hypertension, obesity, raised total blood cholesterol, and high triglyceride levels have been widely considered as modifiable cardio-metabolic risk factors (Capewell et al. 2010). Recent evidence shows that these metabolic cardiovascular risk factors begin at childhood and are predictive of CVD risk in adulthood (Berenson and Srivivasan 2005).

As diet is the first-line intervention in the prevention and treatment of CVD risk factors, many studies have been designed to assess the effect of dietary determinants on the metabolic risk factors (Kim et al. 2008; Reedy et al. 2014). Dietary carbohydrate is the main dietary component affecting insulin secretion and postprandial glycemia (PPG), which has been implicated as the cause of several chronic diseases, including CVD (Ceriello et al. 2006). The glycemic index (GI) ranks the carbohydrate content of individual foods according to their PPG effects and is expressed as a percentage of the response to an equivalent carbohydrate portion of a reference food, such as 50 g of glucose. This concept favors the use of a low glycemic index as a means of characterizing carbohydrates to help people with diabetes manipulate their dietary intake and

manage their diabetes (Jenkins et al. 1981). This approach has been extended and applied to the general population; to date, interest in the possibility that lower GI foods may be beneficial in terms of reducing disease risk has steadily grown (Atkinson et al. 2008; Chiu et al. 2011). Glycemic load (GL) is the product of the GI and total available carbohydrate content of a certain food; this value represents the quantity and quality of carbohydrates in food (Salmeron et al. 1997). Evidence from various epidemiological and interventional studies shows that low dietary GI/GL can improve CVD risk factors in Western and Asian adults with or without diabetes (Huffman et al. 2010; Juanola-Falgarona et al. 2014; Nakashima et al. 2010). However, besides obesity (Hui and Nelson 2006; Murakami et al. 2013; Rouhani et al. 2013), little is known about the relationship between dietary GI/GL and other cardiovascular risk factors, such as dyslipidemia and high blood pressure, in children. Considering previous findings, we hypothesized that dietary GI and/or GL would be positively associated with CVD risk factors in children.

The aim of the present study is to examine the association between dietary GI/GL and CVD risk factors in Chinese children aged 8–12 years. Seven established cardiovascular indicators were analyzed in this study. These factors include fasting plasma glucose (FPG), fasting triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density

lipoprotein cholesterol (LDL-C), systolic blood pressure (SBP), and diastolic blood pressure (DBP).

Materials and methods

Study participants

Schoolchildren from Guangzhou, Guangdong Province, were recruited by multistage cluster sampling. First, we randomly selected three districts from the urban area. In the second stage of sampling, four schools in the three districts were randomly selected. In the third stage of sampling, all of the students aged 8–11 years from these four schools were invited to participate in this study. Children were excluded if they had serious health problems, including any physical and psychological conditions, that could compromise their participation in the study (e.g., disabled children with serious cognitive or psychological dysfunction; children with type 1 or type 2 diabetes; children who take drugs for hypertension; children with congenital heart disease). The sample size was calculated taking into account the higher value of the variance of the lipid parameters obtained in a pilot study of 40 subjects. A confidence level of 95 %, 0.1 relative error and 0.9 power was considered. According to this data, a sample size of 250 subjects was estimated. Finally, 292 children participated in the study. After exclusion of children with missing nutritional, anthropometric, physical, and biochemical data ($n = 51$) and/or children with total energy below 500 kcal or above 4,000 kcal ($n = 7$), only 234 children were found to be

eligible for analysis. Although 234 complete samples were collected, power can reach 0.85. The study was approved by the University Research Ethics Committee. Written informed parental consent and child assent were obtained from all participants.

