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Prediction of a 10-year risk of type 2 diabetes mellitus in the Turkish population

A cross-sectional study

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Abstract

According to the International Diabetes Federation, Turkey will be among the top 10 countries in the world with the highest prevalence of diabetes mellitus (DM) by 2045, with a speculated number of cases of 10.4 million.

This study aimed to predict the 10-year risk of type 2 DM in a Turkish population, assess potential factors of the 10-year risk of DM, and assess the outcomes of Turkey's 2015 to 2020 program for DM.

Individuals aged 20–64 years were categorized and stratified according to age (in ranges of 5 years), sex, and populations of family medicine centers to reflect the whole population. The Finnish Diabetes Risk Score, sociodemographic characteristics, body fat, muscle, bone ratio, blood pressure, and waist-to-height ratio were evaluated.

We found that 9.5% (n = 71) of the population aged 20 to 64 years will have DM within the next 10 years. Low levels of education (odds ratio [OR]: 2.054; 95% confidence interval [CI]: 1.011–4.174), smoking cessation (OR: 2.636; 95% CI: 1.260–5.513), a waist-to-height ratio >0.5 (OR: 6.885; 95% CI: 2.301–20.602), body fat percentage (OR: 1.187; 95% CI: 1.130–1.247), high systolic blood pressure (OR: 1.025; 95% CI: 1.009–1.041), and alcohol consumption (beta-estimation: −0.690; OR: 0.501; 95% CI: 0.275–0.914) affect the 10-year risk of type 2 DM.

Individuals at risk for DM can be easily identified using risk assessment tools in primary care; however, there is no active screening program in the healthcare system, and only proposals exist. In addition to screening, preventive measures should focus on raising awareness of DM, reducing body fat percentage and systolic blood pressure, and decreasing the waist-to-height ratio to <0.5.

Abbreviations: BMI = body mass index, BP = blood pressure, DM = diabetes mellitus, FINDRISC = Finnish Diabetes Risk Score, GDM = gestational diabetes mellitus, OR = odds ratio, T2 DM = type 2 diabetes mellitus.

Keywords: diabetes mellitus, general practice, prevalence, preventive care, primary healthcare, type 2

1. Introduction

Diabetes mellitus (DM) and its associated complications have become a global public health problem. The International Diabetes Federation registered 463 million adults with DM and 5 million deaths from DM and its complications in 2019. It is predicted that the number of patients will increase to 700 million by 2045.[1,2] More than 90% of patients with DM have type 2 DM (T2 DM).

A previous study in the United States of America showed that the annual cost of DM had increased by 26%, reaching $327 billion in 2017, and medical expenditures for DM were 2.3 times higher per patient.[3] In a similar study in Italy, the direct medical cost was €2589 per patient with DM and €1682 for an individual without DM.[4]

The prevalence of DM in Turkey increased from 13.7% to 16.5% in 12 years (1998–2010); it was higher in urban areas than in rural areas.[5] According to the International Diabetes Federation, Turkey spends $3260 per patient annually for DM-related health problems, and the estimated number of affected individuals in Turkey by 2045 is 10.4 million, which will place Turkey in the top 10 countries in the world with the highest prevalence of DM. DM accounts for 23.8% of the total health expenditure in Turkey.[2]

Although responses to environmental factors depend on an individual's genetic architecture, the main drivers of the increase in the prevalence of T2 DM are obesity, sedentary lifestyle, diet, and aging society, which are more common in urban areas.[6,7] According to the Turkish Statistical Institute, the ratio of the urban population has increased from 75.5% to 92.8% in the last 10 years in Turkey.[8] Cities will be the main places to prevent DM in the upcoming years in Turkey. The lifestyle of the urban population is different from that of the rural population; therefore, examining the lifestyle in the urban area is important in terms of DM risk.

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We aimed to determine the 10-year T2 DM risk level using the Finnish Diabetes Risk Score (FINDRISC). In addition, we examined sociodemographic characteristics, anthropometric measurements, and lifestyle factors that can affect the risk level. Finally, we discussed actions for curbing the increasing prevalence of DM and the success of existing policies against DM in Turkey.

2. Methods

2.1. Study design

Our study was conducted in Edirne city center between June 2019 and February 2020 and included individuals aged 20 to 64 years. Using a 5% type 1 error and power of 80%, the sample size was calculated. Stratification was performed, and 744 participants were included in the study. Individuals were categorized and stratified according to age (intervals of 5 years), sex, and populations of family medicine centers to reflect the whole population. Individuals who had previously been diagnosed with DM or prediabetes were not included in the study. Those with gestational DM (GDM) were included in the study if DM reversed after pregnancy.

