Original Article

Validity of Indian Diabetes Risk Score and its association with body mass index and glycosylated hemoglobin for screening of diabetes in and around areas of Lucknow

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Abstract

Objectives: The present study aimed to assess the validity of Indian Diabetes Risk Score (IDRS) and its association with body mass index (BMI) and glycosylated hemoglobin (HbA1c) for screening of diabetes and obesity. **Methodology:** A cross-sectional study was designed, and samples were randomly enrolled from Lucknow and its adjoining areas. Totally, 405 subjects were included in the study. We used diabetes risk factors (age, waist circumference, physical activity, and family history of diabetes) for screening of diabetes and abdominal obesity (AO) and BMI for screening of general obesity. HbA1c was used for confirming the diabetes patients in this population. Statistical analysis was applied to all data using SPSS software (version 20.0). $P < 0.05$ was considered statistically significant. **Results:** All 405 subjects were assessed for diabetic risk factors, BMI, and glycated hemoglobin. Of these, 56.3% subjects were aged ≥50 years. 1° and 2° AO was found in 47.9% and 40% subjects, respectively. About 27.1% subjects were found to have sedentary lifestyle, and 72.6% were found to have no family history of diabetes. According to IDRS, 272 subjects (67.2%) were found at high risk of diabetes (score ≥60). Based on BMI calculation, 198 subjects were obese, of which 79.3% were found at high risk for diabetes. A significant association was found between subjects with higher risk score and BMI ($P < 0.001$). Assessment of HbA1c showed that 97 (23.9%) were prediabetic and 204 (50.4%) were diabetic, of which 63.9% and 77%, respectively was at high risk for diabetes as per IDRS. A significant association was found between subjects with higher risk score and HbA1c ($P < 0.001$). **Conclusion:** Our study fully supports the validity of IDRS, as it can be used as a cost-effective tool for primary mass screening of diabetes. Moreover, its combination with BMI value and HbA1c can be used for strict monitoring for diabetes and obesity at primary health care centers to reduce the early development of diabetes complications and severe obesity comorbidities.

Keywords: Body mass index, diabetes, diabetes risk factors, glycosylated hemoglobin, obesity

Introduction

Diabetes is the 7th leading cause of death and with combination of obesity and hypertension (HTN), this leads to cardiovascular diseases (CVDs) which are the first leading cause of death globally.[1] The prevalence of diabetes mellitus (DM) and obesity are increasing parallel in worldwide.[2] A recent study reported that the number of adults with diabetes in the world increased from 108 million in 1980–422 million in 2014, due to population growth, aging, and the rise in overweight and

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obesity. Globally, the prevalence of diabetes has increased in both gender equally, in men from 43% in 1980 to 90% in 2014 and in women from 50% to 79% in women.[3] India is the second largest contributor to regional mortality, with one million deaths attributable to diabetes. In 2015, India had 69.2 million people with diabetes and 36.5 million impaired glucose tolerance (IGT) people (20–79 years) which are expected to rise to 123.5 million and 63.6 million by 2040, respectively. The prevalence of diabetes is high in urban than in rural India (14.2% vs. 8.3%) and prediabetes prevalence was found to be nearly same (urban 14.5%; rural 14.7%).[4] The majority of people with diabetes (>90%) have Type two DM (T2DM). Unfortunately, more than 50% of people with T2DM still remained undiagnosed.[5] "Asian Indian Phenotype" because of (greater abdominal adiposity, higher waist circumference, and lower body mass index [BMI]) makes Asian Indians more prone to diabetes and premature coronary artery diseases (CADs).[6] Indians are known to have a relatively unfavorable risk profiles for type 2 diabetes and CVD.[7] A follow-up study of Chennai Urban Population-based Study cohort showed that the overall mortality rates were nearly three times higher (18.9 vs. 5.3 per 1000 person-years, $P = 0.004$) in people with diabetes compared to nondiabetic subjects.[8]

