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Association of diet quality during pregnancy with maternal glucose metabolism in Chinese women

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Abstract

Overall diet quality during pregnancy has played an important role on maternal glucose metabolism. However, evidence based on the adherence to the dietary guideline is limited, especially for Asian populations. We aimed to examine the association between adherence to the Chinese dietary guideline measured by the Diet Balance Index for Pregnancy (DBI-P) and maternal glucose metabolism, including gestational diabetes mellitus (GDM) status, fasting and 2-h plasma glucose. Data were obtained from the baseline survey of the Yuexiu birth cohort. We recruited 942 pregnant women at 20–28 weeks of gestation in 2017–2018. Dietary intakes during the past month were collected using a validated semi-quantitative FFQ. The scores of DBI-P were calculated to assess dietary quality. Lower absolute values of the scores indicate higher adherence to the Chinese dietary guidelines. All participants underwent a 75 g of oral glucose tolerance test (OGTT). Multiple linear regression and logistic regression were conducted. The Benjamini–Hochberg method was used to adjust multiple comparisons across DBI-P food components. The value of high bound score indicator, reflecting excessive total food intake, was positively associated with OGTT-2h glucose levels ($\beta = 0{\cdot}037$, $P = 0{\cdot}029$). After adjustment for multiple comparisons, the score of animal food intake was positively associated with OGTT-2 h glucose levels ($\beta = 0{\cdot}045$, $P = 0{\cdot}045$) and risk of GDM (OR = 1·105, $P = 0{\cdot}030$). In conclusion, excessive total food intake was associated with higher postprandial glucose in pregnant women. Lower compliance with the dietary guideline for animal food was associated with both higher postprandial glucose and increased risk of GDM during pregnancy.

Key words: Diet balance index for pregnancy: Diet quality: Glucose metabolism: Gestational diabetes mellitus: Asia

Normal pregnancy is characterised as a 'diabetogenic state' due to the increasing postprandial glucose and decreasing insulin sensitivity[1]. Considerable evidence shows that abnormal glucose metabolism during pregnancy, including hyperglycaemia and gestational diabetes mellitus (GDM), is associated with adverse health outcomes for both mother and offspring[2,3]. The incidence of GDM has risen in recent decades, posing a global public health burden[4].

While there are multiple predictors of GDM (e.g. later age at childbearing, maternal obesity and family history of type 2 diabetes mellitus)[5], maternal diet could play an important role. Most studies have examined the effect of individual food or nutrient on the risk of GDM[6,7]. However, the 'single nutrient' approach may be not enough, considering the complicated interplay among nutrients and the difficulty to assess the independent effect of each nutrient or food precisely[8]. Therefore, research increasingly focuses on overall diet quality to examine diet–diseases associations[9]. Two approaches are usually applied: *a priori* dietary index based on dietary guidelines or diets known to be healthy, and *a posteriori* dietary pattern derived from factor or cluster analysis[9]. Compared with data-driven dietary patterns, dietary index is able to evaluate

Abbreviations: DBI-P, Diet Balance Index for Pregnancy; DQD, diet quality distance; GDM, gestational diabetes mellitus; HBS, high bound score; LBS, low bound score; OGTT, oral glucose tolerance test.

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the association of adherence to the current dietary guidance and disease prevention and is conducive for comparisons across different populations[10]. Associations between posteriori dietary patterns and GDM risk have been widely investigated. However, little work has been done on dietary index and maternal glucose metabolism. The few available data suggested that adherence to the Healthy Food Intake Index (HFII)[11], the Dietary Approaches to Stop Hypertension (DASH)[12], the Mediterranean Diet Index (MDI)[12,13]and the Healthy Eating Index (HEI)[14] may lower maternal glucose levels or GDM risk. Notably, these limited studies were mostly conducted in the Caucasian population. More attention should be paid to Asian women, since this population is at greater risk of GDM than Caucasian women[15,16] and has distinct dietary habits[17].

The Chinese Diet Balance Index (DBI) was designed to assess adherence to the Dietary Guidelines for Chinese[18]. It has been widely used and verified among subgroups in China. The Diet Balance Index for Pregnancy (DBI-P) was adapted from the latest version of DBI (DBI_16) and modified according to recommendations from the Chinese dietary guidelines for pregnant women[19]. The DBI-P can evaluate the adherence to dietary guidelines and reflects overall excessive and inadequate nutrition among pregnant women[19].

