Section A-Research paper
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Dietary Survey in Young Pune Population and Correlation of dietary carbohydrate intake and serum vitamin D Levels with Type 2 Diabetes Mellitus

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Abstract

Background: The burden of diabetes is skyrocketing globally and is a challenge for developing countries like India, where a large young population is suffering from this disease. The increasing rise of obesity and unhealthy lifestyles mainly fuels the prevalence. Type-2 diabetes mellitus (T2DM) at a young age will not only affect the output but make one vulnerable to complications in the future. Insulin resistance is considered as the main reason for T2DM, and several factors are responsible for it. Excess carbohydrate intake, a sedentary lifestyle, and low Vitamin D status are reported to play a significant role.

Objective: This study aimed to investigate the lifestyle factors, amount of carbohydrate intake & serum Vitamin D level of participants with T2DM and to correlate these values with their HbA1c values.

Methodology: A cross-sectional study was done using a questionnaire on 50 diabetic patients aged 25-45 years from Pune City, Maharashtra

Result: The mean HbA1c, fasting, and post-prandial blood sugar levels were 7.29±1.41 %, 135.8±27.46, and 182.8±52.91 mg/dl, respectively. The average carbohydrate consumption per day was 263.17±34.2 gm, of which cereal intake was 152.0±22.27 gm/ day, higher than recommended values, possibly affecting the blood sugar levels. The average Vitamin D status was reported to be 19.7±8.96 ng/ml, lying in the deficient range affecting insulin response by skeletal muscle. A significant correlation was found between Vitamin D status and carbohydrate intake as indicated by p values, 0.0012 and 0.036, respectively.

Conclusion: A high carbohydrate intake with less inclusion of fiber and low levels of Vitamin D status may be responsible for elevated sugar levels.

Keywords: Type 2 Diabetes, Carbohydrates, Vitamin D, glycemic control, insulin resistance, young population

Introduction

Diabetes is a global pandemic of the century and is of the top 10 death-causing diseases worldwide. According to WHO, about 422 million people worldwide are suffering from diabetes(1). Most of the population lives in low and middle-income countries, and 1.5 million deaths are attributed yearly to this disease(2). Type 2 Diabetes which constitute 90% of total diabetes case, was once considered to be a "Western disease" or a disease of the affluent but has now spread globally at a breakneck pace(3). Unlike others, it has been found that the Asian population tends to develop Diabetes at a lower BMI than Caucasians because of the high visceral and body fat(4) In India, 1 in 7 adults lives with diabetes worldwide. There is a prediction of a 69% rise in Diabetes cases, reaching 152 million by 2045(2). It has been estimated that the diabetic population in India will nearly become double from 77 million in 2019 to 134 million in 2045(5)

The worrying factor is the increasing prevalence in children, adolescents, and young adults from this disease. In developing countries like India, Diabetes has been rapidly increasing in the young population (age < 50 years)(6) Young people, which constitute a significant chunk of the total population, are adopting a sedentary lifestyle and are found to have an increased risk of Diabetes and its related complications(7). Physical inactivity is the primary driver of obesity, and its rate has increased in the young population (8). The evolving lifestyle is affecting people's health and mounting the monetary burden on a developing country like India. It is estimated that Diabetes alone takes about 5-25% of the household income in India(9).

The initial treatment of Type 2 Diabetes includes a well-balanced diet, physical activity, weight loss, along initiation of drug therapy. Diet plays a significant role as it can cause or prevent diabetes. It has been seen that the Indian diet are high in carbohydrate and low in protein(10). The quality and quantity of carbohydrates play a vital role in managing diabetes. Refined carbs, high in the glycemic index, show a high insulinogenic response which promotes insulin resistance and Type 2 DM**.** On the other hand, maintaining a good lifestyle helps achieve reasonable glycemic control. An RCT done on 98 individuals suffering from T2DM shows a mean reduction of 0.31% HbA1c compared to standard care, which shows only a 0.04% reduction(11).

Apart from macronutrients, micronutrients play a significant role in developing Type 2 Diabetes. Studies found that Vitamin D deficiency is associated with decreased Insulin release as it has receptors on pancreatic β-cell, stimulating insulin release(12). Vitamin D receptors are also found in skeletal muscle, allowing them to utilize glucose efficiently. But in a Deficiency of Vitamin D, Insulin release is affected. Reduced vitamin D levels are associated with insulin resistance and increased diabetes risk. Even shreds of evidence suggest that vitamin D supplementation reduces insulin resistance(13)

PREVENT-WIN Trial conducted on pre-diabetic overweight/obese females for 78 weeks showed a reduction of 0.41% HbA1c with a significant improvement in Fasting and Post-prandial sugar levels with Vitamin D supplementation(14)

Diabetes is a lifestyle disorder with several co-morbidities, like neuropathy, nephropathy, retinopathy, etc. The major contributor is the rising obesity among the population, which leads to Insulin resistance.

