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Examining the Influence of Vegetarian and Non-Vegetarian Diets on Metabolic Markers and Outcomes for People with Type 2 Diabetes (T2D)

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Abstract

Introduction: In India, data regarding diabetes reversal strategies from a diet perspective is scarce due to the presence of 32 distinct Indian cuisines offering a wide variety of vegetarian and non-vegetarian options. In this study we aim to investigate how a vegetarian or nonvegetarian diet may influence outcomes such as HbA1C and FBS as well as metabolic markers including weight and waist circumference of Type 2 Diabetes Mellitus (T2DM) patients.

Objective: This study aims to investigate how a vegetarian or nonvegetarian diet may influence outcomes such as weight, glycated Haemoglobin (HbA1C), Body Mass Index (BMI) and Fasting Blood Sugar (FBS) in Type 2 Diabetes Mellitus (T2DM) patients.

Methods: Using a continuously updated cloud-based EMR system, 2,835 patients were retrospectively reviewed and categorised into two cohorts: Vegetarian (vegan and lacto-ovo included) (N=1,404) and nonvegetarian (N=1431). Variables like weight, HbA1C, waist circumference and Fasting Blood Sugar (FBS) were measured within 30 days of enrolling in Sugarfit's Diabetes Reversal and Management Program (SDRMP) and from 80-120 days after completing the program. Statistical analysis was used to compare variables between the two cohorts.

Results: The average change in waist circumference was higher in vegetarians than non vegetarians (2.27 *vs.* -0.85 cm, p=6.4-12). The average change in FBS was higher in non vegetarians than vegetarians (34.31 *vs.* 28.06 mg/dL, p=0.014). The difference between average weight and HbA1C was not statistically significant.

Conclusion: Both diets distinctly influence outcomes and metabolic markers for T2DM patients. Post-SDRMP vegetarians demonstrated reduced waist circumference compared to non-vegetarians, most likely due to the program's emphasis on higher protein-to-carb ratio. Alternatively, non-vegetarian populations may have had a higher protein intake from the start, therefore waist reduction may not have been significant for this population. Additionally, further increase in protein and fat intake most likely led to lower fasting sugars. Further prospective studies are needed to confirm our results.

Keywords: Diet preferences; Vegetarian diet; Non vegetarian diet; Type 2 diabetes; Personal coaching; Protein intake

Introduction

Diet plays a significant role for diabetes prevention and management, as dietary patterns and lifestyle choices significantly impact blood glucose levels. The American Diabetes Association (ADA) states that various eating patterns can be effective for managing diabetes [1]. In India, data regarding diabetes reversal strategies from a diet perspective is scarce due to the presence of 32 distinct Indian cuisines offering a wide variety of vegetarian and non-vegetarian options. Several recent research studies have focused on the effects of both vegetarian and non-vegetarian eating patterns on the risk of T2D, glycemic control and the prevention of diabetes-related comorbidities.

Prior studies state that T2D is a poly-etiological, chronic, metabolic disease in different biological species [2-4]. Pancreatic β-cell dysfunction and insulin resistance play an essential role in the development of T2D [5]. Typically, the diagnosis of T2D is based on glycated Haemoglobin (HbA1c), Fasting Blood Sugar (FBS) and weight of T2DM patients including anthropometric characteristics and blood panels measuring metabolic markers including Body Mass Index (BMI) [6].

The International Diabetes Federation (IDF) has launched the 10th edition of the IDF Diabetes Atlas in 2021. According to this edition, 537 million people worldwide have diabetes. Since the first edition in 2000, the estimated prevalence of diabetes in adults aged 20-79 years has more than tripled, increasing from 151 million (4.6% of the global population at the time) to 537 million (10.5%) today. Without sufficient action, it is predicted that 643 million people (11.3% of the population) will have diabetes by 2030. If current trends continue, this number could rise to 783 million (12.2%) by 2045. The IDF has been publishing global estimates of diabetes prevalence for just over 20 years [7]. The prevalence of diabetes has been rising steadily, particularly in low and middle-income countries. This increase is linked to factors such as urbanisation, ageing populations and lifestyle changes associated with urbanisation, such as unhealthy diets and sedentary lifestyles, contributing to the increasing prevalence of diabetes, according to both WHO and IDF assessments [8].

Recent research indicates that elevated levels of plasma glucose, a attribute of diabetes, are the result of perturbations occurring in carbohydrate, fat and protein metabolism [9]. The primary factors driving the diabetes epidemic include rapid changes in dietary patterns, characterised by shifts towards unhealthy diets with higher calorie and glycemic loads, decreased physical activity, urbanisation (including pollution), depression and stress [10]. These factors collectively contribute to the increasing prevalence of diabetes worldwide, under-scoring the importance of addressing lifestyle factors along with dietary patterns in disease prevention and management.