Data were collected using a questionnaire prepared by the researchers through face-to-face interviews with the participants. Informed consent was obtained from the patients for participation and for the purpose of publication before data collection. The FINDRISC was used to determine the 10-year T2 DM risk, as well as sociodemographic characteristics, physical activity status, lifestyle, anthropometric measurements, body fat and muscle ratio, blood pressure (BP), and waist-to-height ratio. Participants with a waist-to-height ratio of ≥0.5 (early health risk indicator) were included in the analysis.[9]

Height was measured with an ADE Mz10020 ultrasonic height meter. Weight, body fat percentage, visceral fat, and basal metabolic rate were measured with Omron BF 511. Waist circumference was measured with a meter rule; the narrowest diameter between the arcus costarum and anterior superior iliac spine was considered. BP was measured using an Omron M7 Intelli cuffed sphygmomanometer. Clinical validations were performed for the devices used in this study.

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2.2. Finnish diabetes risk score

The FINDRISC was established in Finland using the results of 2 cohort studies conducted in 1987 and 1992, respectively; these studies included 2525 participants who were followed up for 10 years and 1976 participants who were followed up for 5 years, respectively. The maximum possible FINDRISC score is 26. The validity and reliability of the FINDRISC score in Turkish patients were studied by Tari Selçuk K and Unal B, and the power of the FINDRISC score to predict newly diagnosed T2 DM was 0.84.[10]

2.3. Statistical analysis

All data analyses were performed using SPSS 19.0. Shapiro–Wilk test was used to assess the normality of distribution. Descriptive statistics, chi-square, Kruskal–Wallis, and Mann–Whitney *U* tests were used to assess the data.

Table 1

Risk level, 10-year diabetes mellitus risk, and participants' distribution according to the Finnish Diabetes Risk Score.

FINDRISC	Risk level	10-year diabetes mellitus risk	% (n)
<7	Low	1% (1/100)	37.9% (282)
7–11	Slightly elevated	4% (1/25)	31.4% (234)
12–14	Moderate	16% (1/6)	16.7% (124)
15–20	High	33% (1/3)	13.2% (98)
>20	Very high	50% (1/2)	0.8% (6)

FINDRISC = Finnish Diabetes Risk Score.

For the regression analysis, 3 models were developed. Model 1 was used to evaluate the relationship between the FINDRISC score and significant categorical independent variables. Model 2 was used to evaluate the relationship between the FINDRISC scores and anthropometric measurements. Model 3 was a multinomial logistic regression model created with significant variables from Models 1 and 2.

The statistical significance level (*P*) is shown with the relevant tests (significant when a two-tailed $P < .05$).

3. Results

The mean age of the participants was 40.31 ± 13.03 (minimum: 20; maximum: 64) years; 47.3% (n = 352) of them were females.

The mean FINDRISC score was 8.72 ± 4.95. Table 1 shows the level of risk, 10-year DM risk, and participants' distribution according to the FINDRISC score.

Combining low and slightly elevated risks and high and very high risks, 3 groups were constituted: low-risk, moderate-risk, and high-risk groups.

Only 49.2% (n = 366) of the participants were screened for DM. The scale score was significantly higher in participants who were previously screened for DM ($P < .001$).

There was an extremely significant relationship between the FINDRISC score and sex ($P = .006$), age ($P < .001$), marital status ($P < .001$), education level ($P < .001$), smoking status ($P < .001$), and alcohol consumption ($P < .001$). There was no significant relationship between the FINDRISC score and income level ($P = .10$) and subsistence status ($P = .13$).

Of women participants, 5.4% (n = 19) had a history of GDM, and 10.5% (n = 37) gave birth to macrosomic babies. Women with a history of GDM and macrosomic babies had significantly higher ($P < .001$ and $P = .001$, respectively) FINDRISC scores.

The DM risk level was high ($P < .001$) in patients with a chronic disease (53% of the participants; n = 394), particularly in obese patients.

The proportion of individuals who exercised regularly was 31.6% (n = 235); it had a significant relationship with the FINDRISC score ($P < .001$).