According to the ICMR-INDIAB study in 2015, the prevalence rate of obesity and central obesity vary from 11.8% to 31.3% and 16.9%-36.3%, respectively, with the majority of cases of central obesity(15). The increasing rise of obesity is mainly responsible for pre-diabetes which eventually lands up into Diabetes as most of the pre-diabetic cases are asymptomatic. According to National Urban Diabetes Survey, the estimated prevalence of prediabetes is 14% in India(16)

Out of many factors for Diabetes, excess sugar intake or eating junk food is one of the main reasons for this disease. With time, our eating habits and food preferences have changed a lot. Nowadays, there is easy access to food because of the growing technology. People feel it easier to order outside food delivered to their doorstep than cook at home, which requires a particular effort.

The number of growing food apps and easy delivery make us more dependable on junk food. Several packaged foods are also readily available, which need just pre-heating or heating in the microwave for a few minutes rather than spending the whole day in the kitchen for cooking. Also, because of the Pandemic, people have become more sedentary. The fear of infection has also limited the movement and dependency on food. Because of these factors, growing cases of obesity have increased the chances of Diabetes in such a population(17). Detecting Diabetes at such a young age will make them dependent on diabetic medication for lifelong and increases the risk of CVD, Kidney disease, and many more(18). It has been seen that in the last two decades, Diabetes has even increased the risk of stroke(19). Few dietary changes, physical activity, and medical help can control blood sugar levels.

Methodology:

- **Study Population:** Diabetic population from Pune City, aged 25-45 years, both males and females.
- **Study design:** Cross-sectional study.
- **Sampling Method**: Convenience Sampling
- **Sample size:** 50 complete responses received from the participants were included.
- **Data collection tool:** A 24-hour dietary recall method was used to calculate the total carbohydrate and carbohydrate intake from various food sources. The recall includes all the major and minor meals; the carbohydrate content of each meal is calculated, and the sum total of carbohydrates is taken. Earlier, it was planned to take a 3-day dietary recall

so that more information could be known about the subject lifestyle and eating pattern but due to noncooperation from the subject, a 24-hour recall was taken.

- **Statistical analysis:** Descriptive statistics were used to compute the demographic characters, and a correlation test was used to link the association between total carbohydrate intake and HbA1c using SPSS software (version 22).

Inclusion criteria	Exclusion criteria
• Known T2DM patients • HbA1c >6.5 • Age 25-45 yrs. • Both male/female • All eating habits • Any family history • Any lifestyle changes • Medication, if any, they are taking	• Age <25 or >45 yrs. • Patients who have taken vitamin D supplements in the last 6 months • Known cardiac or kidney disease • Patients having anaemia, any type of cancer, auto-immune to immunodeficiency diseases • Patients on chronic antibiotics • Pregnant or lactating females

Results:

The demographic characteristics of the participants are presented in Table 1. A complete 50 responses of participants were included in the study with their dietary recall of 24 hours. Out of 50 participants, 60% were males, and 40% were females, with a mean age of 34.9±5.20 years, a mean weight of 84.2±17.1kg, and a BMI of 30.0±4.86 Kg/m^2. Most individuals (88%) were obese with BMI> 25. Females were more obese than men (mean BMI 31±4.2 Kg/m^2 vs. 29.07±5.2 Kg/$m^{2,}$ respectively). 34% of respondents were vegetarian, 56% were nonvegetarian, 10% were ovarian, and none from vegan. 56% of the participants are physically inactive, and only 44% meet the WHO recommendations for the exercise, i.e., 150 min/ week. 60% of people consume alcohol daily, once, or twice weekly. However, smoking was associated with fewer people, only 12%.

Self-reported data regarding biochemical parameters were used for the analysis. Blood reports which give FBG (Fasting Blood Sugar), PPBG (Post Prandial Blood Glucose), and HbA1c Serum Vitamin D levels were collected. Table 2 represents mean values of glycemic control and Vitamin D status. The mean HbA1c, fasting, and postprandial blood sugar levels were 7.29±1.41 %, 135.8±27.46, and 182.8±52.91 mg/dl, respectively. The average Vitamin D status was reported to be 19.7±8.96 ng/ml. There was not much difference in HbA1c and sugar levels when compared gender-wise. Vitamin D status was almost identical in both genders, as shown in Table 3.

