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Impact of Diet on Nutrient Intake, Glycemic Index and Glycemic Load of Meals of Urban Indian Diabetic Population

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Abstract

Background: India is heading toward becoming the global diabetic capital directly interconnected to poor lifestyle and obesity. **Aims and Objectives:** The aim of the study was to find an association between glycemic index (GI) and glycemic load (GL) with macronutrients and fiber in the diet of the urban Indian population. **Materials and Methods:** The dietary intake using food frequency questionnaire and 24–h dietary recall of 240 recruited subjects (male and female), between 25 and 60 years were taken in the study. GI and GL of all meals were calculated using values from National and the International Table of GI and GL. **Results:** Average mean and standard deviation of GI and GL of major meals were on the higher side. A significant correlation between GI of lunch and dinner with total available carbohydrate (CHO) and total starch intake. A positive significant correlation was observed between GI to energy intake at dinner, total available CHO, and total starch. GL of breakfast was negatively correlated to iron, zinc, insoluble, and soluble fiber intake in females. GL for lunch was positively correlated to the intake of total available CHO, total starch, insoluble, and soluble fiber. **Conclusion:** The present study showed high GI and GL of processed foods and refined CHO indicating that dietary habits with high GI and GL foods are an indicator to risk of diabetes and pre-diabetes among both genders.

Keywords: Diabetes, Glycemic index, Glycemic load, Meal, Nutrient intake

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Introduction

Diabetes mellitus is an epidemic in India with more than 62 million entities being diagnosed with this disease. It is anticipated that 79.4 million Indians will be affected by diabetes by 2030. Obesity is considered as one of the major risk factors associated with diabetes.[1] Glycemic Index (GI) based intrusion is an essential tool in managing and preventing type II diabetes mellitus.[2] Epidemiological studies have shown that visceral obesity could be considered as key determinants of insulin resistance, diabetes, and cardiovascular disease than generalized obesity.[3] Even though a large population is on pharmacological treatment, lifestyle changes are the foundation for treating diabetes. Lifestyle changes emphasize on diet along with physical activity. Originally, GI was designed for patients with diabetes mellitus as a food selection guide to select foods with low GI. The GI concept was further extended taking into account the effect of the total amount of carbohydrate (CHO) consumed, therefore, glycemic load (GL) – which is a product of GI and the total quantity of CHO consumed indicates available glucose for energy and storage followed by a CHO containing meal.[4]

The GI concept is an extension of the fiber hypothesis proposing that a diet high in fiber would lower the rate of nutrient entry from the gut.[5] Association between GI and GL is complicated – a high GL food can have low GI if eaten in small quantities. The rate of glucose removal from the plasma along with the rate of glucose absorption of CHO both affects the glycemic index (GI) of foods.[4] Study conducted by Venn and Green concluded that foods with high GI CHOs suppress short-term food intake more effectively in comparison to low GI CHOs which have been more effective over longer periods.[4] Research has shown that not all foods containing CHOs are the main contributors to hyperglycemia; different CHOs respond differently to post prandial blood glucose levels even when they are consumed in the same portion sizes, showing a beneficial effect in diabetic patients.[6] Inadequate data are available on the metabolic effects of low-GI, CHO rich foods containing low fiber; given that many foods do not have these qualities; therefore, it may be appropriate to screen large numbers of starchy foods low in fiber content (especially cereal-based products) in diabetic patients to broaden number of foods with lower GI which can be used by patients with diabetes mellitus as a part of their daily diet and also to assess the importance of food characteristics in being able to diminish the effect of CHO containing foods on post prandial blood glucose concentration.[7]

As diabetes mellitus has become global burden particularly in developing countries,[8] GI food-based intrusion is an essential tool in managing and preventing type II diabetes mellitus. The irony of the situation is that countries where type II diabetes has become an epidemic, there is not much data available on the GI of foods in those regions in comparison to international GI tables.[9] Jennie Brand-Miller *et al*. established that if low GI foods were chosen over high GI foods, it has small but clinically significant impact on patients with