To our knowledge, no study has investigated the association between adherence to dietary guidelines for pregnant women and maternal glucose metabolism by using DBI-P. Thus, we examined the association between adherence to the dietary guideline assessed by DBI-P and glucose metabolism in Chinese women.

Materials and methods

Study design and participants

Data were derived from the baseline survey of the Yuexiu birth cohort (ClinicalTrial.gov number: NCT03023293) in Guangzhou, China. We recruited pregnant women at 20–28 weeks at a maternal and child health hospital between March 2017 and September 2018. Eligible women were those aged 20–45 years, with a singleton pregnancy and accepted FFQ. Women with pre-existing metabolic, endocrine diseases (e.g. diabetes mellitus, CVD and polycystic ovary syndrome), pregnancy infection or mental disorder were excluded. Furthermore, those pregnant women who had missing records on the oral glucose tolerance test (OGTT) and had missing data on core food items were also excluded. In total, 942 pregnant women were included in this study.

The study protocol was approved by the Ethics Committee of the School of Public Health of Sun Yat-Sen University and adhered to the guidelines of the Declaration of Helsinki. All participants were carefully instructed and signed informed consent at initial enrolment.

Dietary data collection

Dietary intake during the past month before OGTT was assessed at 20–28 weeks of gestation via a face-to-face interview, using a semi-quantitative FFQ. The FFQ consisted of eighty-one food items and has been previously shown to be valid and reproducible for use among Chinese women[20]. The participants were asked to report the frequency (never, daily, weekly and monthly) and the number of servings per frequency for each of the food item. With food picture aids, trained interviewers recorded the portion size of the food consumption. Daily food intakes in grams were calculated using the product of daily frequency intake and amount of food intake per day in standard portions. In addition, dietary data were summed up by food group classifications corresponding with the Chinese Food Pagoda[21] for the calculation of DBI-P scores. The average daily intake of total energy was then computed based on the Chinese Food Composition Table[22].

Calculation of Diet Balance Index for Pregnancy

The Chinese DBI-P aims to assess the adherence to the dietary guideline among Chinese pregnant women. Lower absolute scores of the DBI-P denote greater compliance with the Chinese dietary guides for pregnancy. Food components of DBI-P include (1) cereals, (2) vegetables and fruits, (3) dairy products, soyabeans and nuts, (4) animal food (including meat, poultry, fish, shrimp and egg), (5) empty energy food (including cooking oil and alcoholic beverage), (6) condiments (including addible sugar and salt), (7) diet variety, and (8) drinking water. For each component, a score of 0 demonstrates meeting the recommended intake amounts. Positive score denotes excessive intake, while negative score indicates insufficient intake. The diet variety included twelve categories of food: rice and products; wheat and products; maize, coarse grains and products, starchy roots and products; dark-coloured vegetables; light-coloured vegetables; fruit; soyabeans and nuts; milk and dairy products; red meat and products; poultry and game; egg; and fish and shellfish. Scoring details of DBI-P can be found in Supplementary Table S1.

By summing scores for each DBI-P component, three indicators were calculated. The high bound score (HBS) indicates excessive food intake by summing all the positive scores. The low bound score (LBS) indicates inadequate food intake by summing all the absolute value of negative scores. The diet quality distance (DQD) indicates imbalanced food intake by summing the absolute values of both positive and negative scores. The ranges of scores for HBS, LBS and DQD were: 0–44, 0–72 and 0–96, respectively[18,19].

Glucose tolerance test

At 20–28 weeks, pregnant women were routinely screened for GDM with a 75-g, 2-h OGTT test. All participants had fasted overnight for at least 8 h before OGTT. OGTT-0 h glucose (fasting plasma glucose), OGTT-1 h and OGTT-2 h glucose (postprandial glucose) were measured with the glucose oxidase method. According to the International Association of Diabetes and Pregnancy Study Group, the diagnosis of GDM was made when any of the following blood glucose values was met or exceeded: OGTT-0 h, 5·1 mmol/l; OGTT-1 h, 10·0 mmol/l; and OGTT-2 h, 8·5 mmol/l[23].

