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Contemporary Evaluation of Incidence of Pre-diabetes and High Risk for Type 2 Diabetes Mellitus among Adults of Gujarat: A Cross-Sectional Study

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ABSTRACT

Background: In addition to the surge in the incidence and prevalence of type 2 diabetes mellitus (T2DM), currently more of young and middle aged adults are found at risk for T2DM in developing countries like India.

Aim: With this fact in the background, the current study was conducted with an aim to understand the incidence and prevalence of pre-diabetes among adults of Gujarat.

Methods: The survey study was conducted in Sourashtra part of Gujarat (N=230 adults; 32.9±9.6 years), India. Based on Capillary fasting blood glucose (CFBG) subjects were grouped into non-diabetes (n=108), pre-diabetes (n=92, 40%) and T2DM (n=30). Demographic data sheet (DDS) was used to assess the origin, socioeconomic status and habit of the respondents and Indian Diabetes Risk Score (IDRS) screening form to detect the risk for T2DM.

Results: Close to half of the screened subjects were newly diagnosed with pre-diabetes, among which one-ninth of them were (n=9; 9.8%) identified with high risk for T2DM. Statistical assessment manifested female subjects at higher risk based on low physical activity and higher waist circumference as compared to male. Substantially, risk identification with IDRS was in line with the expedited results of CFBG among pre-diabetes.

Conclusion: Incidence of pre-diabetes among adults of Gujarat is found escalating. Matched with the data obtained from DDS, the current study identified diet, physical inactivity and higher waist circumference as most contributing factors increasing incidence of high risk for T2DM among females and more or less the same factors in male as well.

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Introduction

Compared to the previous decades, the prevalence and incidence of pre-diabetes is seeing a rise among young and middle-aged adults of India [1, 2]. A few of the causes could be ignorance among adults for periodic health checks, physical inactivity, habits and resultant abdominal obesity [3-8]. Literature search showed quite a number of studies postulating higher incidence for pre-diabetes and T2DM specifically pin-point the population of Southern and Eastern parts of India. Shockingly reports of 2016 state 56% of T2DM cases go undiagnosed ending up in systemic complications during the diagnosis making it even more difficult to manage. In addition, the reports after 2016 clearly indicate the need for periodic prevalence checks and diagnosis of pre-diabetes among the Indian population [9-12]. Periodic health monitoring is necessary because this would help people adopt appropriate

strategies, which can help in delaying the onset of T2DM.

However, cross-sectional studies aiming at identifying pre-diabetes among the population of Indian origin are found using many different assessment tools to detect pre-diabetes and undiagnosed T2DM [13]. However, the sensitivity specificity of the tools are found differently behaving based on the region, locality and other categories among people at risk for T2DM [14]. Therefore, adopting a pertinent tool is a matter of high importance [15]. One such study reported in 2019, have had used Indian Diabetes Risk Score (IDRS) screening tool, developed by Madras Diabetes Research Federation (MDRF). The sensitivity specificity of the tool is found impressive, making the tool worth us in Indian set up. Nevertheless, this observational study focused only on risk identification among people with fatty liver disease [16].

In any which ways, it is clear that adults of Gujarat are equally at higher risk for T2DM as like any other state of Southern and Eastern India [17]. Which is because the adults of Gujarat are explicitly at higher risk for T2DM even though with few clearly stated reasons like sweet tooth, not enough physical activity, and resultant ignorance laid on anthropometric measures, higher body-fat percentage and body weight mismanagement and such [18-20]. Though, the fact is, there are still many idiopathic reasons which are yet to be identified and eradicated not only to gain a control over the hiking incidence and prevalence of pre-diabetes and early onset of T2DM, but also to avoid the onset of many associated metabolic and endocrine abnormalities [21]. Also, there are no any studies reported from the state of Gujarat reporting male or female are at higher risk for T2DM. Therefore, we in this study used IDRS for identifying the risk for T2DM among male and female adults of Gujarat.

Materials and Methods

Study Design

This cross-sectional observational study was conducted among adults of Bhavnagar (N=230), a peninsular region of Gujarat. Sampling method employed for the screening process is voluntary response non-probability sampling.