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respect to controlled blood sugar levels.[10] Studies documented have shown that low GI foods lower the insulin response and lipid levels, improve blood sugar levels, as well as reduce body weight, thereby preventing secondary risk conditions related to diabetes mellitus.[11]

Materials and Methods

This study is a cross-sectional study with a mixed-method research design. Two hundred and forty diabetic subjects were selected using purposive sampling technique. The subjects recruited were in the age group of 25–60 years, both males and females. Patients fulfilling the inclusion criteria were selected. Data collection was done with the help of a questionnaire which was formulated considering all the aspects of the study. The questionnaire included demographic data, information on social and financial background, physical activity, addictions if any, anthropometric data, recent biochemical values (blood sugar parameters-fasting and post prandial, lipid parameters-total cholesterol, low-density lipoprotein-cholesterol (LDL-C), high-density lipoprotein, triglycerides and very LDL-C, bio-physiological values (blood pressure using a sphygmomanometer), food frequency table and 2 day dietary recall (1 weekday and 1 weekend), and detailed history of past and present medical status for all the subjects. GI and GL of all the major meals were calculated using values from National Institute of Nutrition and the International table of GI and GL values 2002. GL was calculated with the help of the formula:

GL = Total GI of meal *Available CHO of meal/100

The study protocol was explained to all participants and a written informed consent was obtained in the local language of the participant. Signature on the consent form was taken on the preference of language by the subject. This study was approved by a government recognized independent Ethics Committee.

The inclusion criteria were as follows: Subjects who are clinically diagnosed with diabetes (prediabetes and newly detected), subjects who are otherwise healthy with no eating disorders, aged 25–60 years and with otherwise normal mental health. The exclusion criteria were as follows: Patients suffering from renal disorder, liver disorders; patients who have undergone surgery in the past 3 months, patients who have undergone bariatric surgery or have any existing diabetic complications; and patients on alternative medication, children, pregnant, or lactating women. Migrant population and people with variable work timings and shift duties were also excluded from the study.

Results

The mean age of male subjects in the study was 48.78 ± 8.65 years and female subjects were 48.81 ± 9.51 years.

The average BMI of male subjects was 26.82 ± 5.03 kg/m^2 and female subjects was 29.21 ± 5.77 kg/m^2. Higher percentage (37.37%) of male subjects were Grade I obese and 47.51% of females were Grade I obese. About 21.21% of male subjects and 33.33% of female subjects were in Grade II obese category.

There was more variation in the fasting and post-prandial blood sugar (PPBS) levels among these subjects. The male subjects reported an average fasting blood sugar (FBS) of 170.48 ± 87.89 mg/dL and PPBS of 228.74 ± 112.34 mg/dL.

The female subjects reported a lower blood sugar compared to the male subjects. Their FBS was 154.86 ± 74.78 mg/dL and PPBS was 198.93 ± 89.15 mg/dL. Table 1 gives the mean biochemical and bio-physiological parameters of subjects.

Table 1: Mean biochemical and bio-physiological parameters of the subjects

Blood sugar levels	*Males (n=99)*	*Females (n=141)*
Fasting blood sugars (mg/dL)	170.48±87.89	154.86±74.78
Post-prandial blood sugars (mg/dL)	228.74±112.34	198.93±89.15
Blood pressure		
BP-systolic (mmHg)	140.56±17.95	138.11±18.05
BP-diastolic (mmHg)	81.72±10.15	79.59±10.19
Lipid profile (mg/dL)		
Total cholesterol (mg/dL)	155.78±42.64	164.45±35.69
Triglycerides (mg/dL)	162.33±70.31	169.63±82.08
Low-density lipoproteins (mg/dL)	87.37±35.93	91.73±36.79
High-density lipoproteins (mg/dL)	37.36±4.82	45.79±8.81
Very density lipoproteins (mg/dL)	32.28±15.57	33.34±17.72