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Covariates

Information on socio-demographic and health characteristics was collected during the baseline survey. Maternal age (in years) was treated as a continuous variable. The occupation was categorised into four groups (housewives, administrators and technicians, commerce and services, and others). Monthly household income was divided into four groups (≤ 4000, 4001–6000, > 6001–10 000 and > 10 000 RMB). The history of GDM was categorised into three groups (primiparae, yes and no). Family history of diabetes, smoking and alcohol use were treated as dichotomised variables (yes or no). Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ) and was expressed as metabolic equivalent tasks (MET)[24]. Data on height and pre-pregnancy weight measured by trained clinical nurses were obtained from medical records. Pre-pregnancy BMI was calculated subsequently as pre-pregnancy weight (kg) divided by height squared (m^2).

Statistical analysis

Continuous variables which normally distributed were reported as mean ± standard deviation (SD). To evaluate the differences in maternal characteristics across two groups, *t* tests or χ^2 tests were applied. Multiple linear regression and logistic regression analyses were used to evaluate the associations between scores of DBI-P (for each component and three indicators) and maternal glucose metabolism. Model 1 was adjusted for maternal age and pre-pregnancy BMI. Models 2 was further adjusted for history of GDM, family history of diabetes, smoking, alcohol use, physical activities, daily energy intake, occupation and monthly household income. The Benjamini–Hochberg method[25] was used for the *P*-value correction upon multiple comparisons across DBI-P food components. All analyses were performed with SAS 9.4 (SAS Institute). All *P*-values were two-sided, and statistical significance was determined at the *P*-value less than 0·05 level.

Results

Characteristics of the participants

The socio-demographic characteristics of the participants are presented in Table 1. The incidence of GDM was 19 % (179/942). The mean age was 30·8 ± 4·89 years, and mean pre-pregnancy BMI was 20·54 ± 2·93 kg/m^2. Compared with women without GDM, those with GDM had higher age, pre-pregnancy BMI, glucose levels, and higher percentage of history of GDM and had lower physical activity levels ($P < 0·05$).

Scores for the Diet Balance Index for Pregnancy food components and indicators of the participants

Table 2 provides the scores for DBI-P food components and indicators among the participants. The mean scores of cereals,

Table 1. Characteristics of pregnant women by the development of GDM

Characteristic	Total		GDM		Non-GDM		*P*
n	942		179	19·00	763	81·00	
	Mean	SD	Mean	SD	Mean	SD	
Age (years)	30·08	4·89	32·07	5·10	29·62	4·72	<0·001
Pre-pregnancy BMI (kg/m^2)	20·54	2·93	21·38	3·53	20·33	2·73	<0·001
Physical activities (MET-h/week)	31·40	27·27	28·23	22·33	32·13	28·26	0·048
Daily energy intake (kcal)	1803·63	500·10	1830·02	491·46	1797·43	502·22	0·433
OGTT-0 h glucose (mmol/l)	4·42	0·43	4·78	0·57	4·33	0·33	<0·001
OGTT-1 h glucose (mmol/l)	7·80	1·75	9·80	1·71	7·33	1·40	<0·001
OGTT-2 h glucose (mmol/l)	6·73	1·37	8·42	1·39	6·33	1·02	<0·001
Occupation (%)	*n*	%	*n*	%	*n*	%	0·062
Housewives	242	26·62	56	32·75	186	25·20	
Administrators and technicians	218	23·98	45	26·32	173	23·44	
Commerce and services	255	28·05	36	21·05	219	29·67	
Others	194	21·34	34	19·88	160	21·68	
Monthly household income (%)							0·940
≤ 4000 RMB	193	21·07	36	20·57	157	21·19	
4001–6000 RMB	216	23·58	40	22·86	176	23·75	
6001–10 000 RMB	229	25·00	47	26·86	182	24·56	
> 10 000 RMB	278	30·35	52	29·71	226	30·50	
Family history of diabetes (%)							0·501
Yes	142	15·14	30	16·76	112	14·76	
No	796	84·86	149	83·24	647	85·24	
History of GDM (%)							<0·001
Primiparae	357	38·22	57	32·02	300	39·68	
Yes	29	3·10	15	8·43	14	1·85	
No	548	58·67	106	59·55	442	58·47	
Smoking (%)							0·567
Yes	40	4·25	9	5·03	31	4·07	
No	901	95·75	170	94·97	731	95·93	
Alcohol use (%)							0·903
Yes	33	3·50	6	3·35	27	3·54	
No	909	96·50	173	96·65	736	96·46	

GDM, gestational diabetes mellitus; MET, metabolic equivalent task; OGTT, oral glucose tolerance test.