Obesity is a complex condition, one with serious social and psychological dimensions that affects virtually all age and socioeconomic groups and threatens to overwhelm both developed and developing countries.[9] As in developed societies, the risk for obesity in developing countries like India is also strongly influenced by diet and lifestyle, which are changing dramatically as a result of the economic and nutrition transition.[10] According to WHO global estimates, about 13% of the world's adult population (11% of men and 15% of women) were obese in 2014.[11] The prevalence of obesity varies according to age, sex, and region. In India, the percentage of overweight or obese married women between aged 15 and 49 years increased from 11% in National Family Health Survey-2 (NFHS-2) to 15% in NFHS-3.[12] The worldwide prevalence of obesity doubled between 1980 and 2014.[2] Obesity is a major health risk factor linked to CVD, stroke, cancer, HTN, diabetes, and early death.[13] According to the World Health Statistics Report 2012,[14] globally, one in six adults is obese and nearly 2.8 million individuals die each year due to overweight or obesity, and the risk of morbidity and mortality has significantly increased. It recognizes obesity and its complications among the top 10 global risk factors leading to ~40% global death.[15]

The epidemiological survey used BMI as a measure of general obesity, and waist circumference (WC) and waist-hip ratio (WHR) as measures of central/abdominal obesity (AO). Cutoff value of BMI is different for Asian Indians because they tend to develop diabetes at a significantly lower BMI and WC.[16,17] Logue *et al*. confirmed that patients with T2DM have U-shaped association of BMI with mortality[18] and previously it was also reported that the higher BMI is associated with increased risk of coronary heart disease and cardiovascular mortality among people with T2DM.[19] These studies indicate that measuring BMI is important and cost-effective parameter for early screening of obesity and prevalence of T2DM as well as monitoring and managing the T2DM patients also.

The American Diabetes Association (ADA) Standards of Medical Care in Diabetes added, glycosylated hemoglobin (HbA1c) as important criterion for the diagnosis of prediabetes and diabetes (5.7%–6.4% and ≥6.5%, respectively).[20] In T2DM, higher HbA1c indicating poorer control of blood glucose levels. The HbA1c level is proportional to average blood glucose concentration over the previous 4 weeks to 3 months.[21]

Most prevalence studies in India have come from large metropolitan cities[22] and some from rural areas.[4,22,23] Data are needed from smaller towns and their adjoining areas. Lucknow is the capital and one of most populated city of Uttar Pradesh (India) and continuously expanding by adjoined surrounding areas. In our present cross-sectional study, we are using Madras Diabetes Research Foundation-Indian Diabetes Risk Score (MDRF-IDRS) developed by Mohan *et al*.,[24,25] to estimate the usefulness of MDRF-IDRS for detecting the risk of diabetes and to associate this score with BMI and HbA1c for evaluating the burden of obesity (generalized and abdominal) and diabetes.

Particulars	Score
Age (years)	
<35 (reference)	0
35-49	20
≥50	30
Abdominal obesity	
Waist<80 cm (female), <90 (male) (reference)	0
Waist≥80-89 cm (female), ≥90-99 cm (male)	10
Waist≥90 cm (female), ≥100 cm (male)	20
Physical activity	
Exercise (regular) + strenuous work (reference)	0
Exercise (regular) or strenuous work	20
No exercise and sedentary work	30
Family history	
No family history (reference)	0
Either parent	10
Both parents	20
Minimum score	0
Maximum score	100

Source: Mohan *et al*., 2005; Mohan and Anbalagan, 2013.[24,25] Score category; <30: Low risk; <60: Moderate risk; ≥60: High risk

Methodology

Subject selections

This cross-sectional study was approved by the Institutional Ethical Committee of this university. Subjects were enrolled from the adjoining areas of Lucknow (India) with detailed family and medical history, age, physical activities, and other parameters were assessed using a validated questionnaire[26] with informed written consent. The study is in accordance with the guidelines provided by the CPCSEA and World Medical Association Declaration of Helsinki on Ethical Principles for Medical

Research Involving Humans for studies involving experimental animals and human beings, respectively. Screening of subjects was done as per ADA guidelines[20] and MDRF-IDRS.[25] This study was conducted on 405 subjects aged between 25 and 70 years. HbA1c was also measured as one the diagnostic parameter for the confirmation of diabetes. Subjects with ischemic heart disease, angina, myocardial infarction (MI), electrocardiogram abnormalities, those with other concurrent sickness such as chronic liver disease, hypothyroidism or those on drugs such as diuretics and women using oral contraceptives or pregnant were excluded from the study.