The mean body mass index was 26.83 ± 4.71 kg/m^2. The mean waist circumference was 89.16 ± 13.91 cm. Of the participants, 24.5% (n = 182) were obese. The rate of obesity was 22.1% (n = 78) in women and 26.5% (n = 104) in men. The proportion of participants with a risky waist circumference was 27.3% (n = 96) in women and 32.7% (n = 128) in men. When the waist-to-height ratio was grouped according to a cut-off value of 0.5 and compared with the risk according to the FINDRISC score, it was >0.5 in the moderate- and high-risk groups ($P < .001$).

Table 2

Comparison of participants' mean measurements by 10-year type 2 diabetes mellitus risk.

	Low risk (n=516)	Moderate risk (n=124)	High risk (n=104)	P
BMI (kg/m^2)	25.11±3.76	29.80±4.36	31.81±4.05	<.001
Waist circumference (cm)	84.58±12.23	97.66±11.47	101.79±11.79	<.001
Systolic BP (mm Hg)	122.84±14.44	133.37±16.61	132.38±15.47	<.001
Diastolic BP (mm Hg)	78.35±9.71	84.36±10.5	82.74±10.25	<.001
Body fat percentage (%)	24.61±7.76	32.41±7.38	35.49±7.36	<.001
Visceral fat mass (kg)	18.19±7.52	27.18±8.89	31±8.61	<.001

BMI=body mass index, BP=blood pressure.

There was a significant relationship between risk level and weight, body mass index, waist circumference, systolic and diastolic BP, body fat percentage, and visceral fat mass ($P<.001$) (Table 2).

Details of Model 1 are shown in Table 3.

In Model 1, the probability for moderate and high risks was increased by smoking cessation and low education level (both $P<.001$ for elementary school; moderate risk, $P=.012$ and high risk, $P=.005$ for secondary school). Alcohol consumption reduced the moderate risk.

A linear regression analysis was performed to evaluate the relationship between the FINDRISC scores and measurements (Model 2; Table 4).

In Model 2, the probability for moderate and high risks was increased by high systolic BP and waist-to-height ratio >0.5. Since the fat percentage had a borderline high-risk value, it was included in Model 3.

A multi-nominal logistic regression analysis was performed with the significant variables from Models 1 and 2 (Model 3; Table 5).

According to Model 3, the probability for moderate and high risks increased with an increasing body fat percentage, low levels of education, and a waist-to-height ratio >0.05. The probability for moderate risk increased with high systolic BP and smoking cessation. Alcohol consumption reduced the probability of moderate risk.

4. Discussion

In this study, 104 participants (13.9%) had a FINDRISC score of at least 15. In a study of 32,722 individuals in Italy and Spain, 4988 participants (15.2%) had a FINDRISC score of at least 15.[11] The percentages are thought to be similar because of the dietary habits of the Mediterranean region. We estimated that the rate of T2 DM within 10 years in our population would be very high in the absence of any intervention. Based on the FINDRISC scores, we predicted that 9.5% (n=71) of our population would have DM within the next 10 years. This prevalence will only increase if the patients with DM are considered in these predictions. Turkish guidelines recommend the early identification and protection of individuals with a FINDRISC score of at least 20 in the scope of preventive medicine.[12] The World Health Organization and Ministry of Health of the Republic of Turkey published *Turkey's National Program for Diabetes 2015–2020* in 2015. When patients with DM are considered, this program seems ineffective. Only administrative measures were provided in

Table 3

Model 1: Logistic regression model of the effect of categorical independent variables on moderate risk and high risk, based on the Finnish Diabetes Risk Score.

	Estimation	Std. Error	P	OR	95% Confidence interval
Moderate risk*					
Sex (female)	0.270	0.230	.241	1.310	0.834
Smoking (current)	0.254	0.244	.298	1.289	0.799–2.079
Smoking (past)	1.428	0.347	<.001	4.170	2.113–8.227
Alcohol	−0.755	0.283	.008	0.470	0.270–0.819
Education					
Elementary	1.411	0.289	<.001	4.099	2.324–7.229
Secondary	0.926	0.368	.012	2.525	1.227–5.196
High school	0.209	0.261	.424	1.232	0.738–2.056
High risk*					
Sex (female)	0.419	0.255	.101	1.521	0.922–2.509
Smoking (current)	−0.626	0.304	.039	0.535	0.295–0.970
Smoking (past)	1.330	0.357	<.001	3.782	1.879–7.609
Alcohol	−0.479	0.318	.132	0.620	0.332–1.155
Education					
Elementary	1.589	0.304	<.001	4.899	2.702–8.882
Secondary	1.115	0.395	.005	3.049	1.406–6.614
High school	0.025	0.296	.933	1.025	0.574–1.831

OR=odds ratio, Std.=standard.
* Compared with low risk.

