Nutrient Intake Profile and Its Correlation with Glycaemic Control in Selected Elderly Overweight Type 2 Diabetics

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Abstract
Background and Objective: Type 2 Diabetes mellitus (T2DM) is a very common non-communicable disease in India with the number of diabetes cases increasing every year at an alarming rate. Several nutrients are important modulators of glucose metabolism. Glycaemic management in T2DM has become increasingly complex. To assess the management of T2DM in the selected subjects and to find the correlation between the nutrient intake and glycaemic control of diabetics. Research design: It was a cross-sectional hospital based survey, purposive sampling method was used to select 60 type 2 diabetics (vegetarian=30, non-vegetarian=30) aged 60-70years, BMI>22.9 and without complications from a private hospital Coimbatore. Ethical clearance was obtained before the start of the study. Results: Nutrient intake did not meet recommendations. The protein intake of vegetarian and non-vegetarian were 44.41±7.69g and 45.58±6.27g respectively, which were below the recommended protein intake (15% of total daily energy intake), HbA1C was high when compared to reference standard for glycaemic control (<6.5%). Multiple regression statistical analysis revealed that calcium intake influenced HbA1c values in vegetarians, while fat intake influenced HbA1c value in non-vegetarians. Conclusion: This study showed that high carbohydrate intake and low fat intake was associated with high concentrations of HbA1c in high calorie consuming overweight type 2 diabetic patients.

***Keywords*: Type 2 Diabetes mellitus (T2DM), Elderly, Overweight women, Glycaemic control, HbA1c, Nutrient intake**

INTRODUCTION

Many developing nations experience rapid economic and social development with concomitant shifts in lifestyle habits and dietary structure. These changes promote over-nutrition and positive energy balance. In Asia, traditional dietary patterns are being lost as the population adapts to more industrialized and urban food environments. At the same time, people have become vulnerable to sophisticated living environments that have made them increasingly sedentary. These changes have a significant impact on type 2 diabetes risks by increasing body weight and central adiposity, and decreasing physical activity [1].

The relationship between dietary carbohydrate and insulin resistance has been widely discussed [2]. Insulin resistance is not a simple phenotype. Different tissues may have different levels of sensitivity to insulin, and within a single tissue, certain insulin actions may be more or less involved in the process of insulin resistance. The amount of carbohydrate ingested is usually the primary determinant of postprandial response, but the type of carbohydrate also affects this response. Intrinsic variables that influence the effect of carbohydrate containing foods on blood glucose response include the specific type of food ingested, type of starch (amylose versus amylopectin), style of preparation (cooking method and time, amount of heat or moisture used), ripeness, and degree of processing [3]. Increased fiber intake has been associated with reduction in development of diabetes. Low GI diet improves in vitro insulin responsiveness of adipocytes and improves in vivo insulin sensitivity [4]. Further, low GI diet decreases total cholesterol, LDL-C, and plasma triacylglycerol levels and increases HDL-C levels [5].

The relationships between dietary fat and insulin resistance opine that low-fat diets are beneficial in leading to weight loss. Fat intake is also associated with the development of diabetes, with the seven-country study showing that both saturated and monounsaturated fat predicts diabetes. Overall intake of dietary SFAs is positively related to insulin resistance. Replacing SFAs with MUFAs or PUFAs in dietary fat may be a useful dietary intervention to prevent metabolic deterioration [6].

MATERIALS AND METHODS

In the present cross sectional study, convenient sampling method was used to select participants with T2DM aged 60-70 years, BMI>22.9 and without complications as the unit of study at the outpatient Department of Endocrinology, PSG Institute of Medical Sciences and Research, Coimbatore, Tamil Nadu, India was selected as area of study. Sixty type 2 diabetics were selected and divided into two subgroups (vegetarian=30; non-vegetarian=30). Each subgroup consisted of 50 percent males and 50 percent females.

Ethical clearance was obtained from the Institutional Human Ethics Committee of PSG IMS&R, Coimbatore, Tamil Nadu, India. A Pre-tested semi structured questionnaire was used to collect socio-demographic, anthropometric measurements, clinical, and dietary survey data through interview. Socio-demographic characteristics included duration of diabetes, ethnicity, marital status, educational level, income, and employment status.

The biochemical parameters like Fasting Blood Glucose [FBG], Postprandial Blood Glucose [PPBG], and Glycated Haemoglobin [HbA1c] were recorded from the recent medical reports of selected patients. Three days 24 hour food recall was recorded and nutrient intake was calculated using the NSI Diet Cal software. BMI of 22.9 was used to calculate Desirable Body Weight (DBW). Because of age, the habitual physical activity was sedentary. Recommended daily energy intake was compared with Human Energy Requirements given by ICMR [7, 8]. Data was consolidated on MS excel and multiple regression was statistically analyzed in Statistical Package for Social Sciences (SPSS) software version 20.

