

Observational Study

Evaluation of the Finnish Diabetes Risk Score to predict type 2 diabetes mellitus in a Colombian population: A longitudinal observational study

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Abstract

AIM: To assess the performance of the Finnish Diabetes Risk Score (FINDRISC) questionnaire for detecting and predicting type 2 diabetes mellitus (DM2) in a Colombian population.

METHODS: This is a longitudinal observational study conducted in Floridablanca, Colombia. Adult subjects (age ≥ 35 years) without known diabetes, were included. A modified version of FINDRISC was completed, and the glycemia values from all the subjects were collected from the hospital's database. Firstly, a cross-sectional analysis was performed and then, the subsample of prediabetic participants was followed for diabetes incidence.

RESULTS: A total of 772 subjects were suitable for the study. The overall prevalence of undiagnosed DM2 was 2.59%, and the incidence of DM2 among the prediabetic participants was 7.5 per 100 person-years after a total of 265257 person-years follow-up. The FINDRISC at baseline was significantly associated with undiagnosed and incident DM2. The area under receiver operating characteristics curve of the FINDRISC score for detecting undiagnosed DM2 in both men and women was 0.7477 and 0.7175, respectively; and for predicting the incidence of DM2 among prediabetics was 71.99% in men and 67.74% in women.

CONCLUSION: The FINDRISC questionnaire is a useful screening tool to identify cross-sectionally unknown DM2 and to predict the incidence of DM2 among prediabetics in the Colombian population.

Key words: Finnish diabetes risk score; Type 2 diabetes mellitus; Prediabetes; Screening; Colombia

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Core tip: The prevalence of type 2 diabetes mellitus (DM2) is rapidly increasing worldwide, and unfortunately its diagnosis is being made when vascular complications are already exhibited. Since laboratory-based diagnostic methods are costly, the International Diabetes Federation suggests to do an early detection of undiagnosed DM2 patients, and to identify individuals at risk for developing DM2 by simple risk-scoring questionnaires. The present study assesses the performance of the Finnish Diabetes Risk Score questionnaire in a Colombian population, and aims to establish the specific cutoff values for detecting subjects at increased risk of undiagnosed DM2 and for predicting the incidence of DM2 in prediabetic individuals.

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INTRODUCTION

The prevalence of type 2 diabetes mellitus (DM2) is

rapidly increasing worldwide^[1]. Recently, it has been estimated that the number of adults with DM2 will increase between 2010 and 2030 by 69% and 20% in developing and industrialized countries, respectively^[1]. In Colombia the overall prevalence of DM2 is 5.51%, however significant differences are observed and in some regions the prevalence rises to 8.2%^[2]. The increase in the prevalence of DM2 across the world has become an important public health concern given that it is a major risk factor for death and numerous nonfatal complications. Hence, this situation will form a large burden to the patients, their families, and the health care system^[3].

Several studies have demonstrated that DM2 could be prevented, and its complications can be limited when a timely and appropriate intervention is started^[4,5]. However, in the majority of cases detection is delayed and at the time of diagnosis many patients already exhibit signs of microvascular and macrovascular complications^[6]. Remarkably, there has been proposed that Latin American population has an increased vulnerability for developing macrovascular diseases at glycemia levels lower than the internationally established cut points for DM2^[7,8]. Thus, it is clinically important to do an early detection of undiagnosed DM2 patients, and to identify individuals at risk for developing DM2 to implement intensive preventive interventions.

The diagnosis of DM2 is obtained by increased values of fasting plasma glucose (FPG), oral glucose tolerance test (OGTT) and/or glycated hemoglobin (HbA1C)^[9], but the determination of biochemical variables is costly, and this impairs its use as a large scale screening tool. Conversely, simple risk-scoring questionnaires are useful and constitute a more cost-effective DM2 screening approach^[10]. Hence, the international diabetes federation has recommended performing a blood test to detect possible diabetes when a high risk score has been obtained^[11].