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Table 2. Scores for DBI-P food components and indicators by the development of GDM

Food components and indicators	Total		GDM		Non-GDM		
	Mean	SD	Mean	SD	Mean	SD	*P*
Cereal	–3·56	2·95	–3·43	3·16	–3·59	2·90	0·519
Vegetable	–2·52	1·39	–2·37	1·46	–2·55	1·38	0·120
Fruit	–1·73	1·61	–1·68	1·73	–1·74	1·59	0·654
Dairy products	–2·96	1·65	–2·97	1·64	–2·95	1·65	0·928
Soyabean and nut	–2·74	1·89	–2·83	1·86	–2·72	1·90	0·483
Animal food	–0·68	3·55	0·11	3·61	–0·86	3·52	0·001*
Meat and poultry	1·92	2·20	2·27	2·11	1·84	2·22	0·019*
Fish and shrimp	–1·77	1·29	–1·59	1·32	–1·81	1·28	0·034*
Egg	–0·83	1·84	–0·58	2·03	–0·89	1·79	0·042*
Cooking oil	1·47	1·09	1·52	1·05	1·46	1·09	0·482
Alcoholic beverage	0·05	0·31	0·03	0·26	0·05	0·32	0·401
Addible sugar	1·04	1·11	0·94	1·11	1·06	1·11	0·188
Salt	0·95	0·80	0·90	0·71	0·96	0·82	0·337
Diet variety	–2·79	1·85	–2·58	1·93	–2·84	1·83	0·083
Drinking water	–4·91	2·99	–4·74	2·84	–4·95	3·02	0·398
HBS	6·29	3·15	6·69	3·11	6·20	3·16	0·062
LBS	24·68	9·22	23·79	9·40	24·88	9·18	0·153
DQD	30·97	8·77	30·47	8·94	31·08	8·73	0·405

DBI-P, Diet Balance Index for Pregnancy; GDM, gestational diabetes mellitus; HBS, high bound score; LBS, low bound score; DQD, diet quality distance.

vegetables, fruits, dairy products, soyabeans and nuts, fish and shrimp, egg, diet variety, and water and soup were negative, indicated insufficient intake and low variety. In contrast, the mean scores of meat and poultry, cooking oil, alcoholic beverage (scores near to 0), addible sugar, and salt were positive, indicating excessive intake. The mean scores for HBS, LBS and DQD were 6·29, 24·68 and 30·97, respectively. Further details of scores distribution of components and indicators were provided in Supplemental Table S2 and Supplemental Table S3. As shown in Table 2, participants with GDM had higher score of animal food intake than those without GDM ($P < 0·05$).

Scores for the Diet Balance Index for Pregnancy food components and indicators in relation to plasma glucose levels

Tables 3 and 4 present the multiple linear regression models for OGTT glucose levels by DBI-P food components and indicators. After adjustment for potential confounding factors and multiple comparisons, higher score of animal food intake (β: 0·045; SE: 0·015; $P = 0·045$) was significantly associated with higher OGTT-2 h glucose levels. No significant association was observed between scores of other food components and maternal glucose levels. After adjustment for potential confounding factors, higher value of HBS (β: 0·037; SE: 0·017; $P = 0·029$) was significantly associated with higher OGTT-2 h glucose levels. No significant associations were observed between the values of LBS, DQD and maternal glucose levels.

Scores for the Diet Balance Index for Pregnancy food components and indicators in relation to gestational diabetes mellitus

Table 5 shows the association of food components and indicators for DBI-P with risk of GDM. After adjustment for potential confounding factors and multiple comparisons, score of animal food intake (OR = 1·105, 95 % CI 1·038, 1·176) was positively associated with the risk of GDM. No significant relationships were observed between DBI-P indicators and GDM risks.

Discussion

This is the first study that has investigated the association between adherence to dietary guidelines during pregnancy and maternal glucose metabolism based on DBI-P. The current study showed that overall excessive food intake was positively associated with OGTT-2 h glucose levels. Of the DBI-P food components, excessive intake of animal food was associated with higher postprandial glucose levels and an increased risk of GDM.