RESULTS AND DISCUSSION

Optimal treatment for type 2 diabetes incorporates a multiple risk factor approach, including self-management education and ongoing support, medical nutrition therapy (MNT), physical activity, weight reduction if appropriate, and the use of glucose-lowering oral agents or insulin. Careful consideration needs to be given to ameliorating associated risk factors such as hypertension, smoking, and dyslipidemia. In our study we focused on the nutrient composition of the diets of adult female diabetics who were over-weight. To make a distinction in their food habits, we categorized the selected subjects into vegetarians and non-vegetarians.

1.Anthropometric Assessment

We first give a profile of their anthropometric indices in the following Table1. Weight and BMI are important factors in glycaemic control and prevention of complications as age progresses. We had the two groups equally matched with respect to age and the anthropometric indices as indicated by the t values being not significant.

Table 1: Mean Age, Anthropometric Measurements of Selected Participants

Criteria	Vegetarian Mean ± SD	Non-vegetarian Mean ± SD	T value	S / NS
AGE (years)	64.00±3.658	64.67±3.089	0.224	NS
HEIGHT(cm)	156.33±5.235	156.87±7.592	0.376	NS
WEIGHT(kg)	65.73±9.944	68.03±8.261	0.168	NS
BMI (Kg/m^2)	26.912±3.976	27.70347±3.504	0.208	NS

NS – Not significant

The anthropometric parameters were similar in both the groups. The BMI was above the cut-off point for Asians, indicating the risk/ cause of being diabetic as well as poor glycaemic control.

Because of the relationship between body weight (i.e., adiposity) and insulin resistance, weight loss has long been a recommended strategy for overweight or obese adults with diabetes [9]. A number of factors may be responsible for increasing adiposity in people with diabetes, including a reduction in glycosuria and thus retention of calories otherwise lost as an effect of therapeutic intervention, changes in food intake, or changes in energy expenditure [10].

Several research groups have begun to set lower cutoff points for BMI and abdominal obesity among Asians. China and Japan define overweight as a BMI of 24 or higher and obesity a BMI of 28 or higher; in India, overweight is defined as a BMI of 23 or higher, and obesity, a BMI of 27 or higher. And the International Diabetes Federation now includes ethnic-specific criteria for the increases in weight over time were more harmful in Asians than in the other ethnic groups: For every 11 pounds Asians gained during adulthood, they had an 84 percent increase in their risk of type 2 diabetes; Hispanics, blacks, and whites who gained weight also had higher diabetes risks, but again, to a much lesser degree than Asians [11, 12].

Even modest weight gain in adult life is associated with a substantial risk of developing type 2 diabetes, and moderate or severe weight gain in early life is a stronger risk factor for diabetes than is weight gain after age 40 y. For relevance in clinical practice, it might be important to measure the current BMI and to assess comprehensively the history of weight gain or weight loss in earlier decades of adult life to provide a more precise risk profile for the patient. After a latency period of 15–23 y, age at diabetes diagnosis is earlier for overweight subjects and for those with a weight gain 3–12 kg in younger adulthood than in normal-weight subjects and those with marginal weight changes. This finding stresses the importance of maintaining a healthy body weight throughout adult life [13].

2. Nutrient Intake

A healthful eating pattern, regular physical activity, and often pharmacotherapy are key components of diabetes management. For many individuals with diabetes, the most challenging part of the treatment plan is determining what to eat. Both MNT and nutrition therapy should involve a nutrition assessment, nutrition diagnosis, nutrition interventions e.g., education and counselling), and nutrition monitoring and evaluation with ongoing follow-up to support long term lifestyle changes, evaluate outcomes, and modify interventions as needed [14]. Hence, in our study we assessed the daily nutrient intake of the selected subjects. The following Table gives the nutrient intake of the selected subjects.