Table 2: Average mean and standard deviation of nutrient intake of subjects

Nutrients	*Males (n=99)*	*Females (n=141)*
Energy (kcal)	1292±584.87	1035±465.52
Protein (g)	47.62±21.21	38.50±18.95
Energy % of proteins	14	12
Carbohydrate (g)	179.86±87.51	183.77±57.68
Energy % of carbohydrates	56	57
Total available carbohydrate (g)	115.62±69.88	99.48±41.97
Total starch (g)	104.10±69.42	89.84±40.96
Total free sugar (g)	22.98±15.27	19.11±12.87
Total fiber (g)	27.92±11.30	22.49±8.58
Insoluble fiber (g)	21.50±8.29	17.34±6.86
Soluble fiber (g)	5.84±2.67	4.58±1.84
Fat (g)	40.18±27.65	43.52±25.54
Energy % of fat	30	31
Total saturated fat (mg)	10107.55±8032.25	7667.38±7791.43
Total monounsaturated fat (mg)	6924.69±6189.57	6180.31±6847.70
Total polyunsaturated fat (mg)	7205.66±7825.42	5311.13±5446.40
Total trans fat (g)	0.082±0.115	0.061±0.156
Vitamin C (mg)	103.12±75.32	65.12±54.33
Vitamin D3 (mcg)	1.55±1.11	1.50±1.04
Vitamin D2 (mcg)	23.35±11.11	18.75±12.84
Iron (mg)	11.35±5.11	9.03±3.81
Calcium (mg)	448.15±21339.42	396.54±249.24
Chromium (mg)	0.05±0.04	0.04±0.02
Selenium (mg)	80.51±38.39	66.19±35.46
Zinc (mg)	5.98±2.41	4.87±2.03

FBS values higher than 110 mg/dL were observed among 76.76% male subjects and 69.50% female subjects. PPBS value above 240 mg/dL was observed among 80.80% male subjects and 70.92% female subjects.

Table 2 estimates the average nutrient intake for macronutrients and micronutrients for the study population. These values were compared against the currently available recommendations for medical nutrition therapy for the management of diabetes mellitus. The average energy intake was 1292 ± 584.87 kcals and 1035 ± 465.52 kcals in males and females, respectively. The average diet of the study group was estimated to be high in CHO and fat and low in protein and micronutrients. However, it was observed that total fiber intake was within the recommended range.

Tables 3 and 4 report that the average mean and standard deviation of GI and GL of all the major meals were on the higher side. It was observed that all the subjects showed long gaps between meals. The GI and GL was calculated using formula for dietary recall collected from the subjects for the three major meals.

Figure 1 shows the consumption of different edible oils by the participants. The oil that was consumed by the majority of participants was sunflower oil (37.50%), followed by subjects preferring a rotation of oils (15%) and ground nut oil (13.33%).

Furthermore, the correlation between GI of nutrients with different meals was assessed in both genders. Quality of CHOs is measured through GI. Foods are classified as high GI (>70), medium GI (56–69), and low GI (<55). GL of the diet is calculated by measuring the amount of CHO in grams * by the GI of foods/100. GL is classified as high GL (>20), medium GL (11–19) and low GL (<10).[13]

Since GI is determined by the rise in glucose levels from the consumption of CHO, it is expected to show a positive correlation against all meals rich in CHO.

Table 5 shows the correlation between GI of nutrients with different meals in males.

At 95% confidence interval, a correlation was seen between GI of CHO in lunch in male subjects. There was a significant correlation seen between GI of lunch and dinner with the total available CHO ($P = 0.05$) and total starch intake ($P = 0.05$) of their meals.

A similar trend was observed among the female subjects as well. The GI for dinner was significantly negatively correlated to the CHO intake at 1% level of significance which explains that the diet low in total CHO had still given rise to GI post dinner. There was a positive significant correlation between the GI of lunch and the total available CHO intake at lunch (at 5% level of significance), total starch intake at lunch, and the soluble fiber intake at lunch. At 5% level of significance, a positive significant correlation was also observed with GI of dinner to the energy intake at dinner, total available CHO intake at dinner, total starch at 1 % level of significance, while all the other factors were at 5% level of significance [Table 6].

