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Lowering Dietary Glycaemic Index through Nutrition Education among Malaysian Women with a History of Gestational Diabetes Mellitus

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ABSTRACT

Introduction: Gestational diabetes mellitus (GDM) increases risks for type 2 diabetes and cardiovascular diseases. Low glycaemic index (GI) diets improve cardio-metabolic outcomes in insulin-resistant individuals. We examined the feasibility of lowering GI through GI-based-education among Asian post-GDM women. **Methods:** A 3-month investigation was carried out on 60 Malaysian women with a mean age of 31.0±4.5 years and a history of GDM. Subjects were randomised into two groups: LGIE and CHDR. The CHDR group received conventional healthy dietary recommendations only. The LGIE group received GI based-education in addition to conventional healthy dietary recommendations. At baseline and after 3-months, dietary intake of energy and macronutrient intakes including GI diet and glycaemic load was assessed using 3-day food records. Diabetes-Diet and GI-concept scores and physical activity levels were assessed using a questionnaire. Adherence to dietary instructions was measured at the end of 3 months. **Results:** At the end of 3 months, the LGIE group had significant reductions in energy intake (241.7±522.4Kcal, P=0.037, ES=0.463), total carbohydrate (48.7±83.5g, P=0.010, ES=0.583), GI (3.9±7.1, P=0.017, ES=0.549) and GL (39.0±55.3, P=0.003, ES=0.705) and significant increases in protein (3.7±5.4g, 0.003, ES=0.685) and diet fibre (4.6±7.3g, P=0.06). The CHDR group had a significant reduction in fat only (5.7±9.4g, P=0.006, ES=0.606). There was a 30% increase in GI-concept scores in the LGIE group ($p < 0.001$). Changes in GI-concept scores correlated significantly to the reduction in dietary GI (r = -0.642, P=0.045). Dietary adherence was comparable in both groups. **Conclusion:** GI-education improves GI-concept knowledge and helps lower dietary glycaemic index among women with a history of GDM.

Keywords: Diet, gestational diabetes mellitus, glycaemic index, glycaemic load, prevention, type 2 diabetes

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INTRODUCTION

Gestational diabetes mellitus (GDM), an impairment in glucose tolerance during pregnancy, increases risk for development of type 2 diabetes mellitus (T2DM) (Ratner, 2007). Women with previous GDM manifest insulin resistance with 50-60% of them developing T2DM during their lifetime (Metzger *et al.*, 2007). Furthermore, Asians have a higher rate of GDM converting to T2DM (Oldfield *et al.*, 2007). GDM also increases the risk of cardiovascular diseases (Metzger *et al.*, 2007).

To mitigate and manage the risk, weight-loss through lifestyle modification is recommended to these women (Metzger *et al.*, 2007). Conventional recommendations encourage energy-controlled diets high in fibre and whole grains and low in fat (NHLBI, 1998). These recommendations have had limited success in GDM women and few of them achieve weight loss after pregnancy (Stage, Ronneby & Damm, 2004). Meanwhile, evidence suggests that insulin resistance and secretion influence body weight regulation (Pereira *et al.*, 2004). Dietary glycaemic index (GI) and glycaemic load (GL= GI*available carbohydrate (g)), manipulate post-prandial glycaemia and modulate insulin resistance (Pereira *et al.*, 2004). Therefore, lowering GI and GL improves weight-loss especially in hyper-insulinaemic individuals (Pittas *et al.*, 2005). Epidemiological studies have also shown positive associations of GI, GL, with body mass index (BMI) and risk for chronic diseases (Barclay *et al.*, 2008). Hence, a low-GI diet may be potentially beneficial for insulin-resistant healthy individuals, in managing cardio-metabolic risks (Riccardi, Rivellese & Giacco, 2008).

Nevertheless, the feasibility of lowering dietary GI through nutrition education in the free-living Asian population remains unknown. The lack of availability of low-GI foods (Riccardi *et al.*, 2008, Yusof, 2008), and the absence of GI labelling (Brand-Miller, Barclay and Irwin, 2001) may particularly affect the practicality of such an intervention in Asia. We evaluated the feasibility of lowering GI of healthy diets through nutrition education among Asian post-GDM women, in the current Malaysian context. In this investigation, involving Asian women post-GDM, we hypothesised that subjects receiving additional GI-education would significantly lower their dietary GI compared with those who only received conventional healthy dietary recommendations. This investigation was part of a longer one-year trial that aimed at comparing the effectiveness of the two nutrition interventions in managing cardio-metabolic risks among women with a history of GDM.

METHODS

The project received ethic approvals from International Medical University (IMU) and Universiti Kebangsaan Malaysia Medical Centre (UKMMC). The trial was conducted at the endocrinology unit of UKMMC, Kuala Lumpur. The study is registered with Malaysian National Medical Research Register with Research ID: 5183.

