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Original Research:

Body mass index and sociodemographic factors associated with type 2 diabetic complications in vegetarian outpatients in the city of Jaipur, India

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ABSTRACT

Background: The relationship between body mass index (BMI) and other factors with type 2 diabetic complications and comorbidities have not been fully characterized in vegetarian populations.

Purpose of the study: This study aimed to determine whether BMI and sociodemographic factors are associated with the presence of type 2 diabetic complications and comorbidities in vegetarian outpatients attending a diabetes clinic in the city of Jaipur, India.

Methods: A cross-sectional survey was administered to 184 type 2 diabetic outpatients using a questionanire. The questionnaire included questions regarding the participants' diet type, medical history, current health conditions, and sociodemographic profile. The participants' height and weight were also measured.

Results: One hundred and thirty patients (71%) reported themselves to be vegan, lacto-vegetarian, or lacto-ovo-vegetarian. Of these, 63 vegetarian paraticipants (49%) had at least one chronic complication or comorbidity. Vegetarian participants with a BMI≥30 kg/m^2 were significantly more likely to have complications or comorbidities than those with a BMI<23, <24, or <25 kg/m^2. In addition, vegetarian participants who had been living with type 2 diabetes for more than 10 years were significantly more likely than those with a duration of less than 4 years to have complications or comorbidities. Finally, those with a higher level of education were significantly less likely to have complications or comorbidities than those with a lower level of education.

Conclusion: Vegetarian outpatients with a BMI≥30 kg/m^2, those who had been living with type 2 diabetes for more than 10 years, and those with no primary school education need to be targeted to prevent complications or comorbidities.

Keywords: type 2 diabetes, vegetarian, complication, comorbidity, body mass index

Introduction

The complications and comorbidities of type 2 diabetes have enormous public health significance in both developed and developing countries, as they are significant causes of higher morbidity and mortality among diabetic patients[1–6]. In India, non-communicable diseases (NCDs), including cardiovascular disease (CVD), account for more than 60% of all deaths[7]. To prevent type 2 diabetic complications and comorbidities, the introduction of a healthy diet and weight loss are among the most important behavioural changes to make[8,9].

A vegetarian diet has been documented to reduce the risk of CVD in American and European populations, but very few studies have been conducted in South Asian populations[10,11]. Approximately 8% of the world's population were estimated to be vegetarian, vegan, or semi-vegetarian in 2018[12]. In India, more than 35% of the population are vegetarians[13], which accounts for 300–400 million people[14], and the state of Rajasthan has the highest percentage of vegetarians in India (73.2% of men and 76.6% of women[15]). Lacto-vegetarianism is the most common, followed by lacto-ovo-vegetarianism and veganism[15]. The decision to eat a vegetarian diet in India is mainly driven by religious, cultural, and family values, rather than being a choice that is adopted as part of a healthier lifestyle, as occurs in western countries[10,11,14,16].

Previous studies have suggested that vegetarians have a lower body mass index (BMI) than non-vegetarians[10,17]. However, several previous studies have shown that South Asians are relatively vulnerable to the development of diabetes and its complications, even when they have a relatively low BMI[18-20], at least in part due to their so called "thin–fat" body com-

position, comprising a higher abdominal adiposity and lower muscle mass when compared with Caucasian populations[20]. This unique body composition, the vegetarian diet, and differences in BMI-related CVD risk mean that universal BMI cut-offs may not be appropriate for assessing Indian populations[21]. There is still little information on the associations of BMI and other factors with the complications and comorbidities of type 2 diabetes in vegetarian patients in India. However, it would be useful to identify the subsets of the vegetarian population that are at higher risk of developing complications or comorbidities of type 2 diabetes in India. Therefore, the present study aimed to determine whether BMI and other factors are associated with the development of type 2 diabetic complications or comorbidities in vegetarian outpatients attending a clinic in Jaipur, India.

Methods

Data source and data collection procedures

A cross-sectional survey was administered to type 2 diabetic outpatients who attended a diabetes care clinic in the city of Jaipur, India, between October 2017 and November 2018. The clinic is a private community-based clinic that specializes in diabetes and is located in the southwestern part of central Jaipur city, where large numbers of vegetarians reside. On average, 40–80 outpatients visit this clinic for treatment and care during its operating hours. At the clinic, the World Health Organization (WHO) recommended diagnostic criteria for type 2 diabetes[22] are used: a fasting plasma glucose concentration of ≥126 mg/dL, a 2-hour plasma glucose concentration of ≥200 mg/dL, and an HbA1c level of ≥6.5%. The clinic was chosen as the survey site because it is one of the largest diabetes outpatient clinics in Jaipur district.

