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Karmjeet Kaur
Department of Food and Nutrition Punjab Agricultural University, Ludhiana, Punjab, India

Harpreet Kaur
Department of Food and Nutrition Punjab Agricultural University, Ludhiana, Punjab, India

Kiran Bains
Department of Food and Nutrition Punjab Agricultural University, Ludhiana, Punjab, India

Jaswinder K Brar
Department of Food and Nutrition Punjab Agricultural University, Ludhiana, Punjab, India

Corresponding Author:
Karmjeet Kaur
Department of Food and Nutrition Punjab Agricultural University, Ludhiana, Punjab, India

Indian diabetes risk score: A study in rural and urban areas of Ludhiana (Punjab)

Karmjeet Kaur, Harpreet Kaur, Kiran Bains and Jaswinder K Brar

Abstract
Objective: The objective of the study was to identify subjects who are at risk of developing type 2 diabetes in rural and urban area using Indian Diabetes Risk Score.
Design: The sampling design used for the study was 30 cluster multi-stage sampling. A total of 30 locations from Ludhiana district were selected. In the next stage of sampling 12 blocks were selected. From each block two villages (total of 24 villages) and 6 urban locations were selected in order to have a total random sample size of 529 subjects. Two modifiable (Waist circumference and physical activity) and two non-modifiable (Age and family history) factors were taken.
Setting: A cross sectional study.
Subjects: Men and women in the age group of ≥20 years participated in the study.
Results: 529 subjects were assessed for various risk factors of diabetes. Out of these 48% rural and 49% urban subjects were aged ≥50 years. Abdominal obesity was found in 49% rural and 48% urban subjects. About 37% rural and 66% urban subjects were found to have sedentary lifestyle. 83% rural and 89% urban subjects were found to have no family history of diabetes. The study identified that 64% rural and 69% urban subjects were at high risk of developing type 2 diabetes while 35% rural and 30% urban subjects were at moderate risk of developing type 2 diabetes.
Conclusions: As large number of subjects are at risk of developing type 2 diabetes, there is need to implement Indian Diabetes Risk Score in communities for large scale screening of diabetes so that we can aware people and prevent the disease at an early stage.

Keywords: Type 2 diabetes mellitus, Indian diabetes risk score, waist circumference, physical activity, family history

Introduction
As we look into the ancient Indian texts, there is mention of "*Madhumeha*" which is known as "Diabetes mellitus" in modern terms. It indicates the presence of diabetes in India even before 2500 BC. Though there is no evidence how prevalent the disease condition was, but some articles hypothesize that it was quite common in India [1, 2]. Diabetes is a disorder where glucose levels remain high in blood and there is impairment of protein, fat and carbohydrate metabolism. Based on the causes of the diabetes mellitus, the factors which contribute to hyperglycaemia are, reduction in insulin secretion, decrease in glucose utilization and an increase in the production of glucose [3].
The word diabetes has originated from the Greek word *diabanein*, which means to pass through because excessive urine is produced as a symptom of this disease [4]. And the term *diabetes* is commonly referred to diabetes mellitus, which means excessive sweet urine (known as "glycosuria"). The three main types of diabetes are, Type 1 diabetes or IDDM (Insulin-dependent diabetes mellitus), Type 2 diabetes or NIDDM (Non- insulin-dependent diabetes mellitus) or adult-onset diabetes mellitus and gestational diabetes. Screening of patients with diabetes can help in reducing the burden of diabetes on a community as well as on nation [5].
Diabetes is a fast growing disease that will potentially lead to an epidemic in India [6, 7]. The prevalence of diabetes in the rural area is one-quarter that of the urban area for India and other Indian sub-continent countries such as Bangladesh, Bhutan, Nepal, and Sri Lanka [8]. Primary results from a community-based study conducted by the ICMR (Indian Council of Medical research) showed that lower proportion of north Indian population is affected by the disease (Chandigarh with 0.12 million, Jharkhand with 0.96 million people) as compared to Maharashtra and Tamil Nadu (9.2 and 4.8 million, respectively) [8]. The suggested reason for this difference could be due to the north Indians being migrant Asians and south Indians being the host populations [9].

Nowadays diabetes mellitus has become an important public health challenge. It is the major cause of death and disability across the world. Global prevalence of diabetes has doubled between 1980 and 2014 [14]. There is an uncertain future in front of India in relation to the potential burden that diabetes may impose upon the country. According to the International Diabetes Federation (IDF), one in 11 adults had diabetes in 2015 and the number will be one in 10 of 2040) [10]. India is one of the members of the seven countries of the International Diabetes Federation SEA (South East Asia) region. International Diabetes Federation, 2017 shows that globally 425 million people have diabetes and in the SEA region 82 million people have the disease; it could rise to 151 million by 2045. India is at the second position after China with 72.9 million cases of Type 2 diabetes mellitus in the age group of 20-79 years (T2DM) and the predictions say that India will be at number one position with 134.3 million cases of Type 2 diabetes in 2045 [11].