Subjects

Healthy, 20–40 year old Asian women with previous GDM pregnancies (WHO, 2006, criteria) were recruited after a lapse of at least two months since their last-GDM delivery. Further inclusion criteria required that subjects satisfy one of the following conditions that increases risk for T2DM: - body mass index (BMI)>23 kg/m^2(WHO Expert Consultation, 2004), waist circumference (WC)>80cm (WHO Expert Consultation, 2004), dysglycaemia on the screening oral glucose tolerance test (OGTT) (WHO, 2006 criteria used) or a family history of diabetes. Subjects with current diagnosis of diabetes, BMI>40kg/m^2 or BMI<19 kg/m^2 and those enrolled in weight loss programmes were excluded. Subjects with underlying health complications or those on drugs altering study outcomes were also excluded. Subjects who became pregnant during the trial were withdrawn. Written informed consent was obtained from all participants.

All GDM deliveries registered in the institution between January and September 2009 were screened for eligibility. The study was conducted as per Consolidated Standards of Reporting Trials (CONSORT) procedures (Figure 1).

Randomisation

Eligible subjects were randomised according to an allocation list (allocation ratio1:1) generated using randomisation software from John Hopkins Division of Biostatistics. Blocking was used to ensure close distribution of numbers in each group. The researchers were unaware of the block sizes used. Participants were randomised into two groups: CHDR and LGIE. The CHDR group only received conventional healthy dietary recommendations, while the LGIE group received GI-education in addition to the former. Due to the nature of the intervention, blinding was not possible. However, laboratory technicians and physicians reviewing the subjects were blinded to the randomisation.

Dietary intervention

During the one-year trial period, the dietary protocol aimed at achieving approximately 7% reduction in body weight if initial BMI was >23 and to maintain weight if BMI was <23, (NHLBI, 1998). American Heart Association's (AHA) dietary recommendations were taken to represent Conventional Healthy Dietary Recom-mendation (CHDR), since it lowers risk for T2DM and cardiovascular diseases in high risk individuals (Krauss *et al.*, 2000). It is also in line with Malaysian Clinical Practical Guidelines for diabetes prevention. A sample diet plan based on calculated individualised energy requirements (ER) was prepared for all subjects. ER was calculated as basal metabolic rate (BMR) multiplied by an appropriate activity factor (1.2 - sedentary, 1.325 - moderately active and 1.55 - heavy workers) (Rashad, 2006). BMR was calculated using Harris Benedict Equation. If the subject had a BMI>23 and was not breast feeding, energy prescription (EP) was reduced by 500 Kcal. If BMI was<23 or the subject was exclusively breast feeding an infant <6 months of age, ER was the EP. EP was rounded to nearest hundred and capped at 1800 Kcal/day. The proportion of energy contribution from macronutrients was based on AHA recommendations (Krauss *et al.*, 2000).

Nutrition education was primarily imparted to both groups through a single structured one-to-one nutrition education session at the baseline visit, by a research nutritionist. Subjects were taught about the types of diabetes, its risk factors, symptoms and complications, gestational diabetes and its consequences. The importance of maintaining ideal body weight, to prevent diabetes was emphasised. Malaysian Ministry of Health's 5M approach (minimise salt, sugar, and oil, more fruit and vegetables) was used to achieve CHDR (available at *http://www.mpkluang.gov.my/*). A sample menu for the EP was planned along with subjects during the baseline visit using an individualised diet sheet showing the number of servings of each food group they needed per-day. Concepts of serving size and food exchange were taught to both groups. Information on the benefits of exercise, and some practical pointers to enable small attitude changes that help reduce weight were provided. Both groups were also asked to indulge in moderate physical activity for a minimum of 30min, five times a week, targeting a physical activity level (PAL) of 600MET-min/week.

The LGIE group, in addition to all aspects of education detailed above, received a GI-education component at baseline nutrition education session. The GI-education taught them to substitute high-GI foods with low-GI options. Since staple foods

