Original Article#

A Simplified Indian Diabetes Risk Score for Screening for Undiagnosed Diabetic Subjects

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Abstract

Aim : The aim of this study was to develop and validate a simplified Indian Diabetes Risk Score for detecting undiagnosed diabetes in India.

Methods : The risk score was derived from the Chennai Urban Rural Epidemiology Study (CURES), an ongoing epidemiological study on a representative population of Chennai. Phase 1 of CURES recruited 26,001 individuals, of whom every tenth subject was requested to participate in Phase 3 for screening for diabetes using World Health Organization (WHO) 2hour venous plasma glucose criteria [i.e. ≥200 mg / dl]. The response rate was 90.4% (2350 / 2600). The Indian Diabetes Risk Score [IDRS] was developed based on results of multiple logistic regression analysis. Internal validation was performed on the same data.

Results : IDRS used four risk factors: age, abdominal obesity, family history of diabetes and physical activity. Beta co-efficients were derived based on a multiple logistic regression analysis using undiagnosed diabetes as the dependent variable. The beta co-efficients were modified so as to obtain a maximum possible score of 100. Receiver Operating Characteristic [ROC] curves were constructed to identify the optimum value of IDRS for detecting diabetes by WHO consulting group criteria. Area under the curve for ROC was 0.698 (95% confidence interval (CI):0.663 –0.733). An IDRS value ≥ 60 had the optimum sensitivity (72.5%) and specificity (60.1%) for determining undiagnosed diabetes with a positive predictive value of 17.0%, negative predictive value of 95.1%, and accuracy of 61.3%.

Conclusion : This simplified Indian Diabetes Risk Score is useful for identifying undiagnosed diabetic subjects in India and could make screening programmes more cost effective. ©

The recent World Health Organization report suggests that over 19% of the world's diabetic population currently resides in India.[1] This translates to over 35 million diabetic subjects, and these numbers are projected to increase to nearly 80 million by 2030. This rising trend[2,3] predicts a significant health burden due to diabetes in India. Unfortunately more than 50% of the diabetic subjects in India remain unaware of their diabetes status, which adds to the disease burden.[4] This underscores the need for mass awareness and screening programmes to identify and overcome the burden due to diabetes in India. The Government of India has already initiated a National Diabetes Control Programme and is planning to start a diabetes prevention programme shortly. For such programmes to be successful, it is necessary to determine cost effective methods for identifying undiagnosed diabetic subjects in our country.

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In this paper we report on a simplified Indian Diabetes Risk Score [IDRS] for identifying undiagnosed diabetic subjects using four simple parameters, which requires minimum time and effort but can help to considerably reduce the costs of screening.

Methods

The data for the present study was obtained from the Chennai Urban Rural Epidemiology Study [CURES], the methodology of which is detailed elsewhere.[5-8] Phase 1 of CURES recruited 26,001 individuals; Phase 2 focused on the self reported diabetic subjects identified in Phase 1, while Phase 3 recruited every tenth subject (n=2600) screened in Phase 1. Phase 3 had a response rate of 90.4% (i.e. 2350 / 2600 subjects participated). These individuals were invited to our centre for an oral glucose tolerance test (OGTT) (known diabetic subjects underwent fasting and post-prandial glucose tests). In all subjects, family history of diabetes was obtained and details on physical activity were assessed using a validated questionnaire.[5] Waist measurements in centimeters were obtained using standardized techniques.[5] Plasma glucose levels [glucose oxidase- peroxidase] were measured on Hitachi

- 912 Autoanalyser (Hitachi, Mannheim, Germany) using kits supplied by Roche Diagnostics (Mannheim, Germany). Diagnosis of diabetes was based on WHO Consulting Group criteria, i.e. 2 hour venous plasma glucose (2hr PG) ≥ 200 mg / dl.[9]

A Diabetes Risk Score was earlier developed by us based on multiple logistic regression model using four simple parameters namely age, abdominal obesity, family history of diabetes and leisure time physical activity.[10] The regression analysis yielded a risk score, which varied between 0-35. Since this analysis had limited categories under each risk factor, which did not take into account the severity of the risk factor (for example an abdominal obese male with waist circumference >90 and >100 cm were treated alike) we felt the need of modifying the risk score by adding certain categories. In addition, to enable large-scale use of these risk scores, we decided to simplify the Diabetes Risk Score by rounding off the risk score to the nearest 5 and then doubling the same in order to bring the maximum possible score to 100.

The modified risk factors used for this study are:

1. Age : This was categorized into 3 groups; age <35 years was coded as 0, 35- 49 years as 1 and ≥ 50 years as 2.
2. Abdominal obesity : Males: Individuals with waist circumference ≥ 90 – 99 cm for males as 1, those with ≥ 100 cm as 2 and the rest as 0. Females: individuals with waist circumference ≥ 80 -89 cm as 1, those with ≥ 90 cm as 2 and the rest as 0.[11]
3. Family history of diabetes: Individuals with no family history of diabetes were coded as 0, those with one diabetic parent as 1 and those with both parents diabetic as 2.
4. Physical activity: Individuals were coded as 0 if they did leisure time exercise and in addition had physically demanding work in their occupation; individuals who either did exercise or performed physically demanding work were graded as 1 and the rest as 2.