Higher score of HBS in DBI-P reflects higher degree of overnutrition. Overnutrition may occur due to excessive intake of certain foods such as meat and poultry, cooking oil, addible sugar and salt, which dietary guidelines suggest consuming moderately or less[18]. In our study, higher HBS score was associated with higher OGTT-2 h glucose levels. Consistent with this result, a Finnish study showed that higher adherence to the Nordic Nutrition Recommendations (NNR) evaluated by HFII was associated with lower OGTT-2 h glucose load[11]. Data from a non-interventional, multi-centre study indicated that adherence to the healthy Mediterranean diet was associated with better glucose tolerance and lower GDM risk in ten Mediterranean countries[13]. Further, a study conducted in Iceland found the HEI, which is based on the dietary recommendations for Americans, was associated with decreased risk of GDM[14]. However, null associations were found in Australian women, whose diet quality was assessed by the Australian Recommended Food Score (ARFS)[26]. Only 4 % of GDM cases were identified by self-report in this Australian study[26]. The prevalence of GDM determined from self-report may be underreported, which probably results in a loss of statistical power[27]. Vajihe *et al.* reported that the Mediterranean and DASH diets

Table 3. Multiple linear regression of scores for DBI-P food components with maternal glucose levels

Food components	OGTT-0 h glucose			OGTT-1 h glucose			OGTT-2 h glucose		
	β	SE	P	β	SE	P	β	SE	P
Cereal									
Model 1	0·006	0·005	0·656	–0·003	0·019	0·942	0·002	0·015	0·907
Model 2	0·013	0·007	0·594	–0·062	0·030	0·229	–0·030	0·023	0·489
Vegetable									
Model 1	0·001	0·010	0·923	0·004	0·040	0·942	0·028	0·032	0·707
Model 2	0·002	0·012	0·867	–0·041	0·047	0·643	0·019	0·037	0·833
Fruit									
Model 1	–0·003	0·009	0·894	0·017	0·035	0·925	0·022	0·027	0·722
Model 2	–0·006	0·010	0·824	0·001	0·040	0·996	0·020	0·031	0·833
Dairy products									
Model 1	0·008	0·009	0·656	0·085	0·035	0·075	0·016	0·027	0·801
Model 2	0·008	0·010	0·713	0·077	0·041	0·229	–0·005	0·032	0·885
Soyabean and nut									
Model 1	–0·009	0·007	0·656	0·047	0·030	0·264	0·023	0·024	0·707
Model 2	–0·011	0·009	0·594	0·025	0·035	0·719	0·015	0·027	0·833
Animal food									
Model 1	0·001	0·004	0·923	0·052	0·016	0·015	0·042	0·012	0·015
Model 2	–0·001	0·005	0·867	0·050	0·020	0·165	0·045	0·015	0·045
Meat and poultry									
Model 1	–0·007	0·006	0·656	0·065	0·026	0·075	0·047	0·020	0·110
Model 2	–0·010	0·007	0·594	0·045	0·030	0·340	0·028	0·023	0·489
Fish and shrimp									
Model 1	–0·004	0·011	0·894	0·068	0·044	0·264	0·069	0·035	0·141
Model 2	–0·003	0·012	0·867	0·048	0·048	0·596	0·067	0·037	0·274
Egg									
Model 1	0·010	0·008	0·656	0·068	0·031	0·101	0·055	0·024	0·110
Model 2	0·012	0·008	0·594	0·065	0·033	0·229	0·062	0·025	0·113
Cooking oil									
Model 1	0·006	0·013	0·894	0·018	0·053	0·925	0·019	0·041	0·801
Model 2	0·014	0·013	0·675	–0·001	.0556	0·973	0·012	0·043	0·885
Alcoholic beverage									
Model 1	0·013	0·046	0·894	–0·215	0·186	0·413	–0·071	0·146	0·801
Model 2	0·019	0·046	0·841	–0·221	0·186	0·506	–0·050	0·144	0·885
Addible sugar									
Model 1	0·014	0·013	0·656	–0·004	0·051	0·942	0·010	0·040	0·861
Model 2	0·018	0·013	0·594	–0·026	0·054	0·859	–0·006	0·041	0·885
Salt									
Model 1	0·008	0·018	0·894	–0·027	0·072	0·925	0·022	0·056	0·801
Model 2	0·009	0·018	0·841	–0·012	0·074	0·973	0·035	0·057	0·833
Diet variety									
Model 1	–0·007	0·008	0·656	0·038	0·031	0·413	0·042	0·024	0·195
Model 2	–0·010	0·010	0·675	0·010	0·039	0·973	0·038	0·030	0·489
Drinking water									
Model 1	–0·005	0·005	0·656	0·033	0·019	0·252	0·030	0·015	0·141
Model 2	–0·004	0·005	0·713	0·033	0·020	0·294	0·032	0·016	0·210

