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A correlative study of nutritional assessment and blood glucose level of middle aged adults with type 2 diabetes mellitus

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Abstract
This study aims at assessing the dietary pattern of middle aged adults (40-60 years) with Type 2 Diabetes Mellitus. It focuses on correlating the dietary pattern of the subjects with their blood glucose parameters. A sample of 100 middle aged adults with Type 2 Diabetes Mellitus were selected from a diabetic centre in Bangalore city using random sampling technique. Data was collected using a questionnaire, which included basic information, anthropometric measurements, biochemical parameters, dietary pattern, food frequency questionnaire, 24 hours dietary recall, factorial estimation of total energy expenditure. Frequency of consumption of different foods and nutrient requirements was assessed. Results revealed that the Energy, Protein and Carbohydrate intake of the respondents was lower compared to the RDA and expenditure. The mean glycemic load of the meals was moderate. Intake of high glycemic foods led to increase in blood glucose level among the respondents, which may further lead to risk of co-morbidities like hypertension, cardiovascular diseases, obesity, renal problem, etc. Eating right and keeping good control over food intake can keep the blood glucose level under control and greatly reduce the risk for co-morbidities thereby increasing the quality of life and life expectancy among individuals suffering from Type 2 Diabetes Mellitus.

Keywords: dietary pattern, middle aged diabetic adults, factorial estimation of total energy expenditure, glycemic load of the meal, controlled blood glucose level, quality of life

1. Introduction
Diabetes is a metabolic disorder which is characterized by high blood sugar level in the body due to insufficient production of insulin. This may be due to defects in insulin secretion or its action. Diabetes Mellitus is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both.
Main types of diabetes are Type 1 diabetes and Type 2 diabetes. Type 1 diabetes is usually seen in children and is called Insulin Dependent Diabetes Mellitus (IDDM); this is mainly due to defects in insulin secretion. Type 2 diabetes is usually seen in adults and is called Non-Insulin Dependent Diabetes Mellitus (NIDDM); this is mainly due to defects in insulin secretion, action or sometimes both. Other types of diabetes include Maturity Onset Diabetes Mellitus of the Young (MODY), Gestational Diabetes Mellitus (GDM), Insulin Resistance, etc.
Diet plays an important role in the control and management of the ABCs (A1C, Blood pressure, and Cholesterol) of Type 2 diabetes. Intake of food low in simple carbohydrates, low glycemic index and load can have a positive impact on blood glucose level in diabetes patients.
Eating a balanced amount diet every day and taking medications as prescribed can greatly improve blood glucose control and decrease the risk of complications related to diabetes, such as coronary artery disease, renal disease, and nerve damage. Also this helps in weight control.
As most of the diabetics, especially middle-aged adults are into unhealthy dietary habits and have no control over the food they are getting into the complications of diabetes.

2. Review of Literature
An attempt has been made to review and discuss the literature related to the present study and the reviewed literature has been organized under the following headings.
The literature available about diabetes and their dietary pattern includes:
- Prevalence of Diabetes.
- Dietary pattern and Diabetes.
- Importance of following healthy diet in the management of Type 2 diabetes.

2.1 Prevalence of Diabetes
- Ranjith Unnikrishnan (2016) [2] states that India is one of the epicenters of the global Diabetes Mellitus. They say that due to rapid socioeconomic development and demographic changes along with more susceptibility of Indians, the prevalence of type-2 diabetes in India has tremendously increased over past four decades.
- A study conducted by A Ramachandran (2012) [3] on the current status of diabetes in India revealed that approximately 285 million people i.e. 6.6% are suffering from diabetes worldwide in 2010. They have also estimated that this can increase to 438 million i.e., 7.8% by 2030. The study predicts that the largest proportion of increase will take place in developing countries like India. It is said that India ranks number 1 in diabetes and around 50.8 million people in India are suffering from diabetes in

the year 2010 and this can increase to 87.0 million by the year 2030.