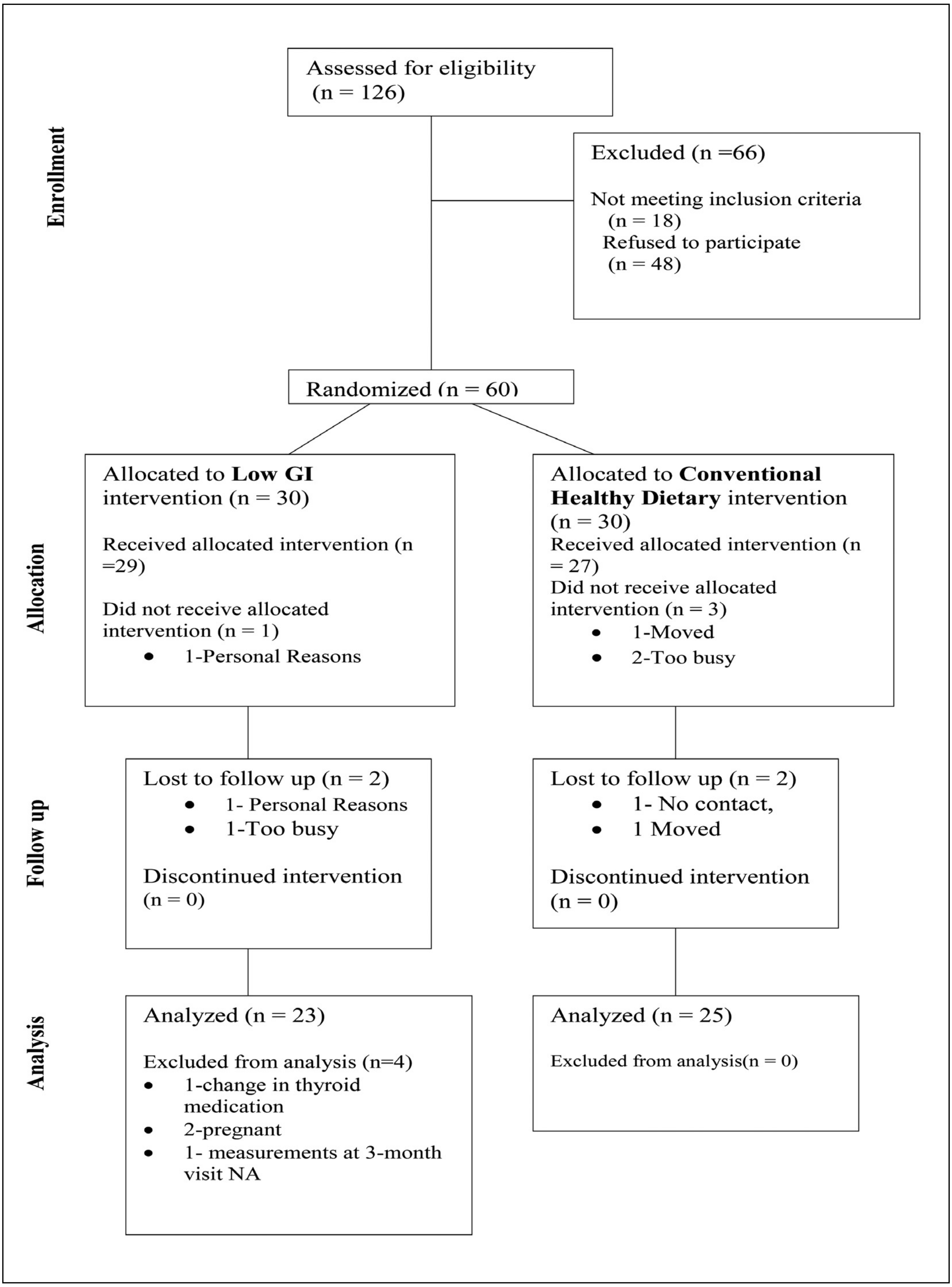

Figure 1. Consolidated standards of reporting trials (CONSORT) diagram of the flow of participants

primarily determine GI, subjects were educated to select low-GI staple foods, namely substituting high-GI rice, bread and breakfast cereals with available low-GI options such as Basmati or brown rice and low-GI multigrain bread (Amano *et al*., 2007). Restricting rice consumption to once per-day, opting for low-GI staple options like noodles or spaghetti at other times and increased consumption of legumes within the prescribed diet, were other strategies used to lower GI. This was necessary since the most widely consumed varieties of local rice were high in GI (Yusof, Talib & Karim, 2005). Numerical GI values of foods were not provided, but foods were classified as high, moderate and low-GI foods to enable easy comprehension. LGIE subjects were asked to include at least one low-GI food during each meal. The GI reference table provided to the subjects is presented in Table 1.

Additionally, similar take-home booklets were provided to both groups of subjects to aid retention and reinforcement of the education provided at baseline. The booklets provided a printed reference of all information discussed during the baseline education visit. The booklets for the two groups were colour coded for easy identification, but otherwise similar in terms of the layout, size and organisation. Content wise, the LGIE group booklets had three additional pages to detail the GI-concept and a GI food reference was included under this section (Table 1). The GI-section was not included in the CHDR booklets. Booklets were made available in English or Malay, as per subject's preference. Vouchers for low-GI bread were made available to LGIE subjects to familiarise them with the relatively new low-GI concept and increase dietary adherence (Yusof, 2008). The vouchers allowed the subjects to receive up to three loaves of low-GI multigrain bread per week (with tested GI value of 42) from pre-assigned shops.

The frequency of contacts was similar between the groups. To keep the study groups motivated, a protocol for two electronic contacts per-month was established. One such opportunity was used to provide information related to diabetes prevention (healthy diet and living) through email/short messaging service (SMS) as per subject's preference for mode and language. The other contact was an SMS reminder to follow recommendations. These modes of communication were chosen, to ease time and travel constraints for subjects.