The information for these risk factors can be obtained based on four simple questions and one anthropometric measurement namely waist circumference. The four questions are:

1. What is your age?
2. Do you have a family history of diabetes? If yes, does your father or mother or both have diabetes?
3. Do you exercise regularly?
4. How physically demanding is your work [occupation]?

Statistical analysis

Statistical analysis was performed using SPSS PC Windows version 10.0 (Chicago, IL).

Multiple logistic regression analysis was done using newly detected diabetes as the dependent variable and the various risk factors as independent variables to obtain the risk scores. Based on the beta co-efficients, we created a score for each parameter. This was then rounded off to the nearest 5 and then doubled in order to bring the maximum possible score to 100. The simplified Indian Diabetes Risk Score (IDRS) was then determined by adding the scores for each risk factor.

Validation

ROC curves were constructed to identify the optimum value (>60%) of IDRS for determining diabetes as diagnosed using WHO consulting group criteria. Sensitivity, specificity, positive and negative predictive values and accuracy for predicting undiagnosed diabetes were calculated for different cut off scores.

RESULTS

Overall, 365 of the 2350 study subjects had diabetes (overall prevalence: 15.5%, males:18.0%, females:13.4%) according to WHO criteria. For developing the diabetes risk score, 143 subjects with known diabetes in Phase 3 were excluded.

Beta co-efficients were derived based on multiple regression analysis. The beta co-efficient for Age was: 35-49 years:0.84 and ≥ 50 years: 1.47. For abdominal obesity: waist ≥ 80 – 89 cm [female] or ≥ 90 – 99 cm [male], 0.44, waist ≥ 90 cm [female] or ≥ 100 cm [male], 0.81. For Physical activity: exercise [regular] or strenuous work at occupation, 1.13 and sedentary, 1.45. For Family History of diabetes: either parent, 0.54 and for both parents, 0.83. These scores were modified as explained in the methodology to obtain a simplified IDRS, which is presented in Table 1. Though physical activity did not show a significant association with diabetes in the

Table 1 : Indian Diabetes Risk Score [IDRS] developed based on multiple logistic regression analysis derived from CURES

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

multiple logistic model, it was still retained in the score as it showed a strong association on univariate regression analysis. Moreover age could be an effect modifier and this might have abolished the significant association of physical activity with diabetes.

ROC's were obtained for IDRS and tested for newly diagnosed diabetes diagnosed using WHO criteria in Phase 3 subjects. The AUC for the ROC was 0.698 (95% CI: 0.663-0.733) (Fig. 1).

Table 2 provides the sensitivity and specificity of different cut-offs for IDRS in CURES for diagnosis of diabetes using WHO criteria. An IDRS value ≥ 60 had the optimum sensitivity (72.5%) and specificity (60.1%) for determining diabetes. The positive predictive value was 17.0%, negative predictive value, 95.1% and the accuracy, 61.3%.

Table 3 presents some examples for deriving the IDRS for individuals with various risk factor patterns to show the usefulness of the screening system.

Discussion

In this study we report on a simplified Indian Diabetes Risk Score for identifying newly diagnosed diabetic subjects in our country. This is of great

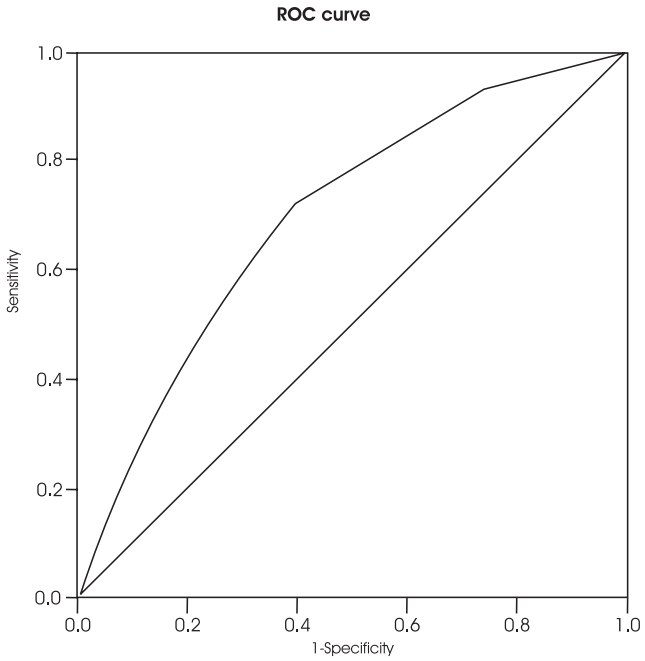

Fig. 1 : ROC curve showing performance of Indian Diabetes Risk Score (IDRS). Chennai Urban Rural Epidemiology Study (CURES) - Phase 3 - Diagnosis of diabetes using WHO 2 hr glucose criteria (n=2,207) AUC: 0.698 (95% Confidence interval: 0.663 –0.733)