A number of predictive risk-scoring models for DM2 are currently available for clinical use^[12-14]. But, most require specific blood test results and this limits its widespread use from a public health perspective. Meanwhile, the Finnish Diabetes Risk Score (FINDRISC)^[15] has demonstrated to be a simple, fast, inexpensive, noninvasive, and reliable tool to identify individuals at high risk for DM2. Therefore, the FINDRISC has been internationally assessed in several countries, including Colombia^[16-20]. However, in our country the ability of FINDRISC to predict the development of incident DM2 was not evaluated, and the specific risk scores for predicting undiagnosed and incident DM2 in our population were not established. Hence, this study aims to assess the performance of the FINDRISC score in detecting undiagnosed DM2 in the general population and to predict incident DM2 among prediabetics. Moreover, the study aims to establish the specific cutoff values for identifying increased risk of undiagnosed DM2 in the general population and incident DM2 among prediabetics in Colombia.

MATERIALS AND METHODS

A longitudinal observational study has been conducted. Between June 1, 2012 and October 31, 2012 adult subjects (age ≥ 35 years) who attended the general practitioner for any reason at the ambulatory service of the Ophthalmological Foundation of Santander - FOSCAL in Floridablanca, Colombia, were involved in the screening. People with known diabetes mellitus (type 1 or 2) were not recruited. Any acute illness, pregnancy in women, and currently use of metformin or other glucose-modifying prescription drugs, were also considered as exclusion criteria.

The subjects were asked to complete a modified version of the FINDRISC score^[15], which evaluates eight variables that are clearly correlated with the risk of DM2: Age, body mass index (BMI), waist circumference (WC), current antihypertensive medication, frequency of fruit and vegetable consumption, physical activity, personal history of high blood glucose, and family history of DM2. Variables are scored according to the risk that they may confer, resulting in a range of 0-26 total points. We adjusted the WC cutoffs points according to the previously described values that confer an increased cardio-metabolic risk in the Colombian population^[21]. As a result, the WC was scored as follows: Men: < 90 cm, the score is 0; 90-98 cm, the score is 3; > 98 cm, the score is 4. Women: < 80 cm, the score is 0; 80-88 cm, the score is 3; > 88 cm, the score is 4.

General practitioners performed the anthropometric measurements. Weight and height were measured with light clothing and no shoes with calibrated scales and a wall-mounted stadiometers, respectively, while participants were asked to stand erect with their head positioned in the Frankfort horizontal plane. WC was measured midway between the lowest rib and the iliac crest using an anthropometric tape. BMI was calculated by dividing body weight by the square of height [BMI = weight (kg)/height (m)²].

Laboratory tests (FPG, OGTT and HbA1C) were collected directly from the hospital's database. Only those tests taken within the two months previous or after the survey were valid for the study. At least one of the tests: FPG, OGTT or HbA1c, should be present to consider the patient as suitable for the study. Classification of glucometabolic state was based on the American Diabetes Association (ADA) criteria^[9]. The diagnosis of DM2 was established when FPG ≥ 126 mg/dL, OGTT ≥ 200 mg/dL and/or HbA1c $\geq 6.5\%$. Prediabetes was diagnosed by the presence of impaired FPG (≥ 100 mg/dL to < 126 mg/dL), impaired OGTT (≥ 140 mg/dL to < 200 mg/dL) and/or impaired HbA1c ($\geq 5.7\%$ to $\leq 6.4\%$).

Thereafter, the subsample of baseline prediabetic participants was followed for diabetes incidence in real life settings. The updated glucometabolic tests (FPG, OGTT and HbA1C) were also collected from the hospital's database, and DM2 incident cases were diagnosed according to the ADA criteria^[9].

Ethics statement

The study protocol was in accordance with the Declaration of Helsinki, and the health research ethics board of the Ophthalmological Foundation of Santander - FOSCAL approved all study procedures. The subjects expressed their interest in participating in the study before they were included. As there were no interventions directly related to the study written informed consent was not required.

Statistical analysis

Descriptive statistics were computed for variables of interests, and included mean values and standard deviations of continuous variables and absolute and relative frequencies of categorical factors. Normality of distribution was checked for continuous variables using the Shapiro-Wilk test and by graphical methods. Wilcoxon Rank Sum test was used to investigate the differences in continuous variables. Testing for differences in categorical variables was accomplished using the Pearson's χ^2 test.