Table 2: Nutrient Intake of the selected subjects compared with RDA and Diabetic Diet

Nutrient	Vegetarians	Non-vegetarians	RDA (ICMR, 2010)	Diabetic Diet
Energy (Kcal)	1580.203 ±285.630	1667.177 ±214.564	1900	1680 (30Kcal/Kg IBW)
Carbohydrates(g)	275.883 ±55.209	284.612 ±41.197	275	252 (60% energy)
Protein (g)	44.413 ±7.697	45.589 ±6.273	63	44.8 or 50-84 (0.8g/Kg IBW; 12-20% energy)
Fat (g)	33.633 ±10.728	38.843 ±8.836	20	37 - 46 (20-25% energy)
Fibre (g)	4.518 ±2.522	4.565 ±1.900	25	42 (25g/1000Kcal)

2. a. Energy and Carbohydrates

Nutrient intake plays a major role in the management of T2DM. Adherence to dietetic recommendations is crucial in the maintenance of fasting and post-prandial blood glucose and the prevention of complications. We found that carbohydrate intake was well above the recommendations (60% of total daily energy intake) while all other nutrients viz., energy, protein and fat were below the recommendations. The dietary modification referred to as the LoBAG diet (low biologically available glucose diet) has the potential for normalizing or nearly normalizing the blood glucose in people with mild to moderately severe type 2 diabetes. These results should be considered to be merely a proof of the concept and should be established in different ethnic groups with respect to their food behavior [15].

The abnormalities underlying T2DM are reversible by reducing dietary energy intake. A low-carbohydrate diet is an effective tool in the treatment of obese patients with type 2 diabetes [16]. The hypothesis was tested that both beta cell failure and insulin resistance can be reversed by dietary restriction of energy intake [17]. They confirmed that the normalization of both beta cell function and hepatic insulin sensitivity in T2DM could be achieved by dietary energy restriction alone. The contribution of energy from the principal components in the two groups along with the RDA for normal population and the recommended diabetic diet is compared in the following figure.

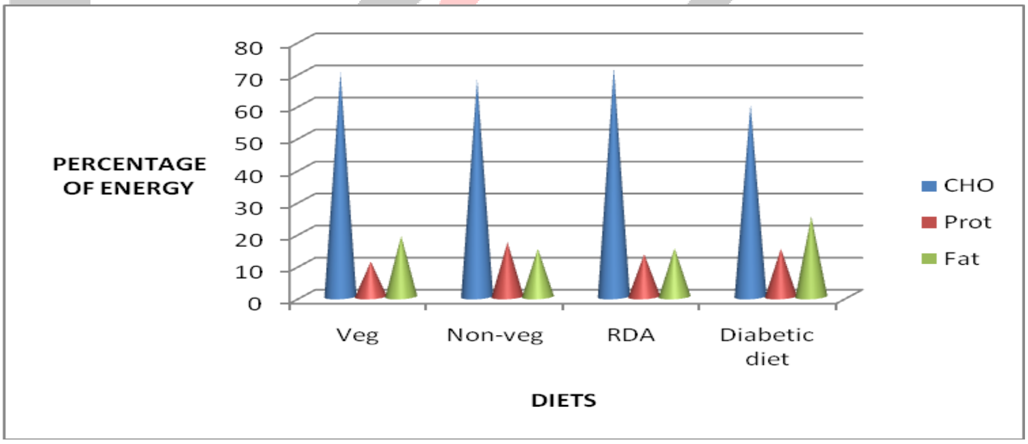

Figure 1: Percentage Contribution of Energy from the Principal Components in the Daily Diet

A diet high in complex carbohydrate and leguminous fibre improves all aspects of diabetic control, and continued use of a low carbohydrate diet alone no longer appears justified [18]. A high intake of dietary fiber, particularly of the soluble type, above the level recommended by the ADA, improves glycaemic control, decreases hyperinsulinemia, and lowers plasma lipid concentrations in patients with T2DM [19]. Therefore, a wide range of carbohydrate intakes may be acceptable in terms of achieving a low risk of T2DM with type and source of carbohydrate being more important than quantity.

Individuals eat combinations of foods, not single nutrients, and thus it is important to study diet and disease relationships [20]. Vegetarian and low-fat vegan studies [21] in individuals with type 2 diabetes were reviewed by several authors. Studies ranged in duration from 12 to 74 weeks, and the diets did not consistently improve glycaemic control or CVD risk factors except when energy intake was restricted and weight was lost. A systematic review found that there is no ideal mix that applies broadly and that macronutrient proportions should be individualized. On an average, it has been observed that people with diabetes eat about 45% of their calories from carbohydrate; 36–40% of calories from fat, and the remainder (16–18%) from protein [22]. However, in South Indian diets the proportion of carbohydrates is higher and that of fat only about half of the recommendations.

In our study since the selected diabetics were over-weight their intakes of total energy, carbohydrate and fat were high and maintained a high body weight resulting in an inability to establish glycaemic control.