Study design

We assessed the age, WC, physical activity, and family history of all enrolled subjects and given score as per MDRF-IDRS. The clinical (HbA1c, normal, <5.7%; prediabetes, 5.7%–6.4%; diabetes, ≥6.5%) and anthropometric (BMI; underweight, <18.5 kg/m^2; normal weight, 18.5–22.9 kg/m^2; overweight, 23–24.9 kg/m^2; and obese, ≥25 kg/m^2) variables were distributed with MDRF-IDRS risk scoring criteria into three groups (<30 for low risk, 30–50 for moderate risk, and ≥60 for high risk).

Definition

T2DM was defined according to the criteria provided by The ADA, HbA1c ≥6.5%.[20]

Generalized obesity (GO) was defined as BMI ≥25 kg/m^2, and for AO, the upper limit for WC of men and women was defined as 90 and 80 cm, respectively. We classified AO: as normal (waist <80 cm in female, <90 in male), 1° obese (waist ≥80–89 cm in female, ≥90–99 cm in male), and 2° obese (waist ≥90 cm in female, ≥100 cm in male).[27,28]

Laboratory investigations

Two-milliliter blood sample was withdrawn in EDTA vial for HbA1c estimation. HbA1c was measured by high-performance liquid chromatography-based method using D10 HbA1c analyzer (Bio-Rad).

Anthropometric measurements

Waist circumference

Measured in the standing position by placing a plastic tape horizontally midway between 12th rib and iliac crest on the midaxillary line.[29] The measurements were repeated twice by using the same device, and mean value was recorded.

Body mass index estimation

Weight was recorded to the nearest kilogram (kg) with the subject standing on the weighing machine without shoes and using minimum of clothing. The same weighing machine was used for all the study subjects, and the machine was tested with a known set of weights for any error.[30] Height was recorded with the subject erect, barefooted, feet together, back and heels against the upright bar of height scale, head upright in Frankfort horizontal plane "look straight ahead." The height measuring equipment consisted of a vertical bar with a steel tape attached. Attached perpendicularly to the vertical bar was a horizontal bar which was brought down snugly on the examinee's head.[31] BMI was calculated from the formula - (BMI = weight in kilogram/[height in meters]^2).

Statistical analysis

Statistical analysis was applied to all data usingIBM SPSS Statistics for Windows, Version 20.0. (IBM Corp., Armonk, NY, USA). Numbers (%) of all clinical (HbA1c) and anthropometric (WC and BMI) parameters were calculated in each MDRF-IDRS group. *P* values were calculated by Chi-square test. All *P* values were two-sided and differences were considered statistically significant for $P < 0.05$; all significant data suggest the strength of association with clinical (HbA1c) and anthropometric (WC and BMI) parameters.

Madras Diabetes Research Foundation-Indian Diabetes Risk Score

Mohan *et al*. have developed the MDRF-IDRS using four simple variables, namely, age, WC, regular exercise, and family history.[24,25] The individuals were classified as having high risk (score ≥60), moderate risk (score 30–50), and low risk (score <30) out of a total score of 100. MDRF-IDRS has a sensitivity and specificity of over 60% for a cutoff ≥60 and can be used to do a selective screening for diabetes and obesity in Indian population.

MDRF-IDRS developed based on multiple logistic regression analysis derived from Chennai Urban and Rural Epidemiology Study (CURES).

Results

Totally, 405 subjects were included in this study. Of these, more than half the diabetics (56.3%) were above the 50 years, followed by subjects (31.5%) between the age of 35 and 45 years. WC was measured, and it was found that maximum number of subjects (47.9%) was having 1° obesity, followed by 40% subjects with 2° obesity. Only 12.1% were normal. Physical activity was assessed on the basis of job profile, walking habit, and including gym in their daily routine. It was found that only 14.6% subjects were physically active, 58.3% subjects were physically moderate, and 27.1% subjects were physically sedentary. Family history of diabetes was assessed by face-to-face questioning and included only those subjects who have one parent/both parents known diabetic or no one has diabetes. In this study, 72.6% subjects did not have any family history of diabetes and 27.4% subjects had either one parent/both parents diabetic [Table 1].