The correlation between GL of nutrients with different meals was assessed in both genders. Among the male subjects, the GL of lunch has a significant positive correlation with the CHO

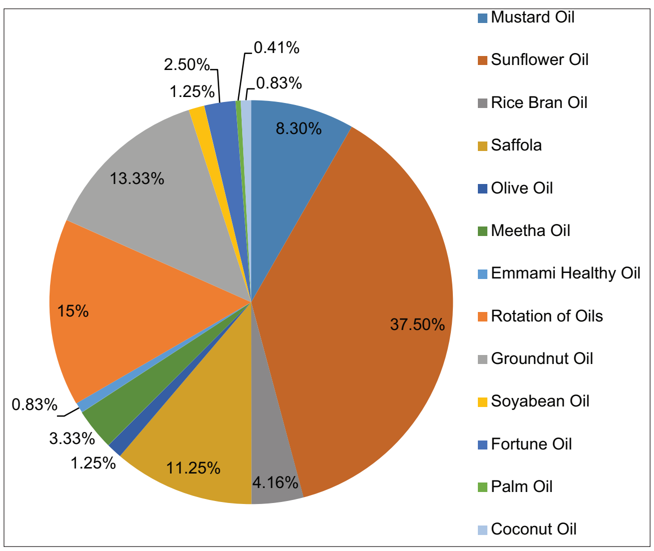

Figure 1: Consumption of different edible oils

Table 3: Glycemic index of the meals of the subjects

Glycemic index	*Males (n=99)*	*Females (n=141)*
Breakfast	84.50±45.49	81.51±39.59
Lunch	116.82±47.09	118.52±49.01
Dinner	116.82±50.77	112.55±47.71

Table 4: Glycemic load of the meals of the subjects

Glycemic load	*Males (n=99)*	*Females (n=141)*
Breakfast	22.24±18.01	19.90±14.17
Lunch	23.95±9.5	24.40±10.08
Dinner	23.84±10.23	22.95±9.60

Table 5: Pearson's correlation between glycemic index of nutrients with different meals in males

Nutrients	*GI breakfast*	*GI lunch*	*GI dinner*
Energy (kcal)	−0.061	0.171	0.152
Protein (g)	−0.106	0.030	0.063
Carbohydrate (g)	−0.108	0.214*	0.193
Total available carbohydrate (g)	−0.183	0.216*	0.257*
Total starch (g)	−0.185	0.217*	0.253*
Total free sugar (g)	0.005	−0.005	0.029
Total fiber (g)	0.049	0.082	0.056
Insoluble fiber (g)	−0.074	0.073	0.173
Soluble fiber (g)	−0.007	0.125	0.141
Fat (g)	0.049	0.082	0.056
Total saturated fat (mg)	0.016	−0.016	−0.066
Total monounsaturated fat (mg)	0.014	0.007	0.071
Total polyunsaturated fat (mg)	−0.049	0.030	0.106
Total trans fat (g)	0.130	0.140	0.074
Vitamin C (mg)	−0.053	0.138	0.015
Vitamin D3 (mcg)	0.026	0.012	−0.042
Vitamin D2 (mcg)	−0.010	−0.062	0.112
Iron (mg)	−0.060	0.021	0.087
Calcium (mg)	−0.058	0.153	0.066
Chromium (mg)	−0.030	0.105	−0.066
Selenium (mg)	−0.077	−0.092	−0.029
Zinc (mg)	−0.120	0.059	0.215

*Correlation is significant at the 0.05 level (2-tailed)

Table 6: Pearson's correlation between glycemic index of nutrients with different meals in females