Ethics

The study was a part of a randomized control trial aiming at identifying and recruiting pre-diabetes for a yoga-based mechanism of action study. Institutional ethical clearance (Res/IEC-SVYASA/74/2020) and data was collected in September-October, 2021. Signed informed consent was obtained from S-VYASA's Institutional Ethical committee before data collection.

Selection and Description of Participants

Subjects were screened based on the inclusion criteria: male and female between the age 20 to 60 years, residing in Bhavnagar, Gujarat for more than 10 years and consenting to get their capillary fasting blood glucose (CFBG) checked. Those who are physically and mentally challenged and/or with a history of systemic disorders, overweight or obese (BMI>30 kg/m^2), diagnosed with T2DM for more than 5 years, people with diabetes related complications, and those who are on night shift works, alcoholics and/or consuming more than 4 servings of beverages (coffee, tea, soft drinks, and other sweetened drinks) a day were excluded from the survey. STROBE guidelines were followed during the planning, designing and data collection.

Assessments

The assessments included capillary fasting blood glucose (CFBG), anthropometric measures, Indian Diabetes risk score screening from (IDRS) and Demographic data sheet (DDS). CFBG was checked after 12 hour overnight fasting on commercially available glucometer (Dr. Morepen's glucometer device, model: GLUCO ONE BG-03 auto; Serial No: GB 1410042; 4* reliability). Based on the CFBG, screened subjects were grouped into group 1 (CFBG > 126mg/dl), group 2 (CFBG: 100-125 mg/dl) and group 3 (CFBG <100mg/dl). Categorization of people based on risk for T2DM, into low (0-29), medium(30-59) and high(60-100) for T2DM under each of the groups were done based on the total score of response marked by the respondents on 2 modifiable (waist circumference and physical activity) and 2 non modifiable factors (age and family history) of IDRS (total score: 100) [14]. Waist circumference was assessed using a standard measuring tape.

Demographic data sheet was used to understand the diet pattern, age, gender, origin, habits, diabetes duration, known pre-diabetes and duration, diabetes complication and nature and duration of physical activity of the subjects. Entire screening was done in six weeks (9th September, 2020 to 24th October 2020; 6:45 am to 8:30 am of all the days, including Saturdays, Sundays and holidays.

Data Analysis and Dropouts

Data was tabulated in Microsoft Excel and was subjected for basic analysis in excel. Further, logistic regression analysis was done in IBM SPSS statistical software version 23.0. However, few CFBG data of range 100-105 mg/dl (n=3) and samples with technical errors (n=2) displayed on the device were excluded from the analysis.

Results

Demographic Details

Demographic data sought from the participants indicated that all the participants were of Indian Nationality, from same geographic area (Urban) with no cultural distinctiveness. Instinctively, majority of the participants of the survey were post graduates (n=176; 76.5%), lower middle socio-economic status (n=192; 83.5%) and with a preference to sweet taste (n=192; 82.6%) (Table 1). Also, majority of the subjects were under the age range of 20-29 years (n=131; 56.9%). Most of the obtained details were not found to be skewed.

Table 1: Demographic data

Age	**20-29**	**30-39**	**40-49**	**50-69**
	131(56.9)	**20(8.7)**	**20(8.7)**	**59(25.7)**
Socio economic status (SES)	Upper SES (> 2,70,000 INR/ annum)	Lower middle SES (70,000-2,70,00 INR/ annum)	Low SES (<70,000 INR/ annum)	Unsure/ Not willing to reveal
	34(14.8)	192(83.5)	4(1.7)	-
Education	Post Graduate	Graduate	Under Graduate	Not willing to reveal
	176(76.5)	42(18.3)	12(5.2)	-
Profession	Government job	Government job	Non-Government Job	Nil/ House hold work/ Not willing to reveal
	29(12.6)	4(1.7)	180(78.3)	17(7.4)
Taste preference	Sweet	Salty	Spicy	Nothing specific
	190(82.6)	10(4.3)	17(7.4)	13(5.7)

Distribution of Scores under Each Domain of IDRS

Initially the screened volunteers (N=230; average age 32.9±9.6 years) were categorized into three groups based on their CFBG values: Group 1 comprised of people with type 2 diabetes mellitus (n=30; 180±60 mg/dl), Group 2 with newly diagnosed pre-diabetes (n=92; 110±7 mg/dl) and Group 3 were people with normal glucose tolerance (n=108; 91±6mg/dl)). Each of subjects these group constituents were further categorized into high (IDRS: 60-100), medium (IDRS: 30-59) and low risk (IDRS: 0-29) for T2DM (Table 2).