Moreover, we used unconditional multivariate logistic regression models to assess the associations between the FINDRISC score and undiagnosed and incident DM2. These analyses were adjusted for potential confounders, such as gender and age. We re-coded the FINDRISC into tertiles and compared the risk of DM2 in each tertile with the lowest category of risk (reference group).

To assess performance of the FINDRISC score with respect to undiagnosed and incident DM2, receiver operating characteristics (ROC) curves, sensitivity, specificity, positive predictive values and negative predictive values (NPV) were calculated. The maximum values of the Youden's index^[22] were used as a criterion for selecting the optimum cut-off points. All statistical analysis was carried out by a biomedical statistician using Stata statistical software, release 12.0 (Stata Corporation, College Station, TX, United States). A $P < 0.05$ was considered statistically significant.

RESULTS

A total of 772 subjects were suitable for the study, of which 544 (70.47%) were women. The overall mean age was 58.34 ± 12.07 years, the overall prevalence of undiagnosed DM2 was 2.59% (95%CI: 1.46-3.71), and the prevalence of prediabetes was 24.09% (95%CI: 21.06-27.11) (Table 1). Baseline demographic, anthropometric and metabolic characteristics of the study population are presented in Table 1, and the prevalences of FINDRISC questionnaire components are presented in Table 2.

The FINDRISC score was positively associated with undiagnosed DM2 (Table 3). The risk of DM2 increased with increasing tertiles of FINDRISC. Compared with participants in the lowest tertile, the risk of DM2 was 5.69 times higher for those in the highest tertile (OR = 5.69, 95%CI: 1.56-20.67).

Table 1 Baseline characteristics of the study population according to gender

| Variables | Total (n = 772) | Men (n = 228) | Women (n = 544) |
|---|-----------------|----------------|----------------------------|
| ¹ Age, yr | 58.34 (12.07) | 58.63 (12.67) | 58.22 (11.82) |
| ¹ BMI, kg/m ² | 27.36 (4.56) | 27.08 (4.56) | 27.47 (4.56) |
| ¹ Waist circumference, cm | 91.91 (10.47) | 97.05 (10.88) | 89.78 (9.52) ² |
| ¹ Fasting plasma glucose, mg/dL | 94.41 (12.60) | 96.17 (13.94) | 93.68 (11.94) ² |
| ^{1,4} Oral glucose tolerance test, mg/dL | 107.89 (32.82) | 111.11 (36.55) | 106.23 (30.75) |
| ^{1,4} HbA1c, % | 6.49 (1.27) | 6.39 (1.24) | 6.56 (1.31) |
| Undiagnosed DM2, n(%) | 20 (2.59) | 6 (2.63) | 14 (2.57) |
| Prediabetes, n(%) | 186 (24.09) | 61 (26.75) | 125 (22.98) |
| FINDRISC score | 11.84 (4.80) | 11.00 (4.71) | 12.18 (4.80) ³ |

¹Data are presented as mean ± SD for continuous variables; ²Wilconcox Rank Sum test *P* < 0.05; ³Wilconcox Rank Sum test *P* < 0.005; ⁴Variable with missing values. BMI: Body mass index; DM2: Type 2 diabetes mellitus; FINDRISC: Finnish Diabetes Risk Score; HbA1c: Hemoglobin A1c.

Table 2 Prevalence of components of the Finnish Diabetes Risk Score according to gender n (%)