Dietary assessment and calculation of dietary GI and GL

Nutritional intake was assessed by a three-day dietary record (two weekdays and one day of the weekend). The parents of students were instructed to record detailed items and descriptions of all foods and beverages consumed by their children. The names, serving sizes, cooking methods, and brand names of the foods consumed were recorded. When estimating the portion sizes of food, parents were asked to use food pictures, including 12 categories of 194 kinds of food and 2 kinds of tableware; a total of 650 three-dimensional food pictures were used to assist parents in recording the sizes of food more accurately (Wang 2008). The completed three-day dietary record sheets were collected by trained researchers in the schools. We checked the information in the record sheets and clarified any vague information with the family or child using food pictures and standard eating utensils. The energy and nutrient intakes were calculated by Nutrition Calculator software, version 2.65 (Bowen Company, Beijing, China), which uses the 2002 Chinese Food Composition Tables. The intake of each food type was expressed in terms of kcal/day and g/day.

GI values (using glucose as the reference) were assigned to carbohydrate-containing foods from the 2002 Chinese Food Composition Tables and the 2008 International Tables of Glycemic Index and Glycemic Load Values (Atkinson et al. 2008; Yang et al. 2006). This method consisted of four steps: (a) Determine whether the food contains a carbohydrate content of 9% or less. If yes, assign a GI value of 0. Otherwise, proceed to the next step. (b) Determine whether there is a direct link to a food in the international GI table or the Chinese food composition tables. If yes, assign that value. Otherwise, proceed to the next step. (c) Assign a GI value according to similarity with another food. (d) Assign a GI value according to the median value for the corresponding food group. The GL of each food was calculated by multiplying the available carbohydrate content of the food by its GI.

Dietary GL was calculated by multiplying the GI value of each individual food item by the amount (g) of carbohydrate consumed from the said food item and then dividing the sum of the products by 100. Dietary GI was calculated by dividing the dietary GL by the total amount (g) of carbohydrate consumed and then multiplying this value by 100 (Wolever et al. 1991).

Anthropometric measurements and physical activity

Body height was measured to the nearest 1 mm with the participants standing upright in their bare or stockinged feet against a stadiometer. Participants were

lightly dressed, and their bodyweight was measured to the nearest 0.1 kg by a medical digital scale. BMI was calculated as W/H^2 , where W is the weight (in kg) and H is the height (in m). The BMI-for-age Z-score is a quantitative measure of the deviation of a specific BMI value from the mean of the said population; this score was calculated as described by the WHO reference from 2007 (World Health Organization 2007). The reference population used in this work is the fixed population recommended by the WHO; obesity was defined as described in the references developed by WHO. Children with a BMI Z-score of $>2SD$ were defined as obese. Blood pressure was measured from the right arm with a validated mercury sphygmomanometer (model XJ11D; China) and a TZ-1 stethoscope. Measurements were made by nurses with professional training. Each participant was seated and in a relaxed state for at least 10 min before measurement and underwent blood pressure measurements twice; the average of the two values is reported in this work. Physical activity was assessed with the “Children’s Leisure Activities Study Survey” Chinese edition questionnaire, which includes a list of common activities for daily life. The reliability and validity of this questionnaire have been confirmed in Chinese children (Huang et al. 2011). Physical activity was expressed in terms of metabolic equivalent hours per week (MET-hours/week). In this study, we calculated the moderate-to-vigorous physical activity (MVPA) for each participant.

Biochemical parameters

Blood samples were collected from all eligible subjects in the morning after overnight fasting for least 12 h. Collection was performed by nurses with professional training. Venous blood samples were taken from the antecubital vein and collected into EDTA-containing vacuum tubes. Samples were centrifuged at 3000 rpm, aliquoted, and stored at -80°C . All biochemical analyses on blood were performed at a biomedical analysis company accredited by Peking University. An indwelling venous line was used for measurements of glucose, TG, TC, HDL-C, and LDL-C levels. FPG was determined via a glucose oxidization method by using an automated autoanalyzer. Serum TC and TG were measured by routine enzymatic methods. HDL-C and LDL-C were detected by a radiommunity assay. All values are expressed as mmol/L.

Statistical analysis

A descriptive analysis of the baseline characteristics of all participants was performed in terms of frequency distribution (categorical variable), mean, and standard deviation (continuous variables). We also used computational means and percentages of demographic characteristics, physical activity, and nutrition intake to adjust for dietary energy via the residual methods (Willett et al. 1997); blood glucose and lipids were analyzed by tertiles of dietary GI and GL. Differences between variables across dietary GI and GL were evaluated by

one-way ANOVA for quantitative variables and the chi-squared test for qualitative variables.