Table 2 : Sensitivity and specificity of IDRS

IDRS	Proportion of total study subjects in CURES (%)	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
≥ 10	99.4	100	0.7	10.2	100	10.7
≥ 20	99.0	99.5	1.1	10.2	97.5	11.1
≥ 30	93.3	97.7	7.2	10.6	97.2	16.7
≥ 40	75.9	93.1	25.5	12.4	97.0	32.4
≥ 50	62.8	84.9	39.4	13.6	95.8	43.0
≥ 60	42.9	72.5	60.1	17.0	95.1	61.3
≥ 70	20.9	42.7	81.1	20.3	92.6	77.2
≥ 80	6.0	15.1	95.0	25.4	90.8	86.9
≥ 90	0.9	2.3	99.3	26.3	90.0	89.5
≥ 100	0.1	0.5	99.9	50.0	89.9	89.7

Table 3 : Some examples for deriving risk scores [IDRS]

Example	Gender	Age	Waist circumference [cm]	Occupation + Exercise	Family history of diabetes	Score
1	Male	60	101	Retired + Regular Exercise	Both parents	
Score	—	30	20	20	20	90
2	Female	53	88	House wife + Regular exercise	One parent	
Score	—	30	10	20	10	70
3	Male	45	92	Professional + Regular exercise	One parent	
Score	—	20	10	20	10	60
4	Female	47	79	Servant Maid + No exercise	One parent	
Score	—	20	0	20	10	50
5	Male	32	96	General Manager + No exercise	None	
Score	—	0	10	30	0	40
6	Female	29	77	Software Engineer + Regular exercise	None	
Score	—	0	0	20	0	20
7	Male	25	80	Supplier of gas cylinder by tricycle [8 hours]+ Regular exercise	None	
Score	—	0	0	0	0	0

significance as use of such scoring system could prove to be a cost effective tool for screening of diabetes. Further, use of such a risk score would be of great help in developing countries like India where there is a marked explosion of diabetes and over half of the cases remain undiagnosed diabetes.

Various studies in the West have derived different diabetes risk scores, based on simple anthropometric, demographic and behavioral factors, to detect undiagnosed diabetes.[12-15] We have also recently proposed a diabetes risk score suitable for detecting undiagnosed diabetes in South Asia.[10] The main aim of the present study was to derive a simplified score to be used at the national level in India for screening of diabetes. As there are ethnic differences in the risk factors for diabetes, it becomes necessary to determine ethnic specific scores. The risk factors used in this study are those recommended by the American Diabetes Association.[16] The studies in the west have used some biochemical parameters or have included questions on fruit or vegetable consumption or antihypertensive therapy[12-15] for deriving risk scores. As there are difficulties in standardization of food portions across different cultural and socioeconomic groups, we decided not to use questions on diet. We also avoided using antihypertensive medication, as less than 50% of the known hypertensives in India take any medication.[17]

Compared to other studies on risk scoring for diabetes, this study has the following merits: it uses four simple easily obtainable factors and is done on a very high-risk population. In addition, the study is conducted on a representative sample of a large metropolitan city in India, the demographic of which is similar to the rest of the India.[18] Hence the results can be extrapolated to the whole of India. However, the main limitation is that the findings are based on a cross-sectional study and needs further validation in prospective studies.

IDRS can help in cost effective screening for diabetes as it uses simple, safe and inexpensive measures. Moreover it would help to do selective screening instead of universal screening. For example, if we were to screen a population of 1,00,000 adults in a city using a 2 hour post load plasma glucose, assuming the cost of one glucose estimation including blood collection to be Rs.30/-, the cost would work out to Rs.30,00,000. For the same population, if a two step procedure is used for screening for diabetes, i.e. use IDRS first and then screen only those likely to have diabetes, only 43% of the population who have a score ≥ 60, will have to be screened. This would capture over 72% of the undiagnosed diabetic subjects. If the screening test is carried out on all these individuals then the cost would work out to Rs.12,90,000. Even if we add a cost of Rs.1,50,000 for collecting information on IDRS, the overall cost would only work out to Rs.14,40,000. Thus there would be a cost saving of almost 50%, which in this case is Rs.15,60,000/-. Assuming that the prevalence of undiagnosed diabetes in the population studied is the same as that observed in CURES i.e. 10.1%[3], then 10,100 individuals will be found to have diabetes using the one step screening method at the cost of Rs.30,00,000, while the two-step procedure will pickup 7,272 individuals with diabetes at 50% of the cost.

In conclusion this study provides a simplified Indian Diabetes Risk Score for identifying undiagnosed diabetic subjects in India. This is the first study to our knowledge to have evolved a simplified diabetes risk score, which has categorized the risk factors based on their severity. Use of the IDRS can make mass screening for undiagnosed diabetes in India more cost effective.

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