| Variables | Total (n = 772) | Men (n = 228) | Women (n = 544) |
|--------------------------|-----------------|---------------|--------------------------|
| Age (yr) | | | |
| < 45 | 106 (13.73) | 35 (15.35) | 71 (13.05) |
| 45-54 | 207 (26.81) | 59 (25.88) | 148 (27.21) |
| 55-64 | 203 (26.30) | 51 (22.37) | 152 (27.94) |
| > 64 | 256 (33.16) | 83 (36.40) | 173 (31.80) |
| BMI (kg/m ²) | | | |
| < 25 | 250 (32.38) | 75 (32.89) | 175 (32.17) |
| 25-30 | 331 (42.88) | 105 (46.05) | 226 (41.54) |
| > 30 | 191 (24.74) | 48 (21.05) | 143 (26.29) |
| WC (cm) | | | |
| M: < 90; W: < 80 | 121 (15.67) | 50 (21.93) | 71 (13.05) ² |
| M: 90-98; W: 80-88 | 272 (35.23) | 84 (36.84) | 188 (34.56) |
| M: > 98; W: > 88 | 379 (49.09) | 94 (41.23) | 285 (52.39) |
| PA (30 min/d) | | | |
| Yes | 362 (46.95) | 112 (49.12) | 250 (46.04) |
| No | 409 (53.05) | 116 (50.88) | 293 (53.96) |
| Vegetables - fruits | | | |
| Daily | 433 (56.09) | 112 (49.12) | 321 (59.01) ¹ |
| No daily | 339 (43.91) | 116 (50.88) | 223 (40.99) |
| Hypertension | | | |
| Without medication | 442 (57.25) | 136 (59.65) | 306 (56.25) |
| With medication | 330 (42.75) | 92 (40.35) | 238 (43.75) |
| Hyperglycemia antecedent | | | |
| No | 634 (82.12) | 199 (87.28) | 435 (79.96) ¹ |
| Yes | 138 (17.88) | 29 (12.72) | 109 (20.04) |
| Familiar antecedents DM2 | | | |
| No | 473 (61.27) | 147 (64.47) | 326 (59.93) |
| Grandparents | 72 (9.33) | 26 (11.40) | 46 (8.46) |
| Parents | 227 (29.40) | 55 (24.12) | 172 (31.62) |

¹Pearson's χ^2 test (χ^2) *P* < 0.05; ²Pearson's χ^2 test (χ^2) *P* < 0.005. DM2: Type 2 diabetes mellitus; BMI: Body mass index; WC: Waist circumference; PA: Physical activity; M: Male; F: Female.

Table 3 Odds ratios of undiagnosed type 2 diabetes mellitus according to Finnish Diabetes Risk Score tertiles at baseline

| | Undiagnosed DM2 (FPG ≥ 126 mg/dL and/or OGTT ≥ 200 mg/dL and/or HbA1c ≥ 6.5%) | | | | | | | | |
|--------------------------|---|-------|----------------|-------------------------|------------|----------------|-------------------------|------------|----------------|
| | 1 st tertile | | | 2 nd tertile | | | 3 rd tertile | | |
| | OR | 95%CI | <i>P</i> value | OR | 95%CI | <i>P</i> value | OR | 95%CI | <i>P</i> value |
| Unadjusted | 1.0 | - | - | 2.45 | 0.60-9.92 | 0.207 | 5.69 | 1.56-20.67 | 0.008 |
| Gender-adjusted | 1.0 | - | - | 2.49 | 0.61-10.10 | 0.199 | 5.88 | 1.60-21.54 | 0.007 |
| Age- and gender-adjusted | 1.0 | - | - | 2.28 | 0.55-9.35 | 0.252 | 4.93 | 1.28-18.92 | 0.020 |

1st tertile: ≤ 10; 2nd tertile: 11-14; 3rd tertile: ≥ 15. OR: Odds ratio; DM2: Type 2 diabetes mellitus; FPG: Fasting plasma glucose; HbA1c: Hemoglobin A1c; OGTT: Oral glucose tolerance test.

Table 4 Hazard ratios of incident type 2 diabetes mellitus according to Finnish Diabetes Risk Score tertiles at baseline, during follow-up and among the subsample of prediabetic patients

| | Incident DM2 (FPG \geq 126 mg/dL and/or OGTT \geq 200 mg/dL and/or HbA1c \geq 6.5%) | | | | | | | | |
|--------------------------|---|-------|---------|-------------------------|------------|---------|-------------------------|------------|---------|
| | 1 st tertile | | | 2 nd tertile | | | 3 rd tertile | | |
| | HR | 95%CI | P value | HR | 95%CI | P value | HR | 95%CI | P value |
| Unadjusted | 1.00 | - | - | 3.67 | 0.77-17.36 | 0.101 | 5.31 | 1.15-24.43 | 0.032 |
| Gender-adjusted | 1.00 | - | - | 3.93 | 0.81-18.89 | 0.087 | 5.75 | 1.22-27.03 | 0.027 |
| Age- and gender-adjusted | 1.00 | - | - | 3.52 | 0.70-17.53 | 0.124 | 4.81 | 0.93-24.85 | 0.061 |