There are various risk factors of diabetes. High incidents of Type 2 diabetes in population is associated with cultural changes in the diets, which were consumed previously. Obesity is strongly related to diet and lifestyle which in India, are changing drastically due to economic and nutrition transition [12]. Being overweight or obese is also a risk factor for CVD, stroke, cancer, HTN, diabetes and early death [17]. WHO global estimates showed that world's 11% adult men and 15% adult women were obese in 2014 [13]. In India, the percentage of overweight/obese married women between aged 15 -49 years has increased from 11% in National Family Health Survey-2 (NFHS-2) to 15% in NFHS-3 [15]. According to World Health Statistics Report 2012, globally, one in six adults is obese and around 2.8 million individuals die every year due to overweight and obesity [16].

In the epidemiological studies, BMI is used as a measure of general obesity, waist circumference and waist to hip ratio as a measure of central/abdominal obesity (AO) [18]. Cutoff value of BMI is different for Asian Indians because Asian Indians tend to develop diabetes at a significantly lower BMI and waist circumference [19, 20]. It has been confirmed by Logue *et al* that patients with Type 2 diabetes have U-shaped association of BMI with mortality [21] and it was found that higher BMI is associated with increased risk of coronary heart disease and cardiovascular mortality among Type 2 diabetics. It becomes important to measure BMI for early screening of obesity and prevalence of Type 2 diabetes as well as monitoring and management of T2DM pateints [18]. As it has been noticed that with a given BMI (Body mass index), Asian Indians have comparatively higher waist circumference, higher waist-hip ratios, more subcutaneous and visceral fat and more insulin resistance than European individuals [22].

Recently, risk scores based on simple anthropometric and demographic variables have been devised to detect high-risk individuals named Indian Diabetes Risk Score (IDRS) [23, 65]. This IDRS is a simple tool, which can be used by the community health worker to screen the high-risk population. The IDRS has a sensitivity of 72.5% and specificity of 60.1% and is derived based on the largest population based study on diabetes in India CURES (Chennai Urban Rural Epidemiology Study). The advantage of IDRS are its simplicity, low cost and its easy applicability for mass screening programmes [24].

IDRS uses two modifiable risk factors (waist circumference and physical inactivity) and two non-modifiable risk factors (age and family history of diabetes), providing a clear message that changes in the modifiable risk factors can alter the score of the individual, the risk score can be considerably reduced and increased. Subjects with high IDRS, regardless of their blood sugar status, are ideal candidates for life style modification as these risk factors are not only for type 2 diabetes but also for cardiovascular disease [24]. Knowledge and awareness about type 2 diabetes are not adequate in India. Various diabetes screening as well as education programmes are instantly needed both in rural and urban areas.

Early recognition of the high risk individuals would help in taking appropriate intervention in the form of dietary changes, increasing physical activity, thus helping to prevent, or at least delay, the onset of Type 2 diabetes. This means that identification of at risk individuals using Indian Diabetes risk score can be a step towards awareness as well as prevention of Type 2 diabetes in India.

Objectives

The objective of the study was to identify the individuals who are at high risk of Type 2 diabetes using Indian Diabetes Risk Score in rural and urban areas of Ludhiana.

Methods

30 cluster multi-stage sampling design was used for the study. In the current study, 30 locations from Ludhiana district were selected targeting adult men and women. As the district Ludhiana has 12 blocks, two villages from each block (total of 24 villages) and 6 locations from the urban area were selected to get a total random sample size of 529 subjects in the age group ≥ 20 years (Fig. 1 and 2).

A pre designed pre tested interview schedule was used to interview a person. An informed verbal consent was obtained prior to data collection. Anthropometric measurements including height, weight, waist circumference of each subject were obtained using standardized methods [25]. Body mass index for the subjects was estimated using formula given by WHO expert consultation for Asians [26].

Adult subjects aged 20 years or more with or without family history of Diabetes mellitus and who were cooperative were included in the study. All pregnant and lactating females were excluded. Any subject suffering from severe illness or taking any kind of medicine were also excluded from the study.

Indian Diabetes Risk Score (IDRS) was used to ascertain the risk of developing Type 2 diabetes.

Indian Diabetes Risk Score

Indian Diabetes Risk Score	Score
Age	
<35 years	0
35-49 years	20
≥ 50 years	30
Waist circumference	
Waist <80 cm (female), <90 cm (males)	0
Waist ≥80-89 cm (female), ≥90-99 cm (males)	10
Waist ≥90 cm (female), ≥100 cm (males)	20
Physical activity	
Regular vigorous exercise or strenuous (manual) activities at home/work	0
Regular moderate exercise or moderate physical activity at home/work	10
Regular mild exercise or mild physical activity at home/work	20
No exercise and/or sedentary activities at home/work	30
Family history of diabetes	
No diabetes in parents	0
One parent is diabetic	10
Both parents are diabetic	20

Analysis for 'high risk population' was done as per Indian Diabetes Risk Score (IDRS) [23]. Subjects with IDRS "≥60", "30 to <60" and "<30" were considered as High risk, Moderate risk, and Low risk, respectively for Type 2 diabetes.

Statistical Analysis
Data was analysed using SPSS Inc. 23.0 and Medcalc statistical software. Z test for two proportions was used. Pearson's Chi-square was used as a test of significance.

Ethical Issues: This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Ethical Committee of Punjab Agricultural University. Verbal informed consent was obtained from all subjects. Verbal consent was witnessed and formally recorded.