To evaluate the relationship between dietary GI, GL, and the CVD risk factors (TC, TG, HDL-C, LDL-C, SBP, DBP, and FPG), the general linear model was used. The means of CVD risk factors were calculated for each GI/GL tertile with adjustments for confounding variables. First, Model 1 focused on age and gender. Model 2 controlled for age, gender, total energy intake (for dietary GI only), percentage of energy from available carbohydrate (%)(for dietary GI only), percentage of energy from protein (%), percentage of energy from fat (%), fiber, and physical activity. Finally, Model 3 further adjusted for the BMI-for-age Z-score. Physical activity was transformed into the natural logarithm to achieve normal distribution in the general linear model. All analyses were conducted using SPSS (version 17; SPSS Inc., Chicago, IL, USA), and all statistical tests with $P < 0.05$ were deemed significant.

Results

The characteristics of the study participants are summarized in Table 1. Among the 234 study participants, 51.3% were females and 48.7% were males. The dietary mean GI was 61.8 ± 10.3 , while the dietary mean GL was 120.6 ± 45.3 . The mean energy intakes from protein, fat, and carbohydrate were $14.7\% \pm 3.3\%$, $30.8\% \pm 8.3\%$, and $54.5\% \pm 9.3\%$, respectively.

The characteristics of study population according to the tertiles of dietary GI and GL are shown in Table 2. Higher dietary GI was associated with lower dietary fat intake ($P = 0.041$). A significant difference across dietary GI tertiles was noted for LDL-C ($P = 0.033$) and TG ($P = 0.032$). While the middle tertile of GI had the lowest LDL, this parameter was not considered a good representative of the data because the lowest and middle tertiles featured very similar LDL levels. Participants with higher dietary GLs tended to report higher intakes of carbohydrates, protein, total energy ($P < 0.001$), and dietary fiber ($P = 0.022$). Across the tertiles of dietary GL, differences in LDL-C were also observed ($P = 0.039$). In terms of physical activity, no significant differences were found between the highest and lowest tertiles of dietary GI and GL.

The mean concentrations of TC, TG, HDL-C, LDL-C, SBP, DBP, and FPG according to the tertiles of GI and GL intake are presented in Table 3. In all three models, higher dietary GI was associated with lower HDL-C. Values were adjusted according to age, gender, physical activity, total energy intake, percentage of energy from carbohydrate (%), percentage of energy from protein (%), percentage of energy from fat (%), fiber, and BMI-for-age Z-score. As GI intake increased, mean HDL-C levels decreased by 0.15 mmol/L, from 1.55 mmol/L in the lowest tertile to 1.40 mmol/L in the highest tertile ($P = 0.005$). A positive significant relationship was found between dietary GI

and TG; this relationship only existed in Model 3 ($P = 0.037$). The relationship between dietary GL and LDL-C differed across tertiles in all models, although the middle tertile tended to show the highest levels of LDL-C; no significant differences were observed between the lowest and highest tertiles. No associations were found between dietary GL and the remaining CVD risk factors.

Discussion

To the best of our knowledge, the link between dietary GI/GL and the CVD risk factors among Chinese children has not previously been documented. This school-based cross-sectional study was conducted among 8–11 year-old children in south China. The mean dietary GI and GL of all participants were 61.7 ± 10.3 and 120.6 ± 45.3 , respectively. Data on the dietary GI/GL of Chinese children have not been reported elsewhere in the literature. By comparison, the mean dietary GI and GL of children aged 9–13 in Australia (Chun Yu Louie et al. 2011) were reported to be 54.7 ± 4.6 and 149.1 ± 40.5 , respectively, in 2011. Different dietary patterns may influence dietary GI and dietary GL. Numerous traditional and special Chinese foods exist, and these can be classified according to a folk culture, district, religion, and festival. The more popular classes are divided by district, including the styles of Guangdong, Beijing, Shanghai, and North–West, among others. Our study was conducted in Guangzhou, the capital city of Guangdong. In the typical Guangdong diet, the

majority of the carbohydrates comes from processed grains, predominantly white rice. White rice has high GI values that contribute to most of the total GI of children and adults in southern China (Hui and Nelson 2006; Yu et al. 2013) this fact could explain why the dietary GI values in our study were higher than the average for Australia.