A venue-based time-location sampling method was used to recruit type 2 diabetic outpatients who were >18 years old. During the operating hours,

all outpatients who attended the clinic were asked to participate in the survey, which was administered by trained interviewers. The interviewers explained the purpose of the survey and its confidentiality in Hindi, in accordance with the principles of the Declaration of Helsinki. Adult patients who agreed to participate in the survey provided their written consent, then underwent measurement of their height and weight. They were then interviewed, using a semi-structured questionnaire. A total of 203 diabetic outpatients agreed to participate in the survey and 184 completed the questionnaire and body measurements. The questionnaire included a question regarding the participants' diet type, and each of which was classified as non-vegetarian (27.7%), vegan (6.0%), lacto-vegetarian (61.4%), ovo-vegetarian (1.1%), lacto-ovo-vegetarian (2.2%), or other (1.6%), respectively. Vegan, lacto-, ovo-, and lacto-ovo-vegetarians were categorized as "vegetarian". The questionnaire also requested self-reported information on the patients' sociodemographic and health-related behavioral characteristics as well as their medical history of complications or comorbidities. The study was approved by the ethics committe of the Biyani Group of Colleges in 2017 (#24-048).

Dependent and independent variables and measurements made

The main dependent variables were the complications and comorbidities of type 2 diabetes, which comprised macrovascular diseases, microvascular diseases, hypertension, and dyslipidemia. The macrovascular diseases comprised coronary heart disease (CHD), stroke, and peripheral vascular disease (PVD), and the microvascular diseases comprised nephropathy, neuropathy, and retinopathy. Those who self-reported that they were currently under treatements or taking any drugs of (1) hypertension, (2) dyslipidemia, (3) CHD, (4) stroke, (5) PVD, (6) nephropathy, (7) neuropathy, and/or (8) retinopathy were defined as "complications or cormobidities of type 2 diabetes". The independent variables were age, sex, level of educa-

tion, duration of type 2 diabetes, smoking status, frequency of sugar-sweetened beverage (SSB) intake, and BMI. SSBs were defined as any type of non-diet soda, squash drink, fruit juice, energy drink, coffee, tea, or other hot drinks containing sugar or flavored syrup. BMI was calculated as weight (kg)/height $(m)^2$ and was used to classify patients into three groups: (1) normal weight as <25 kg/m^2, (2) overweight as 25–29.9 kg/m^2, and (3) obese as ≥30 kg/m^2; according to the WHO criteria. Other BMI cut-offs for overweight individuals (24–29.9 and 23–29.9 kg/m^2) were also used in the analyses as the WHO suggests BMI cut-off points for overweight as 23–27.5 kg/m^2 in Asian populations, compared with standard overweight cut-off points of 25–29.9 kg/m^2 in Western populations.

Data analysis

Multivariable logistic regression analysis was performed to determine the associations between the independent variables and the presence of complications or comorbidities, after adjusting for age and sex. BMI was included as a variable in separate logistic regression models, using the three different cut-off points. All statistical analyses were performed using SPSS, Version 21 (IBM Corp., Armonk, NY, USA). P <0.05 was considered to represent statistical significance.

Results

The total sample size was 130 individuals who were vegetarian and completed the questionnaire and body measurements. Table 1 shows the characteristics of the type 2 diabetic participants, classified according to the status of their complications or comorbidities. The mean age of the participants was 56.2 years (53.4 years for those without complications/comorbidities, and 59.2 years for those with complications/comorbidities). More than one-fourth of both the vegetarian participants with complications/comorbidieits

(27.0%) had had no education, while only 10.4% had no education among those without complications/comorbidities. More than half of the vegetarian participants with complications/comorbidities (52.4%) reported that they had been living with type 2 diabetes for ≥10 years, compared with only 29.9% of those without complications/comorbidities, who had been living with type 2 diabetes for ≥10 years. The percentage of vegetarians who reported SSB intake of at least once a day was only 20.9% among those without complications/comorbidities, compared with 34.9% among those with complications/comorbidities. The mean BMI of vegetarians with complications/comorbidities was 27.0 kg/m^2, while that of those without complications/comorbidities was 25.1 kg/m^2. The proportion of participants who were obese (BMI ≥30 kg/m^2) was 25.4% for those with complications/comorbidities, and only 11.9% for those without complications/comorbidities.