DBI-P, Diet Balance Index for Pregnancy; OGTT, oral glucose tolerance test; GDM, gestational diabetes mellitus.
Model 1 was adjusted for age and pre-pregnancy BMI.
Model 2 was adjusted for age, pre-pregnancy BMI, family history of diabetes, history of GDM, smoking, alcohol use, physical activities, daily energy intake, occupation and monthly household income.
For DBI-P food components, *P*-values were further adjusted for multiple comparisons using the Benjamini–Hochberg method.

were associated with decreased risk of GDM in Iranian pregnant women[12].

The indicator DQD and LBS were used to evaluate the imbalanced and insufficient dietary intake, respectively[18]. The imbalance of dietary intake of our study participants was mainly due to insufficient intake. The score of water and soup accounted for the largest proportion of LBS score. In contrast, other healthy food components such as fruits and vegetables occupied a relatively small proportion. This may explain the null association between LBS and maternal glucose metabolism. Few studies have evaluated the diet quality of pregnant women with glucose metabolism, using priori dietary indices. Furthermore, most existing studies have focused on Western population. Due to differences in dietary intakes between Western and Eastern countries and the higher prevalence of GDM within the Asian population[16], more epidemiological studies are needed in Asian population.

Score for the total animal food is the sum of scores for meat, poultry, fish, shrimp and egg. In this study, total animal food intake was positively associated with postprandial glucose levels and GDM risk. However, when meat, poultry, fish, shrimp and egg were analysed separately, we found no significant association. This may suggest that the effect of combined dietary factors may be more easily detectable than that for isolated nutrients and foods[9]. Excessive intake of animal fat during pregnancy was observed in previous studies[28,29]. Participants with GDM

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Table 4. Multiple linear regression of scores for DBI-P indicators with maternal glucose levels

	OGTT 0-h glucose			OGTT 1-h glucose			OGTT 2-h glucose		
DBI-P indicators	*β*	SE	*P*	*β*	SE	*P*	*β*	SE	*P*
HBS									
Model 1	0·002	0·004	0·592	0·036	0·018	0·046	0·039	0·014	0·006
Model 2	0·004	0·005	0·411	0·020	0·022	0·359	0·037	0·017	0·029
LBS									
Model 1	0·000	0·002	0·809	–0·013	0·006	0·034	–0·010	0·005	0·040
Model 2	0·001	0·003	0·811	–0·014	0·010	0·169	–0·015	0·008	0·055
DQD									
Model 1	0·001	0·002	0·652	–0·010	0·007	0·128	–0·006	0·005	0·237
Model 2	0·001	0·002	0·593	–0·007	0·009	0·416	–0·005	0·007	0·440

DBI-P, Diet Balance Index for Pregnancy; OGTT, oral glucose tolerance test; HBS, high bound score; LBS, low bound score; DQD, diet quality distance; GDM, gestational diabetes mellitus.
Model 1 was adjusted for age and pre-pregnancy BMI.
Model 2 was adjusted for age, pre-pregnancy BMI, family history of diabetes, history of GDM, smoking, alcohol use, physical activities, daily energy intake, occupation and monthly household income.

Table 5. Association between food components and indicators of DBI-P and risk of GDM