2. b. Protein

The greatest difference was with reference to protein intake. The protein intake of both vegetarian and non-vegetarian groups was lower than the recommended protein intake of 63 grams/day (15% of total daily energy intake). Insulin plays a metabolic role in building body proteins and amino acids which are building blocks of insulin. Associations between protein intake from different sources and type 2 diabetes (T2DM) have been inconsistent [23]. Therefore, in their results from the Melbourne Collaborative Cohort Study and a meta-analysis of prospective studies they conclude that higher intakes of total and animal protein were both associated with increased risks of T2DM, whereas higher plant protein intake tended to be associated with lower risk of T2DM.

The evidence base to guide recommendations for dietary protein intake in relation to the prevention and management of diabetes is mixed. Higher protein intake may reduce risk of developing diabetes and improve metabolic control only when weight loss is achieved. However, an iso-caloric high protein diet and higher branched-chain amino acid intake may increase insulin resistance, which could adversely affect metabolic parameters. The American Diabetes Association (ADA) standards of care recommendations include using an individualized approach in diabetes medical nutrition therapy with regard to protein intake and dietary macronutrient composition [24].

In our study we found the greatest deviation from recommendations in the case of protein intake. Also we would like to point out that though we have data on vegetarians and non-vegetarians, the latter's intake of protein may also be predominantly plant sources. So we would like to stress on the insufficiency of dietary protein rather than the source of the protein. Further as their BMI was above the normal (22.9) for Indians, we see that increasing protein intake would improve glycaemic control only through weight reduction.

The dietary intake of protein for individuals with diabetes is similar to that of the general public and usually does not exceed 20% of energy intake. A number of studies in healthy individuals and in individuals with T2DM have demonstrated that glucose produced from ingested protein does not increase plasma glucose concentration but does produce increases in serum insulin responses [9, 15]. Abnormalities in protein metabolism may be caused by insulin deficiency and insulin resistance; however, these are usually corrected with good blood glucose control [25]. Small, short-term studies in diabetes suggest that diets with protein content ≥20% of total energy reduce glucose and insulin concentrations, reduce appetite, and increase satiety [26, 27]. However, the effects of high-protein diets on long term regulation of energy intake, satiety, weight, and the ability of individuals to follow such diets long term have not been adequately studied.

The high-protein intake during weight loss (WL) preserves lean tissue mass but eliminates the WL induced improvement in muscle insulin action [28]. The authors suggest that this occurs through increasing oxidative stress and modulating WL-induced changes in cell structure and organization. In individuals with type 2 diabetes, protein does not appear to have a significant effect on blood glucose level but does appear to increase insulin response [29, 15].

2. c. Fat

Evidence is inconclusive for an ideal amount of total fat intake for people with diabetes; therefore goals should be individualized; fat quality appears to be far more important than quantity. Currently, insufficient data exist to determine a defined level of total energy intake from fat at which risk of inadequacy or prevention of chronic disease occurs, so there is no single adequate intake or recommended daily allowance for total fat [30].

The use of coconut oil has generated discussion regarding its possible effects on health due especially to its composition, since SFA may contribute to atherosclerosis and consequently, for the development of cardiovascular diseases. However, although being composed largely of SFA, coconut oil has a significant amount of lauric acid, which may avoid the fat deposition in organs and blood vessels and, therefore, it is not considered as a potential atherogenic fat [31]. In addition, flavonoids and polyphenols present in CO may have a beneficial effect regarding the improvement of oxidative stress, involved in the etiology of various diseases, including type-2 diabetes mellitus [32].

People with diabetes mellitus are at high risk for cardiovascular disease. They often have hyperlipidemia. Their meal plan should aim for 30% or less of calories derived from fat and 10% or less saturated fats. Monounsaturated fats, like those found in olive oil, are best. Men with higher intakes of saturated fat had a higher BMI, a lower level of physical activity, and were more likely to smoke cigarettes and less likely to have hypercholesterolemia. The cross-sectional association with hypercholesterolemia probably reflects changes in diet after diagnosis. Furthermore, a higher intake of saturated fat was associated with lower intakes of alcohol, cereal fiber, and magnesium. Similar associations were observed for intake of oleic acid (the predominant monounsaturated fat in the diet), trans-fat, and total fat. Characteristics differed less according to intake of linoleic acid (the predominant polyunsaturated fat in the diet) and α-linolenic acid. High intakes of long-chain n-3 fatty acids were associated with a healthier lifestyle [33].