Measurement of outcome variables

Socio-demographic details were obtained with a simple questionnaire during screening. Dietary intake, knowledge scores, and PAL were measured at baseline and after 3-months. All assessments were done by a single researcher to avoid inter-observer variability.

Dietary intake

Dietary intake was assessed using 3-day food records (for two weekdays and one day of the weekend) collected at baseline and after 3 months of intervention. Subjects were trained to use 3-day food records at the screening visit. Pictures of household utensils were provided to assist subjects with recording food amounts. A research nutritionist reviewed all food records with the subjects at each visit, to ensure completeness of entries. Plausible dietary intake reporters were defined as those with EI: BMR between 1.2 and 2.4. Low-energy-reporters (LER) had EI: BMR<1.2 and over-reporters had an EI: BMR> 2.4 (Black, 2000).

Nutrient intake was calculated using DietPLUS Version3, an Excel-based Malaysian food composition database with nutrient, GI and GL calculators (Shyam, Kock Wai & Arshad, 2012). The GI and GL calculators were programmed using GI value assignment to foods with unknown local GI values from those published in the international GI database (Shyam *et al*., 2012). GL was calculated as the product of GI and carbohydrate intake divided by 100

Table 1. Reference glycaemic index used in the study for LGIE group

Food	*Low GI*	*Moderate GI*	*High GI*
Recommendation	*Encouraged*	*Moderation advised*	*Discouraged*
Cereals and grains			
Rice 1 serving (1/2 cup of cooked rice)	Parboiled	Basmati rice, brown rice, White rice with yoghurt (curd rice)	White rice, fragrant rice, Jasmine rice, glutinous rice
Bread (1 serving = 1 std bread slice size)	Multi-grain bread	Pita bread, Chappati made from wheat atta with dhal	White bread, whole-meal bread
Breakfast Cereal 1 serving = ½ cup	All bran, museli, Coarse oat bran	Quick Cooking/ Instant Oats	Cornflakes, chocolate coated cornflakes, sugar coated cornflakes
Noodle and pasta 1 serving= ½ cup	Macaroni, fettuccini spaghetti , noodles	Udon noodles plain	Kuew teow (fried) Rice noodles (fried)
Biscuits 1 serving= 3 pieces	Cream crackers - high calcium	Digestive biscuits, Whole Meal biscuits, oatmeal biscuits	Wafers, sugar coated biscuits
Vegetables (serving size as advised)	Green peas, carrot, green vegetables	Sweet corn, sweet potato, yam	Pumpkin, tapioca potato
Fruits (serving size as advised)	Apple, orange, pear, plum, strawberry, dates	Grapes, banana, papaya, mango, raisins, pineapple	Watermelon, lychee
Legumes and nuts (serving size as advised)	Baked beans, Kidney beans, soya beans, chick peas, lentils (dhal), mung beans, dried peas	-	-
Dairy products (serving size as advised)	Skim milk, low fat milk , low fat yoghurt	Condensed sweetened milk	-

LGIE: Low-GI Group; CHDR: Conventional Healthy Dietary Recommendation Group

(Yusof, 2008). Diet GL was calculated by summing GL of foods consumed in the day and diet GI, as-per the formula Diet GI= Diet GL*100/ amount of carbohydrate in diet (Yusof, 2008). Using DietPLUS ensured that all dietary intakes including diet GI and GL were calculated in a single step. Also, foods were assigned a particular GI value consistently at all times.

Dietary adherence

Dietary adherence was measured using self-reported and calculated dietary adherence scores as described previously (Dansinger *et al*., 2005). Self-reported adherence scores were subjective and reported by subjects based on their self-evaluation of their adherence to dietary instructions as a whole. Subjects were asked to self-report adherence as a percentage score from 0-100 (where, 0% = no adherence, 100% = total adherence).

Calculated adherence scores used mathematic modelling to objectively calculate adherence as the ratio of the change achieved to change suggested. Adherence scores ranged between 0 and 1, (0 =no adherence, 1 = total adherence) (Dansinger *et al*., 2005). Changes in energy intake (EI), percentage of calories from fat (fat en %) and additionally, for LGIE group, changes in GI were calculated to measure dietary adherence. The algorithm for calculating adherence scores is provided in Table 2. Total adherence score was finally calculated as an average of two adherence aspects (EI and fat intake) for CHDR and three aspects for LGIE (EI, fat intake and diet GI) groups.

Physical activity level assessments

Validated English and Malay versions of International Physical Activity (IPAQ) - Short Questionnaire were used to assess Physical activity levels (PAL). PAL was expressed as MET-min per week (metabolic equivalents per minute). Calculation of PAL using the IPAQ short form requires summation of the duration (in minutes) and frequency (days) of walking, moderate-intensity and vigorous-intensity activities. Subjects were categorised based on their total MET-min per week scores into low, moderate and high PAL according to IPAQ-Short scoring protocol. Low activity included individuals who did not meet the criteria for moderate and vigorous intensity categories (<600 MET-min/week). Individuals achieving a minimum of at least 600 MET-min/week were placed under moderate PAL category. High PAL categorically was taken to represent those who achieved a minimum of 3000 Met-min/ week. (International Physical Activity Questionnaire (IPAQ) Research Group, November 2005).