1st tertile: \leq 12; 2nd tertile: 13-16; 3rd tertile: \geq 17. HR: Hazard ratio; DM2: Type 2 diabetes mellitus; FPG: Fasting plasma glucose; HbA1c: Hemoglobin A1c; OGTT: Oral glucose tolerance test.

Table 5 Finnish Diabetes Risk Score to identify undiagnosed type 2 diabetes mellitus by gender

| FINDRISC score | Undiagnosed DM2 (FPG \geq 126 mg/dL and/or OGTT \geq 200 mg/dL and/or HbA1c \geq 6.5%) | | | | |
|------------------------|--|-----------------|---------|---------|----------------|
| | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | Youden's index |
| Cutoff value \geq 11 | | | | | |
| Men | 83.3 | 49.1 | 4.2 | 99.1 | 0.324 |
| Women | 85.7 | 37.2 | 3.5 | 99.0 | 0.228 |
| Cutoff value \geq 12 | | | | | |
| Men | 66.7 | 56.8 | 4.0 | 98.4 | 0.234 |
| Women | 85.7 | 44.9 | 3.9 | 99.2 | 0.306 |
| Cutoff value \geq 13 | | | | | |
| Men | 66.7 | 66.2 | 5.1 | 98.7 | 0.328 |
| Women | 78.6 | 54.3 | 4.4 | 99.0 | 0.329 |
| Cutoff value \geq 14 | | | | | |
| Men | 66.7 | 75.2 | 6.8 | 98.8 | 0.419 |
| Women | 71.4 | 62.6 | 4.8 | 98.8 | 0.340 |
| Cutoff value \geq 15 | | | | | |
| Men | 50.0 | 81.1 | 6.7 | 98.4 | 0.310 |
| Women | 57.1 | 70.7 | 4.9 | 98.4 | 0.278 |
| Cutoff value \geq 16 | | | | | |
| Men | 33.3 | 86.0 | 6.1 | 98.0 | 0.193 |
| Women | 50.0 | 76.2 | 5.3 | 98.3 | 0.262 |
| Cutoff value \geq 17 | | | | | |
| Men | 33.3 | 88.3 | 7.1 | 98.0 | 0.216 |
| Women | 50.0 | 81.9 | 6.8 | 98.4 | 0.318 |

DM2: Type 2 diabetes mellitus; FPG: Fasting plasma glucose; OGTT: Oral glucose tolerance test; HbA1c: Hemoglobin A1c; PPV: Positive predictive value; NPV: Negative predictive value; FINDRISC: Finnish Diabetes Risk Score.

A total of 20 incident cases of DM2 (10.75%, 7 men and 13 women) among baseline prediabetic individuals occurred during 265.257 (82.234 men and 182.923 women) person-years of follow-up. The overall incidence of subsequent DM2 development was 7.5 (95%CI: 4.9-11.7) per 100 person-years. The incidence rates were slightly higher in men (8.5, 95%CI: 4.0-17.8, per 100 person-years) than in women (7.1, 95%CI: 4.1-12.2, per 100 person-years), but the difference was not statistically significant. Likewise, compared with participants in the lowest tertile of FINDRISC score at baseline, the risk of incident DM2 was 5.31 times higher for those in the highest tertile (HR = 5.31, 95%CI: 1.15-24.43) (Table 4).