In 2011, the Evidence Analysis Library (EAL) of the Academy of Nutrition and Dietetics found strong evidence that dietary MUFAs are associated with improvements in blood lipids based on 13 studies including participants with and without diabetes. According to the EAL, 5% energy replacement of saturated fatty acid (SFA) with MUFA improves insulin responsiveness in insulin-resistant and type 2 diabetic subjects. CVD is a common cause of death among individuals with diabetes. As a result, individuals with diabetes are encouraged to follow nutrition recommendations similar to the general population to manage CVD risk factors. These recommendations include reducing SFAs to <10% of calories, aiming for <300 mg dietary cholesterol/day, and limiting trans fat as much as possible [34].

In a cross-sectional study demonstrated an independent association between HbA1c concentration and both total fat intake and the pattern of dietary fat intake. They provide further support to efforts promoting modifications in the intake of dietary fat [35].

2. d. Fibre

Most studies on fiber intake in people with diabetes are of short duration, have a small sample size, and evaluate the combination of high-fiber and low–glycaemic index foods, and in some cases weight loss, making it difficult to isolate fiber as the sole determinant of glycaemic improvement [36]. Data from the Nurse's Health Study examining whole grains and their components (cereal fiber, bran, and germ) in relation to all-cause and CVD-specific mortality among women with type 2 diabetes suggest a potential benefit of whole-grain intake in reducing mortality and CVD. As with the general population, individuals with diabetes should consume at least half of all grains as whole grains [37].

Recently, investigators have also considered the possibility that factors other than fibre that are contained in cereals and legumes may influence the risk for chronic diseases. Some of these include micronutrients such as selenium and vitamin E, antioxidants, phytochemicals, isoflavins and lignans. Since many of these factors occur together in cereals it is difficult to determine the precise benefits of each. Cross-sectional studies suggest that lack of dietary fibre may be a causative factor in type 2 diabetes and have shown an inverse relationship between fibre intake and blood insulin levels; implying that fibre improves insulin sensitivity [38].

The common coexistence of hyperlipidemia and hypertension in people with diabetes requires monitoring of metabolic parameters (e.g., glucose, lipids, blood pressure, body weight, renal function) to ensure successful health outcomes. Nutrition therapy that includes the development of an eating pattern designed to lower glucose, blood pressure, and alter lipid profiles is important in the management of diabetes as well as lowering the risk of CVD, coronary heart disease, and stroke. Successful approaches should also include regular physical activity and behavioral interventions to help sustain improved lifestyles [39].

3. Glycaemic Parameters

The biochemical parameters showed higher mean values for vegetarians. On the whole, FBG, PPBG and HbA1c were high when compared to reference standard for glycaemic control (FBG ≤ 126 mg/dl; PPBG ≤ 200 mg/dl; HbA1c ≤ 6.5% respectively, American Diabetes Association [40]) in both the groups.

Table 3: Mean Biochemical Parameters of Selected Subjects

Criteria	Vegetarian	Non-vegetarian	T values*
	Mean ± SD	Mean ± SD	
FBG (mg/dl)	161.57±62.921	137.83±44.425	0.1625
PPBG(mg/dl)	256.80±96.029	221.73±82.036	0.2370
HbA1c (%)	8.513±2.055	7.947±1.6563	0.7501

*****– not significant ($P \geq 0.05$)

A 5-week randomized, crossover study design was used with a 5-week washout period between diets, which concluded that the diet containing 30% of total food energy from protein, with a corresponding decrease in carbohydrate content, resulted in a moderate but highly statistically significant mean decrease in glycohemoglobin (8.1–7.3%) after 5 weeks on the diet. In that study, along with 30% of total energy from protein the lower carbohydrate diet not only reduced the post-meal glucose concentration but also considerably reduced the overnight fasting glucose concentration. In addition, the percentage of glycohemoglobin concentration at the end of the 5-week study period was decreased from a mean of 9.8 to 7.6%. The study was designed to be 5 weeks in duration because 33 days had been reported to be the half-time for glycohemoglobin to reach a new steady state [26].

A multiple regression analysis was calculated predicting HbA1c based on nutrient intake of vegetarian participants. The regression equation was not significant for carbohydrates, protein, fat and fibre. We obtained an R square of 0.216, F (5,24) = 1.324, $p \leq 0.0005$, $r^2 = 0.216$. The intake of carbohydrates, protein, fat and fibre do not predict HbA1c. In multiple regression analysis for non-vegetarian participants, HbA1c, F (5,24) = 0.300, $p \leq 0.0005$, $r^2 = 0.213$. Since the independent variable variation in dependant variable is 21%. In this study, the statistical analysis results revealed that calcium intake will influence HbA1c values in vegetarians, while fat intake will influence HbA1c value in non-vegetarians.