	Model 1			Model 2		
Food components and indicators	OR	95 % CI	*P*	OR	95 % CI	*P*
Food components						
Cereal	1·035	0·976, 1·097	0·493	1·029	0·939, 1·128	0·713
Vegetable	1·060	0·937, 1·198	0·592	1·071	0·928, 1·237	0·625
Fruit	1·015	0·912, 1·129	0·905	1·000	0·884, 1·132	0·996
Dairy products	0·991	0·890, 1·102	0·926	0·964	0·849, 1·094	0·713
Soyabean and nut	0·933	0·850, 1·023	0·432	0·884	0·790, 0·989	0·155
Animal food	1·085	1·032, 1·140	0·015	1·105	1·038, 1·176	0·030
Meat and poultry	1·135	1·043, 1·234	0·023	1·123	1·018, 1·238	0·150
Fish and shrimp	1·136	0·993, 1·299	0·315	1·143	0·985, 1·326	0·289
Egg	1·070	0·977, 1·173	0·432	1·083	0·980, 1·196	0·351
Cooking oil	1·045	0·890, 1·227	0·805	1·033	0·872, 1·223	0·818
Alcoholic beverage	0·811	0·433, 1·517	0·767	0·815	0·431, 1·543	0·713
Addible sugar	0·963	0·818, 1·134	0·816	0·924	0·776, 1·100	0·625
Salt	0·878	0·700, 1·102	0·493	0·896	0·706, 1·138	0·625
Diet variety	1·064	0·966, 1·171	0·493	1·079	0·952, 1·223	0·588
Drinking water	0·998	0·942, 1·057	0·941	0·999	0·938, 1·063	0·996
Indicators						
HBS	1·067	1·011, 1·126	0·018	1·065	0·996, 1·139	0·066
LBS	0·992	0·974, 1·011	0·428	0·992	0·961, 1·025	0·635
DQD	1·000	0·980, 1·020	0·981	1·005	0·978, 1·033	0·733

DBI-P, Diet Balance Index for Pregnancy; GDM, gestational diabetes mellitus; HBS, high bound score; LBS, low bound score; DQD, diet quality distance.
Model 1 was adjusted for age and pre-pregnancy BMI.
Model 2 was adjusted for age, pre-pregnancy BMI, family history of diabetes, history of GDM, smoking, alcohol use, physical activities, daily energy intake, occupation and monthly household income.
For DBI-P food components, *P*-values were further adjusted for multiple comparisons using the Benjamini–Hochberg method.

showed excessive intake of animal food and had a higher consumption of animal food than women without GDM in our study. Many 'single food' studies have found that higher consumption of red meat, processed meat and egg were associated with higher maternal glucose levels and an increased risk of GDM[30,31]. Previous study also showed that seafood pattern was associated with a higher risk of GDM[17,32]. The potential mechanism by which the intakes of animal food may influence the GDM risk is complex. Animal food are rich in saturated fat, which may advance obesity, a leading risk factor for GDM[5]. In addition, animal food such as egg, meat and poultry are sources of cholesterol, heme iron, advanced glycation end products, and amino acids, which can cause β-cell damage, decreased insulin secretion or insulin resistance[31,33–37]. Furthermore, fish and shrimp are the main contributors to arsenic, which have been shown to be associated with increasing insulin resistance, decreasing insulin sensitivity and impairing insulin production[38–42].

In the present study, no significant association was observed between vegetables or fruits and maternal glucose metabolism. Dietary intake enriched with plant-derived foods, such as vegetables and fruits, presents a low glycaemic pattern and may has a favourable impact on the incidence of GDM[43]. We speculate that the null association in our study may be due to the little variation of vegetables and fruits intakes among study participants. Analyses with alcoholic beverage also showed no significant association with maternal glucose metabolism. Supplementary Table S2 showed that only 2·44 % of the participants reported alcohol consumption. In contrast, a Norwegian study found that not all dietary recommendations were followed during pregnancy, with 35 % of the women reported alcohol consumption causing for concern[28]. The low intake of alcohol in our study may make it hard to discover the harmful influence of alcohol.

This study has several limitations. First, owing to the observational nature of our study, we cannot rule out all the residual confoundings and mediators such as gestational weight gain[44]. However, our analysis has accounted for many confounding factors including physiological characteristics, socio-demographic characteristics, physical activity and energy intake. Second, the association of certain healthy nutrients (PUFA, Ca, vitamin D, etc)[45,46] and glucose metabolism could not be evaluated by DBI-P. However, the DBI-P consist of three dietary indicators and diverse food components covering all aspects of a healthy diet, which allows us to observe the potential diet–disease association resulting from cumulative intakes of food groups. Third, causation could not be established from this observational study. However, the causal inversion can be ruled out in our study, since habitual dietary intake was collected before the OGTT test and any diet intervention.

Conclusions

We found that the excessive total food intake, particularly animal food intake, was associated with higher postprandial glucose in pregnant women. High animal food intake during pregnancy was also associated with increased risk of GDM.

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Supplementary material

For supplementary material/s referred to in this article, please visit ·https://doi.org/10·1017/S0007114523000107

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