Table 1: Characteristics of vegetarian type-2 diabetic participants, classified according to the status of their complications/comorbidities

			Complications/comorbidities with vascular diseases, hypertension, and dyslipidemia				
	Total (N=130)		No (n=67)		Yes (n=63)		
Item	N	%	N	%	N	%	P
Age	Mean (SD)	56.2 (11.2)	Mean (SD)	53.4 (11.0)	Mean (SD)	59.2 (10.8)	
	Range	24-87	Range	24-73	Range	28-87	
Age group							0.130
18–39 years	12	9.2	8	11.9	4	6.3	
40–59 years	71	54.6	40	59.7	31	49.2	
≥60 years	47	36.2	19	28.4	28	44.4	
Sex							0.498
Female	60	46.2	29	43.4	31	49.2	
Male	70	53.8	38	56.7	32	50.8	
Level of education							0.016
No education	24	18.5	7	10.4	17	27.0	
Primary, secondary, or vocational school completed	53	40.8	26	38.8	27	42.9	
College, university, or post graduate school completed	53	40.8	34	50.7	19	30.2	
Duration of type 2 diabetes (year)	Mean (SD)	8.4 (7.1)	Mean (SD)	7.4 (7.5)	Mean (SD)	9.6 (6.5)	
	Range	0-35	Range	0-35	Range	0-30	
Duration of type 2 diabetes (years)							0.027
0–4	42	32.3	27	40.3	15	23.8	
5–9	35	26.9	20	29.9	15	23.8	
≥10	53	40.8	20	29.9	33	52.4	
Past or current smoker							0.553
No	114	87.7	59	88.1	55	87.3	
Yes	16	12.3	8	11.9	8	12.7	
Frequency of SSB intake							0.056
≤5–6 times a week	94	72.3	53	79.1	41	65.1	
At least once a day	36	27.7	14	20.9	22	34.9	
BMI	Mean (SD)	26.0 (4.5)	Mean (SD)	25.1 (3.9)	Mean (SD)	27.0 (4.9)	
	Range	17.7-41.1	Range	17.7-34.2	Range	17.9-41.1	
BMI category type 1							0.084
<25 kg/m^2	60	46.2	36	53.7	24	38.1	
25–29.9 kg/m^2 (overweight)	46	35.4	23	34.3	23	36.5	
≥30 kg/m^2 (obese)	24	18.5	8	11.9	16	25.4	
BMI category type 2							0.072
<24 kg/m^2	45	34.6	28	41.8	17	27.0	
24–29.9 kg/m^2 (overweight)	61	46.9	31	46.3	30	47.6	
≥30 kg/m^2 (obese)	24	18.5	8	11.9	16	25.4	
BMI category type 3							0.021
<23 kg/m^2	33	25.4	23	34.3	10	15.9	
23–29.9 kg/m^2 (overweight)	73	56.2	36	53.7	37	58.7	
>30 (obese)	24	18.5	8	11.9	16	25.4	

Table 2 shows the adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for the factors affecting the likelihood of having a complication or comorbidity. As outlined in Table 2, multivariate analyses using models 1–3 indicated that obese participants with a BMI ≥30 kg/m^2 were significantly more likely to have complications or comorbidities than those with BMIs <25, <24, or <23 kg/m^2, respectively (OR=3.44, 95% CI: 1.10–10.75; OR=3.60, 95% CI: 1.11–11.66; and OR=4.71, 95% CI: 1.35–16.42, respectively). Models 1 and 2 presents that the likelihood of having a complication or comorbidity was significantly higher for vegetarian participants who had been living with diabetes for ≥10 years than for those who had been liviging with it for <4 years (OR=2.76, 95% CI: 1.06–7.20 for Model 1 and OR=2.68, 95% CI: 1.02–7.01 for Model 2). Vegetarian participants who had completed college, university, or postgraduate education were significantly less likely than those who had no education to have a complication or comorbidity (OR=0.26, 95% CI: 0.08–0.85 for Model 1; OR=0.26, 95% CI: 0.08–0.84 for

Table 2: Adjusted ORs and 95% CIs for the factors associated with complications/comorbidities in vegetarian participants (N=130)