Both low-fat vegan diet and conventional diabetic diet were associated with sustained reductions in weight and plasma lipid concentrations. In an analysis controlling for medication changes, a low-fat vegan diet appeared to improve glycaemia and plasma lipids more than did conventional diabetes diet recommendations [21].

Much of the effect of the intervention diets on glycemia appears to be mediated by weight reduction. The principal diet change in the conventional diet group was a reduction in energy intake, which appears to be due to reduced portion sizes rather than to changes in macronutrient balance, which was close to the recommended percentages for protein, carbohydrate, and monounsaturated fat at baseline and changed only slightly during the study. This change in energy intake was nonetheless sufficient to lead to sustained weight loss

CONCLUSION

In a study on overweight subjects with relatively high serum insulin, low carbohydrate and low fat hypocaloric diets both made a reduction in serum glucose but the reduction was not statistically significant. However, the low carbohydrate diet led to an improvement in insulin sensitivity [39]. Another study showed that the substitution of fat for carbohydrate is associated with low concentrations of HbA1c in high calorie consuming type 2 diabetic patients [41]. Our study participants had high carbohydrate and low fat intakes and they were overweight, hence their HbA1c was high and not significantly associated with nutrient intakes. The energy intake in our study was higher than recommended values. The beneficial effects of low carbohydrate and low fat diets in several studies are attributable to the calorie restriction. Such an effect was not involved in our study.

Carbohydrate as the easiest to break down is the body's preferred energy source. Carbohydrate effect in stimulating insulin secretion leads to increase in carbohydrate, but a decrease in fat oxidation [30]. So, it can be expressed that fat oxidation is determined primarily by the gap between total energy expenditure and the amount of energy ingested in the form of carbohydrate and protein, rather than by the amount of fat consumed [42]. Indeed, it seems that the effect of dietary macronutrient composition on several aspects of metabolic control may be the most important in a high calorie diet compared to low calorie or iso-caloric diet; because in low calorie or iso-caloric diet all of ingested and absorbed macronutrients should be oxidized to supply body needs. But, if the calorie intake is more than energy expenditure, more dietary fat may remain and induce weight gain, change cell membrane fatty acid composition and increase insulin resistance [43].

In our study, the reason for no significant relationship between energy intake and HbA1c might be due to the increment of carbohydrate proportion of the diet following to increment in caloric intake, that high carbohydrate may attenuate the effects of high calorie intake on blood glucose control. In addition, since calorie intakes of 25 and 30 kcal/kg body weight are respectively the cut off points of the effects of carbohydrate and total fat on HbA1c; so, the association coefficients of dietary carbohydrate or fat with HbA1c were significantly higher in the lower values of energy intake. The beneficial effects of high carbohydrate diet may be related to high contents of dietary fiber, Fructo-oligosaccharides, resistant starch and indigestible carbohydrates that may increase peripheral insulin sensitivity and insulin secretion and decrease glucose release of the liver [44]. In our study fibre intake was very poor in both groups and hence the poor glycaemic control.

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REFERENCE

[1] Siegel K, Narayan KM, Kinra S., 2008, Finding a policy solution to India's diabetes epidemic. Health Aff (Millwood); 27: 1077–1090.
[2] Bessesen D.H, 2001, The Role of Carbohydrates in Insulin Resistance, The Journal of Nutrition, PP-2782-2786
[3] American Diabetes Association, 2008, Nutrition Recommendations and Interventions for Diabetes - A position statement of the American Diabetes Association, Diabetes Care, Volume 31, Supplement 1, January, S61-78
[4] Frost, G., Leeds, A., Trew, G., Margara, R., & Dornhorst, A. 1998, Insulin sensitivity in women at risk of coronary heart disease and the effect of a low glycemic diet. Metabolism, 47(10), 1245-1251.
[5] Frost G, Leeds AA, Dore CJ, Madeiros S, Brading S, Dornhorst A., 1999, Glycaemic index as a determinant of serum HDL-cholesterol concentration. Lancet; 353:1045-8.
[6] Lovejoy J.C, 2002, The influence of dietary fat on insulin resistance, Curr Diab Rep. Oct; 2(5):435-40.