2.2 Dietary Pattern and Diabetes

- Susan L. Colles (2013) [4] conducted a clinic-based study on the dietary beliefs and eating pattern of type-2 diabetes patients in urban north India. The study aimed at characterizing the eating pattern, knowledge, beliefs and determinants of food choices in urban north Indians. A sample size of 258 individuals was selected who attended the outpatient clinics in New Delhi, India. Data regarding clinical, anthropometric and biochemical parameters were recorded. The study depicts that the subjects had poor food choices. Average consumption of fruits/ vegetables was low, though the intention of the subjects was to manage diabetes it was inversely associated with increased waist circumference and food choices.
  Saturated fat usage in their diet at household level was common and this was associated with taste preference, waist circumference, HbA1c% and lipid levels of the subjects. The study concluded that greater emphasis on regular dietary and behavioral counseling may be required for the subjects.

2.3 Importance of following healthy diet in the management of Type-2 diabetes

- Linda M. Delahanty (2017) [5] conducted a study on the importance of diet in diabetes management. According to the study eating a consistent amount of food every day and taking medications as directed can greatly improve blood sugar control and decrease the risk of diabetes related complications such as coronary heart disease, kidney disease and nerve damage. Also they say that following healthy dietary pattern can contribute to weight loss which in turn helps the body to produce and use insulin efficiently.
- Mohammad Asif (2014) [6] conducted a study on the prevention and control of type-2 diabetes by changing lifestyle and dietary pattern. He says type-2 diabetes is a noncommunicable disease which is tremendously increasing at global level and is a leading cause of premature deaths. According to the study minor changes which a person makes in his lifestyle can greatly prevent the occurrence of diabetes. He says that adherence to the healthy diet with regular physical activity can bring down the blood glucose level to normal and maintain it in the same pace. The findings of the study depict that the experimental group who strictly followed the low glycemic diet had significantly improved their glucose tolerance along with weight reduction. On the other hand the placebo group did not show any marked difference.

3. Methodology

Aim of the Study: The present study aims at assessing the nutritional status of the subjects and correlating it with their blood glucose parameters.

4. Objectives of the Study

- Nutritional assessment (anthropometric, dietary, biochemical) of the selected subjects.
- To correlate the glycemic load of the meal consumed by the selected subjects with their blood glucose parameters.

5. Hypothesis

The hypothesis formulated in the study is:

- There is a significant increase in the blood glucose level with the consumption of high glycemic food among the subjects.

6. Research Design

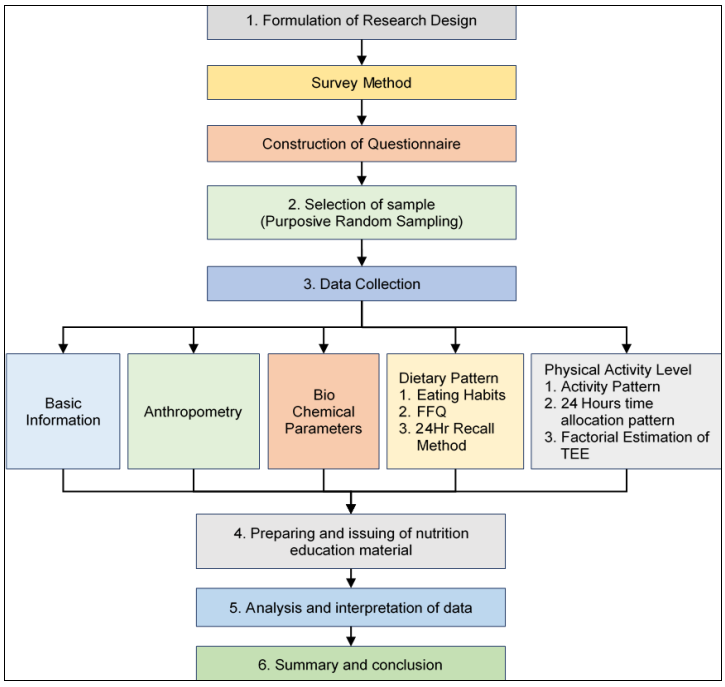

Fig 1: Research Design

6.1 Construction of Questionnaire
For the present study a detailed questionnaire was constructed to elicit information on various aspects related to:
- Basic information
- Anthropometric measurements
- Biochemical parameters
- Dietary habits
- Frequency of consumption of various foods
- 24 hours dietary recall

6.2 Sample Selection
The study was conducted in Diacon Hospitals (Diabetes care and Research Centre), Bangalore city. A total of 100 middle aged Type 2 diabetic patients were selected of which 47 were male and 53 were female. The sample selected for the study included middle aged adults whose age group was between 40-60 years. Simple random sampling method was used to choose the subjects.