When distributing all 405 subjects as per MDRF-IDRS, more than two-third of subjects (67.2%) were at high risk (score ≥60) for diabetes, followed by 29.6% with moderate risk (score 30–50), and only 3.2% were at low risk (score <30) for diabetes [Table 2].

When we measured general obesity and compared with diabetes risk score, we found 49% (198) were obese, of which 98% were either at high risk or moderate risk for developing diabetes

(79.3% and 18.7%, respectively). Similarly, all subjects (60) who were overweight were either at moderate or high risk (38.3% and 61.7%, respectively) of developing diabetes. None were under low-risk category. Of the 114 subjects who were having normal weight based on BMI, more than half of them (56.1%) were at high risk of developing diabetes. A significant association was found between subjects with high-risk score and BMI [$\chi^2 = 37.18$, $P < 0.001$, Table 3].

When HbA1c level was analyzed, it was found that around two-third number of subjects (74.4%) were in prediabetic (24%) and diabetic range (50.4%) (5.7–6.4% and ≥6.5%, respectively). The remaining (25.7%) had normal HbA1c level. Of the 204 diabetic subjects, 77% were at high risk, and of the 97 prediabetic subjects, 63.7% were at high risk of developing diabetes as per the MDRF-IDRS criteria. Subjects who had normal HbA1c level are also at high risk of developing diabetes (51%). Significant association was found between subjects with higher risk score and HbA1c [$\chi^2 = 25.71$, $P < 0.001$, Table 4].

Table 1: Distribution of study subjects according to Madras Diabetes Research Foundation-Indian Diabetes Risk Score

Particulars	Score	*n* (%)
Age (years)		
<35 (reference)	0	50 (12.3)
35-49	20	127 (31.4)
≥50	30	228 (56.3)
Abdominal obesity		
Normal; waist <80 cm (female), <90 (male) (reference)	0	49 (12.1)
1° obese; waist ≥80-89 cm (female), ≥90-99 cm (male)	10	194 (47.9)
2° obese; waist ≥90 cm (female), ≥100 cm (male)	20	162 (40.0)
Physical activity		
Active; exercise (regular) + strenuous work (reference)	0	59 (14.6)
Moderate; exercise (regular) or strenuous work	20	236 (58.3)
Sedentary; no exercise and sedentary work	30	110 (27.1)
Family history		
No family history (reference)	0	294 (72.6)
Yes family history	20	111 (27.4)

Values are expressed as *n* (%)

Table 2: Madras Diabetes Research Foundation-Indian Diabetes Risk Score distribution

Score category	*n* (%)
Low risk (<30)	13 (3.2)
Moderate risk (30-50)	120 (29.6)
High risk (≥60)	272 (67.2)
Total	405 (100)

Values are expressed as *n* (%)

Discussion

In this present study, we used MDRF-IDRS for newly diagnosed diabetic subjects in the adjoining areas of Lucknow (India). We also used BMI for screening of general obesity and HbA1c for confirming of diabetes in this study subjects. We found 31.4% middle aged and 56.3% old aged subjects. The prevalence of obesity and diabetes increases with increasing age. A study 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. Out of which, 80% patients had associated HTN. This badly affects the lifespan and quality of life with increasing age.[32] In our study, 1° and 2° AO were prevalence in 47.9% and 40% subjects, respectively. The study states that with increasing obesity, prevalence of diabetes increases and severe obese people have greater chance to develop CVD. Overweight and general obesity and AO are associated with increased risk of CVD and heart failure.[33,34] Anjana *et al.* reported that a large percentage of people in India are inactive and have sedentary lifestyle and less than 10% engaging in recreational physical activity,[35] which is similar to our findings. The people who have sedentary lifestyle are more prone to become obese and diabetic in future and long-term impact of this sedentary lifestyle make them victim of CVD and MI also. A similar study was also reported from the US.[36] According to the studies conducted by Mohan *et al.* and Gupta *et al.* found that people with sedentary and moderate physical activity had a high risk for diabetes.[37,38] In our study, we found 27.4% subjects had family history of diabetes. It indicated that this population need early screening and regular monitoring of diabetes because genetic predisposition convert them from normal to diabetic in any stage of the life by reduction of beta-cells function.[39] A Yemenite origin-based study reported that males with recent-onset diabetes of Yemenite origin have a significant reduction of beta-cell function and reduced ability to compensate for insulin resistance compared with diabetic males of non-Yemenite origin due to early loss of beta-cell in diabetic males. Yemenite origin males have a significantly higher maternal inheritance of diabetes.[39] Studies conducted by Ramachandran *et al.* and Gupta *et al.* found 47% and 31.5%, subjects, respectively had diabetes who had a positive family history.[40,41]