However, the representation of risk categories across the three groups was intuitive. In Group 1 (n=21; 70%), and group 3 (n=56; 51.9%) majority of subjects were found in medium risk category, while in-group 2, the majority were belonging to low risk category (n=61; 66.3%). Although, overall assessment on group 2,estimated the prevalence of pre-diabetes among adults of Gujarat as 40%, among which almost 1/9th of the subjects with pre-diabetes (n=9; 9.8%) were found at high risk for incidence of T2DM (Table 2).

Table 2: Group and Gender based categorization of Glycemic, anthropometric and IDRS based parameters of risk for T2DM; CFBG- Capillary fasting blood glucose; SD- Standard deviation; %- percentage

Group	**Gender wise distribution n (%)**	**Mean Age (± SD) in years**	**Mean CFBG (±SD) in mg/Dl**	**Mean W.C (±SD) in centimetres**	**Risk according to IDRS**		
					High risk n (%)	**Medium risk n (%)**	**Low risk n (%)**
Group 1	Female (n=13; 43.2)	36.8±7.5	186.5±63.3	85.5±6.2	2(15.4)	9(69.2)	2(15.4)
	Male (n=17; 56.7)	43.5±6.1	176.7± 55.7	96.8±7.7	5(29.4)	12(70.6)	-
	Sub Total (n=30; 13)	54.7±16.2	179.9±59.6	91.9±8.9	7(23.3)	21(70)	2(6.7)
Group 2	Female (n=52; 56.5)	30.6±8.1	114.9±4.8	90.9±7.5	6(11.5)	28(53.4)	18(34.6)
	Male (n=40; 43.5)	30.6±8	114.7±4.7	101.2±8.1	2(5)	33(82.5)	5(12.5)
	Sub total (n=92; 40)	33.6±9.4	114.8±4.7	95.4±9.3	8(8.7)	23(25)	61(66.3)
Group 3	Female (n=47; 43.5)	29.2±7.6	92.3±4.8	76.6±6.2	2(4.3)	29(61.7)	16(34)
	Male (n=61; 56.5)	31.1±10	89.9±6.9	86.4±5.5	2(3.2)	27(44.3)	32(52.5)
	Sub Total (n=108; 47)	40.6 ±7.4	180.9±58.2	82.1±7.5	4(3.7)	56(51.9)	48(44.4)

Modifiable Factors

Based on the waist circumference majority of subjects of group 1 were at medium risk category (n=16; 53.3%), whereas in group 2 (n=50; 54.3%), majority were at high risk for T2DM and in group 1 majority belonged to low risk category (n=86; 79.6%). Although, in group 2 and 3, female subjects were found at high risk for T2DM with comparatively higher W.C, whereas among people of group 1, higher W.C among male participants were observed to have contributing higher towards risk for T2DM. On check for status of physical activity as another modifiable factor of significance in increasing risk for diabetes, majority of subjects of group 1 were found at medium risk (n=27; 90%). while among subjects of both group 2 (n=43; 46.7%) and 3 (n=46; 42.6%) majority were in moderate risk for T2DM (Table 3). Above that, female subjects were found to have higher risk for T2DM, reportedly with low physical activity status when compared to male.

Table 3: Distribution of risk score among three groups on modifiable (waist circumference and physical activity) and non-modifiable (age and family history) factors.

