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Original Research Article

The Predictors of Type 2 Diabetes Mellitus in Punjab, India

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ABSTRACT

The present cross sectional study was carried out on 516 subjects with type 2 diabetes mellitus (T2DM) and 234 control subjects from tertiary health care hospitals to identify the predictors of T2DM. In univariate testing diabetes mellitus was observed to be strongly associated with age group 46-55 years (P=0.04), sedentary life style (P=0.004), smoking (P=0.04), drinking alcohol (P=0.008), systolic blood pressure >120mmHg (P<0.001), low density lipoprotein (LDL) >100mg/dl (P=0.001), triglycerides (TG) >150mg/dl (P<0.001), high density lipoprotein (HDL) <40mg/dl (P<0.001), stat in use (P<0.001), body mass index (BMI) >25kg/m² (P<0.05), waist hip ratio in both males and females (P=0.42 &P=0.031 respectively). In multivariate logistic regression model (backward stepwise) living sedentary lifestyle emerged as a strongest independent risk factor for diabetes, which triples the risk of T2DM (OR 2.9, 95%CI: 1.98-4.28, P<0.001) than physically active subjects. Other risk factors like, systolic blood pressure >120mmHg, low density lipoprotein >100mg/dl, triglycerides >150mg/dl and smoking were observed as independent risk predictors of diabetes.

Keywords: Type 2 diabetes, independent predictors, risk variables, Punjab.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) a chronic metabolic disorder has become a major health problem all over the world. Its prevalence has been increasing especially in the developing countries. As a result, its formidable effects have been seen in some countries which are expected to increase, if remain untreated. 382 million people have been already afflicted to diabetes and it is projected that this number will rise to 592 million in 2035. [1] India is having the largest number of diabetic people in the world (40.9 million) and it is predicted that it will rise to 79.4 million by the year 2030. [2] The prevalence of T2DM in India is 18.6 percent in urban and 9.2 percent in rural population. [3] Government's National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular disease and Stroke (NPCDCS) reported that 6.34 percent of the population is suspected to have diabetes in Punjab. [4]

The significant causes of this rising prevalence is increased insulin resistance, abdominal adiposity, population growth, advancing age, urbanization and physical inactivity, however, these factors vary substantially from one geographic region to the other. [2,5] The imperative sequels of unabated and untreated diabetes may further impinge upon its pathology and exacerbate the risk of hypertension, cardiovascular diseases, neuropathy, nephropathy, retinopathy and depression. [6,7] The understanding of risk variables and independent factors that may influence the subjects for the risk of T2DM is very important for its better management and

effective treatment. The present cross sectional study was therefore, conducted on 750 subjects of Punjab in order to understand the variables that pose threat to a commoner for the risk of developing T2DM.

MATERIALS AND METHODS

The present cross-sectional study was carried out on subjects having T2DM attending endocrinology outpatient departments (OPD) of some reputed hospitals of Punjab like Government Rajindra Hospital, Patiala, Aggarwal Healthcare Centre, Patiala, Civil Hospital, Bathinda, Dayanand Medical college and Hospital, Ludhiana, Civil hospital, Ludhiana, Civil Hospital Ferozpur, Arora Hospital, Amritsar, BJS Bal Memorial Hospital, Gurdaspur (Figure.1).

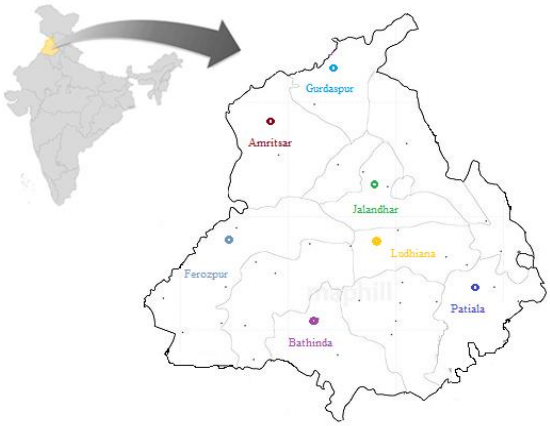

Figure 1.Showing places of data collection

All the subjects in the present study were diagnosed according to the American Diabetes Association [8] criteria where the threshold for fasting plasma glucose (FPG) concentration should be ≥ 126mg/dl (no caloric intake for at least 8 hours).Relatives or attendants of patients were screened and those who were found negative for FPG test, taken as controls. In order to examine the extent of association of various risk factors with T2DM, a total of 1068 subjects were screened and 750 qualified for inclusion. Some subjects were either unwilling or non-consenting hence, excluded. Finally 516 subjects with T2DM and 234 control subjects were enrolled in the present study. The inclusion criterion was: consenting T2DM patients belonging to Punjab and exclusion criteria was: subjects not from Punjab or had any other neurological, endocrinological, cardiovascular or psychiatric disorder and complicated hypertension (Figure 2). All subjects gave their written consent prior participation and the study was approved by the Institutional Ethical Committee.