Table 3: Association of Madras Diabetes Research Foundation-Indian Diabetes Risk Score with body mass index

Variables	Low risk, *n* (%)	Moderate risk, *n* (%)	High risk, *n* (%)	Total	χ^2 (*P*)
BMI (kg/m^2)					
Underweight (<18.5)	4 (12.1)	15 (45.5)	14 (42.4)	33	37.18 (<0.001)*
Normal weight (18.5-22.9)	5 (4.4)	45 (39.5)	64 (56.1)	114	
Overweight (23-24.9)	0	23 (38.3)	37 (61.7)	60	
Obese (≥25)	4 (2.0)	37 (18.7)	157 (79.3)	198	
Total	13 (3.2)	120 (29.6)	272 (67.2)	405	

Values are expressed as *n* (%). **P*<0.05 is statistically significant. BMI: Body mass index

Table 4: Association of Madras Diabetes Research Foundation-Indian Diabetes Risk Score with glycated hemoglobin

Variables	Low risk, *n* (%)	Moderate risk, *n* (%)	High risk, *n* (%)	Total	χ^2 (*P*)
HbA1c (%)					
Normal (<5.7)	3 (2.9)	48 (46.1)	53 (51.0)	104	25.71 (<0.001)*
Prediabetic (5.7-6.4)	2 (2.1)	33 (34.0)	62 (63.9)	97	
Diabetic (≥6.5)	8 (3.9)	39 (19.1)	157 (77.0)	204	
Total	13 (3.2)	120 (29.6)	272 (67.2)	405	

Values are expressed as *n* (%). **P*<0.05 is statistically significant. HBA1c: Glycated hemoglobin

Nearly 29.6% and 67.2% subjects were found moderate risk to high risk of diabetes in our study. The previous studies were conducted in Chennai by Mohan *et al.* and in Puducherry and Tamil Nadu by Gupta *et al.* 43%, 19%, and 31.2% subjects, respectively, were found in high-risk category. This risk difference may be due to variance in ethnicity and lifestyles of the population as our study was done in Lucknow and adjoining areas which is located in North India, whereas Mohan *et al.* conducted their study in Chennai and Gupta *et al.* conducted their study in rural and urban areas of South India.[37,38,41] Gutch *et al.* reported that North Indians are becoming more prone for diabetes and obesity-related diseases such as dyslipidemia because of rapid westernization in lifestyles and diet and continuous migration from small towns and rural areas to metropolitan cities for employment.[42]

Our study indicated that the prevalence of overweight and obesity increases with increasing diabetes risk and found higher prevalence of overweight and obesity at moderate to high risk for diabetes. It was previously reported that chances of high diabetic risk increases with increase in BMI.[38] In our study, a significant difference was found for BMI when compared with diabetes risk (χ^2 = 37.18, P < 0.0001). Similarly, the correlation of BMI and diabetes risk showed that, with increasing BMI (from <18.5 kg/m^2 to more than 30 kg/m^2), chances of high risk for developing DM also increases significantly.[38]