IDRS parameter	Category	Group 1 (n=30)	Male n (%)	Female n (%)	Group 2 n=92)	Male n (%)	Female n (%)	Group 3 (n=108)	Male n (%)	Female n (%)
Age	Low Risk (<30 years)	5(16.7)	1(20)	4(80)	52(56.5)	14(26.9)	38(73.1)	83(76.9)	46(55.4)	37(44.6)
	Medium risk (30-50 years)	22(73.3)	13(59.1)	9(40.9)	33(35.9)	20(60.6)	13(39.4)	17(15.7)	9(52.9)	8(47.1)
	High risk (<50 Years)	3(10)	3(100)	nil	7(7.6)	5(71.4)	2(28.6)	8(7.4)	6(75)	2(25)
Waist circumference (W.C) in centimeters)	Low risk (<80 cm)	4(13.1)	2(50)	2(50)	6(6.5)	3(50)	3(50)	86(79.6)	51(59.3)	35(40.7)
	Medium risk (80-89cm)	16(53.3)	9(56.2)	7(43.8)	36(39.1)	20(55.6)	16(44.4)	19(17.6)	9(47.4)	10(52.6)
	High risk (>90cm)	10(33.3)	6(60)	4(40)	50(54.3)	17(34)	33(66)	3(2.8)	1(33.3)	2(66.7)
Physical activity	Low risk (Very active)	2(6.7)	1(50)	1(50)	25(27.2)	8(32)	17(68)	28(25.9)	18(64.3)	10(35.7)
	Medium risk (Moderately active)	27(90)	16(59.3)	11(40.7)	43(46.7)	28(65.1)	15(34.9)	46(42.6)	30(65.2)	16(34.8)
	High risk (Under active)	1(3.3)	-	1(100)	24(26.1)	4(16.7)	20(83.3)	34(31.5)	13(38.2)	21(61.8)
Family history (FH)	Low risk (no FH)	19(63.3)	9(47.4)	10(52.6)	77(83.7)	31(40.3)	46(59.7)	92(85.2)	52(56.5)	40(43.5)
	Medium risk (one parent with diabetes)	11(36.7)	8(72.7)	3(27.3)	15(16.3)	9(60)	6(40)	16(14.8)	9(56.3)	7(43.7)

Non-Modifiable Factors

Age, as one of the non-modifiable factors contributing towards increasing risk for T2DM, when taken into consideration, majority of subjects of group 1 (n=22; 72.3%) were found with medium risk, where on the other hand, subjects of group 2 (n=52; 56.5%) and group 3 (n=83; 76.9%) were with low risk for T2DM. Of all the 3 groups, compared to female, male subjects with higher age were found to have higher risk for T2DM. Among the total subjects screened, none were with a family history of both parents being with T2DM. In addition, the check for the distribution of subjects across groups resulted in identifying majority in group 1 (n=19; 63.3%), 2 (n=77; 83.7%) and 3 (n=92; 85.2%) being at low risk for T2DM. However, more of male subjects were reportedly with considerably high family history among the 3 groups.

Pearson's correlation test showed a positive association of CFBG with waist circumference (r=.439; *P<.001*) and overall IDRS score (r=.406; *P<.001*). Similarly, age of the subjects were also found positively correlated with total IDRS (r= .656; *P<.001*). Nonetheless, except for family history, all other factors of IDRS were strongly related to total IDRS score, indicating the applicability of the screening form on the population (Table 4). Moreover, exploratory factor analysis denoted physical activity and family history as most impactful factors interconnecting other assessed parameters and factors of IDRS checked in the current survey (X^2= 16.06; *P.042*) (Table 5). Likewise, derived values of the study presumed the role of CFBG, age and waist circumference as major factors increasing incidence of high risk for T2DM. Also, among the subjects with high-risk for T2DM (n=9), females (n=8) were found to at high risk as compared to male (n=1) (Table 6).

Table 4: Pearson's correlation output

Components correlated		Pearson's r	p value	Lower 95% CI	Upper 95% CI
CFBG	W.C (IDRS)	0.439	< .001	0.328	0.538
CFBG	Total IDRS Score	0.406	< .001	0.292	0.509
Age	Total IDRS Score	0.656	< .001	0.576	0.724
W.C	Total IDRS Score	0.464	< .001	0.356	0.56
AGE (IDRS)	Total IDRS Score	0.672	< .001	0.594	0.737
W.C (IDRS)	Total IDRS Score	0.59	< .001	0.499	0.668
PA (IDRS)	Total IDRS Score	0.411	< .001	0.298	0.513

Table 5: Exploratory factor analysis output; applied rotation method is Promax

Factors	Uniqueness	df	Chi square value	Significance value (p)
CFBG	.750	8	16.060	.042
Age	.153			
Waist circumference	.426			
IDRS components				
Age	.002			
Waist circumference	.005			
Physical activity	.956			
Family history	.900			