Socioeconomic status was evaluated according to the updated version of Kuppuswamy and Pareekh scale [9] and categorized according to per capita per month income in rupees, which emerged as ≤10,000 (low income group), 10,000-50,000 (middle income group) and>50,000 (high income group). Physical activity was determined on the basis; if subject was doing at least 30 minutes of aerobic exercise/walk, was considered active otherwise sedentary. Lipid levels, duration of diabetes, statin use and glucose levels were noted down from their medical records. Information regarding marital status, education level, smoking, drinking alcohol was recorded by interviewing them. Anthropometric measurements such as height and weight were measured and body mass index (BMI) was calculated according to Quetelet equation (BMI = weight in kilograms/ height in meters squared). For waist hip ratio, waist circumference was measured at the midpoint between the lower margin of ribs and the superior border of the iliac crest. Hip circumference was measured around the widest portion of the buttocks. Systolic and diastolic blood pressure was noted down as a mean of two tests conducted after an interval of 3 minutes in sitting position after 15 minutes of rest.

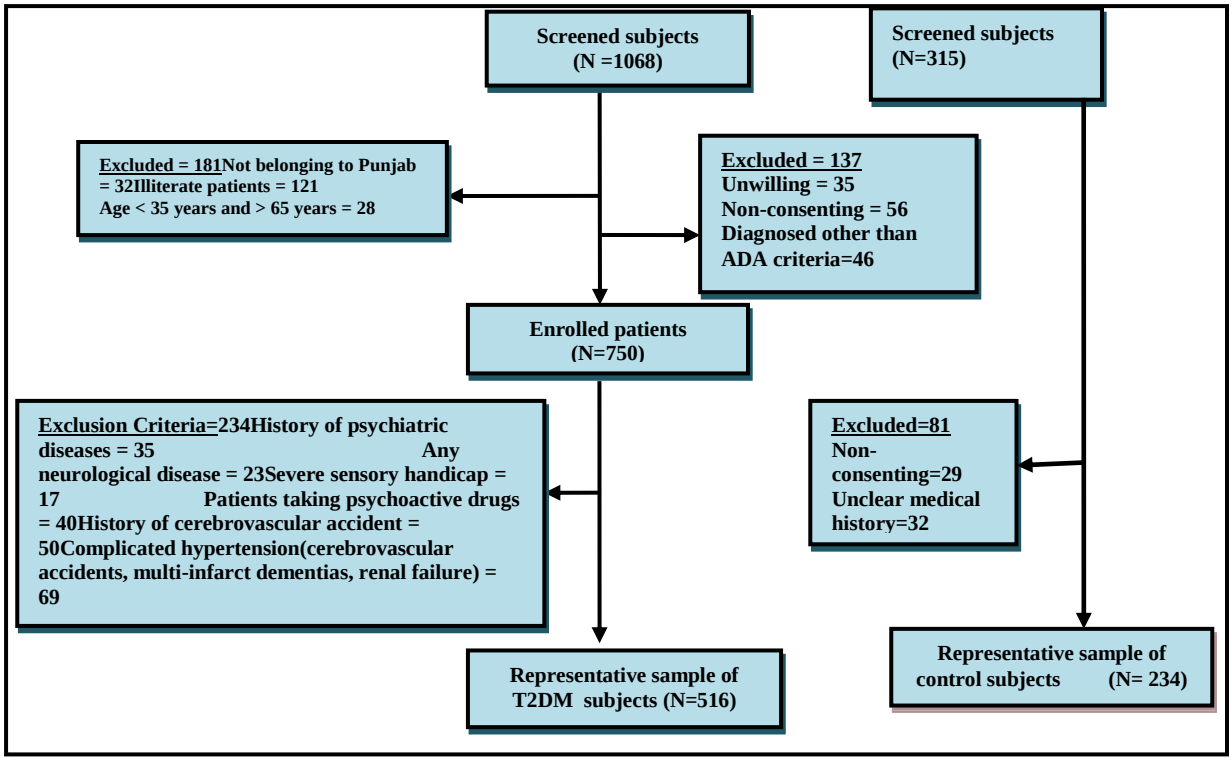

Figure 2: Flow diagram showing data collection.