Results
IDRS consists of total four parameters, two modifiable (waist circumference and physical activity) and two non-modifiable (age and family history). IDRS parameters of rural and urban subjects are given in Table 1. On evaluating the risk status of study subjects for Type 2 diabetes mellitus using IDRS, following results were found.

Age
The significant number of the rural men (57%) were in the age group of ≥50 year and 39% were in the age group of 35-49 year. Similarly, majority of the urban men (52%) were in the age group of ≥50 year and 38% were in the age group of 35-49 year. It was found that the majority of the rural women (55%) were in the age group of 35-49 year whereas the urban women subjects (41%) were in the age group of ≥50 year. Only 4% rural and 13% urban women were below the age 35 year.

Abdominal obesity (waist circumference)
As central obesity is important risk factor for Type 2 diabetes, it was observed that majority of the study subjects (49% rural, 48% urban, respectively) had waist circumference (WC) ≥ 100cm for males and ≥ 90cm for females followed by 31 per cent rural and 35 per cent urban subjects who had waist circumference ≥90-99cm for males and ≥80-89cm respectively. 20 per cent rural and 17 per cent urban subjects had waist circumference <80 cm for females and <90 cm for males. Central/abdominal obesity was considered to be present when waist circumference ≥ 90 cm in males and ≥ 80 cm in females [27, 28].
It has been reported that majority of the male patients had a waist circumference in the range of 91-100 cm, whereas females were in the range of 81-90 cm [29].

Physical activity
It was found that majority of the (37%) rural subjects were involved in sedentary activity, 35% in mild physical activity, 17 per cent in moderate physical activity and 11% in strenuous physical activity. On the other hand, among the urban subjects, majority of the subjects had sedentary physical activity (66%), 24% had mild physical activity and 8% subjects were involved in vigorous or strenuous physical activity.

Family history
It has been found that majority of the rural and urban study subjects had no family history of Type 2 diabetes (83 and 89%, respectively). About 15% rural and 18%urban subjects had one parent diabetic and only 1% rural and 3% urban subjects had both parents diabetic. It is observed that majority of the rural (84%) and urban (80%) women had no history of familial diabetes. Fourteen percent rural and 17% urban women had one parent diabetic.

Indian Diabetes Risk Score (IDRS)
The current study identified 45% rural and 54% urban men to be in the high risk category according to IDRS (Fig. 3). It has been calculated as given in the Indian diabetes risk score, majority of the rural and urban men (52% rural, 45% urban) had moderate risk of developing Type 2 diabetes and only 2% rural and 2% urban subjects had low risk of Type 2 diabetes in the coming years.
It has been observed that majority of the rural (77%) and urban (83%) women had a high risk of developing Type 2 diabetes followed by 22% rural and 17% urban women had moderate risk of developing Type 2 diabetes and only 1% rural women are at the safer side, who had low risk of developing Type 2 diabetes (Fig. 4).

Body mass index and IDRS score of men and women
When obesity (Table 2) was compared with diabetes risk score, it was found that 19% overweight, 44% pre obese and 18% (sum of obesity grade1 and grade 2) obese rural men were at high risk of being Type 2 diabetic. While 15% overweight, 23% pre obese and 4% obese subjects were at moderate risk of Type 2 diabetes. 38 and 18% rural men who had normal BMI were also at moderate and high risk of developing Type 2 diabetes, respectively. Similarly 20% overweight, 47% pre obese and 7%, obese urban men were at high risk of developing Type 2 diabetes. It was found that 20% overweight, 32% pre obese and 12% obese urban men, were in the moderate risk category of Type 2 diabetes. While 28 and 23% urban men having normal BMI were at moderate and high risk of developing Type 2 diabetes, respectively.
Data further revealed that (Table 3) 22% overweight, 33% pre obese and 17% obese rural women were at high risk of being Type 2 diabetic. It was found that 17% overweight, 17% pre obese and 2% obese subjects were at moderate risk of developing Type 2 diabetes. While 34 and 22% rural women who had normal BMI were also at moderate and high risk of developing Type 2 diabetes, respectively. Similarly among urban women, 13%, overweight, 40% pre obese and 6% obese subjects were at high risk of developing Type 2 diabetes. It was observed that 9% overweight and 27% pre obese subjects were in the moderate risk category of Type 2 diabetes. While 55 and 37% urban women having normal BMI were at moderate and high risk of developing Type 2 diabetes, respectively. Ahmed have found 14.8% overweight and 6.7% obese subjects were at high risk of developing Type 2 diabetes [30]. Khan *et al* have found 79.3% obese subjects were in high risk category of Type 2 diabetes [18].

Relationship of sex with certain IDRS parameters
Chi square analysis (Table 4) showed that there was highly significant (p<0.01) relationship between the sex and physical activity of study subjects. It was found that comparatively lowest percentage of study subjects were engaged in regular exercise and strenuous work. It was observed that 12% of male, were engaged in regular exercise and strenuous work however 10% of females were engaged in exercise. It was found that 71% of males were engaged in moderate physical

activity however in females only 27% of subjects were found to be engaged in exercise or strenuous work. This depicts that sex has very significant relationship with physical activity of the subjects. It was also observed that subjects engaged in sedentary work or no exercise, had significantly higher ($p \leq 0.01$) percentage of females were involved in sedentary work or no exercise whereas, only 17% of males were found to be involved in sedentary work or no exercise at all. It can be concluded that higher percentage of males were engaged in physical activity as compared to females.