6.3 Data Collection
The questionnaire was personally administered by the interviewer by adapting personal interview method to elicit information from the subjects.
The various aspects included in the questionnaire were:

6.4 General Information
The general information regarding age, gender, marital status, type of family, family income, number of children, religion, occupation, education, place of residence and habits were collected.

6.5 Anthropometric Assessment
Height, weight, BMI, waist circumference, hip circumference and waist to hip ratio were the parameter selected for anthropometric assessment. Weight of the respondents was recorded in kilograms (kg). Weight was measured using calibrated weighing machines with minimum clothing and with bare foots. Zero adjustment of the scale was checked before measuring the weight each respondent. Height of the respondents was recorded in centimeters (cm). The respondents were made to stand on the height scale straight and upright, bare foot with the heels, shoulders and back of the head touching the stand. The standard protocol of WHO was followed to take the anthropometric measurements. Using the height and weight BMI was calculated. After measuring the waist and hip circumference the waist to hip ratio was calculated.

6.6 Dietary Habits
Data regarding the food habits of the respondents were collected which included information on 24 hours dietary recall, consumption of non-vegetarian foods, number of meals consumed, skipping of meals and food frequency questionnaire (FFQ).

6.7 24 Hours Dietary Recall
In the present study information on food consumed by the subjects since last three days was collected using 24 hours dietary recall method. Using this information the average intake of energy, protein, fat and carbohydrates for three days was calculated. Based on the carbohydrate intake and glycemic index of different foods given by American Diabetic Association the glycemic load for each meal was calculated. The energy expenditure was calculated using the Harris Benedict formula and calories were distributed as 65% of carbohydrates, 15% protein and 20% fat. These values were then compared with the intake and percentage adequacy was calculated. The calculated value of glycemic load was compared to the standards.

Table 1

Reference values for each meal	Glycemic load
<10	Low
11-19	Medium
>20	High

***Source*:** American Diabetic Association

6.8 Statistical Analysis and Interpretation of Data
The analysis and interpretation of data included coding and decoding of the questions and the same was subjected to statistical analysis. The statistical tests performed included percentage, mean, standard deviation, chi-square test, student t test and standard t test. The results were presented and appropriate conclusion is drawn and compared with set objectives and the formulated hypothesis of the study.

7. Results and Discussion

Table 2: Classification of Respondents by Food habits

Characteristics	Category	Respondents	
		Number	Percent
Food habit	Vegetarian	36	36.0
	Non-vegetarian	64	64.0
Number if meals	Two	2	2.0
	Three	93	93.0
	Four	5	5.0
Skip meals	No	65	65.0
	Sometimes	35	35.0
Meal you skip	Break fast	15	15.0
	Lunch	20	20.0

N=100

Majority of the respondents (64%) are non-vegetarian and the other 36% are vegetarian. About 93% follow three meal patterns. Also majority (65%) don't skip their meals and other 35% skip their meals sometime. Among the ones who skip their meal about 20% skip their lunch.

Table 3: Mean Response on Anthropometric measurements by Gender

No.	Measurements	Mean ± SD		't' Test
		Males (n=43)	Females (n=57)	
1	Height (cm)	163.9±7.2	157.1±6.8	7.21*
2	Weight (kg)	73.6±10.5	66.9±10.7	3.15*
3	Waist (cm)	94.4±6.7	63.2±9.3	0.75 NS
4	Hip (cm)	102.4±7.4	101.6±9.9	0.46 NS
5	BMI	27.4±3.3	27.2±4.9	0.15 NS
6	W/H	0.92±0.1	0.92±0.1	0.46 NS

* Significant at 5 % level NS: Non-significant

With respect to waist to hip ratio the results indicates equal response among male and female subjects. The difference in anthropometric measurements is found to be significant for height (t= 7.21) and weight (t= 3.15). For other four measurements i.e. waist circumference, hip circumference, BMI and waist to hip ratio statistical evidence showed non-significant at 5 percent level.