Table 4

Model 2: Linear regression model of the effect of measurements on moderate risk and high risk, based on the Finnish Diabetes Risk Score.

	Estimation	Std. Error	*P*	OR	95% Confidence interval
Moderate risk*					
Fat percentage	0.068	0.068	.315	1.071	0.937–1.223
Skeletal muscle	−0.073	0.055	.185	0.930	0.835–1.035
Basal metabolic rate	0.002	0.002	.189	1.002	0.999–1.006
Visceral fat	0.028	0.059	.639	1.028	0.916–1.153
Systolic BP	0.028	0.010	.004	1.029	1.009–1.048
Diastolic BP	0.005	0.015	.750	1.005	0.975–1.035
Waist-to-height ratio (>0.5)	1.630	0.383	.001	5.102	2.410–10.803
High risk*					
Fat percentage	0.161	0.082	.051	1.174	1.000–1.380
Skeletal muscle	0.100	0.063	.112	1.106	0.977–1.251
Basal metabolic rate	−0.002	0.002	.262	0.998	0.993–1.002
Visceral fat	0.036	0.068	.600	1.036	0.907–1.184
Systolic BP	0.030	0.011	.005	1.030	1.009–1.052
Diastolic BP	−0.026	0.017	.120	0.974	0.942–1.007
Waist-to-height ratio (>0.5)	1.875	0.558	.001	6.519	2.185–19.444

* Compared with low risk.
BP = blood pressure, OR = odds ratio, Std. = standard.

the program; there were no specific targets. This is one of the reasons for the program's failure.[13]

The mean FINDRISC score of our participants was 8.72 ± 4.95. In a study conducted by Makrilakis et al[14] in Greece, the mean FINDRISC score was 13.1 ± 4.9. This difference may be explained by the higher mean age of the participants in the study by Makrilakis et al (35–75 [mean, 56.2] years). The risk of DM increased with increasing age. Previous studies that evaluated the risk of DM using the FINDRISC score found that the risk of DM increased with increasing age.[15,16] Since this is a confirmed finding, it would be important for young individuals to take preventive measures against DM. Only 49.2% (n = 366) of the participants were previously screened for DM. The scale score was significantly higher in participants who considered

Table 5

Model 3: Multi-nominal logistic regression model of the effect of categorical variables and measurements, based on the Finnish Diabetes Risk Score.

	Estimation	Std. Error	*P*	OR	95% Confidence interval
Moderate risk*					
Fat percentage	0.092	0.022	<.001	1.097	1.052–1.144
Systolic BP	0.025	0.008	.002	1.025	1.009–1.041
Sex	−0.095	0.344	.783	0.910	0.464–1.784
Smoking (current)	0.357	0.268	.184	1.429	0.844–2.417
Smoking (past)	0.969	0.376	.010	2.636	1.260–5.513
Alcohol	−0.690	0.306	.024	0.501	0.275–0.914
Education					
Elementary	0.678	0.327	.038	1.971	1.038–3.741
Secondary	0.258	0.403	.522	1.294	0.587–2.851
High school	0.131	0.287	.649	1.140	0.649–2.001
Waist-to-height ratio (>0.5)	1.683	0.390	<.001	5.380	2.507–11.548
High risk*					
Fat percentage	0.171	0.025	<.001	1.187	1.130–1.247
Systolic BP	0.016	0.009	.065	1.017	0.999–1.034
Sex	−0.636	0.382	.095	0.529	0.250–1.118
Smoking (current)	−0.528	0.337	.117	0.590	0.305–1.141
Smoking (past)	0.717	0.403	.075	2.048	0.930–4.511
Alcohol	−0.412	0.361	.254	0.662	0.326–1.344
Education					
Elementary	0.720	0.362	.047	2.054	1.011–4.174
Secondary	0.249	0.451	.580	1.283	0.530–3.105
High school	−0.060	0.339	.859	0.941	0.485–1.829
Waist-to-height ratio (>0.5)	1.929	0.559	.001	6.885	2.301–20.602

BP = blood pressure, OR = odds ratio, Std. = standard.
* Compared with low risk.

themselves in the risk group and screened for DM. These results show that T2 DM has a high chance of being predicted by individuals and physicians.