The area under ROC curve (AUROC) of the FINDRISC score for detecting undiagnosed DM2 in both men and women was 0.7477 (95%CI: 0.5722-0.9232) and 0.7175 (95%CI: 0.5868-0.8481), respectively (Figure 1). The performance assessment of the FINDRISC score for identifying individuals at risk of undiagnosed DM2 is shown in Table 5. At the cutoff value of 14 in both

men (sensitivity = 66.7%; NPV = 98.8%) and women (sensitivity = 71.4%; NPV = 98.8%), the Youden's index was the highest for undiagnosed DM2 (0.419 in men and 0.340 in women).

The ROC curve for the incidence of DM2 among the prediabetic subsample by FINDRISC is shown in Figure 2. The AUROC curve were 0.7199 (95%CI: 0.5355-0.9043) in men and 0.6774 (95%CI: 0.5401-0.8146) in women. Given a Youden's index of 0.383 in men and 0.305 in women, FINDRISC cutoff values for incident DM2 were calculated to be 13 (sensitivity = 85.7%; NPV = 95.2%) in men and 16 (sensitivity = 69.2%; NPV = 93.4%) in women (Table 6).

DISCUSSION

Key findings

The current study assessed the performance of the FINDRISC questionnaire, and demonstrates that this can work reasonably well as screening tool, detecting cross-sectionally undiagnosed DM2 in the general population,

Table 6 Finnish Diabetes Risk Score to predict incident type 2 diabetes mellitus by gender, during follow-up and among the subsample of prediabetic patients

| FINDRISC score | Incident DM2 (FPG \geq 126 mg/dL and/or OGTT \geq 200 mg/dL and/or HbA1c \geq 6.5%) | | | | |
|------------------------|---|-----------------|---------|---------|----------------|
| | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | Youden's index |
| Cutoff value \geq 12 | | | | | |
| Men | 85.7 | 44.7 | 22.2 | 94.4 | 0.304 |
| Women | 92.3 | 28.0 | 15.2 | 96.3 | 0.202 |
| Cutoff value \geq 13 | | | | | |
| Men | 85.7 | 52.6 | 25.0 | 95.2 | 0.383 |
| Women | 92.3 | 34.4 | 16.4 | 97.0 | 0.267 |
| Cutoff value \geq 14 | | | | | |
| Men | 71.4 | 60.5 | 25.0 | 92.0 | 0.319 |
| Women | 84.6 | 39.8 | 16.4 | 94.9 | 0.244 |
| Cutoff value \geq 15 | | | | | |
| Men | 57.1 | 65.8 | 23.5 | 89.3 | 0.229 |
| Women | 76.9 | 49.5 | 17.5 | 93.9 | 0.263 |
| Cutoff value \geq 16 | | | | | |
| Men | 42.9 | 68.4 | 20.0 | 86.7 | 0.112 |
| Women | 69.2 | 61.3 | 20.0 | 93.4 | 0.305 |
| Cutoff value \geq 17 | | | | | |
| Men | 42.9 | 73.7 | 23.0 | 87.5 | 0.165 |
| Women | 53.9 | 66.7 | 18.4 | 91.2 | 0.205 |
| Cutoff value \geq 18 | | | | | |
| Men | 42.9 | 79.0 | 27.3 | 88.2 | 0.218 |
| Women | 46.2 | 76.3 | 21.4 | 91.0 | 0.224 |

DM2: Type 2 diabetes mellitus; FPG: Fasting plasma glucose; OGTT: Oral glucose tolerance test; HbA1c: Hemoglobin A1c; PPV: Positive predictive value; NPV: Negative predictive value; FINDRISC: Finnish Diabetes Risk Score.

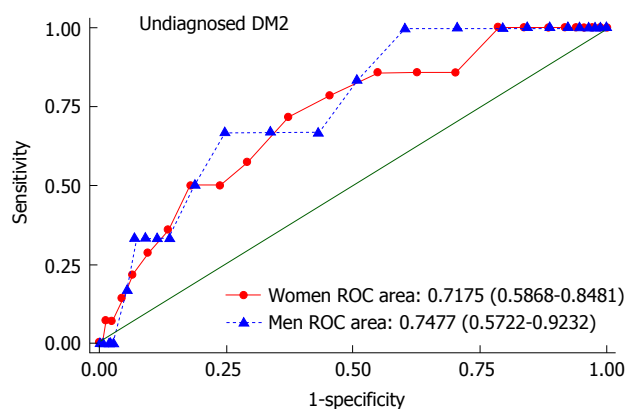


Figure 1 Receiver operating characteristics curves for the prevalence of undiagnosed type 2 diabetes mellitus by gender and Finnish Diabetes Risk Scores. DM2: Type 2 diabetes mellitus; ROC: Receiver operating characteristics.