Sample size calculation and Power of the Study: In order to determine the number of participants needed to detect pertinent effects within groups was calculated using the formula for sample size (n)= $(z_{1-}\alpha)^2 * P (1-P) / \acute{\varepsilon}^2$ given by Lawanga and Lemesho. [10] Where $z_{1-}\alpha$ is confidence level at 95%, whose standard value is 1.96. 'P' is estimated prevalence of diabetes in the previous studies and 'ε' is allowable error (relative precision). In the present study the sample size was calculated on the basis of 6.34 percent prevalence of diabetes in Punjab [4] and relative precision of 2.5 percent with 95 percent confidence interval. Therefore required sample size= 3.84 (6.34*93.66)/2.5*2.5 = 456.The present study comprises 516 diabetic subjects, which is sufficient to detect significant effects within groups.

Statistical power of the present study was calculated as a *priori power* analysis according to the method given by Cohen [11] with a software G* Power. [12] A sample size of 750 subjects in the present study delivered 90% statistical power to discriminate efficiently between H_0 and H_1, based on the *priori* analysis with effect size of 0.5 (Cohen's d), $\alpha = 0.05$ (two tailed)

Statistical Analysis: Data is presented as Mean±Standard Deviation or percentages. The difference between the groups was examined using chi-square test for categorical variables and student's t-test for continuous variables. A linear regression was applied to investigate the association between T2DM and risk variables (GLM procedure). Those variables which showed linear relationship with the dependent variable ($P<0.10$) in univariate testing were further included in the multivariate logistic regression analysis (backward stepwise) to identify independent association of the significant variables. The significance was checked at 5 percent level but for multiple comparisons, Bonferroni correction was applied accordingly.

RESULTS

The present study comprised of 516 T2DM subjects and 234 non-diabetic healthy controls. Mean age of men and

women were 48.26±7.65 and 47.94±8.88 respectively. Out of these 750 subjects, 423 (56.4 percent) were men and 327 (43.6 percent) were women (table 1). Mean glucose levels were observed to be higher in women (139.7±34.8) than men (134.9±35.3) and the differences were statistically significant (P<0.05).

No statistical difference was observed when subjects were categorised according to sex. The differences of mean age (Mean ± SD) between diabetic subjects (48.26±7.65) and non-diabetic subjects (47.94±8.88) was also non-significant (P=0.61). Hence, the study was very well matched for age and sex (P>0.05). About 31 percent T2DM subjects were smokers and 60 percent were alcohol drinkers. 54.85 percent T2DM subjects were taking statins. Diabetic subjects had significantly higher mean BMI values (29.18±4.18), mean systolic (141.5±9.9) and diastolic blood pressure (87.5±7.6) than their non-diabetic counterparts. Although, mean WHR value was slightly higher in T2DM than non-diabetics, but the differences were non-significant statistically (P>0.05). Diabetic subjects had significantly higher concentrations of mean LDL (150.4±49.8), TG (188.3±47.5) and HDL (45.7±5.8) than non-diabetic subjects, however despite the higher levels of total cholesterol in T2DM, the differences were found to be statistically non-significant (table 2).

Table 1: Distribution of Subjects according to age and sex

Total subjects N=750				
Variables	**Men, n (%)**	**Women, n (%)**	**Total, n (%)**	**P Value**
Subjects	423 (56.4)	327 (43.6)	750 (100)	-------
Age groups				
35-45 years	142 (33.55)	109 (33.33)	251 (33.46)	0.95
46-55 years	185 (43.74)	130 (39.75)	315 (42.00)	0.27
56-65 years	96 (22.69)	88 (26.92)	184 (24.54)	0.18
Glucose levels	134.9± 35.3	139.7 ± 34.8	137.7± 37.8	<0.0001

Table 2: Distribution of subjects according to diabetes.