Concept-knowledge assessments

Questionnaires to assess diet-diabetes knowledge and GI-concept were administered at baseline and after 3 months of intervention. Questions to assess diet-diabetes knowledge (Pamenter & Wardle, 1999; Pierce *et al*., 2001; Yusof, 2008) and GI-concept (Burani, 2006; Yusof, 2008) were drawn from previously published questionnaires. The questionnaires were checked for content and face validity, cultural appropriateness, discrimination and coding. The questionnaires were also translated into Malay and verified through back-translation procedures. The questionnaire was pre-tested on 57 women who did not participate in this study, but were in the

Table 2. Algorithm for dietary adherence score calculation

Calculated Score	*interpretation*	*Dietary adherence score*		
		Energy intake	*Fat intake*	*Diet GI reduction**
0	Zero adherence	EI>EP	Fat en% >30en%	Increase in GI
1	Total adherence	EI≤EP	Fat en% ≤30en%	GI ↓ ≥ 10 points
Between 0 and 1	Partial adherence that not meeting prescribed levels.	Partial ↓ EI, not reaching recommended EI reductions	↓ Fat en% that not reaching recommended ≤30en%,	↓ GI <10points
		DAS (EI) = Achieved ↓ EI /Prescribed ↓ EI	DAS (fat en%) = Achieved ↓ fat en% / Prescribed ↓ fat en%	DAS (GI) = achieved ↓ GI / prescribed ↓ GI

*- Only calculated for Low- GI group, EI: energy intake, EP: energy prescribed, GI: glycaemic index, ↓: reduction

same age group (20-40y). The questionnaire was then tested for internal consistency using Cronbach-α for each of the two sections. The finalised version of the questionnaire had 15 items for diet-diabetes knowledge assessment and 15 items for GI-concept. The questionnaires used a multiple choice format. The diet-diabetes knowledge questionnaire included questions on physiology of diabetes and concepts of healthy diets in diabetes prevention and had a maximum possible score of 22. The GI questionnaire included simple questions relating to ranking glycaemic response elicited by foods, in accordance to the educational content provided and a maximum possible score of 15. The Cronbach-α values for the diet-diabetes and GI-concept sections of the questionnaire in the pilot-test were 0.66 and 0.75 respectively. The values are close or above the widely accepted cut-off value of 0.70.

The responsiveness score was used to estimate how well the knowledge assessment questionnaires measured concept-knowledge score changes due to the intervention. Responsiveness was calculated as a ratio of mean change in score to the standard deviation of the change in score after intervention (Kirshner & Guyatt, 1985). These scores demonstrate the ability of questionnaires to evaluate changes in knowledge scores after intervention (Kirshner & Guyatt, 1985).

Statistical analyses

Glycaemic management was the primary objective for the complete one-year trial. The sample size was calculated to detect a clinically significant difference of 1.5mmol/L (Yamaoka & Tango, 2005), in 2h-postprandial blood glucose (2HPP), after 1 year of intervention, with a power of 80%. The calculation assumed that the standard deviation of 2HPP was 1.5mmol/L (Lin, Wen & Yu, 2005). Calculated sample size required 17 subjects per group. To account for higher attrition rates in lifestyle interventions, and since post-partum period poses barriers to participation in intensive interventions (Swan, Kilmartin & Liaw, 2007), we recruited a bigger sample.

Statistical analyses were performed using IBM SPSS (Version 19, Somers, NY). Data normality was tested using Shapiro-Wilks test. Results are presented as mean±SD, unless indicated. Log transformations were attempted to improve normality and homoscedasticity for variables, when necessary. Differences between groups were assessed by independent samples *t*-tests, when the variances for groups were similar; Kruskal–Wallis test, otherwise. Paired samples *t*-tests or Mann–Whitney U-test were used to compare differences within groups, based on whether the normality of the difference score was met. The statistical significance standard was set at 5%. Effect size (ES) statistics were computed to compare the effects of the diet treatments. ES was computed by dividing the mean difference by standard deviation. ES was interpreted as follows: ES<0.2 = 'small', ES 0.2-0.6 = 'moderate' and ES≥0.7 = 'large' effect.

Difference in dietary intakes between the two groups was assessed using all dietary records collected. Macronutrients and diet GL were also assessed between groups after adjustment using univariate data analysis when appropriate. Furthermore, whenever appropriate, we performed a univariate analysis for dietary variables using baseline values as covariates.

The associations between educational and economic status and diet-diabetes and GI-concept scores were studied using Spearman's correlation. Association between log transformed values of changes in dietary GI and change in GI-concept scores were studied using Pearson's correlation.