Women had higher FINDRISC scores than men. This is consistent with several previous studies.[17,18] However, the multi-nominal logistic regression analysis showed no difference between the sexes.

There was a significant relationship between education and FINDRISC levels. Participants with a primary school level of education and lower education were in the high-risk group, whereas university graduates were in the lower-risk group. A study of 20,633 adults in the United States between 1999 and 2010 reported that the risk of DM increased significantly as the education level increased.[16] Another study in a Turkish population found that a low level of education was associated with a higher risk of DM.[19] Health literacy increases with an increasing level of education. Thus, it is a protective factor for diseases.

Although smokers and alcohol consumers do not have healthy lifestyles, they have a lower risk for DM than non-smokers/ex-smokers and non-alcohol consumers, respectively. This is consistent with existing literature.[16,17] Alcohol consumption decreased the risk of DM. Smoking did not change the risk. While the probability for a high risk was decreased by smoking, smoking cessation increased the probability for moderate risk. No previous study has shown the effect of smoking cessation on the risk of DM. This may be explained by the appetite-reducing effect of smoking, increase in metabolic rate by stimulating nicotinic receptors, the inability of existing receptors to be saturated when an individual quits smoking, or other chemicals in tobacco.[20]

Individuals with a history of DM in their immediate family were in the high-risk group, as mentioned in other studies.[17,21] Physicians should lay emphasis on detailed family history taking and implementation of early precautions against DM during the counseling of their patients.

Participants with a higher mean systolic BP had an increased risk of developing DM. The presence of hypertension as a chronic disease also increased the risk of DM. This is consistent with existing studies.[17,19,22–24] Individuals should be aware that combating hypertension also means combating DM, and that well-managed hypertension in primary care will also contribute to preventing DM. With the failure in the fight against hypertension and DM, there is a need for new guidelines for primary care that will provide means of managing these diseases simultaneously.

This study compared the participants' exercise status with the FINDRISC scores and found that the group without any physical activity was at high risk, whereas the group that exercised at least 30 min a day was at a lower risk. There are many existing studies supporting the association between physical inactivity and higher FINDRISC scores.[19,22,25]

We found that 34.9% of women and 30.9% of men had waist circumferences above the threshold measurements,[12] and they had a higher risk of DM. Studies have shown that an increased waist circumference is associated with a higher DM risk, which supports our results.[18,22,26] Ashwell et al[9] found that a waist-to-height ratio above 0.5 was associated with a high health risk. This current study found that a waist-to-height ratio above 0.5 increased the probability for a moderate risk by 5.380 and that for high risk by 6.885. This suggests the need for early precautions, which can be performed easily in primary care.

An increased visceral fat mass led to an increase in the DM risk score. A study conducted in Bulgaria found a strong correlation between the FINDRISC score and body fat percentage and visceral fat mass; this is consistent with our study.[23] Cost-effective evaluations can be made using measuring devices that can be used easily in primary care. With the help of such devices, prevention and monitoring of diseases, especially DM, may be possible.

4.1. Limitations

At the time we applied for permission, blood tests such as fasting plasma glucose, oral glucose screening test, and glycated hemoglobin levels were not permitted in field studies conducted in family medicine centers in Turkey; therefore, they were not performed in this study. For this reason, previous tests, diagnoses, and statements of the participants were used to consider them as healthy. Individuals with undiagnosed pre-diabetes and diabetes should be clearly distinguished in future studies. Smoking and alcohol consumption were not quantified, and the results might vary with quantity. Another limitation of our study is the small sample size, which makes it hard to avoid data bias and confounding effects. Moreover, the socio-cultural differences between regions and populations limited the generalizability of our results to the whole country.

5. Conclusion

The 10-year prevalence of DM according to the FINDRISC score is above the expected level. The data evaluation indicated that the policies and activities conducted to prevent DM in our region failed to produce the desired results. There are many modifiable risk factors that increase the risk of DM. Individuals with these risk factors should be identified and evaluated early, personalized protective programs should be implemented, and individuals at risk should be followed up closely. The use of the FINDRISC score, which is a practical, cost-effective, and easily applicable test in primary care, can identify high-risk individuals and help in taking early measures that can bring success in combating DM in Turkey.

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