The main finding in this study is that higher dietary GI was negatively associated with the concentration of HDL-C and positively associated with TG, after controlling for probable confounders. Numerous studies in adults tend to show that low-GI diets may reduce the risk of CVD disease by reducing TG, TC, or LDL cholesterol concentrations (Goff et al. 2013; Jebb et al. 2010; Zhang et al. 2010). These diets may also raise HDL-C (Jenkins et al. 2008; Yanai et al. 2014), although not all studies show this response. In contrast to the growing number of studies on the relationship between dietary GI/GL and blood lipids in adults, little is known regarding these relationships in children.

Our results agree with a parallel-group, randomized controlled trial that was recently conducted on 22 obese children (Parillo et al. 2012); that is, changes in TG concentrations were significantly lower in low-GI diets than in high-GI diets. No differences were found between dietary GI and TC or LDL-L in our study. However, the results of a previous RCT meta-analysis of low GI diets on blood lipids in adults (Goff et al. 2013) contrasted ours; this previous work

showed evidence that low GI diets significantly reduced TC and LDL-C without affecting HDL-C or TG. This disparity of results between studies may be attributed to differences in the study populations. Despite of this, the results of the current study also indicate that low-GI diets in Chinese children are associated with more favorable lipid profiles and may be cardioprotective. Other studies have shown that low-GI diets are associated with lower high-sensitivity CRP (Wolever et al. 2008) and that PAI-1 concentrations could be used as markers of inflammation and risk of thrombosis (Jarvi et al. 1999). These mechanistic reasons could explain why low-GI diets may protect against CVD.

No differences were found between dietary GL and blood lipids or FPG, except for LDL-C. However, instead of the highest tertile, the middle tertile tended to show the highest LDL-C levels. This trend is of great interest. In adults, the relationship between GL and LDL-C has yet to be clarified. A positive correlation between GL and LDL-C has been reported in some studies (Denova-Gutiérrez et al. 2010; Levitan et al. 2008), but not in others (Castro-Quezada et al. 2015; Hosseinpour-Niazi et al. 2013). Randomized diet trials have demonstrated that diets with reduced dietary GL are an appropriate strategy to control the blood lipid levels and glucose responses of poorly controlled diabetic adults (Afaghi et al. 2012); similar results were observed in diabetic children and teenagers (Queiroz et al. 2012). The benefits of low GL in

CVD risk factors may be more obvious among diabetics than in non-diabetics. Given the scarcity of data for normal children, the results underscore the need for more prospective and intervention studies with standardized GI/GL evaluation and data collection procedures in this population.

No associations were found between dietary GI/GL and blood pressure in our study, which agrees with two other observational studies conducted in a population of adults and older-aged people (Castro-Quezada et al. 2015; Lin et al. 2012). However, another prospective study in a population of adolescent showed that high dietary GI and GL intake is associated with a modest increase in BP in adolescents, particularly in females (Gopinath et al. 2012). The disparity of our results with these previous findings may be attributed to differences in study populations.

The main strength of this study is that few reports have studied the relationship between dietary GI/GL and the abovementioned CVD risk factors in Chinese school children. This study also features some limitations. First, the cross-sectional nature of the study does not permit assessment of causality because of the uncertain temporality of the association. Therefore, the results of this study should be viewed as exploratory for hypothesis generation and interpreted with caution; future independent studies are necessary to verify these results.

The limited published GI values for several food items included in Chinese food is another limitation of this study. In contrast to Western cooking, the recipes of which are followed strictly, Chinese cooking allows for a more creative approach. Such an approach explains why Chinese food is always absent in international GI and GL tables (Chen et al. 2010). Given the scarcity of data on the GI values of Chinese traditional food, related research on this area is limited; thus, a GI database for Chinese traditional food should be established. Furthermore, we cannot discount the effects of underreporting, especially among children who consume food or beverages without the guidance of their parents; thus, actual intakes may have been underestimated to a certain extent. Despite these limitations, however, the assessment methodologies of dietary intake and GI and GL values used in this study are commonly adopted by other studies and similar to the previous studies reviewed above.