A complete dietary recall for 24 hours was taken from the participants, and each item was jolted out in detail to calculate the total carbohydrate intake. Each item was categorized to calculate the carbohydrate intake. Table 4 shows the average carbohydrate consumption by the participants.

The average carbohydrate consumption per day was 263.17±34.2 gm, of which cereal intake was 152.0±22.27 gm/ day, and fiber intake was 28.3±3.77 gm/day. They primarily consume wheat and rice, and only 30% of respondents eat millet with jowar as a preference. Fruits and vegetable intake was also low, 20.4 ±12.9 g and 28.3±11.1 g, respectively. Graph 1 shows the differential carbohydrate intake in which the majority portion (56%) comes from cereal only while other food groups like vegetables and fruits constitute 11 and 8%, respectively. The consumption of pulses is also low, 10%, and the overall fiber is 10% of their total diet.

A correlation between carbohydrate intake, Vitamin D status, and HbA1c, as shown in Graphs 2 and 3 and a p-value of 0.05, is considered significant. A significant correlation exists between Vitamin D and HbA1c levels, as most diabetic people have low Vitamin D, evidenced by a p-value of 0.0019 (two-tailed test). Also, a significant correlation is observed between HbA1c levels and total carb intake because most diabetic people take high amounts of carbohydrates, evidenced by a p-value of 0.0346.

Table1. Demographic Character of T2DM Participants

Parameters	
Mean age (in years)	34.9±5.20
Gender (n=50)	
Male	30
Female	20
Mean Body weight (kg)	84.2±17.1
Male Mean body weight (kg)	88.7±18.6
Female Mean body weight (kg)	77.4±11.8
Mean Body mass index (kg/m2)	30.0±4.86
Mean Male BMI (kg/m2)	29.07±5.2
Mean Female BMI (kg/m2)	31±4.2
Dietary Preference	
Vegetarian	17
Non-Vegetarian	28
Ovarian	5
Vegan	0
Physical Activity	
Exercise	22
No Exercise	28
150 min/ week	15
>150 min/week	7
Alcohol Consumption	30
Smoking	6

Table 2. Glycemic Control and Vitamin D Status of T2DM Participants

Parameters	**Mean Values**
HbA1c (%)	7.29±1.41
FBS (mg/dL)	135.8±27.46
PPBS (mg/dL)	182.8±52.91
Vitamin D (ng/ml)	19.7±8.96

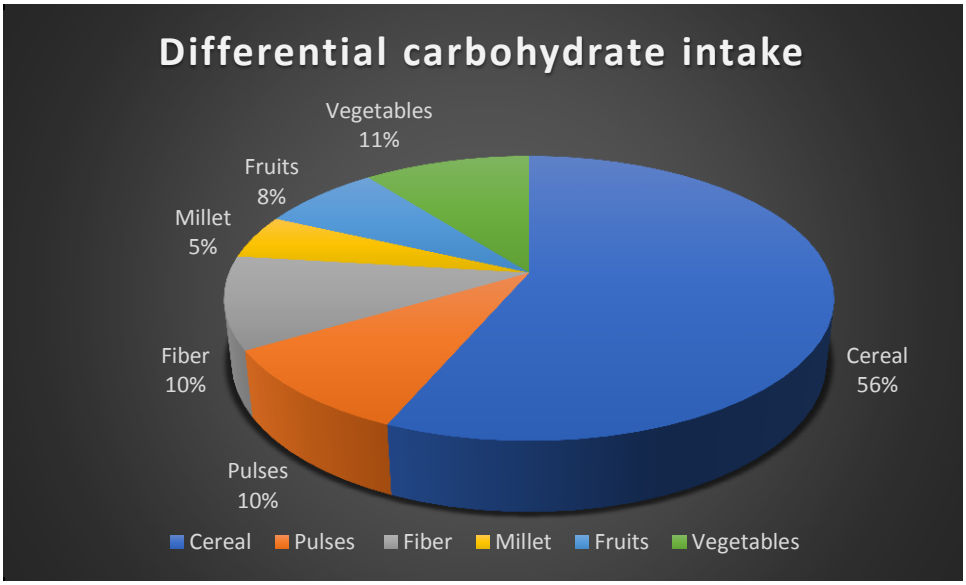
Table 3. Gender-wise Glycemic Control and Vitamin D status of T2DM participants