The relationship between abdominal obesity and gender of subjects is described in Table 4. A significant ($p \leq 0.01$) relationship between abdominal obesity and gender was observed. 30 percent of males had waist circumference in reference range (<90 cm) whereas only 11 percent of females had waist circumference (<80 cm) under normal range. Further it was observed that 58% of females had waist circumference ≥90 cm however significantly lower percentage of males (36%) were found to have waist circumference ≥100 cm which puts them at high risk. The results indicated that 58% of females and 36% of males had waist circumference ≥90 cm and ≥100 cm, respectively. It depicted that higher percentage of females had abdominal obesity compared to males.

The data for risk of Type 2 diabetes showed that very few subjects i.e. 2% females and 3% males were at low risk of having Type 2 diabetes in future. 44% females and 52% males fell in the category of moderate risk of Type 2 diabetes. It was found that 54% females were at high risk of Type 2 diabetes. It could be due to the fact that 63% women were not involved in any exercise and were living sedentary lifestyle and nearly 58% of them had high abdominal obesity. Similarly 45% of males were at high risk of Type 2 diabetes due to lack of exercise (17%) and high abdominal obesity (36%). Similar results were given by Brahmbhatt *et al* [31].

In another study, 2.80% study subjects were in low risk, (28.40%) in moderate risk and (68.80%) were in high risk group as per the IDRS [32]. Jayakiruthiga *et al* have reported 57.6% subjects were in the high risk category followed by 33.9% who were in the moderate risk category of developing Type 2 diabetes [34].

Receiver operating curve (ROC)

An ROC (Receiver operating curve) curve (Fig. 5) was constructed in Medcalc statistical software to determine the optimal cut-off point for identifying non- T2DM and T2DM cases. An IDRS of less than 60 was optimal for identifying non-T2DM and ≥60 for identifying T2DM with (AUC, 0.680: CI, 0.648-0.710).

In the receiver operating characteristics analysis, IDRS had an area under the curve of 0.680 (P<0.0001) (Table 5). The best cut-off point for IDRS was 60 with sensitivity, specificity and Youden Index of, 65.53%, 59.74% and 0.2526, respectively. The findings of our study indicate that IDRS has significant predictive value for detecting undiagnosed Type 2 diabetes and IDRS is also a much stronger risk indicator than examining individual risk factors like age, family history, obesity and physical activity. Higher IDRS scores increased the specificity but sensitivity significantly decreased. Conversely lower IDRS values increased the sensitivity but the specificity decreased significantly. Thus the study confirms and validates the IDRS score of >60 as being the best cut off point for identifying undiagnosed Type 2 diabetes [35]. IDRS >60 had 62.2% sensitivity and 73.7% specificity with AUC 0.668 [35].

ROC analysis was conducted and an IDRS ≥60 had an area under the curve (AUC), 0.894, sensitivity 83.8% and specificity 81.0% to predict Type 2 Diabetes mellitus [36]. Sowmiya *et al* has reported 68.2% sensitivity and 75.5% specificity at a cut off score of 60 [37]. Arun *et al* has reported that IDRS has sensitivity of 81.40%, specificity 72% with positive predictive value 31.7% and diagnostic accuracy of 73.3% [38].

Discussion

In the current study we have used Indian Diabetes risk score for assessing individuals who are at high risk of developing Type 2 diabetes in Ludhiana (Punjab). We have also used BMI as screening of general obesity. We have found that 47% and 48% rural subjects were in middle age and old age, respectively while 48% and 39% urban subjects were in middle age and old age, respectively.

Studies have shown that with the increase in the age group of the study population, the percentage of the individuals belonging to the high-risk group also increased [40, 41]. Similar findings have been reported by other studies [42, 43, 44]. Association of increase in age and prevalence of Type 2 diabetes was also reported by several studies [45, 46, 47]. Ageing also induces decrease insulin sensitivity and alteration of beta cell functional in the face of increasing insulin resistance [48].

The prevalence of obesity and diabetes increases with increasing age. Jain *et al* have reported that the prevalence rate of T2DM in elderly population is 30.42% with almost equal numbers of both sexes and 64.04% have central obesity [49]. It definitely affects the quality of life an individual with increasing age. In our study only 20% rural and 17% urban subjects has normal waist circumference, rest of the subjects were found centrally/abdominally obese. Studies have shown association between abdominal obesity and Type 2 diabetes and Obesity has been confirmed as a risk factor for Type 2 diabetes [50, 51] Khan *et al* have shown similar findings, 1° and 2° abdominal obesity were prevalent in 47.9% and 40% subjects, respectively [18]. A significant association had been found between sedentary activity and Type 2 diabetes [43]. and decreasing physical activity was associated with Type 2 diabetes (52). Physical inactivity accounts for 14% of diabetes mellitus globally, which is a significant risk factor for obesity, which again has relation with Type 2 diabetes [27] Anjana *et al* found that a large number of people in India have inactive and sedentary lifestyle and around less than 10% are engaged in recreational physical activity, [53] which is similar to our research findings. Individuals who live sedentary lifestyle are more at risk to become obese and Type 2 diabetic in future. Mohan *et al* and Gupta *et al* also reported that subjects having sedentary and moderate physical activity had a higher risk for Type 2 diabetes [54, 55].