Table 6: Factors increasing risk for type 2 diabetes among pre-diabetes; M=Male; F=Female; W.C= Waist circumference

Risk for T2DM	Gender	FBS (in mg/dl)	Age (in years)	W.C (in cm)
High	M(n=1); F(n=8)	116±3.7	44.2±8.5	100.8±7.4
Medium	M(n=34); F(n=26)	115.2±5	35.2±8.8	96.7±8.8
Low	M(n=5); F(n=18)	113.4±4.1	25.2±2.9	89.8±8.9

Discussion

As known, the prevalence and incidence of pre-diabetes among youngsters is surging. Current multi-centric village based observational study conducted with an objective of estimating the prevalence of pre-diabetes and high risk for type 2 diabetes among adults of Gujarat identified a higher prevalence of pre-diabetes among adults of Gujarat, low physical activity and higher waist circumference as and factors. However, female subjects were found with utmost risk compared to male, indicating the need for higher care and attention on glycemic and anthropometric measures among females than male.

Moreover, the sweet taste preference and consumption of high glycemic index items among the study population presumably corresponded to low activity status. And, these habits would have resulted in increased waist circumference, hiking risk for T2DM. However, this study also witnessed postgraduates and people of lower middle category socio economic status being at high risk, stating the study findings on glycemic and anthropometric measures as tallied to the demographic status of the individuals [22]. Subsequently, higher stress, anxiety, changes in quality and quantity of diet and habits are probably the major triggers of the time, resulting in endocrine disharmony ending up adults in pre-diabetes [23].

Furthermore, witnessing the study outcomes, it is clear that all the four factors are more or less equally liable for the etiopathogenesis of high risk for T2DM, increasing the prevalence of pre-diabetes and T2DM and similar findings are already reported, although no recent studies are found reporting the same. Even though, amidst the pandemic, when stress and emotional upsurges are commonly reported complaints, early identification of the high-risk individuals in right time across different states of India, might help govern the hike in the prevalence of most common metabolic endocrine disorders like type 2 diabetes and its asymptomatic risk phase named pre-diabetes and simultaneously getting to know the need for adopting therapeutic interventions with no delay [24].

Summing up, prevalence based cross sectional and experimental studies are widely found conducted in Southern parts of India like Karnataka and Tamil Nadu [24]. But the studies are also reportedly inconclusive with lack of statistical findings and observational studies from Western part of India are few. Hence this study adopted a better statistical approach for reporting the high prevalence of pre-diabetes among young and middle-aged adults of Gujarat. The finding was found aligned with factors like diet, waist circumference, lack of physical activity, and family history. Therefore, this study propagates the need for half yearly blood glucose check and organizing health education programs on diet and habit modification to achieve glucose homeostasis. Additionally, it is imperative to conduct large scale observational studies across other parts of Western India, to ensure early detection and adopting right measures to manage and prevent the onset of pre-diabetes and progression to type 2 diabetes mellitus.

Strength of the Study

The current study findings are robust with the statistical support. Also, the gender distribution is equal and female are found with higher risk than male, highlighting higher need for attention among female adults among state of Gujarat. Study did not include elderly adults. Demographic details of the population showed almost similar pattern of taste preference, educational and socio-economic status among majority of the participants, which could let the researcher sum up the findings on encouraging better care among young and middle aged adults.

Limitations of the Study

Capillary fasting blood glucose was the only glycemic variable checked. As majority of the volunteered subjects belonged to similar educational and socio-economic background, statistical assessment based on different demographic details was not conducted. Compared to the total population of Sourashtra part of Gujarat, the current study sample size is considerably low.

Conclusion

The current study estimated a higher incidence of pre-diabetes among young and middle-aged adults of Gujarat and the reason for this would be lack of physical activity, diet and higher waist circumference in addition to the family history. However, large-scale studies are to be conducted in order to assess the role of quality and quantity of diet, and other predominant risk factors, postulating higher incidence of pre-diabetes among females separately and on males as well, increasing the incidence for high risk for T2DM among population of Gujarat.

Conflict of Interest

Authors declare no actual or potential conflicts from the authors or from the institute in getting this research work published. The study was completely unbiased by all means, with no financial or personal inappropriate interferences involved in, all throughout the work. Also, the manuscript has been read and approved by all the authors

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