Total subjects (N=750)				
Variables	**Diabetic subjects N (%) 516 (68.8)**	**Non-Diabetic subjects N (%) 234 (31.2)**	**Total subjects N (%) 750 (100)**	**P value**
Men	289 (56)	134 (57.26)	423 (56.4)	0.75
Women	227 (43.94)	100 (42.74)	327 (43.6)	
Age (years)	48.26 ± 7.65	47.94 ± 8.88	47.83 ± 9.79	0.614
BMI (kg/m²)	29.18 ± 4.18	27.96 ± 3.44	28.35 ± 3.88	0.001
WHR (cm)	0.99 ± 0.076	0.979 ± 0.072	0.99 ± 0.02	0.090
Smoking				
Smokers	158 (30.62)	58 (24.78)	216 (28.89)	0.102
Non –smoker	209 (40.51)	116 (49.58)	325 (43.34)	0.020
Ex-smoker	149 (28.87)	60 (25.64)	209 (27.87)	0.36
Alcohol Drinking				
Drinker	309 (59.88)	106 (45.29)	415 (55.35)	0.0002
Non-drinker	128 (24.08)	73 (31.19)	201 (26.88)	0.07
Ex-drinker	79 (15.34)	55 (23.02)	134 (17.87)	0.007
Blood pressure (mmHg)				
Systolic	141.5 ± 9.9	132.4 ± 10.2	133.5 ± 11.6	0.001
Diastolic	87.5 ± 7.6	80.5 ± 6.5	85.3 ± 7.43	
Lipid Levels (mg/dl)				
Total cholesterol	230.0 ± 75.2	220.1 ± 54.4	229.0 ± 78.4	0.07
Low density lipoprotein	150.4 ± 49.8	142.7 ± 51.2	144.7 ± 63.8	0.05
Triglycerides	188.3 ± 47.5	139.6 ± 45.5	165 ± 61.1	0.001
High density Lipoprotein	45.7 ± 5.8	45.3 ± 7.8	45.2 ± 6.7	0.43
Statin use				
Users	233 (45.15)	47 (20.08)	280 (37.33)	
Non-users	283 (54.85)	187 (79.92)	470 (62.67)	<0.001

Table 3.Univariate testing of variables for the risk of diabetes.