It was observed that positive family history strongly predicted the risk of developing Type 2 diabetes [51]. A study in urban and rural area of Lucknow had reported that 50% of the subjects had both parents diabetic, 21.4% had either parent diabetic and 12.7% of the study subjects had no family history of Type 2 diabetes [38]. Another study conducted a study in Madhya Pradesh and found that 25% of the study subjects had both parents diabetic followed by history with either parents i.e. 17.30% and 7.14% subjects had no history of Type 2 diabetes [56].

In our study we found 16% rural and 21% (16% and 21% is the sum of one parent and both parents categories) urban

subjects had positive history of diabetes. Which clearly depicts that this specific group of subjects need early and regular screening and monitoring of blood glucose because due to the genetic predisposition they can get Type 2 diabetes at any stage of life by reduction of beta cell function [57]. A study has reported that men with recent-onset of diabetes having Yemenite origin were found to have significant reduction of beta-cell function and decreased ability to compensate for insulin resistance compared with diabetic men of non-Yemenite origin because of early loss of beta-cell in diabetic men. It was found that Yemenite origin men had a significantly higher maternal inheritance of diabetes [57]. Ramachandran *et al*. and Gupta *et al*. also found 47% and 31.5%, subjects, respectively had diabetes who had a positive family history [58, 59].

The current study identified that 35% and 64% rural subjects were in moderate and high risk category of Type 2 diabetes, respectively while 30% and 69% urban subjects were in moderate and high risk category of Type 2 diabetes, respectively. It was found that rural subjects are equally at risk of developing Type 2 diabetes because rural population is undergoing lifestyle transition due to socio- economic growth. Many villages have undergone drastic change in living standards and lifestyle [35]. Monthly per capita consumer expenditure (MPCE) is estimated to have also grown by about 21% from 1993-94 to 2007-08 in rural India (National Sample Survey report No.530). Various studies have reported 43%, 25.7 and 31% subjects in the high risk category [23, 40, 59]. Toppo *et al* found that (urban subjects aged >30 years) 57.63% individuals in the high risk category followed by 37. 43% in the moderate risk category and low risk only 4.92% individuals [56].

As Asian Indians tend to develop diabetes at a significantly lower BMI and waist circumference [19, 20]. Our study has also indicated the similar trend, subjects, who are obese, according to BMI, are at risk of diabetes but the subjects who have normal BMI are also at moderate and high risk of developing diabetes. Similarly, it was also found that WC is a better predictive marker of obesity-related disease risk than body mass index in South Indian population [20]. NICE guidance also suggested that the measurement of waist circumference should be used because normal as well as overweight subjects as per BMI have increased and high risk of obesity-related diseases, respectively [60].

When relationship of sex with IDRS paremeters was assessed, It was found that significantly higher number of females are not doing exercise and have sedentary lifestyle. Brahmbhatt *et al* have also found similar trend and reported prevalence of physical activity among males and females 64% and 49%, respectively [31]. A study conducted by ICMR reported prevalence of physical activity among males and females as 60% and 40%, respectively [53]. While a study conducted in Ahmedabad, Gujarat reported prevalence of physical activity among males and females up to 68% and 32%, respectively [62]. We have found that significantly higher number of women are abdominally obese. Brahmbhatt et al have reported the prevalence of abdominal obesity 44% and 84% among males and females, respectively [31]. While a study conducted in North India using the same cut-off values for waist circumference reported prevalence of abdominal obesity up to 62% and 75% among males and females, respectively [63]. Another study conducted in South India reported it up to 31% and 66% among males and females, respectively [64]. and Chi square analysis has shown that large women are more at risk of developing Type 2 diabetes because of sedentary lifestyle along with abdominal obesity so women need to be more aware regarding Type 2 diabetes and managing their blood glucose levels.

Table 1: IDRS parameter among men and women

Parameter	Men		Z-value	Women		Z-value	Total		Z-value
	Rural (n=172)	Urban (n=56)		Rural (n=238)	Urban (n=63)		Rural (n=410)	Urban (n=119)	
Age (years)									
<35	7(4)	6(11)	1.86*	9(4)	8(13)	2.73***	16(4)	14(12)	3.26***
35-49	67(39)	21(38)	0.19NS	131(55)	26(41)	1.95NS	198(47)	47(39)	1.69*
≥50	98(57)	29(52)	0.68NS	98(41)	29(46)	0.69NS	196(48)	58(49)	0.18 NS
Abdominal obesity(Waist circumference in cm)									
Waist <80 cm (female), <90 cm (males)	56(33)	13(23)	1.32NS	27(11)	7(11)	0.05NS	83(20)	20(17)	0.83 NS
Waist ≥80-89 cm (female), ≥90-99 cm (males)	56(33)	20(36)	0.44NS	71(30)	22(35)	0.78NS	127(31)	42(35)	0.89 NS
Waist ≥90 cm (female), ≥100 cm (males)	60(35)	23(41)	0.84NS	140(59)	34(54)	0.69NS	200(49)	57(48)	0.17 NS
Physical activity									
Vigorous exercise/strenuous activity	18(10)	10(18)	1.46NS	29(12)	0(0)	2.91***	47(11)	10(8)	0.95 NS
Moderate exercise/moderate activity	69(40)	1(2)	5.40***	2(1)	0(0)	0.73NS	71(17)	1(1)	4.61***
Mild exercise/mild activity	75(44)	16(29)	2.00**	67(28)	13(21)	1.20NS	142(35)	29(24)	2.11**
No exercise/sedentary activity	10(6)	29(52)	7.94***	140(59)	50(79)	3.00***	150(37)	79(66)	5.78***
Family history									
No family history	140(81)	56(84)	3.48***	202(85)	50(79)	1.05NS	342(83)	106(89)	1.51
Either parent	30(17)	10(15)	0.07NS	32(13)	11(17)	0.81NS	62(15)	21(18)	0.67 NS
Both parents	2(1)	1(1)	0.36NS	4(2)	2(3)	0.75NS	6(1)	3(3)	0.79 NS
IDRS score									
Low risk <30	4(2)	1(2)	0.24NS	2(1)	0(0)	0.73NS	6(1)	1(1)	0.52 NS
Medium risk 30-50	90(52)	25(45)	1.00NS	53(22)	11(17)	0.83NS	143(35)	36(30)	0.94 NS
High risk of diabetes≥60	78(45)	30(54)	1.07NS	183(77)	52(83)	0.96NS	261(64)	82(69)	1.06 NS