Diets can be classified into vegetarian and non-vegetarian options, each impacting blood glucose regulation differently [11]. Vegetarian diets, characterised by the exclusion of animal flesh, vary widely in composition but often prioritise plant-based foods such as fruits, vegetables, legumes, nuts and whole grains. Conversely, non-vegetarian diets incorporate animal-derived foods such as meat, poultry, fish, dairy and eggs. The distinct nutritional profiles of these dietary patterns prompt exploration into their differential impacts on glycemic control, insulin sensitivity, lipid metabolism and overall metabolic health in individuals with T2D [12].

Compared to meat-eaters, vegetarians in the EPIC-Oxford study consume relatively higher amounts of carbohydrates, polyunsaturated fat, dietary fibre, folic acid, vitamin C, vitamin E and magnesium, while their intake of protein, saturated fat, retinol, vitamin B_{12} and zinc is relatively lower [13]. Vegetarians consumed greater amounts of legumes, vegetables, roots and tubers, dairy and sugar, whereas nonvegetarians had a greater intake of meat, cereals, fruits, fish, spices, salt, fats and oils [14]. The whole vegetarian diet is also associated with improved glycemic control, better weight management and enhanced insulin sensitivity [15,16]. Meat is a rich source of essential proteins, vitamins (including A, B_1, B_{12} and niacin), iron, zinc and other micronutrients.

However, recent epidemiological studies suggest that increasing meat consumption, especially in processed forms, may have adverse health effects. High protein intake from animal sources is strongly linked to rising BMI among non-vegetarians [17]. Additionally, non-vegetarians tend to have lower intakes of fibre, β-carotene and magnesium compared to those following vegetarian diets and higher intakes of saturated fats, trans fats, arachidonic acid and docosahexaenoic acid, which may increase the risk of T2D [18]. While non-vegetarian sources such as poultry, red meat and fish can provide high-quality protein, they also pose risks related to higher saturated fat consumption and potential negative impacts on lipid profiles and insulin resistance. Cross-sectional studies have shown that consuming lean meat, which is low in saturated fatty acids, does not raise blood cholesterol or LDL-cholesterol levels. Add-itionally, it provides a substantial amount of bioavailable protein [19].

Both vegetarian and non-vegetarian diets offer distinct advantages and disadvantages in managing T2D. Therefore, consuming a balanced diet that includes the appropriate amount of protein from either vegetarian or non-vegetarian sources, along with dietary fibre and incorporating physical activity is essential for managing diabetes and reducing weight. Studies indicate that up to 90% of the population can prevent T2D by adhering to a healthy diet and lifestyle [20].

This study provides a comprehensive review on the effects of balanced vegetarian or non-vegetarian dietary habits on HbA1c, FBS, weight and BMI in T2D patients. Our analysis highlights the distinct impacts of these diets on critical health markers, deepening our understanding of the role diet plays in managing T2D. By examining the physiological mechanisms, epid-emiological trends and clinical outcomes associated with these dietary patterns, we aim to offer insights that can inform personalized dietary recommendations and optimise T2D management strategies.

Methodology

The Sugarfit Diabetes Reversal and Management Program (SDRMP) is a pioneering initiative in diabetes care, offering personalized interventions that integrate advanced technology with expert guidance from diabetes expert physicians and health coaches. The program focuses on customised nutrition plans customized to individual dietary preferences and health needs, along with personalized exercise routines. SDRMP aims to empower individuals to take control of their health, improve well-being and achieve effective diabetes management and reversal through comprehensive, individualised care. This support includes strategies for enhancing adherence to treatment plans, addressing the psychological aspects of diabetes management and establishing healthy lifestyle habits.

One reliable strategy employed is utilizing Physical Activity Levels (PAL) and Basal Metabolic Rate (BMR) to calculate recommended calorie intake. PAL accounts for the energy expended through physical activity, while BMR represents the energy expended at rest. Adjusting calorie intake according to individual needs and Body Mass Index (BMI) ensures that recommendations are personalized to each participant's unique circumstances. Nutritionally balanced diet plans were recommended, comprising 50% carbohydrates which includes 35 kg-40 kg of fiber, 20%-25% protein and 25%-30% fat. Diet plans consist of various options based on the cuisine chosen by the individual and the food preference options include vegetarian, non-vegetarian and eggetarian.