After using (≥25 kg/m^2) cutoff value of BMI to consider GO, 49% subjects were found generalized obese, while on the basis of WC 87.9% subjects were found to have AO. A studies by Kumar *et al.* reported that there is a large difference in generalized and AO between immigrant groups from developing countries, especially in South Asians.[43] A multiregional Indian study reported that the prevalence of GO, AO, and combined obesity were significantly higher among urban population as compared to rural population, and this study further noted that the prevalence of AO was higher than GO.[44] Another study reported that the age-standardized prevalence of GO (≥23 kg/m^2) was 45.9%, while that of AO was 46.6%.[17] It is also recommended that (≥23 kg/m^2) cutoff value of BMI might be given more productive results in our study subjects. As Deepa *et al.* suggested that obese prevalence rate vary markedly depending on cut points used.[17] In our study, the prevalence of AO was found 1.8-fold higher than GO. Mamtani and Kulkarni showed that AO using WC is a better predictor of the risk of diabetes compared to WHR, abdominal volume index, and conicity index in Western India population.[45] Similarly, it was also found that WC is a better predictive marker of obesity-related disease risk than BMI in South Indian population.[17] NICE guidance suggested that the measurement of WC should be used because normal weight and overweight people as per BMI have increased and high risk of obesity-related diseases, respectively.[46] Similarly, The Heart Outcomes Prevention Evaluation study reported that abdominal adiposity worsens the prognosis of patients with CVD.[47]

We analyzed HbA1c and found 24% prediabetic and 50.4% diabetic subjects in our study. We found 63.9% of 24% prediabetes subjects and 77.0% of 50.4% diabetes subjects are at high risk of diabetes and diabetes complications as per MDRF-IDRS (score ≥60). Our findings are close to the reports of Mohan *et al.*, in which they had also found that subjects with diabetes had higher risk of developing diabetic complications.[48]

In our study, we found that MDRF-IDRS is the simple and cost-effective tool to serve for a primary care physician or a health worker to screen diabetes and AO. This tool is also useful to monitor diabetes and obesity and early detection of diabetes complications, especially CAD and peripheral vascular disease.

Along with AO, measuring BMI is also essential to identify the GO, because BMI is the most widely used anthropometric parameter which includes weight and height. It was observed that with increasing duration of disease, diabetic patient loss weight and has low BMI; however, severe obese patients have gradually high BMI. Both conditions are alarming stage for obese and diabetes patients and need regular monitoring. Zhao *et al.* demonstrated in a prospective cohort study that BMI has U-shaped association with all-cause mortality risk among Afro-American and white patients with T2DM and they reported that both Afro-American and white have significantly increased risk of all-cause mortality in low BMI and in high BMI as compared to moderate BMI.[49]

Assessment of HbA1c with diabetes risk is also essential tool to identify the diabetes patients because HbA1c reduction in type 2 diabetes is associated with increased insulin sensitivity.[50] Assessment of HbA1c with diabetes risk score also helps to identify developing diabetes complications. Because HbA1c has a strong association with prevalent CVD risk factors in Asian-Indian subjects with normal glucose tolerance (NGT).[51] A study reported that the prevalence of CAD is nearly 1.5 times higher among subjects with IGT compared with NGT.[52] HbA1c is also useful to reduce the risk of CVD and MI. For each 1% increase in the level of HbA1c, the relative risk of CVD increases by 1.18%, whereas each 1% decrease in HbA1c levels is associated with a 37% reduction in microvascular complications and a 14% reduction in MI.[53,54]

Both general and central obesity have been associated with a number of metabolic abnormalities including prediabetes, type 2 diabetes (T2DM), HTN, metabolic syndrome, and CVDs.[55,56] The obesity and HTN have become the causes for developing diabetes.[57] Similarly, in a study by Mandal, reported that the prevalence of T2DM and HTN increases with increasing weight (overweight/obese) of individuals.[58] Another study also reported that patients with type 2 diabetes (T2DM) demonstrated highest co-prevalence for the combination of overweight/obesity and HTN (66.0%), overweight/obesity and CKD (19.1%), and overweight/obesity and CVD (17.0%).[59]

Conclusion

Our study fully supports the validity of IDRS as it can be used as a cost-effective tool for mass screening of diabetes. Moreover, its combination with BMI value and HbA1c can be used for strict monitoring for diabetes and obesity so that timely intervention can be done to reduce the early development of diabetes complications and severe obesity comorbidities.

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Conflicts of interest

There are no conflicts of interest.

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