IDRS implies Indian diabetes risk score

Figure in the parenthesis represent percentages.*Significant at 10%; **Significant at 5%; *** Significant at 1% NS-Non Significant

Table 2: Distribution of subjects (men) according to their body mass index (BMI) and diabetes risk as per Indian diabetes risk score (IDRS)

Body mass index	Category	Diabetes risk as per Indian diabetes risk score							
		Low risk		Moderate risk		High risk		Total	
		Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
<18.5	Underweight	1(25)	0	18(20)	2(8)	1(1)	1(3)	20	3
18.5-22.99	Normal	0	1(100)	34(38)	7(28)	14(18)	7(23)	48	15
23-24.99	Overweight	2(50)	0	13(15)	5(20)	15(19)	6(20)	30	11
25-29.99	Pre-Obese	1(25)	0	21(23)	8(32)	34(44)	14(47)	56	22
30	Obese	0	0	0	0	0	0	0	0
30-40	Grade I	0	0	03(3)	2(8)	12(15)	2(7)	15	4
40.1-50	Grade II	0	0	1(1)	1(4)	2(3)	0	3	1
>50	Grade III	0	0	0	0	0	0	0	0
Total		4(2)	1(1)	90(52)	25(45)	78(45)	30(54)	172	56

Figures in parentheses represent the percentage

Table 3: Distribution of subjects (women) according to their body mass index (BMI) and diabetes risk as per Indian diabetes risk score (IDRS)

Body mass index	Category	Diabetes risk as per Indian diabetes risk score							
		Low risk		Moderate risk		High risk		Total	
		Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
<18.5	Underweight	1(50)	0	16(30)	1(9)	12(7)	2(4)	29	3
18.5-22.99	Normal	1(50)	0	18(34)	6(55)	41(22)	19(37)	60	25
23-24.99	Overweight	0	0	9(17)	1(9)	41(22)	7(13)	50	8
25-29.99	Pre-Obese	0	0	9(17)	3(27)	60(33)	21(40)	69	24
30	Obese	0	0	0	0	0	0	0	0
30-40	Grade I	0	0	1(2)	0	25(14)	3(6)	26	3
40.1-50	Grade II	0	0	0	0	3(2)	0	3	0
>50	Grade III	0	0	0	0	1(0.5)	0	1	0
Total		2(1)	0	53(22)	11(17)	183(77)	52(83)	238	63

Figures in parentheses represent the percentage

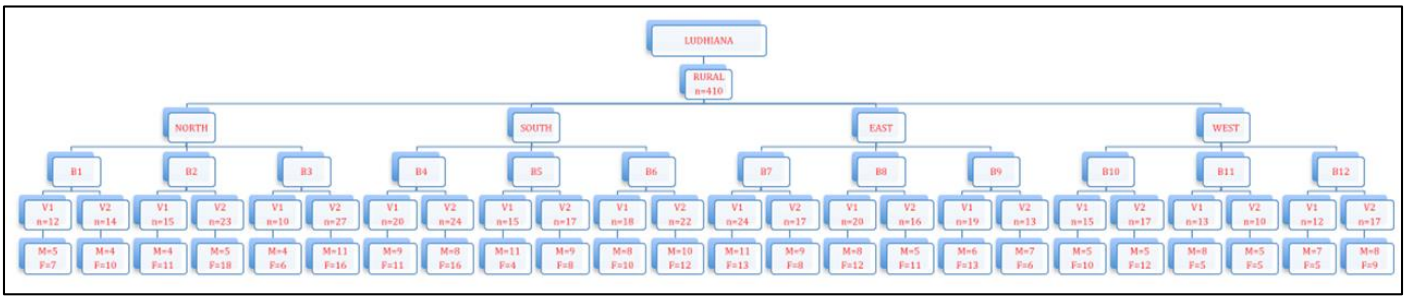
Table 4: Relationship of gender with certain IDRS parameters (n=529)