The SDRMP, a retrospective study, enrolled 1200 patients diagnosed with T2D who actively participated in the program for a duration of 90 days, demonstrating adherence to program protocols. Data was collected from those participants utilizing a cloud-based EMR system, which serves as a digital platform for storing, managing and accessing patient medical records. These participants were divided into two distinct groups: The vegetarian cohort (group 1) consisted of 600 individuals, including vegans and lacto vegetarians, while the non-vegetarian cohort (group 2) also comprised 600 participants. Various parameters, such as HbA1C, FBS, weight and BMI, were evaluated at baseline during enrollment and again after 90 days (quarter 1) in the program. Additionally, a control group was established to provide comparative data for assessing the effectiveness of the program.

The control group comprising 110 individuals diagnosed with Type 2 Diabetes (T2D) who were undergoing conventional pharmacotherapy and dietary pattern but were not enrolled in the SDRMP, was included for comparative analysis. Data for the control group were obtained through a retrospective collection of HbA1c, fasting blood sugar, weight and medication history of T2D patients at baseline and after 3 months. This study underwent review and approval by the Sehgal Nursing Home Institutional Ethics Committee in Delhi, India. Additionally, informed consent was obtained from each participant prior to their inclusion in the study.

Baseline measurements, conducted within 15 days of enrollment, serve as an essential starting point for understanding participants' health status and parameters. These initial assessments establish a foundational understanding and provide a benchmark for comparison throughout the program. By capturing data on key health indicators such as HbA1c, FBS, weight and BMI at the outset, SDRMP can customize personalized dietary and regimen strategies to meet each participant's specific needs and goals effectively.

After 90 days in the program, an evaluation is conducted to assess the efficacy and sustainability of the interventions. This time frame allows for the examination of improvements in health outcomes, providing valuable insights that guide further adjustments or maintenance strategies as required. By incorporating these specific time intervals, the SDRMP adopts a holistic approach to monitoring progress and optimising health outcomes for participants. This systematic approach ensures that interventions are continually refined to support long-term health and well-being.

Statistical analysis

The descriptive statistics of both groups were calculated for age, height, weight, HbA1c, FBS and BMI.

The Wilcoxon signed-rank test **(Table 1)** was utilised to analyse paired comparisons within each group, comparing baseline measurements with those taken after 90 days. Additionally, the Mann-Whitney U test **(Table 2)** was employed to compare the distributions of variables between the two independent groups (vegetarian and non-vegetarian) at each time point.

Table 1: Pooled changes in weight, HbA1c, BMI and FBS levels in response to both vegetarian and non-vegetarian diets: Statistical estimation of p-value using Wilcoxon signed-rank test.

Parameter	Vegetarian group			Non-vegetarian group		
	Mean	SD	p-value	Mean	SD	p-value
Baseline HbA1c (%)	8.9	1.8	<0.001	8.6	1.6	<0.001
Q1 HbA1c (%)	7.4	1.2		7.2	1.1	
Baseline FBS (mg/dL)	167.6	59.7		170	56.2	
Q1 FBS (mg/dL)	132.6	59.7		125.5	36.3	
Baseline weight (kg)	75.3	13		77.6	14.1	
Q1 weight (kg)	73.5	12.6		75.8	13.7	
Baseline BMI (kg/m^2)	26.9	4.4		27.2	4.3	
Q1 BMI (kg/m^2)	26.2	4.2		26.6	4.2	

Table 2: Statistical estimation of p-value using Mann-Whitney U test.

Parameters	p-value
HbA1c	0.3131
FBS	<0.001
Weight	0.8657
BMI	0.6354

Results

This retrospective study included a total of 1,200 participants enrolled in the SDRMP, with 600 in group 1 (vegetarian) and 600 in group 2 (non-vegetarian). Group 1 comprised 455 male and 145 female participants, with a mean age of 48 ± 11 years and a mean height of 168 ± 8 cm **(Table 3)**. Group 2 consisted of 448 males and 152 females, with a mean age of 50 ± 11 years and a mean height of 168 ± 8 cm **(Table 4)**.

Table 3: Descriptive statistics for group 1: Data are presented as means and SD except for gender.

Parameters	Group 1 (vegetarian) (n=600)	
	Mean	SD
Age (Years)	48.85	11.8
Male (n)	455	
Female (n)	145	
Height (cm)	167.4	8.4
Baseline weight (kg)	75.3	13
Baseline BMI (kg/m^2)	26.9	4.4
Baseline HbA1c (%)	8.9	1.8
Baseline FBS (mg/dL)	167.6	59.7

Table 4: Descriptive statistics for group 2: Data are presented as means and SD, except for gender.