[7] Indian Council of Medical Research, Expert Group, 2010. Nutrient Requirements and Recommended Dietary Allowances for Indians: A Report of the Expert Group of the Indian Council of Medical Research.
[8] Raghuram TC, Pasricha S, Sharma RD. Diet and diabetes, 2003. National Institute of Nutrition, Hyderabad: ICMR; p. 12-22.
[9] Franz MJ, Bantle JP, Beebe CA, Brunzell JD, Chiasson JL, Garg A, Holzmeister LA, Hoogwerf B, Mayer-Davis E, Mooradian AD, Purnell JQ, Wheeler M., 2002, Evidence-based nutrition principles and recommendations for the treatment and prevention of diabetes and related complications. Diabetes Care 25:148 –198.
[10] McMinn JE, Baskin DG, Schwartz MW., 2000, Neuroendocrine mechanisms regulating food intake and body weight. Obes Rev; 1:37–46.
[11] Misra,A., P Chowbey, BM Makkar, NK Vikram, JS Wasir, D Chadha, Shashank R Joshi, S Sadikot, R Gupta, Seema Gulati, YP Munjal, 2009, Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. J Assoc Physicians India.;57:163-170.
[12] International Diabetes Federation, 2006, The IDF consensus worldwide definition of metabolic syndrome. Brussels..
[13] Schienkiewitz,A., Schulze,MB., Hoffmann,K., Kroke,A., and Boeing,H., 2006, Body mass index history and risk of type 2 diabetes: results from the European Prospective Investigation into Cancer and Nutrition (EPIC)–Potsdam Study1–3 Am J Clin Nutr;84:427–33.
[14] Lacey K, Pritchett E., 2003, Nutrition care process and model: ADA adopts road map to quality care and outcomes management, J Am Diet Assoc; 103: 1061–1072.
[15] Gannon MC, Nuttall JA, Damberg G, Gupta V, Nuttall FQ, 2001, Effect of protein ingestion on the glucose appearance rate in people with type 2 diabetes. J Clin Endocrinol Metab 86:1040–1047.
[16] Nielsen JV, Jonsson E, Nilsson AK., 2005, Lasting improvement of hyperglycaemia and bodyweight: low-carbohydrate diet in type 2 diabetes. A brief report. Ups J Med Sci. Jan 1;110(2):179-83.
[17] Lim EL, Hollingsworth KG, Aribisala BS, Chen MJ, Mathers JC, Taylor R., 2011, Reversal of type 2 diabetes: Normalisation of Beta Cell Function in Association with Decreased Pancreas and Liver Triacylglycerol. Diabetologia. Oct 1; 54(10):2506-14.
[18] Simpson HC, Lousley S, Geekie M, Simpson RW, Carter RD, Hockaday TD, Mann JI., 1981, A high carbohydrate leguminous fibre diet improves all aspects of diabetic control. The Lancet. Jan 3; 317 (8210): 1-5.
[19] Chandalia M, Garg A, Lutjohann D, von Bergmann K, Grundy SM, Brinkley LJ., 2000, Beneficial effects of high dietary fiber intake in patients with type 2 diabetes mellitus. New England Journal of Medicine. May 11;342(19):1392-8.
[20] Jones-McLean EM, Shatenstein B, Whiting SJ., 2010, Dietary patterns research and its applications to nutrition policy for the prevention of chronic disease among diverse North American populations, Appl Physiol Nutr Metab; 35:195–198.
[21] Barnard N.D., Cohen J., Jenkins D.J.A., Turner-McGrievy G., Gloede L., Green A., and Ferdowsian H., 2009, A low-fat vegan diet and a conventional diabetes diet in the treatment of type 2 diabetes: a randomized, controlled, 74-wk clinical trial Am J Clin Nutr;89(suppl):1588S–96S.
[22] Oza-Frank R, Cheng YJ, Narayan KM, Gregg EW., 2009, Trends in nutrient intake among adults with diabetes in the United States: 1988-2004. J Am Diet Assoc 2009; 109:1173–1178.
[23] Shang, X., Scott, D., Hodge, A.M., English, D.R., Giles, G.G., Ebeling, P.R., and Sanders, K.M., 2016, Dietary Protein Intake and Risk of Type 2 Diabetes: Results from the Melbourne Collaborative Cohort Study and a Meta-Analysis Of Prospective Studies, AJCN.116.140954 V1 104/5/1352.
[24] ADA, 2013, Standards of Medical Care in Diabetes Diabetes Care. 2013 Jan; 36(Suppl 1): S11–S66. Published online 2012 Dec 10. doi: 10.2337/dc13-S011
[25] Gougeon R, Styhler K, Morais JA, Jones PJ, Marliss EB, 2000, Effects of oral hypoglycemic agents and diet on protein metabolism in type 2 diabetes. Diabetes Care 23: 1–8,.
[26] Gannon MC, Nuttall FQ., 2004, Effect of a high-protein, low-carbohydrate diet on blood glucose control in people with type 2 diabetes. Diabetes 53:2375–2382,
[27] Gannon MC, Nuttall FQ, Saeed A, Jordan K, Hoover H, 2003, An increase in dietary protein improves the blood glucose response in persons with type 2 diabetes, Am J Clin Nutr 78:734 –741.
[28] Smith,G.I., Yoshino, J., Kelly, S.C., Reeds, D.N., Okunade, a., Patterson, B.W., Klein, S., and Mittendorfer, B., 2016, High-Protein Intake during Weight Loss Therapy Eliminates the Weight-Loss-Induced Improvement in Insulin Action in Obese Postmenopausal Women, Cell Reports 17, 849–861.
[29] Papakonstantinou E, Triantafillidou D, Panagiotakos DB, Iraklianou S, Berdanier CD, Zampelas A, 2010, A high protein low fat meal does not influence glucose and insulin responses in obese individuals with or without type 2 diabetes. J Hum Nutr Diet; 23:183–189.
[30] Flatt JP, Ravussin E, Acheson KJ, and Jequier E., 1985, Effects of dietary fat on postprandial substrate oxidation and on carbohydrate and fat balances, J Clin Invest 1985, 76:1019–1024.
[31] Dayrit, C.S., 2003, Coconut Oil: Atherogenic or Not ? (What Therefore Causes Atherosclerosis?). Philippine Journal of Cardiology, 31, 97-104.
[32] Vasudevan, D.M., 2013, Coconut Oil and Health Controversy. International Journal of Health and Rehabilitation Sciences, 2, 157-164.
[33] van Dam, R.M., Willett, W.C., Rimm, E.B., Stampfer, M.J., and Hu, F.B., 2002, Dietary Fat and Meat Intake in Relation to Risk of Type 2 Diabetes in Men, Diabetes Care, Mar; 25(3): 417-424.