Nutrients	*GI breakfast*	*GI lunch*	*GI dinner*
Energy (kcal)	−0.016	−0.037	0.182*
Protein (g)	−0.116	−0.051	0.130
Carbohydrate (g)	0.003	0.083	−0.250**
Total available carbohydrate (g)	−0.115	0.221**	0.273**
Total starch (g)	−0.113	0.211*	0.274**
Total free sugar (g)	−0.084	−0.123	0.098
Total fiber (g)	−0.060	0.147	0.191*
Insoluble fiber (g)	−0.107	0.166	0.193*
Soluble fiber (g)	−0.071	0.170*	0.176*
Fat (g)	0.006	−0.148	0.061
Total saturated fat (mg)	0.010	−0.106	0.074
Total monounsaturated fat (mg)	−0.048	−0.109	0.021
Total polyunsaturated fat (mg)	−0.086	−0.041	0.064
Total trans fat (g)	0.066	−0.155	0.095
Vitamin C (mg)	0.013	0.138	0.041
Vitamin D3 (mcg)	−0.144	−0.038	0.162
Vitamin D2 (mcg)	−0.058	0.140	0.112
Iron (mg)	−0.210*	0.067	0.112
Calcium (mg)	−0.078	−0.106	0.054
Chromium (mg)	−0.051	0.051	0.051
Selenium (mg)	−0.195*	0.012	0.070
Zinc (mg)	−0.201*	0.093	0.205*

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed)

Table 7: Pearson's correlation between glycemic load of nutrients with different meals in males

Nutrients	*GL breakfast*	*GL lunch*	*GL dinner*
Energy (kcal)	−0.007	0.174	0.164
Protein (g)	−0.078	0.036	0.074
Carbohydrate (g)	−0.029	0.212*	0.201
Total available carbohydrate (g)	−0.155	0.212*	0.263*
Total starch (g)	−0.159	0.214*	0.260*
Total free sugar (g)	0.030	0.002	0.037
Total fiber (g)	−0.086	0.098	0.171
Insoluble fiber (g)	−0.122	0.075	0.189
Soluble fiber (g)	−0.049	0.129	0.153
Fat (g)	0.053	0.088	0.068
Total saturated fat (mg)	0.082	−0.014	−0.055
Total monounsaturated fat (mg)	0.081	0.015	0.077
Total polyunsaturated fat (mg)	−0.062	0.042	0.112
Total trans fat (g)	0.112	0.147	0.081
Vitamin C (mg)	−0.044	0.144	0.023
Vitamin D3 (mcg)	−0.086	0.019	−0.050
Vitamin D2 (mcg)	−0.043	−0.058	0.109
Iron (mg)	−0.166	0.030	0.092
Calcium (mg)	−0.105	0.162	0.069
Chromium (mg)	−0.068	0.111	0.001
Selenium (mg)	−0.090	−0.086	−0.027
Zinc (mg)	−0.195	0.066	0.227*

*Correlation is significant at the 0.05 level (2-tailed). GL: Glycemic load

Table 8: Pearson's correlation between glycemic load of nutrients with different meals in females

Nutrients	*GL breakfast*	*GL lunch*	*GL dinner*
Energy (kcal)	−0.085	−0.024	0.183*
Protein (g)	−0.137	−0.035	0.137
Carbohydrate (g)	−0.071	0.093	0.248**
Total available carbohydrate (g)	−0.125	0.228**	0.267**
Total starch (g)	−0.116	0.215*	0.267**
Total free sugar (g)	−0.081	−0.102	0.109
Total fiber (g)	−0.188	0.163	0.198*
Insoluble fiber (g)	−0.207*	0.181*	0.200*
Soluble fiber (g)	−0.180*	0.191*	0.181*
Fat (g)	−0.053	−0.139	0.069
Total saturated fat (mg)	−0.054	−0.092	0.077
Total monounsaturated fat (mg)	−0.079	−0.105	0.026
Total polyunsaturated fat (mg)	−0.084	−0.038	0.061
Total trans fat (g)	0.000	−0.153	0.095
Vitamin C (mg)	−0.084	0.164	0.042
Vitamin D3 (mcg)	−0.084	−0.041	0.160
Vitamin D2 (mcg)	−0.145	0.143	0.117
Iron (mg)	−0.026**	0.089	0.120
Calcium (mg)	−0.136	−0.099	0.059
Chromium (mg)	−0.073	0.072	0.054
Selenium (mg)	−0.209*	0.015	0.075
Zinc (mg)	−0.250**	0.105	0.212*