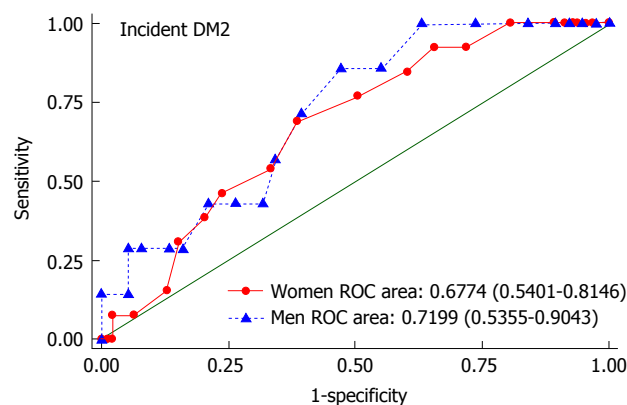


Figure 2 Receiver operating characteristics curves for the incidence of type 2 diabetes mellitus by gender and Finnish Diabetes Risk Scores, during follow-up and among the subsample of prediabetic patients. DM2: Type 2 diabetes mellitus; ROC: Receiver operating characteristics.

and longitudinally incident DM2 among individuals with prediabetes in Colombia. Our findings show a positive association between the FINDRISC score, undiagnosed DM2 in the general population and incident DM2 among prediabetic subjects. Moreover, in our population the FINDRISC score had an AUROC of 0.7477 in men and 0.7175 in women for identifying individuals at increased risk of undiagnosed DM2, and an AUROC of 0.7199 in men and 0.6774 in women for predicting incident DM2, which is comparable to that obtained in other similar studies^[18,19]. Using an optimal cutoff value of greater or equal to 14 both in men and women, this screening tool had good performance in identifying undiagnosed DM2. Meanwhile, FINDRISC cutoff values of 13 in men and 16 in women at baseline were defined as optimal to predict

DM2 in the subsample of prediabetic individuals.

DM2 is a strong, independent risk factor for cardiovascular disease and death^[3,23], and many epidemiologic analyses have identified a progressive relationship between prediabetes and these outcomes^[24,25]. Therefore, identifying individuals with undiagnosed DM2 and detecting individuals at risk for developing DM2 is essential to lead this target population the preventive actions, minimizing human and economic costs of diabetic complications^[9,11]. However, there are almost no symptoms of prediabetes or DM2 and as a consequence its detection is often delayed and at the time of diagnosis advanced complications are frequently present. It is estimated that approximately one-third of all people

with DM2 may be undiagnosed^[1,2]. Hence, using a simple and valid questionnaire, such as the FINDRISC score, as a preliminary screening method followed with more invasive and accurate diagnosis in primary care constitute a cost-effective and practical method with a potentially high national impact in terms of public health.

The efficiency of risk scores may vary between populations, and therefore, these should be validated in each population before use. The FINDRISC questionnaire was developed in Finland^[15], and has been validated in other populations studied so far^[16-20], demonstrating to be a simple and inexpensive tool that can identify those at high risk of having abnormalities in the glucose metabolism. Certainly, a previous study had already demonstrated the usefulness of FINDRISC to identify cross-sectionally people with glucose metabolism disorders in Colombia^[20], however in that study the cutoff level to identify patients at risk was chosen arbitrary. In that study, people with 13 or more FINDRISC points were screened with an OGTT, and they found this cutoff point to be useful to identify people with glucose metabolism disorders. Furthermore, this previous study did not assess the ability of FINDRISC in predicting incident DM2.