In conclusion, dietary GI is inversely associated with HDL-C concentrations but positively associated with TG concentrations after controlling for confounding factors. This indicates that diets with a low GI in Chinese children are associated with a more favorable lipid profile that may be cardioprotective..

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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Table_1 Characteristics of study participants

	Participant(n=234)
Age(year)	9.5±1.2
BMI-Z score	-0.03±1.41
Total cholesterol (mmol/L)	4.43±0.91
HDL cholesterol (mmol/L)	1.49±0.35
LDL cholesterol (mmol/L)	2.61±0.75
Triglyceride (mmol/L)	0.85±0.44
Fasting plasma glucose (mmol/L)	4.56±0.37
Physical activity (MET-hour/week)	59.7±47.5
Total energy(kcal/day)	1415.8±349.5
Protein* (g/day)	52.2±17.8
Protein (%/energy)	14.7±3.3
fat* (g/day)	47.4±15.7
fat (%/energy)	30.0±8.3
Carbohydrate* (g/day)	194.3±63.0
Carbohydrate (%/energy)	54.5±9.3
Dietary fiber (g/day)	17.7±5.1
Systolic blood pressure (mmHg)	98.6±9.4
Diastolic blood pressure (mmHg)	61.5±9.4
Diary glycemic index	61.8±10.3
Diary glycemic load	120.6±45.3

All values are the mean±SE

* Nutrient intakes were energy adjusted using the residual method

Table_2 Characteristics of the population by tertiles of dietary glycemic index and glycemic load

Characteristics*	Tertiles of dietary glycemic index				Tertiles of dietary glycemic load			
	1	2	3	P*	1	2	3	P
range	26.5-58.7	58.8-65.7	66.2-100.0	—	32.3-95.6	97.1-137.5	137.9-266.8	—
Participants (n)	78	78	77		78	78	77	
Female (%)	47.4	46.1	60.5	0.142	56.6	46.1	51.3	0.231
Age (year)	9.1±0.9	9.4±1.0	9.4±0.9	0.084	9.3±0.9	9.3±0.9	9.5±1.0	0.295
Physical activity (MET-hour/week)	54.1±37.5	68.4±57.1	57.1±45.9	0.150	61.1±49.0	57.2±41.4	61.3±52.6	0.841
Total energy(kcal/day)	1405.5±369.9	1436.1±364.5	1405.5±315.4	0.820	1172.2±247.8	1369.8±276.9	1705.1±291.0	<0.001
Protein ^a (g/day)	49.8±15.9	53.1±113.4	53.7±21.0	0.341	43.9±14.1	52.6±16.7	60.1±18.8	<0.001
Fat ^a (g/day)	50.1±16.0	48.0±14.3	44.1±14.9	0.041	47.6±14.1	46.8±15.1	47.8±16.5	0.92
Carbohydrate ^a (g/day)	186.4±64.6	197.9±71.8	198.6±51.0	0.401	141.1±37.0	183.1±33.9	258.7±48.0	<0.001
Dietary fiber (g/day)	17.5±5.7	17.1±3.6	16.4±5.9	0.409	16.3±5.1	16.5±4.7	18.3±5.5	0.022
BMI-z score	0.17±1.49	0.03±1.31	-0.32±1.47	0.096	-0.02±1.21	0.31±1.56	-0.13±1.50	0.789
TC(mmol/l)	4.34±0.97	4.40±0.73	4.56±1.01	0.307	4.47±0.66	4.53±0.34	4.32±0.94	0.408
HDL-C (mmol/L)	1.52±0.38	1.51±0.31	1.43±0.36	0.228	1.49±0.33	1.52±0.40	1.45±0.32	0.495
LDL-C(mmol/l)	2.54±0.67	2.51±0.53	2.79±0.96	0.033	2.46±0.53	2.77±0.87	2.60±0.78	0.039
TG(mmol/l)	0.75±0.33	0.84±0.42	0.94±0.54	0.032	0.79±0.36	0.84±0.47	0.91±0.48	0.213
FPG(mmol/l)	4.55±0.47	4.55±0.38	4.57±0.35	0.912	4.57±0.48	4.55±0.35	4.56±0.37	0.956
SBP(mmHg)	99.3±8.7	97.0±8.6	99.5±10.8	0.204	98.7±8.6	99.0±10.2	98.1±9.6	0.818
DBP(mmHg)	63.2±7.3	61.3±6.4	63.2±8.7	0.184	62.1±6.8	63.3±8.0	62.3±7.8	0.538