*Correlation is significant at the 0.05 level (two-tailed). **Correlation is significant at the 0.01 level (2-tailed). GL: Glycemic load

intake from lunch, the total available CHO, and total starch intake (at 5% level of significance). The GL of dinner was also found to be significantly positively correlated to the total available CHO, total starch, and zinc intake from dinner with a 5% of significance [Table 7].

Among the female subjects, the GL of breakfast was negatively correlated to insoluble fiber intake (at 5% level of significance), soluble fiber intake (at 1% significance), and iron and zinc intake (at 1% level of significance). The GL for lunch was positively correlated to the total available CHO intake (at 1% level of significance), total starch intake, insoluble fiber intake, and soluble fiber intake (at 5% level of significance) [Table 8].

Discussion

Asian diets are CHO concentrated diets, therefore not only the quantity but also the quality has a major role in maintaining the blood sugar levels. Foods high in GI promote high glycemic as well as insulin response leading to insulin resistance and exhausting beta-cells thus causing type II diabetes mellitus.

There have been many cross-sectional as well as longitudinal studies over the years showing a strong link between type II diabetes mellitus and high CHO diets and it is also connected with obesity, especially in Asian Indians.

The quality of CHO consumed is also equally responsible for maintaining optimum blood sugar levels. CHOs are divided into complex and simple CHOs. Most foods which are rich in fiber such as brown rice, pulses, lentils, and green leafy vegetables are complex CHOs and foods which are refined, processed and high in sugar such as bakery, fruit juices, aerated drinks, and sports drinks are simple CHOs. The famous saying of "Moderation is Key" holds very true here and is extremely important for good health. Thus, a balance in daily diet is very important.

The high CHO intake of Indians (66–75%) must be reduced to 50–55%. Increasing the energy from proteins by 20–25%- primarily from vegetarian sources, energy from fats (20–30%) – especially from MUFA along with adequate amount of fiber in the diet is essential to prevent and manage non-communicable diseases.[12]

In the present study, an attempt was made to understand the impact of diet on nutrient intake, GI, and GL of meals of urban Indian diabetic population. Data on clinical studies have shown that consuming low GI foods reduce the risk of type II diabetes mellitus,[13] significantly lowers insulin resistance and the incidence of metabolic syndrome.

As diabetes mellitus has become global burden particularly in developing countries, GI food-based intrusion is an essential tool in managing and preventing type II diabetes mellitus. Studies documented have shown that low GI foods lower insulin response and lipid levels, improve blood sugar levels, as well as reduce body weight, thereby preventing secondary risk conditions related to diabetes mellitus.

Some of the limitations of the study are as follows: The study was conducted in COVID-19 pandemic; hence, the data collection was restricted and body fat analysis and weight circumference could not be taken. HbA1c levels could not be measured as the doctor under whom the study was conducted did not believe in asking the patients to measure HbA1c and thus it could not be a part of the study.

From the above study, we trust that including GI values of Asian countries will augment its use and application of GI in research as well clinical practice by nutritionists across the globe. GI values will also improve consumer knowledge and help them select healthier food options. The present study indicates that dietary habits high in GI and GL are an indicator to risk of diabetes and pre-diabetes among both men as well as women.

Conclusion

From the above study, we trust that including GI values of Asian countries will augment the use and application of GI in research as well as clinical practice by nutritionists across the globe. GI values will also improve consumer knowledge and help them select healthier food options. The current study indicates that dietary habits high in glycemic index and glycemic load are an indicator to risk of diabetes and pre–diabetes among both men as well as women.

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