Table 4: Classification of Respondents on Bio-chemical parameters by Gender

No.	Measurements	Mean ± SD		't' Test
		Males (n=43)	Females (n=57)	
1	FBS	167.6±84.6	174.4±64.2	0.45 NS
2	PPBS	230.1±100.7	236.6±89.2	0.34 NS
3	RBS	191.8±81.1	190.8±70.2	0.07 NS
4	HbA1c	8.84±2.2	8.85±2.0	0.03 NS

NS: Non-significant

With respect to FBS, PPBS and HbA1c it is evident that female response is found to be higher compared to male respondents. With respect to RBS the results indicates male response to be higher compared to female respondents. The difference in bio-chemical parameters is found to be non-significant for all the four parameters.

Table 5: Classification of Respondents by Bio-chemical parameters

No.	Bio-chemical parameters		Respondents						χ^2 Test
			Normal		Abnormal		Total		
			N	%	N	%	N	%	
1	FBS (80-130 mg/dl)	Male	18	38.3	29	61.7	47	100.0	0.01 NS
		Female	20	37.7	33	62.3	53	100.0	
		Combined	38	38.0	62	62.0	100	100.0	
2	PPBS (<180 mg/dl)	Male	13	27.7	34	72.3	47	100.0	0.46 NS
		Female	18	34.0	35	66.0	53	100.0	
		Combined	31	31.0	69	69.0	100	100.0	
3	RBS (<200 mg/dl)	Male	31	66.0	16	34.0	47	100.0	0.00 NS
		Female	35	66.0	18	34.0	53	100.0	
		Combined	66	66.0	34	34.0	100	100.0	
4	HbA1C (< 10.0 %)	Male	35	74.5	12	25.5	47	100.0	0.01 NS
		Female	39	72.6	14	27.4	53	100.0	
		Combined	74	74.0	26	26.0	100	100.0	

N=100 NS: Non-significant

In Table 5, with respect to FBS and HbA1c female respondents shows higher values (62.3%) (27.4%) compared to male respondents (61.7%) (25.5%). Regarding PPBS male respondents shows higher values (72.3%) compared to female respondents (66%). Results indicate equal response by both male and female respondents for RBS values (34%). The difference in Bio-chemical parameters between genders found to be non-significant for all the four parameters.

Table 6: Classification of Respondents by Food Frequency consumption

No.	Foods	Frequency of Consumption (%)							
		Daily	Weekly Thrice	Weekly Twice	Weekly Once	Once in Fortnight	Monthly	Occasi-onally	Never
A	Cereals								
1	Rice	89	4	5	0	0	1	0	1
2	Wheat	75	11	9	5	0	0	0	0
3	Ragi	60	6	6	4	3	1	3	17
4	Millets	6	2	5	8	0	5	2	72
B	Pulses								
1	Grams	30	13	29	24	2	1	0	1
2	Dhals	97	2	1	0	0	0	0	0
C	Vegetables								
1	Roots & tubers	5	11	14	29	22	4	3	12
2	Other vegetables	92	3	3	2	0	0	0	0
3	Green leafy Veg.	28	29	27	13	1	1	0	1
D	Fruits								
1	Fresh	32	11	21	17	9	1	3	6
2	Dry	15	6	5	20	8	9	16	21
E	Milk and milk products								
1	Milk	91	2	2	0	2	0	0	3
2	Milk products	68	8	4	9	2	1	1	7

F	Meat and meat products								
1	Meat	0	4	7	13	8	17	8	43
2	Chicken	0	5	11	31	9	7	1	36
3	Fish	2	3	1	11	6	14	23	40
4	Egg	5	7	13	19	10	5	1	40
5	Pork	1	0	1	0	0	5	4	89
G	Sugar and Jaggery	14	4	3	7	11	13	32	16
H	Beverages	80	0	4	4	1	3	2	6
I	Nuts and oilseeds	14	6	6	20	8	9	16	21
J	Bakery foods	1	1	3	9	4	11	32	39
K	Fast foods	0	2	2	8	15	11	31	31
L	Sweets	1	0	1	2	2	16	54	24
M	Fried foods	1	1	4	24	24	19	14	12

Table 6 indicates the Classification of Respondents by Food frequency consumption. With respect to cereals it is found that majority of the respondents (89%) consume rice daily followed by wheat which is consumed by 75% of respondents daily and 60% consume Ragi on daily basis. It is also found that 72% of the respondents do not consume millets.