RESULTS

Fifty-one subjects completed the 3-months intervention (25 subjects from CHDR and 26 from LGIE group). One subject in LGIE group had thyroid medication altered during this period. Hence, data from this subject were excluded. At 3 months, two subjects in LGIE group tested positive for pregnancy and their data were also excluded from the analyses. Data from 25 subjects in CHDR-group and 23 subjects from LGIE group were used in the final analysis. Baseline characteristics of the subjects were comparable between groups as shown in Table 3.

Dietary intake

Dietary data before and after 3-months of intervention are presented in Table 4.

The mean EI: BMR ratio for CHDR and LGIE groups were 1.17±0.27 and 1.33±0.32 respectively (P=0.054).

At baseline, the groups were comparable for EI and distribution of energy from macronutrients in their diet. The average percentage of calories from carbohydrates, protein and fat were 53, 16 and 31% respectively. At baseline, dietary fibre intake in either group did not meet the recommended levels of 25g (Krauss *et al.*, 2000).

After 3 months, EI reduced significantly in LGIE (241.7±522.4, P=0.037, ES =0.463), but not in the CHDR group. Also, at 3 months, subjects with BMI $\geq$23 significantly reduced EI from baseline (-256±415Kcal, P=0.001), as compared to those with BMI<23 (-16±271 Kcal, P=0.441).The percentage of subjects restricting EI to prescribed or lower levels was comparable between groups (Table 4).

GI was significantly lowered in the LGIE group from baseline to three months (4±7, P=0.017, ES = 0.549). However, in the CHDR group, a slight increase in GI was recorded (2±7, P=0.215, ES=0.254). The reduction in mean GL was also significant in the LGIE group (39.0±55.3, P=0.003, ES=0.705). Again, the CHDR group had a slight elevation in dietary GL.

After three months, total carbohydrate intake decreased significantly from baseline

Table 3. Baseline characteristics of subjects (mean± SD) at randomisation

Characteristics	*LGIE*	*CHDR*
N	30	30
Age (y)	30.5 ± 4.44	31.4±4.57
Education (% of subjects)		
Primary or lower	20	10
Secondary	40	37
Tertiary	40	53
Percentage of subjects with monthly family income		
Above RM 3500/approx >USD1166	30	30
Between RM1500-3500/approx between USD500-1166	47	53
Below RM1500/approx <USD500	23	17
No. of pregnancies	2.0±1.03	2.5±1.64
No. of GDM pregnancies	1.14±0.35	1.38±0.73
No. of children	1.9 ±0.9	2.07±1.16
Time lapse since last GDM delivery (mo)	4.6±1.61	6.4±8.19
No. of subjects breast feeding*	0	3
Weight (kg)	65.9±11.3	62.1±12.1
BMI (kg/m^2)	26.7±4.6	25.5±4.6
Waist circumference (cm)	78.7±16.8	78.9±16.7

LGIE: Low-GI Group; CHDR: Conventional Healthy Dietary Recommendation Group; RM: Malaysian Ringgit, USD: US Dollars, GDM: gestational diabetes mellitus,*- breast-feeding refers to those reportedly exclusively breastfeeding an infant<6 months of age

Table 4. Dietary intake of LGIE and CHDR groups at baseline and 3 months (Mean±SD)

Dietary variable	*LGIE (n=23)*				*CHDR(n=25)*			
	Baseline	*3 month*	*Change*	*P*[1]	*Baseline*	*3 month*	*Change*	*P*[1]
Energy (Kcal)	1929±477	1687±391	-242±522*	.037	1679±399	1569±336	-111±471	.252
Total CHO(g)	263±79*	214±52	-49±84***	.010	219±60	220±51	-0.3±60	.981
CHO en%	54.6±9.7	51.7±5.2	-2.9±10.8	.212	53.5±7.4	56.5±6.4*	-3.0±10.4**	.159
Protein (g)	71.0±20.1	74.9±18.3**	4.0±22.3	.402	69.0±22.7	61.0±15.5	-8.0±26.4	.141
Protein en%	15.2±2.7	18.9±4.8	3.7±5.4	.003	15.9±3.0	18.4±6.3	2.5±7.0	.085
Fat(g)	65.4±22.1	58.0±19.8	-7.5±25.4	.174	58.1±17.4	49.1±15.3	-9.0±23.6	.070
Fat en%	30.0±7.8	28.7±5.9	-1.3±9.8	.520	30.5±5.5	24.8±6.7**	-5.7±9.4	.006
Diet GI	60.7±5.0	56.9±5.3	-3.9±7.1**	.017	62.1±6.2	63.9±5.0**	1.8±7.3	.215
Diet GL	161.9±53.6	122.9±34.7	-39.0±55.3**	.003	136.9±37.5	141.1±37.2†	4.2±40.8	.611
Dietary fibre(g)	13.2±5.8	18.3±6.1***	4.6±7.3**	.006	12.6±5.2	13.0±4.1	0.1±5.8	.945

LGIE: Low-GI Group; CHDR: Conventional Healthy Dietary Recommendation Group; CHO-carbohydrate, GI-glycaemic index, GL-glycaemic load, P[1] statistical significance of within the groups

* indicates values significantly different between groups *(P<0.05); **(P=<0.01); ***(P=<0.001);

† Diet GL at 3 months significantly different at P=0.032 when controlled for baseline GL and carbohydrate intake

in LGIE group (48.7±83.5g, P=0.010, ES=0.583), but no significant change was observed in the CHDR group.