	Complications/comorbidities with vascular diseases, hypertension, and dyslipidemia								
	Model 1			Model 2			Model 3		
	OR	*P*	95% CI	OR	*P*	95% CI	OR	*P*	95% CI
Age groups									
15–39 years									
40–59 years	1.43	0.623	0.35–5.86	1.36	0.673	0.33–5.57	1.33	0.690	0.32–5.50
≥60 years	1.68	0.502	0.37–7.62	1.61	0.539	0.36–7.25	1.62	0.531	0.36–7.32
Sex									
Female									
Male	1.12	0.811	0.45–2.78	1.09	0.847	0.44–2.72	1.05	0.920	0.42–2.62
Level of education									
No education									
Primary, secondary, or vocational school completed	0.44	0.153	0.14–1.36	0.44	0.150	0.14–1.35	0.45	0.171	0.14–1.41
College, university, or postgraduate school completed	0.26	0.025	0.08–0.85	0.26	0.024	0.08–0.84	0.27	0.029	0.08–0.87
Duration of type 2 diabetes (years)									
0–4									
5–9	1.56	0.384	0.57–4.28	1.58	0.378	0.57–4.32	1.51	0.425	0.55–4.19
≥10	2.76	0.038	1.06–7.20	2.68	0.045	1.02–7.01	2.54	0.060	0.96–6.68
Past or current smoker									
No									
Yes	1.50	0.505	0.46–4.92	1.46	0.533	0.45–4.77	1.56	0.465	0.47–5.13
Frequency of drinking SSB									
≤5-6 times a week									
At least once a day	2.00	0.122	0.83–4.80	2.04	0.110	0.85–4.87	2.07	0.106	0.86–5.00
BMI category type 1									
<25 kg/m^2									
25–29.9 kg/m^2 (overweight)	1.48	0.364	0.63–3.47						
≥30 kg/m^2 (obese)	3.44	0.034	1.10–10.75						
BMI category type 2									
<24 kg/m^2									
24–29.9 kg/m^2 (overweight)				1.48	0.371	0.63–3.49			
≥30 kg/m^2 (obese)				3.60	0.033	1.11–11.66			
BMI category type 3									
<23 kg/m^2									
23–29.9 kg/m^2 (overweight)							2.11	0.121	0.82–5.42
≥30 kg/m^2 (obese)							4.71	0.015	1.35–16.42

Model 2; and OR=0.27, 95% CI: 0.08–0.87 for Model 3).

Discussion

To the best of our knowledge, this is the first study to provide insights into the relationships and risk factors associated with complications and comorbidities in vegetarian diabetic outpatients in India. In this case study, participants with a BMI ≥30 kg/m^2 were significantly more likely than those with BMIs <23, <24, or <25 kg/m^2 to have a complication or comorbidity. However, moderately overweight vegetarian participants with BMIs of 23–29.9 kg/m^2, 24–29.9 kg/m^2, or 25–29.9 kg/m^2 were not significantly more likely to have a complication or comorbidity than those with BMIs <23, <24, or <25 kg/m^2, respectively. These findings in a vegetarian population differ from those encountered in non-vegetarian patients in India or other parts of South Asia, and imply a protective effect of being vegetarian[14, 16], such that moderately overweight vegetarians (23–29.9 kg/m^2) do not have a higher risk of developing a complication or comorbidity. However, obese vegetarians, with a BMI ≥30 kg/m^2, have a higher risk. According to previous studies, vegetarian diets are associated with lower CVD risk, characterized by lower serum cholesterol and lower blood pressure[8, 10, 11], as well as better glycemic control, which can prevent the emergence of diabetic complications and comorbidities[8, 14, 16].

Previous studies have revealed that a BMI cut-off of ≥25 kg/m^2 may not be appropriate for use in screening for diabetes, hypertension, or CVD in the general South Asian population[21, 23–27]; this may be particularly true for vegetarian South Asians. In our sample of vegetarians, when the cut-off point for being overweight was a BMI ≥23 kg/m^2, the OR with complications/comorbidities was higher (OR=4.71) than when the cut-off point was a BMI ≥25 kg/m^2 (OR=3.44) or ≥24 kg/m^2 (OR=3.60). These results indicate that a single universal cut-off for being overweight might not be appro-

priate for vegetarian populations in in the city of Jaipur, India.