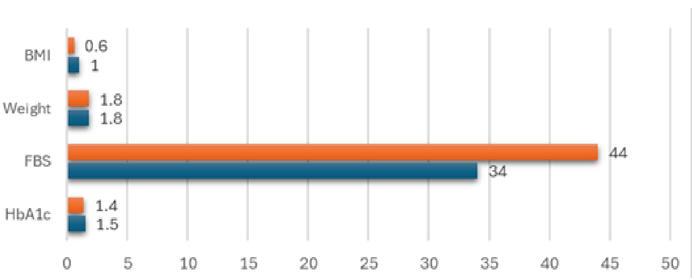
Parameters	Group 2 (non-vegetarian) (n=600)	
	Mean	SD
Age (Years)	50.2	11.1
Male (n)	448	
Female (n)	152	
Height (cm)	168.5	8.7
Baseline weight (kg)	77.6	14.1
Baseline BMI (kg/m^2)	27.2	4.3
Baseline HbA1c (%)	8.6	1.6
Baseline FBS (mg/dL)	170	56.2

Group 1: Statistically significant differences were observed in HbA1c, FBS, weight and BMI within 90 days in the program from baseline, with a p-value <0.001 **(Table 1)**. The baseline values were HbA1c (8.9 ± 1.8%), FBS (167.6 ± 59 mg/dL), weight (75.3 ±

13 kg) and BMI (56.9 ± 4.4 kg/m²). After 90 days (Q1), the values were HbA1c (7.4 ± 1.2%), FBS (132.6 ± 59.7 mg/dL), weight (73.5 ± 13 kg) and BMI (26.2 ± 4.2 kg/m²).

Group 2: The observed differences in HbA1c, FBS, weight and BMI from baseline to the first quarter were statistically significant, with a p-value of <0.001 **(Table 1)**. Baseline values were HbA1c (8.6 ± 1.6%), FBS (170 ± 56.2 mg/dL), weight (77.6 ± 14.1 kg) and BMI (27.2 ± 4.3 kg/m²). After 90 days, the values changed to HbA1c (7.2 ± 1.1%), FBS (125 ± 36.3 mg/dL), weight (75.8 ± 13.7 kg) and BMI (26.6 ± 4.2 kg/m²).

The comparative analysis of health parameters indicates no statistically significant difference in the change in HbA1c levels (p=0.3131), BMI (p=0.6354) or weight (p=0.8657) **(Table 2)** between vegetarians and non-vegetarians, indicating similar glycemic control improvements in both groups. However, the test reveals a very strong statistically significant difference in the change in FBS levels (p<0.001), highlighting notable variations between the groups over the study period as depicted in **Figure 1**.



	HbA1c	FBS	Weight	BMI
: Diff non veg	1.4	44	1.8	0.6
: Diff veg	1.5	34	1.8	2

Figure 1: Pooled changes in weight, HbA1c, BMI and FBS levels in response to both vegetarian and non-vegetarian diets.

Discussion

Increasing evidence suggests that plant-based dietary patterns are effective in both prevention and management of T2D [16]. While vegetarian diets offer therapeutic benefits, the specific foods consumed are significant, unhealthy vegetarian diets linked to refined grains, saturated fats and added sugars can increase T2D risk, whereas diets rich in whole grains, fruits, vegetables, nuts, legumes and unsaturated fats are beneficial [21].

In this investigation, SDRMP assessed the impact of protein-enriched vegetarian and non-vegetarian dietary regimens on significant metabolic indicators and health outcomes among individuals with T2D. Our results provide persuasive evidence that both dietary patterns lead to significant improvements in weight, HbA1c levels, BMI and FBS over a 90-days study period. Notably, a non-vegetarian diet, often incorporating lean meat and grain-free meals, has been found to be particularly effective in lowering FBS levels as compared to a vegetarian diet, which typically includes grain meals along with vegetables, highlighting the importance of personalized dietary interventions for managing glycemic control.

Recent studies state that clinician knowledge and patient education are essential to ensure adherence to a healthy diet, which can offer therapeutic effects regardless of the specific type followed [22]. This underscores the necessity for personalized nutrition strategies in clinical practice [23]. The study advocates for a customized approach to diabetes care, integrating dietary patterns, exercise regimens and mindfulness practices to enhance overall well-being in individuals with T2D.

Conclusion

The findings emphasise the importance of personalized dietary interventions customized to individual preferences, metabolic requirements and health conditions to optimise glycemic control and overall well-being. In summary, integrating dietary regimens with fitness routines and mindfulness practices provides a customized approach to diabetes care, promoting enhanced well-being in individuals with T2D. Future research should prioritise investigating the long-term effects of various dietary patterns and specific dietary components in diverse populations to establish comprehensive, evidence-based guidelines for diabetes management.

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