After three months, percentage of calories from protein significantly rose from baseline only in the LGIE group (4±5%, P=0.003, ES=0.685). There was only a marginal change in the CHDR group (3±7.0%, P=0.085, ES=0.357). After 3 months, both groups restricted fat en% to <30%, the recommended range for risk reduction (Krauss *et al.*, 2000). Fat en% was significantly reduced in the CHDR group (5.7±9.4%, P=0.006, ES=0.606), but the change in the LGIE group (1.3±9.8%, P=0.520, ES = 0.133) was not significant.

Dietary fibre intakes were significantly increased from baseline in the LGIE group (5±7g, P=0.06, ES =0.630) after three months, but the change in the CHDR group was very small (0.1±6g)

Dietary adherence

Self-reported and calculated dietary adherence scores are presented in Table 5. Self-reported adherence and calculated adherence scores for EI and fat en% did not vary between groups.

Reported PAL was comparable between groups both at baseline and at three months. Percentage of subjects who met minimum recommended PAL at three months in CHDR and LGI were 75% and 70% respectively.

Concept-knowledge assessment

In the reliability analysis, Cronbach-α value for diet-diabetes section of the questionnaire in the study group was 0.68 at 3 months. The GI-concept section had a baseline Cronbach-α value of 0.76. The responsiveness scores of the questionnaires to changes in the measured diet-diabetes knowledge and GI-concept components were 0.5 and 2.0 respectively.

At baseline, diet-diabetes (r= 0.274, P=0.041) and GI-concept (r= 0.287, P=0.032) scores were significantly correlated with subjects' education level. Scores for diet-diabetes knowledge were significantly associated with GI-concept knowledge (r=0.563, P<0.001).

Both groups had similar diet-diabetes concept-knowledge scores at baseline and at three months. However, both groups demonstrated improvements from their baseline scores at the third month visit (CHDR 59 to 65%, P=0.09, LGIE 55 to 64%, P=0.002). GI-concept scores were similar in both groups at baseline (LGIE vs. CHDR: 6.5±6 vs.5.5±3, P= 0.520). At the end of three months, mean GI-concept scores out of the maximum possible score of 15 (measured only in the LGIE group) was significantly

Table 5. Comparison of dietary adherence scores between groups after three months of intervention (Mean ± SD)

Dietary adherence scores	*LGIE*	*CHDR*	*p*
EI adherence (%)	55 ± 43	68 ±44	0.335
Fat adherence (%)	60 ± 46	82 ±34	0.193
GI adherence (%)	52 ± 47	Not Evaluated	NA
Self-reported adherence scores (%)	66 ± 12	57 ± 17	0.15
Percentage of subjects with BMI<23 restricting EI to EP or lower (%)	57	50	1.0
Percentage of subjects with BMIe"23 restricting EI to EP or lower (%)	25	56	0.607

SRAS-Self-reported adherence scores, EI- energy intake, EP-energy prescribed higher compared to baseline (6.5 ±6 to 11±5, P<0.001). This signifies a 30% increase in scores from baseline (43 to 73%).

Educational levels did not correlate with changes in diet-diabetes concept-knowledge scores in the CHDR (r = 0.11, P= 0.594) and LGIE (r = -0.189, P=0.401) groups at three months. Similarly, education levels were not correlated with GI-concept score changes (r = 0.07, P=0.744). However, logarithmic transformation of changes in GI-concept scores and diet GI were significantly correlated (r = -0.642, P=0.045).

DISCUSSION

This was one of the first studies to investigate the feasibility of lowering GI of healthy diets through nutrition education among Asian women post-GDM. The GI-education was administered within the framework of conventional dietary recommendations as suggested by Riccardi *et al.*(2008). The success of GI-nutrition education is established by the understanding and retention of the GI-concept knowledge among the LGIE subjects. In addition, the ease of application of the GI-concept is evident from the changes in food consumption pattern reported by the LGIE subjects and the significant lowering of their estimated dietary GI. The study population was free-living, with the actual food consumption being *ad libitum*. Hence, the study truly evaluated the feasibility of lowering GI in a predominantly rice-consuming Asian population, through GI-education. These results may therefore be implemented in real life practice in postpartum management of GDM women.