* For quantitative and qualitative variables data are shown as mean±SD and percentages, respectively.

† Nutrient intakes were energy adjusted using the residual method.

Table_3 Association between dietary glycemic index and dietary glycemic load with cardiovascular risk factors

Characteristics	Tertiles of dietary glycemic index				Tertiles of dietary glycemic load			
	low	middle	high	P	low	middle	high	P
TC(mmol/L)								
Model 1 [*]	4.49	4.44	4.63	0.274	4.41	4.51	4.43	0.613
Model 2 [†]	4.48	4.46	4.62	0.364	4.32	4.50	4.48	0.497
Model 3 [‡]	4.27	4.42	4.61	0.059	4.33	4.50	4.46	0.521
HDL-C(mmol/L)								
Model 1 [*]	1.54 [§]	1.51	1.41	0.030	1.49	1.52	1.43	0.250
Model 2 [†]	1.55 [§]	1.51	1.43	0.029	1.53	1.53	1.39	0.118
Model 3 [‡]	1.55 [§]	1.50	1.40	0.005	1.54	1.52	1.39	0.118
LDL-C(mmol/L)								
Model 1 [*]	2.56	2.51	2.77	0.056	2.50	2.77	2.56	0.044
Model 2 [†]	2.56	2.52	2.76	0.076	2.50	2.78	2.56	0.048
Model 3 [‡]	2.55	2.52	2.77	0.077	2.50	2.78	2.56	0.049
TG(mmol/L)								
Model 1 [*]	0.76	0.84	0.93	0.054	0.78	0.86	0.88	0.385
Model 2 [†]	0.77	0.85	0.92	0.132	0.79	0.85	0.87	0.764
Model 3 [‡]	0.75 [§]	0.85	0.94	0.037	0.82	0.85	0.87	0.844
FPG(mmol/L)								
Model 1 [*]	4.57	4.55	4.58	0.849	4.60	4.53	4.57	0.477
Model 2 [†]	4.57	4.55	4.57	0.933	4.61	4.53	4.55	0.548
Model 3 [‡]	4.56	4.55	4.58	0.864	4.60	4.53	4.56	0.569
SBP(mmHg)								
Model 1 [*]	99.6	96.8	99.4	0.131	98.9	99.1	97.8	0.673
Model 2 [†]	99.8	96.8	99.2	0.105	99.3	99.2	97.3	0.671
Model 3 [‡]	99.4	96.8	99.6	0.097	99.2	99.0	97.6	0.128
DBP(mmol/L)								
Model 1 [*]	63.3	61.1	63.2	0.112	62.2	63.3	62.1	0.529
Model 2 [†]	63.3	61.0	63.2	0.076	62.3	63.2	62.2	0.405
Model 3 [‡]	63.3	61.0	63.4	0.073	62.4	63.6	62.2	0.601

^{*} Model 1 adjusted for age, and gender

[†] Model 2 further adjusted for physical activity(METs/week), total energy intake (kcal/d) (for dietary GI only), percentage of energy from carbohydrate(%) (for dietary GI only), percentage of energy from protein(%),percentage of energy from fat(%), fiber(g/d). physical activity were transformed into their natural logarithm in order to achieve normal distribution in the linear regression models.

[‡] Model 3 further adjusted for BMI-for-age Z-score.

[§] Adjustments for multiple comparisons have made between any two tertile, P<0.05