Parameters	**Male**	**Female**
HbA1c (%)	7.29±1.41	7.02±0.91
FBS (mg/dL)	137.1±27.5	133.9±27.9
PPBS (mg/dL)	185.6±62.0	178.7±36.2
Vitamin D (ng/ml)	19.6±9.5	19.7±8.2

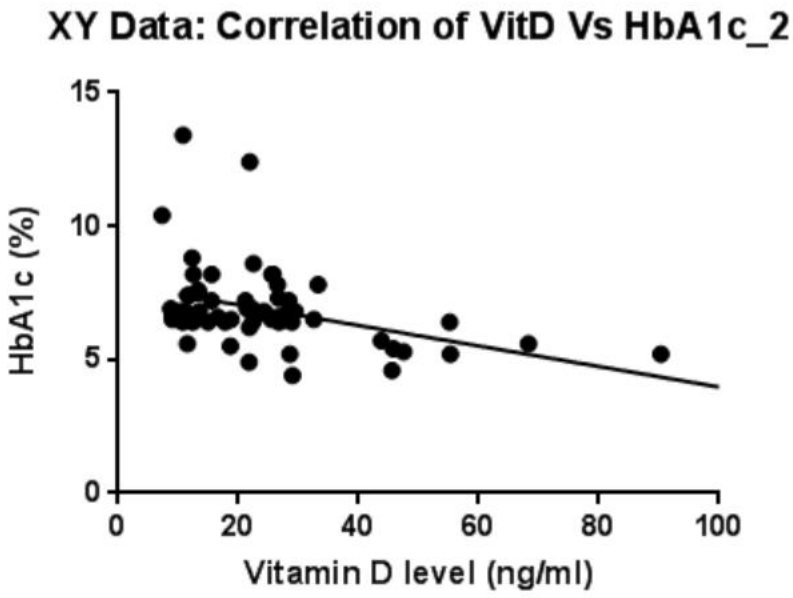
Table 4. Total Carbohydrate Consumption by T2DM Participants

	Quantity (g/ day)
Total carbohydrate	263.17±34.2
Cereal	152.0±22.27 (Mainly wheat & rice)
Pulses	26.86±11.94
Fibre	28.3±3.77
Millet	13.4±21.5 (30% respondent eat millet)
Fruits	20.4 ±12.9
Vegetables	28.3±11.1

Graph 1. Differential carbohydrate intake by T2DM Participants



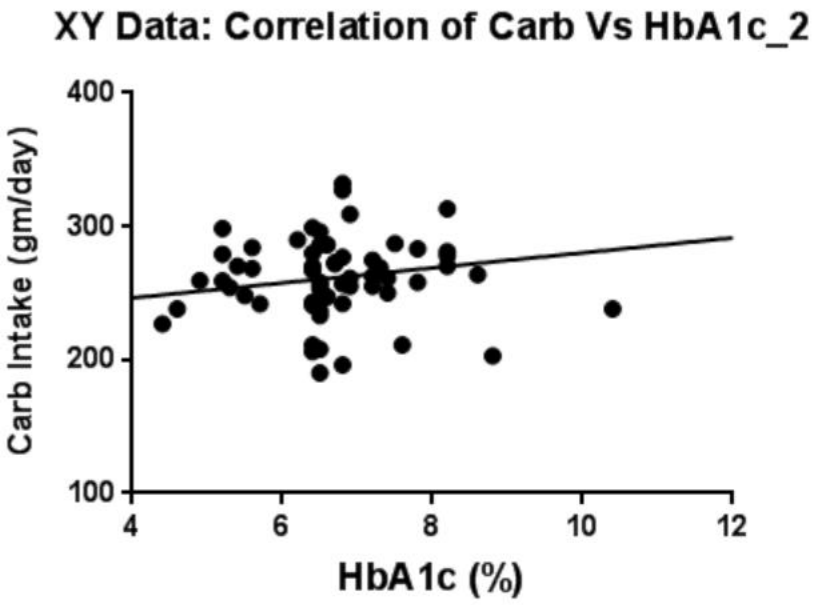
Graph 2. Correlation between Vitamin D vs HbA1c:



P (two-tailed)	0.0019
P value summary	**

R squared	0.1495

Graph 3. Correlation between carbohydrate intake vs HbA1c



P (two-tailed)	0.0346
P value summary	*

R squared	0.07227

Discussion:

The demographic characteristics of participants show that 88% of the individual are obese, having BMI greater than 25. Greater BMI is a risk factor for all non-communicable diseases like diabetes, CVD, and liver disease(20). Females are more obese than males, and abdominal obesity is seen to be more in most cases. More than half of the population is sedentary and doing no exercise. According to WHO, 150 to 300 minutes per week of moderate aerobic exercise is necessary for all adults(21). Physical activity and diet are essential for regulating blood sugar levels(22) The lifestyle pattern of the participants is noted in terms of smoking and alcohol consumption, and it was found that the majority of the population was consuming alcohol (60%) but less trend toward smoking. A healthy lifestyle is significant in managing NCDs (Non-Communicable Diseases). Weight reduction proves to have better results in managing the blood sugar level. A study reported that 5 kg weight reduction reduces 58% the incidence of Diabetes. Even with every kilogram reduction in the participants, a 16% reduction in diabetes was observed(23).

The study shows that respondents eat more carbohydrates than dietary recommendations (24). The average daily carbohydrate consumption is 263.17±34.2 g, more than double the guidelines. The consumption of fruits and vegetables was shallow, 20.4 ±12.9 g/day and 28.3±11.1 g/ day, respectively, which was very low than WHO guidelines on carbohydrate consumption(25)A systematic review shows that more than four servings of fruits and vegetables daily reduces the risk of weight gain and women's waist circumference(26). Only 30% of respondents had millets with a preference for jowar (Sorghum). These foods are good sources of fiber which help to

manage blood sugar levels, but most of the participants are not including these food groups, which may be a reason for their high blood sugar levels. Many studies indicate that higher carbohydrate consumption is associated with a higher risk of cardiovascular disease in T2DM obese patients, especially in the Asian Indian population (27) This study shows that their diet is high in carbohydrates with less fiber, which affects the postprandial sugar level as indicated by the high values.

Vitamin D is also an important parameter affecting the blood sugar level. The average Vitamin D levels of the participants were 19.7±8.96 ng/ml, which is deficient. Epidemiological studies show that a lack of Vitamin D is linked to various diseases, including skeletal to non-skeletal issues(28). Vitamin D is known to enhance insulin secretion, reducing insulin resistance. Vitamin D receptors (VDR) are present in the skeletal muscles, effectively utilizing glucose and thus maintaining blood sugar levels(29). Thus, a Vitamin D deficiency for a long time affects the muscle cells. Maintaining an adequate level of Vitamin D is essential for the proper functioning of insulin and the uptake of glucose by skeletal muscle.

A significant correlation is observed between Vitamin D status and carbohydrate intake with HbA1c values as indicated by their p-values. These two factors play an essential role in regulating blood sugar levels. However, the R-square value was observed to be low in both cases, which indicates that other factors were also crucial for maintaining effective glycemic control as Diabetes is a multifactorial disease. However, improving Vitamin D status, decreasing carbohydrate intake, and an active lifestyle could help manage Diabetes.

Conclusion

Data from the present cross-sectional study shows that Diabetic participants have a high intake of carbohydrate, which has less fiber in it. They also have deficient serum Vitamin D levels. Most of them lead a sedentary lifestyle because of which they have high BMI, which can increase the risk for further co-morbidities. Due to the modern lifestyle, they rarely go out, which impacts their serum Vitamin D levels. So, advising these young patients with dietary changes like including fiber in fruits and vegetables and switching from simple carbohydrates to complex and particular sorts of physical exercise daily help to manage their blood sugar levels effectively. Supplementation with Vitamin D is also an effective way to achieve appropriate levels, improving insulin sensitivity. Counseling these patients about a well-balanced diet, the importance of physical activity, and Vitamin D supplementation helps effectively manage Diabetes and helps to prevent the co-morbidities in the future.

Scope of the Study:

The present study is a pilot study planned to be extended by taking a larger sample size with more parameters determining their lifestyle behavior to determine various reasons for their elevated blood sugar levels.

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The study received no specific grant from any funding agency.

Conflict of Interest

None declared

Author's Contribution

Anu Mahajan reviewed related literature, conceptualized, and collected the data, ran statistical analysis and interpretation of results, and prepared the initial draft of the study. Ruchu Kuthiala planned and supervised the study and prepared the manuscript draft. Arti Muley was the second reviewer, interpreted results, and helped draft the manuscript.

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