Regarding pulses grams are consumed by 30% of the respondents on daily basis followed by 29% who consume it twice in a week. Whereas dhal is consumed daily by 97% of the respondents.

With respect to Vegetables, Roots and Tubers are consumed by 29% of the respondents once in a week followed by 22who consume it once in fifteen days. (46) Other vegetables consumption is 92% on daily basis, green leafy vegetables are consumed by 29% of the respondents three times a week followed by 28% who consume it daily.

With respect to fruits, especially fresh fruits were consumed daily by 32% of the respondents followed by 21% who consumed it two times a week. It is also found that 6% of the respondents never consume fresh fruits. Around 21% of the respondents never consume dry fruits followed by 20% who consume it once in a week. 91% of the respondents consume milk daily. Milk products are consumed daily by 68% of the respondents followed by 8% who consume it three times in a week.

Meat, especially mutton is never consumed by 43% of the respondents, followed by 17% who consume it fifteen days once. Chicken is never consumed by 36% of the respondents followed by 31% who consume it once in a week. Both egg and fish is not consumed by 40% of the respondents. Around 89% of the respondents never consume pork followed by 5% who consume it once in a month.

Sugar and Jaggery is consumed occasionally by 32% of the respondents followed by 16% who never consume them and 14% who consume it daily. Beverages were consumed daily by 80% of the respondents. Nuts and oilseeds were never consumed by 21% of the respondents followed by 20% who consume it once in a week.

Bakery foods were never consumed by 39% of the respondents followed by 32% who consumed it occasionally. 31% of respondents never consume fast foods followed by equal number of the respondents who consume fast food occasionally.

Sweets were occasionally consumed by 54% of the respondents followed by 24% who never consume it. Fried foods are consumed by 24% each fifteen days once and once in a week followed by 19% who consume it once in a month.

Table 7: Comparison of Intake of Nutrients with RDA and adequacy value among Males

No.	Nutrients	RDA	Intake		Adequacy (%)	Standard 't'Test
			Mean	SD		
1	Energy (kcal)	2320	1752.2	329.9	75.5	7.30*
2	Protein (g)	60	51.2	11.4	85.3	3.28*
3	Fat (g)	25	39.9	10.3	159.6	6.14*
4	CHO (g)	319	301.9	78.6	94.6	0.92 NS

N=18* Significant at 5% Level NS: Non-significant,

Above table compares the intake of various nutrients i.e. energy, protein, fat and CHO with their RDA among males. The intake of energy (1752.2), protein (51.2) and CHO (301.9) is lower compared to their RDA (2320) (60) (319). The intake of fat (39.9) is higher when compared to RDA (25) and is found to be almost 1.5 times more than the recommendations. The % adequacy of nutrients is found to be 75.5%, 85.3%, 159.6% and 94.6% for energy, protein, fat and Carbohydrates respectively.

Table 8: Comparison of Intake of Nutrients with RDA and adequacy value among Females

No.	Nutrients	RDA	Intake		Adequacy (%)	Standard 't' Test
			Mean	SD		
1	Energy (kcal)	1900	1589.8	326.5	83.7	3.29*
2	Protein (g)	55	45.9	8.8	83.5	3.58*
3	Fat (g)	20	44.6	11.6	223.0	7.35*
4	CHO (g)	261	290.4	91.0	111.3	1.12 NS

N=12* Significant at 5% Level, NS: Non-significant,

Above table compares the intake of various nutrients i.e. energy, protein, fat and CHO with their RDA among males. The intake of energy (1589.8) and protein (45.9) is lower compared to their RDA (1900) (55). The intake of fat (44.6) and CHO is higher (290.4) when compared to their RDA (20) (261) and is found to be almost 2 times more than the recommendations. The % adequacy of nutrients is found to be 83.7%, 83.5%, 223% and 111.3% for energy, protein, fat and CHO respectively. The statistical tests show a significant difference between the intake and RDA for energy (t= 3.29*), protein (t= 3.58*) and fat (t=7.35*) There is no significant difference between the intake and RDA for CHO.