It is worth highlighting that there are several methodological differences between the several studies that have validated the FINDRISC questionnaire; modified or shortened versions have been used, in some studies the plasmatic glycemia tests have been only performed in subjects with a particular score, and in other cases prediabetes or metabolic syndrome has been also considered as an outcome. Therefore, the present study should be compared to these previously conducted studies with caution.

An important aspect of the present study is the assessment of the capacity of FINDRISC in the short-term prediction of incident DM2 among prediabetic individuals. To our knowledge, this is the first longitudinal validation of the FINDRISC questionnaire conducted in Latin America, while just other one study of similar characteristics was conducted in Europe. Soriquer *et al.*^[19] reported that in Spanish subjects with prediabetes the best prediction of risk of incident DM2 was found in those subjects with a FINDRISC score ≥ 9 . It should be noted that gender-specific cutoff values were not estimated in this previous study making thus comparisons difficult with our study.

Strengths and weaknesses of the study

There are some study limitations that warrant consideration. First, the participants were drawn from a unique healthcare center in Floridablanca and, thus, the results may not be applicable to the rest of Colombia. Second, the number of participants was relatively small, although the results were similar to those of other studies in different populations and larger cohorts^[16-20], which supports the validity of our present findings. Third, in most cases the diagnosis of DM2 was based on only one plasmatic value (FPG, OGTT or HbA1c

when performed), not two as recommended, and this may cause a serious bias in respect the definition of the main outcome event underestimating the true prevalence/incidence of DM2. However, diagnosis based on a single test result is accepted in epidemiological studies. In addition, it is noteworthy that this study was conducted in real life conditions, and the Colombian health system restricts the use of OGTT and HbA1c in patients with FPG < 100 mg/dL. Fourth, in our study most respondents were women, and this situation may partly be explained by behavioral habits, women are more likely to participate in completing questionnaires, they visit their physician more often, and usually pay more attention to their health.

This study has also considerable strengths. First, the diagnosis of DM2 was not self-reported. Second, all the analyzed subjects have available at least one plasmatic glycemia value. Third, the age distribution of the participants was wide and included the vast majority of the high-risk population.

In conclusion, the present study has assessed the performance of the FINDRISC questionnaire, demonstrating this as a useful screening tool to identify unknown DM2 in a cross-section of the Colombian population, and to predict incident DM2 among prediabetics. Moreover, we have demonstrated that a cutoff value greater or equal to 14 is the more appropriate detecting any previously undiagnosed DM2 in our population, both in men and women. Meanwhile, the optimal cutoff values for predict incident DM2 in prediabetic individuals were 13 in men and 16 in women.

COMMENTS

Background

The prevalence of type 2 diabetes mellitus (DM2) is increasing worldwide, but unfortunately its diagnosis is being made, in a high percentage, when vascular complications are already present. Therefore, the International Diabetes Federation recommends identification of persons at risk using simple risk-scoring questionnaires. Thus, this study aims to assess the performance of the Finnish Diabetes Risk Score (FINDRISC) questionnaire for detecting and predicting DM2 in a Colombian population.

Research frontiers

The FINDRISC questionnaire has been assessed and validated in several countries, including Colombia. However, in the authors' country the ability of FINDRISC to predict the development of incident DM2 has not been evaluated.

Innovations and breakthroughs

In the present study, the FINDRISC score demonstrated to be a useful screening tool to identify unknown DM2 in a cross-section of the Colombian population, and to predict incident DM2 among prediabetics.

Applications

Using a simple and valid questionnaire, such as the FINDRISC score, as a preliminary screening method for DM2 followed by more invasive and accurate diagnostic exams in primary care, constitute a cost-effective and practical method with a potentially high national impact in terms of public health.

Terminology

The FINDRISC is a simple, fast, inexpensive, noninvasive, and reliable tool to identify individuals at high risk for DM2.

Peer-review

This is a good observational study. Authors assessed the performance of the FINDRISC questionnaire in a Colombian population to detect undiagnosed DM2 in the general population and to predict incident DM2 among prediabetics. The study design is clear and the results are well to present. It demonstrated that the modified FINDRISC questionnaire is a good tool to detect undiagnosed DM2 and to predict incident DM2 in Colombian population.

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