Gender	Exercise (regular)+ Strenuous work	Exercise (regular)or Strenuous work	No exercise and sedentary work	Chi-Square (df)	P-value
Physical activity					
Female	29(10)	82(27)	190(63)	117.43(2)***	0.000
Male	28(12)	161(71)	39(17)		
Abdominal obesity					
Gender	1*	2#	3$		
Female	34(11)	93(31)	174(58)	36.445(2)***	0.000
Male	69(30)	76(33)	83(36)		
Risk of diabetes					
Gender	Low risk	Moderate risk	High risk		
Female	7(2)	132(44)	162(54)	4.318NS	0.1154
Male	7(3)	119(52)	102(45)		

*Waist <80 cm:female,<90:male (reference)
#Waist ≥80-89 cm:female, ≥90-99 cm: male
$Waist ≥90 cm:female, ≥100 cm: male
*Significant at 10%; **Significant at 5%; *** Significant at 1%
NS-Non Significant

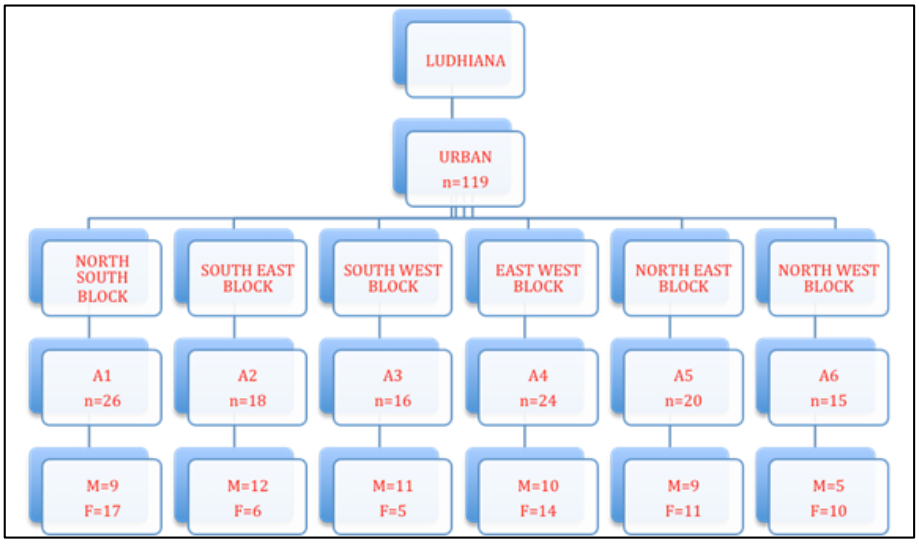
Table 5: Sensitivity and specificity at different cutoffs of Indian Diabetes Risk Score in the screened population (n=880)

Criterion	Sensitivity	95%CI	Specificity	95% CI	+LR	-LR	+PV	-PV
≥0	100.00	99.0-100.0	0.00	0.0-0.7	1.00	-	39.89	-
>10	100.00	99.0-100.0	0.38	0.05-1.4	1.00	0.00	40.0	100.0
>20	99.15	97.5-99.8	1.32	0.5-2.7	1.00	0.65	40.0	70.0
>30	97.72	95.6-99.0	8.13	5.9-10.8	1.06	0.28	41.4	84.3
>40	94.59	91.7-96.7	19.66	16.4-23.3	1.18	0.28	43.9	84.6
>50	85.19	81.0-88.7	35.16	31.1-39.4	1.31	0.42	46.6	78.2
>60	65.53	60.3-70.5	59.74	55.4-63.9	1.63	0.58	51.9	72.3
>70	39.89	34.7-45.2	85.26	81.9-88.2	2.71	0.71	64.2	68.1
>80	6.55	4.2-9.7	97.54	95.8-98.7	2.67	0.96	63.9	61.1
>90	1.14	0.3-2.9	100.00	99.3-100.0	-	0.99	100.0	60.4
>100	0.00	0.0-1.0	100.00	99.3-100.0	-	1.00	-	60.1



B=Block
V=Village
M=Male
F=Female

Fig 1: Total Sample from Ludhiana (Rural +Urban) =529 (M=228,F=301) Sample selection from rural areas of Ludhiana n=410 (M=172, F=238)



B=Block
A=Area
M=Male
F=Female

Fig 2: Sample selection from urban areas of Ludhiana n=119 (M=56, F=63)