Table 9: Comparison of Intake and Expenditure of Nutrients among Males

No.	Nutrients	Intake		Expenditure		Student's 't'Test
		Mean	SD	Mean	SD	
1	Energy (kcal)	1752.2	329.9	1923.7	363.4	2.00*
2	Protein (g)	51.2	11.4	73.6	15.0	5.04*
3	Fat (g)	39.9	10.3	26.5	15.5	3.05*
4	CHO (g)	301.9	78.6	297.9	59.9	0.17 NS

N=30 * Significant at 5% level NS: Non-significant

Above table compares the intake of various nutrients i.e. energy, protein, fat and CHO with their expenditure calculated using factorial method among males. The intake of energy (1752.2) and protein (51.2) is lower compared to their expenditure (1923.7) (73.6). The intake of fat (39.9) and CHO is higher (301.9) when compared to their expenditure (26.5) (297.9) and is found to be almost 2 times more than the recommendations. The statistical tests show a significant difference between the intake and expenditure for energy (t= 2.00*), protein (t= 5.04*) and fat (t=3.05*) There is no significant difference between the intake and expenditure for CHO among male respondents.

Table 10: Comparison of Intake and Expenditure of Nutrients among Females

No.	Nutrients	Intake		Expenditure		Student's 't'Test
		Mean	SD	Mean	SD	
1	Energy (kcal)	1589.8	326.5	2060.8	425.8	3.04*
2	Protein (g)	45.9	8.8	71.8	15.5	5.03*
3	Fat (g)	44.6	11.6	23.6	6.4	5.49*
4	CHO (g)S	290.4	91.0	303.3	77.3	0.37 NS

N=30 * Significant at 5% level, NS: Non-significant

Above table compares the intake of various nutrients i.e. energy, protein, fat and CHO with their expenditure calculated using factorial method among females. The intake of energy (1589.8), protein (45.9) and CHO (290.4) is lower compared to their expenditure (2060.8) (71.8) (303.3) The intake of fat is higher (44.6) when compared to expenditure (23.6) and is found to be almost 2 times more than the expenditure. The statistical tests show a significant difference between the intake and expenditure for energy (t= 3.04*), protein (t= 5.03*) and fat (t=5.49*). There is no significant difference between the intake and expenditure for CHO among female respondents.

Table 11: Glycemic load of the meals consumed by the respondents

No.	Meal	Consumption (g)	
		Mean	SD
1	Break fast	10.8	2.2
2	Lunch	11.1	2.6
3	Dinner	11.6	2.4
	Total	33.4	5.5

N=30

Table 9 depicts the Glycemic load of the meals consumed by the respondents. It is found that the mean glycemic load of breakfast is 10.8 and that of lunch and dinner is 11.1 and 11.6 respectively. When compared with the standards the glycemic load of all the three meals is found to be moderate.

Table 12: Relationship between Glycemic load and Blood glucose parameters

No.	Parameters	Correlation co-efficient® for glycemic load of the meal
1	FBS	+0.004
2	PPBS	+0.312
3	RBS	+0.274
4	HbA1c	-0.076

N=100

Above table depicts the relationship between Glycemic load and Blood glucose parameters. The results indicate that there is a positive correlation between glycemic load of the meals with FBS, PPBS and RBS values. Amir Ziaee conducted a study on Effect of Low Glycemic Load Diet on Glycated Hemoglobin (HbA1c) in Poorly-Controlled Diabetes Patients in the year 2012 demonstrated that alternative low glycemic load diet can be effective in controlling HbA1c and FBS. Though the statistical analysis shows negative relationship between glycemic load of the meal and HbA1C values, strict glycemic control aids in maintaining normal HbA1C values.

8. Conclusion

The study reveals that intake of high glycemic foods, unhealthy lifestyle and lack of education has led to increase in blood glucose level among the respondents. Above factors also increase the respondent's risk for other co-morbidities like hypertension, cardiovascular diseases, obesity, renal problem, etc. Hence keeping good control over the food, lifestyle modifications, nutrition education along with the practicing regular physical activity can keep the blood glucose level under control and greatly reduce the risk for co-morbidities thereby increasing the quality of life and life expectancy among individuals suffering from Type-2 Diabetes Mellitus.

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