[34] Academy of Nutrition and Dietetics Evidence Analysis Library, 2011. Available from http://andevidencelibrary.com/template.cfm?template=guide_summary&key= 2984#supportevidence [Internet]. Accessed on 16.01.2017.

[35] Harding AH, Sargeant LA, Welch A, Oakes S, Luben RN, Bingham S, Day NE, Khaw KT, Wareham NJ., 2001, Fat Consumption and HbA1c Levels The EPIC-Norfolk Study. Diabetes care. Nov 1; 24 (11): 1911-6.

[36] Wolfram T, Ismail-Beigi F., 2011, Efficacy of high-fiber diets in the management of type 2 diabetes mellitus. Endocr Pract 2011; 17:132–142.

[37] Liu S., Stampfer MJ., Hu FB., Giovannucci E., Rimm E., Mason JE., Hennekens CH. And Willett WC., 1999, Whole-grain consumption and risk of coronary heart disease: results from the Nurses' Health Study, Am J Clin Nutr., Sep;70(3):412-9

[38] Schulze MB, Liu S, Rimm, EB., Manson, JE., Willett, WC. and Hu FB., 2004. Glycemic index, glycemic load, and dietary fiber intake and incidence of Type 2 diabetes in younger and middle-aged women. Am J Clin Nutr 80 (2); 348–56.

[39] Meckling KA, O'Sullivan C, Saari D., 2004, Comparison of a low-fat diet to a low carbohydrate diet on weight loss, body composition, and risk factors for diabetes and cardiovascular disease in free-living, overweight men and women. J Clin Endocrinol Metab, 89:2717–2723.

[40] American Diabetes Association, 2012, Diagnosis and classification of diabetes mellitus, Diabetes care, 35(Supplement 1), S64-S71.

[41] Shadman Z., Khoshniat M., Poorsoltan N., Akhoundan M., Omidvar M., Larijani B., Hoseini S., 2013, Association of high carbohydrate versus high fat diet with glycated hemoglobin in high calorie consuming type 2 diabeticsJournal of Diabetes & Metabolic Disorders, 12:27.

[42] Hession, M, Rolland, C. Kulkarani, U., Wise, A., & Broom, J., 2009. Systematic review of randomised controlled trials of low-carbohydrate vs. low-fat/low-calorie diets in the management of obesity and its comorbidities. Obes Rev 10 (1); 36–50.

[43] Galgani JE, Uauy RD, Aguirre CA, Diaz EO, 2008, Effect of the dietary fat quality on insulin sensitivity. Br J Nutr, 100:471–479.

[44] Gao Z, Yin J, Zhang J, Ward RE, Martin RJ, Lefevre M, Cefalu,WT., and Ye,J., 2009, Butyrate improves insulin sensitivity and increases energy expenditure in mice. Diabetes, 58:1509–1517.

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