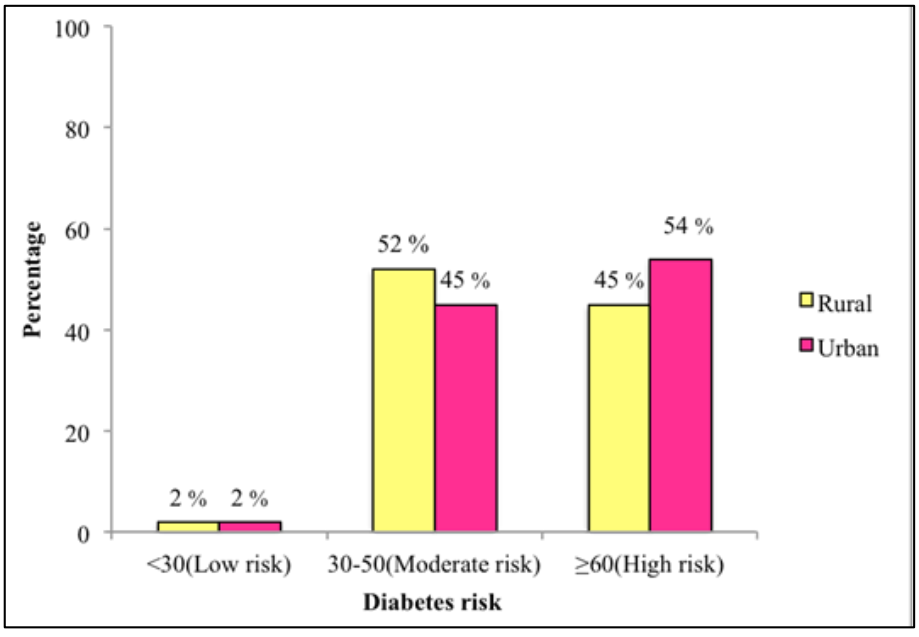


Fig 3: IDRS score of selected rural and urban men

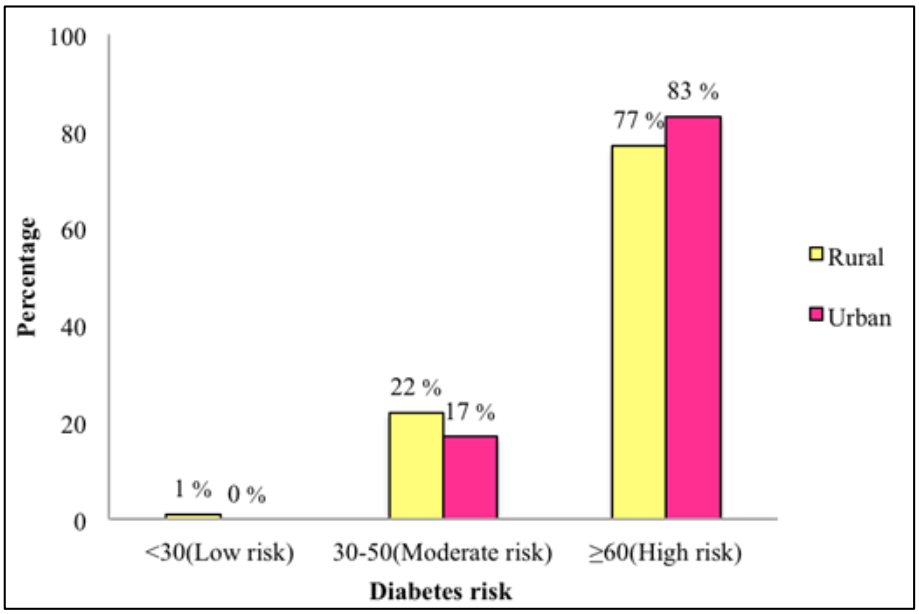


Fig 4: IDRS score of selected rural and urban women

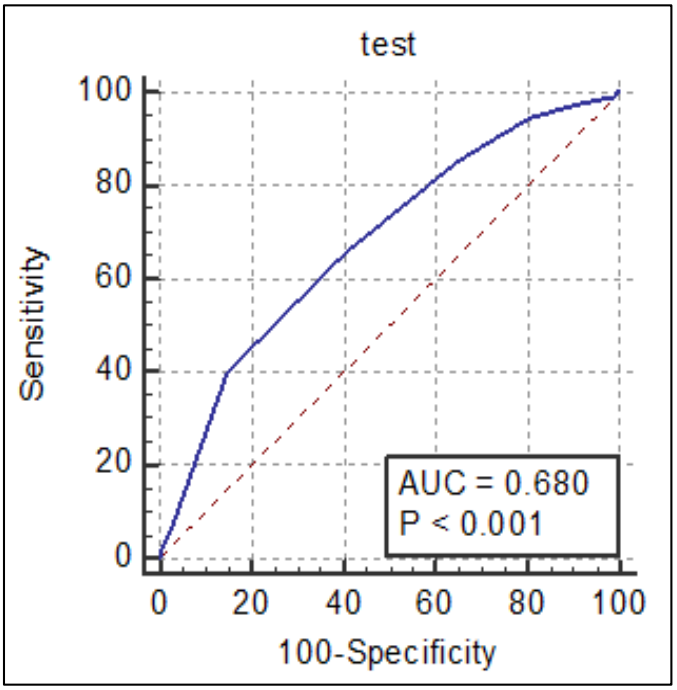


Fig 5: ROC curve showing performance of Indian diabetes risk score

Conclusion

Based on the results, Subjects, who had scores 60 or more than 60 were ideal candidates for lifestyle modifications. Both are useful in estimating the existence of pre-diabetes also (which is reversible)[39]. Among the risk categories the high risk categories has been strongly associated with the development of Type 2 diabetes in comparison with moderate risk. The high-risk category people had more prevalence of risk factors which puts them at risk of Type 2 diabetes. This point can be utilized to focus this category for lifestyle changes for reversing the effect of modifiable risk factors. Simultaneously awareness about the risk factors and the ways to reverse and prevent them should be increased at all the levels of health contacts.

Indian diabetes risk score is an easy and cost effective tool for mass screening of Type 2 diabetes. It should be used in community based screening to find out high-risk individuals especially in developing countries like India. Timely intervention can prevent the early development of Type 2 diabetes, its complications and obesity related other comorbidities.

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