Total Subjects (N= 750)					
Variable	**Diabetic Subjects Number (%) 516 (68.8)**	**Non diabetics subjects Number (%) 234 (31.2)**	**Odds Ratio**	**(95%CI)**	**P Value**
Gender					
Men	289 (56.01)	134 (57.26)	Referent	0.77-1.44	0.81
Women	227 (43.94)	100 (42.74)	1.05		
Age					
35-45 years	152 (29.45)	87 (37.17)	Referent		
46-55 years	237 (45.93)	92 (39.32)	1.47	1.03-2.11	0.04
56-65 years	127 (24.62)	55 (23.51)	1.32	0.88-2.00	0.22
Education Level					
Matriculation	160 (31.00)	39 (16.68)	Referent		
Secondary	209 (40.52)	93 (39.74)	0.55	0.36-0.84	0.007
Graduation & above	147 (28.48)	102 (43.58)	0.35	0.23-0.54	<0.001
Socio-economic Status (group)					
High income	181 (35.08)	63 (26.92)	Referent		
Middle income	200 (38.76)	93 (39.74)	0.75	0.51-1.09	0.16
Low income	135 (26.16)	78 (33.34)	0.60	0.40-0.90	0.02
Physical Activity					
Active	207 (40.12)	121 (51.71)	Referent	1.17-2.18	0.004
Sedentary	309 (59.88)	113 (48.29)	1.60		
Smoking					
Non-smokers	209 (40.51)	116 (49.58)	Referent		
Smokers	158 (30.62)	58 (24.78)	1.51	1.04-2.20	0.04
Ex-smokers	149 (28.87)	60 (25.64)	1.38	0.95-2.01	0.11
Alcohol drinking					
Non-drinkers	128 (24.08)	73 (31.19)	Referent		
Drinkers	309 (59.88)	106 (45.29)	1.66	1.16-2.39	0.008
Ex-drinkers	79 (15.34)	55 (23.02)	0.82	0.52-1.28	0.45
Blood pressure: SBP					
≤ 120mmHg	242 (46.89)	194 (82.91)	Referent		
>120 mmHg	274 (53.11)	40 (17.09)	5.49	3.75-8.04	<0.001
Blood pressure: DBP					
≤ 80mmHg	259 (50.19)	123 (52.56)	Referent		
>80mmHg	257 (49.81)	111 (47.44)	1.10	0.81-1.50	0.60
Total Cholesterol					
≤ 200 mg/dl	253 (49.04)	119 (50.85)	Referent		
>200 mg/dl	263 (50.96)	115 (49.15)	1.08	0.79-1.47	0.70
Low Density Lipoprotein					
≤ 100 mg/dl	247 (47.86)	142 (60.68)	Referent		
>100mg/dl	269 (52.14)	92 (39.32)	1.68	1.23-2.30	0.001
Triglycerides					
≤ 150 mg/dl	246 (47.67)	157 (67.09)	Referent		
>150 mg/dl	270 (52.33)	77 (32.91)	2.24	1.62-3.09	<0.001
High Density Lipoprotein					
≥ 40 mg/dl	244 (47.28)	154 (65.82)	Referent		
<40mg/dl	272 (52.72)	80 (34.18)	2.15	1.56-2.96	<0.001
Statin use					
Non users	283 (54.85)	187 (79.92)	Referent		
Users	233 (45.15)	47 (20.08)	3.28	2.28-4.71	<0.001
Body mass Index ($Kg.m^{-2}$)					
<18.4	22 (4.26)	32 (13.67)	Referent		
18.5-24.9	15 (2.91)	11 (4.74)	1.98	0.77-5.12	0.24
25-29.9	75 (14.53)	38 (16.23)	2.87	1.47-5.6	0.003
30-34.9	285 (55.23)	99 (42.30)	4.19	2.32-7.55	<0.001
35-39.9	77 (14.94)	27 (11.53)	4.15	2.06-8.33	<0.001
>40	42 (8.13)	27 (11.53)	2.26	1.09-4.68	0.042
Waist hip ratio (cm) in men (n=423)	(n=259)	(n=134)			
≤ 90 cm	133 (25.77)	75 (32.04)	Referent		
>90cm	127 (24.61)	59 (25.21)	1.21	0.80-1.85	0.42
Waist hip ratio (cm) in women (n=327)	(n=227)	(n=100)			
≤80cm	99 (19.18)	52 (22.22)	Referent		
>80cm	128 (24.84)	38 (16.23)	1.77	1.08-2.90	0.031

Table 4: Multivariable backward stepwise regression analysis to determine factors which are independently associated with the risk of type 2 diabetes mellitus

Variables	β ± SE	OR	95% CI	P
Sedentary life style	1.07 ± 1.96	2.9	1.98-4.28	<0.001
Systolic Blood Pressure > 120mmHg	0.94 ± 0.34	2.55	1.32-4.93	0.005
Low Density Lipoprotein >100mg/dl	0.46 ± 0.21	1.58	1.04-2.41	0.034
Triglycerides >150mg/dl	0.49 ± 0.25	1.64	1.00-2.72	0.050
Smoking	0.47 ± 0.16	1.60	1.16-2.20	0.004

Risk factors influencing diabetes: From the univariate testing of the variables (table 3), unadjusted odds ratios were calculated which revealed that diabetes occurred irrespective of the gender. Subjects who fall in the age range of 46-55 years had 1.47 times the risk of diabetes (OR 1.47, 95%CI: 1.03-2.11, P=0.04) in comparison to comparatively younger subjects (35-45 years) as well as with subjects with age range 55-65 years. Widow/widower subjects had protective effect against the development of T2DM (OR 0.47, 95%CI: 0.27-0.81, P=0.001) in comparison to unmarried subjects. Secondary level and higher education seems to protect subjects from the risk of T2DM (P<0.001). Similarly lower income group subjects had lesser chances of having T2DM (OR 0.60, 95%CI: 0.40-0.90, P=0.02) than higher income group individuals. Subjects with sedentary life style had 1.6 times higher risk (OR 1.60, 95%CI: 1.17-2.18, P=0.004) of T2DM. Smoking (OR 1.51, 95%CI: 1.04-2.20, P=0.04), alcohol drinking (OR 1.66, 95%CI: 1.16-2.39, P=0.008), systolic blood pressure >120mmHg(OR 5.49, 95%CI: 3.75-8.04, P<0.001), LDL>100mg/dl (OR 1.68, 95%CI 1.23-2.30, P=0.001), TG>150mg/dl (OR 2.24, 95%CI: 1.62-3.09, P<0.001), HDL<40mg/dl (OR 2.15, 95% CI: 1.56-2.96, P<0.001) and statin use (OR 3.28, 95%CI: 2.28-4.71, P<0.001) emerged as significant variables which influence the risk of developing T2DM. Subjects who had BMI of 25-29.9 $kg.m^{-2}$and higher levels are at significant risk of T2DM in comparison to subjects having BMI < 18.4 $kg.m^{-2}$. Similarly, WHR>80cm added 1.77 fold higher risk of T2DM.