In addition, we found that the duration of type 2 diabetes and level of education were significantly associated with the presence of a complication or comorbidity. These findings are consistent with the results of previously published studies, which showed that a longer duration of type 2 diabetes is associated with the development of both macrovascular and microvascular complications[2,27–29]. Moreover, previous studies have suggested that type 2 diabetic patients who are better educated and more knowledgeable regarding the major causes of diabetes, such as obesity and unhealthy eating habits, the risk factors associated with the development of complications and comorbidities, and the importance of regular monitoring of blood glucose and blood pressure, are more likely to be able to slow the progress of the disease and to prevent related complications[9].

The present study had some limitations. First, the participants were recruited from a private diabetes clinic, and are therefore unlikely to be representative of all vegetarian diabetic outpatients in India. Second, we did not construct separate multivariate regression models for micro- and macrovascular complications, or for hypertension or dyslipidemia, due to the small sample size. In addition, the models did not include potential confounding factors, such as a family history of diabetes, physical activity level, information regarding glycemic control, or other treatments. Third, we did not measure waist circumference, waist-to-height ratio, or waist-to-hip ratio, which could have been useful to avoid potential confounding by differing body proportions. Finally, this was a cross-sectional survey that does not permit conclusions to be drawn with regard to causal links between type 2 diabetes and the complications and comorbidities. The major strength of the present study was the comprehensive assessment of the association between BMI and the presence of diabetic complications or comorbidities in vegetarian populations.

Conclusions

Targeted care management, involving an emphasis on compliance with health education messages, regarding the importance of regular screening, monitoring, and glycemic control, is critical to preventing diabetic complications and comorbidities in vegetarian type 2 diabetic outpatients, and particularly in those with a BMI ≥30 kg/m^2, type 2 diabetes duration of ≥10 years, and no primary school education.

List of abbreviations

BMI: body mass index
CVD: cardiovascular disease
WHO: World Health Organization
CHD: coronary heart disease
PVD: peripheral vascular disease
SSB: sugar-sweetened beverage
OR: odds ratio
CI: confidence interval

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Supplemental Table 1: Presence of type 2 diabetic complications or comorbidities in vegetarian participants

Item	Veg (N=130)	
	N	%
Macro-vascular disease (CHD, stroke, and/or PVD)		
No	120	92.3
Yes	10	7.7
Microvascular disease (neuropathy, nephropathy and/or retinopathy)		
No	123	94.6
Yes	7	5.4
Hypertension		
No	73	56.2
Yes	57	43.8
Dyslipidemia		
No	127	97.7
Yes	3	2.3
Complications/comorbidities with both vascular diseases, hypertension, dyslipidemia		
No	67	51.5
Yes	63	48.5

Supplemental Table 2: Unadjusted associations between independent variables and complications/comorbidities in vegetarian participants (N=130)

	Complications/comorbidities with vascular diseases, hypertension, and dyslipidemia		
	n/N	%	*P*
Age group			0.130
18–39 years	4/12	33.3	
40–59 years	31/71	43.7	
≥60 years	28/47	59.6	
Sex			0.308
Female	31/60	51.7	
Male	32/70	45.7	
Level of education			0.016
No education	17/24	70.8	
Primary, secondary, or vocational school completed	27/53	50.9	
College, university, or postgraduate school completed	19/53	35.8	
Duration of type 2 diabetes			0.027
0–4 years	15/42	35.7	
5–9 years	15/35	42.9	
≥10 years	33/53	62.3	
Past or current smoker			0.553
No	55/114	48.2	
Yes	8/16	50.0	
Frequency of SSB intake			0.056
≤4 times a week	41/94	43.6	
≥5 times a week	22/36	61.1	
BMI category type 1			0.084
<25 kg/m^2	24/60	40.0	
25–29.9 kg/m^2 (overweight)	23/46	50.0	
≥30 (obese)	16/24	66.7	
BMI category type 2			0.072
<24 kg/m^2	17/45	37.8	
24–29.9 kg/m^2 (overweight)	30/61	49.2	
≥30 (obese)	16/24	66.7	
BMI category type 3			0.021
<23 kg/m^2	10/33	30.3	
23–29.9 kg/m^2 (overweight)	37/73	50.7	
≥30 kg/m^2 (obese)	16/24	66.7	
BMI category			0.053
<25 kg/m^2	24/60	40.0	
≥25 kg/m^2	39/70	55.7	
BMI category			0.056
<24 kg/m^2	17/45	37.8	
≥24 kg/m^2	46/85	54.1	
BMI category			0.013
<23 kg/m^2	10/33	30.3	
≥23 kg/m^2	53/97	54.6	