Communication of GI-concept and its understanding posed no challenge to lowering dietary GI in this study, contrary to previous opinion (Beebe, 1999). The LGIE group significantly improved their GI-concept scores by 30% after three months. Furthermore, changes in dietary GI were associated with changes in GI-concept scores showing that the concept works well amongst Asian post-GDM women aged 20-40years. The improvement in GI-concept scores or changes in dietary GI were unaffected by educational or economic status of subjects, implying that the GI-concept may work well in Asian populations, across various socio-economic strata. These findings add to existing evidence for the feasibility of lowering dietary GI among free-living Asians through nutrition education (Amano *et al.*, 2007, Yusof, 2008).

After three months, a statistically significant seven-point difference in dietary GI was obtained between groups (57 vs. 64, P<0.001). However, this reduction in dietary GI was still below the clinically relevant 10-point difference (Goff *et al.*, 2003). Previous Asian trials that did not provide low-GI foods to subjects, and had a trial duration of three months, achieved comparable differences in dietary GI between groups (around six units), but documented significant changes in glycated A1c, fasting glucose and waist circumference (Amano *et al.*, 2007, Yusof, 2008). The extended duration of follow-up for this trial will evaluate further changes in GI reduction and its metabolic outcome.

The baseline dietary intake of subjects in the study, including the distribution of calories from macronutrients was in concordance with those reported in a previous study among Malaysian women with previous GDM (Chew *et al.*, 2011). At three months, both diet groups in our study conformed to AHA dietary recommendations with respect to fat en%. The effected EI changes were also similar when excluding under-reporters. However, during the three-month period, the CHDR-group had reduced fat en% (6±9%, P=0.006, ES=0.606) to a greater extent while simultaneously increasing the energy contribution from carbohydrates (3.0±10%, P=0.159, ES=0.289). Therefore, despite mean carbohydrate intakes being similar in both groups (214±52 and 220±51g) at three months, the LGIE group had significantly lower percentage of calories (52±5%) coming from carbohydrates compared to the CHDR group (57±6%). A similar trend for slightly lower carbohydrate en% and higher fat en% in the low-GI group was noticed in an earlier Asian trial (Yusof, 2008).

Despite these changes in macro-nutrient distributions, changes in diet GI (P=0.002) and GL (P=0.001) in this study were significantly different between groups, even when controlled for changes in carbohydrate intake. This shows that the changes in dietary GI and GL were predominantly due to selection of low GI foods rather than a reduction in carbohydrate quantity.

Dietary adherence did not differ between conventional healthy and low-GI diet groups with similar energy prescriptions in this study. Hence, adherence to iso-caloric low-GI and conventional diets is similar among Asians. Also, low-GI education had an added benefit of improving dietary fibre intake as has been documented previously (Yusof, 2008), while conventional dietary recommendations failed to do so.

Irrespective of dietary changes, both diets resulted in comparable changes in anthropometric and blood pressure during the three-month period (data not presented here). Hence, with energy prescriptions being similar, intensive reduction of dietary fat to around 25% and lowering dietary GI (with fat en% <30%) in this study group yielded comparable results in terms of dietary adherence and changes in anthropometric and blood pressure outcomes. We also acknowledge that this short three-month period could have been inadequate for the diets to influence anthropometric and blood pressure measurements in our subjects, as the recommended 10-point clinically significant GI difference was not achieved during this time. However, the long term metabolic impact of sustained reductions in fat en%, achieved in the CHDR-group as compared to the LGIE group will be addressed by the one year follow-up.

This study was limited by the fact that the dietary intake including GI and GL were calculated based on reported intakes, though attempts were made to ensure completeness of reporting. Fifty- two percent of the subjects were identified as under-reporters in this trial. However, similar instances of high prevalence of under-reporting have been documented in earlier trials on overweight and obese women (Livingstone & Black, 2003). Dietary trials are also limited by food records which do not capture details of food processing and other factors affecting dietary variables, including GI.

We also acknowledge that repeated use of questionnaires increased the possibility of recall bias. However, in this study, such a bias would have been minimal since the baseline questionnaire administration took place a week before the intervention and the post-test questionnaire was administered three months after the intervention. Also, the educational intervention content did not selectively address items in the questionnaire, but took a holistic educative approach at explaining dietary (CHDR and CHDR + GI) concepts in general. Hence the increase in scores may be taken to represent an actual increase in concept knowledge.

We acknowledge the unavailability of glycaemic parameters at three months post-intervention as a limitation. Hence this paper does not provide evidence for the effectiveness of the low GI intervention in maintaining glucose homeostasis. However, the research protocol includes measurement of metabolic parameters at six months and one year after intervention. These measurements will provide objective evidence for the long-term effectiveness of adding GI-education to conventional healthy dietary recommendations in managing cardio-metabolic risks among post-GDM women.

In conclusion, while implementing lifestyle changes after GDM pregnancy is a recognised public health challenge (Swan *et al*., 2007) , this study demonstrated that it is feasible to lower GI through nutrition education in free-living Asian women post-GDM. Understanding of GI-concept was independent of educational and economic status of the subjects. Additionally, GI-education improved dietary quality in terms of protein and fibre intakes.

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CONFLICT OF INTEREST

The authors have no potential conflict of interest to declare.

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