Independent risk predictors: Table 4 shows the multiple backward step-wise regression analysis to determine factors which were independently associated with diabetes after adjusting the effect of confounders. Sedentary life style appeared to be an independent risk factor that approximately tripled the risk of T2DM (OR 2.9, 95%CI: 1.98-4.28, P<0.001) as compared to subjects with active lifestyle. Other factors which independently influenced the risk of diabetes were systolic blood pressure >120 mmHg (OR 2.55, 95%CI:1.32-4.93, P=0.005), LDL >100mg/dl (OR 1.58, 95%CI: 1.04-2.41, P=0.034) and TG>150mg/dl (OR 1.64, 95%CI: 1.00-2.72, P=0.05). Smoking also conferred substantial risk of diabetes independently (OR 1.60, 95%CI: 1.16-2.20, P=0.004).

DISCUSSION

The present cross sectional study examined risk variables for their association with T2DM in 750 subjects of Punjab. Punjab is a flourished state with highest per capita income where people are exposed to sedentary lifestyle. Because of this, they are more prone to health hazards especially obesity. [13] Sedentary lifestyle is considered to be a significant risk marker for T2DM whereas physical activity helps in reducing the risk of diabetes and its future outcomes. [14] Several epidemiological studies strongly put forth that sedentary lifestyle can increase T2DM risk many times [15,16] whereas, physical activity is associated with weight maintenance and lower risk of obesity and T2DM. [17] In agreement to these studies, present study also exposed that subjects with sedentary lifestyle have

approximately 3 fold higher risk of T2DM than physically active subjects. Higher blood pressure is reported to be a strong predictor for the risk of T2DM. [18] It has been reported that patients with hypertension are at 2-3 times higher risk of developing diabetes than normotensives. [19] Furthermore, a meta-analysis of prospective studies comprising 4.1 million adults [20] revealed that raised systolic blood pressure of 20mmHg increases the risk of diabetes by 58% (HR 1.58, 95% CI: 1.56-1.59) and a higher diastolic pressure of 10mmHg was associated with 52% risk of diabetes (HR 1.52, 95% CI: 1.51-1.50) however, this risk attenuates when adjusted with age and BMI. In the present analysis subjects having higher SBP (>120mmHg) had 2.55 times greater risk of developing diabetes, though diastolic blood pressure (DBP) did not emerge as a independent predictor of T2DM. In the present analysis higher LDL >100mg/dl and TGs >150mg/dl appeared independent risk predictors for T2DM. Higher lipid levels or diabetic dyslipidemia and atherogenic lipoproteins are reported to contribute substantially towards cardiovascular diseases (CVD) [21] concluded that pre-diabetic subjects have higher lipid levels as the risk for future CVDs even before the onset of clinical diabetes. In an 8 year follow-up, San Antonio Heart study [22] discerned that those subjects who develop diabetes during these years had higher levels of TC, LDL, TG, fasting glucose, insulin, BMI, BP and lower levels of HDL in comparison to those subjects who remained non-diabetics. Their results indicated that pre-diabetic subjects having higher lipid levels (possibly because of obesity and hyperinsulinemia) become clinical diabetics. Numerous clinical reports have shown the association between active cigarette smoking, glycemic control and development of diabetes. [23,24] However, it is evident that confounding social factors can also interact. In the animal studies also, it has been shown that prenatal or neonatal exposure to nicotine led to the loss of pancreatic β-cells, hence, production of less insulin. [25] In agreement to this, the present study exposed that smoking increases the risk of T2DM by 1.60 times.

This is the first study from Punjab which reported that smoking, sedentary lifestyle, higher SBP and higher concentration of LDL and TG are independent risk factors for the development of T2DM in the subjects of Punjab, however, more epidemiological and clinical studies in future will help in confirming these predictors.

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