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The prevalence and identification of risk factors for type 2 diabetes mellitus and impaired glucose tolerance in Kayseri, central Anatolia, Turkey

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Abstract Type 2 diabetes mellitus is a chronic disease which causes neurologic, cardiac, vascular, ocular and renal complications. The present study documented the prevalence of diabetes and associated risk factors in 1774 adults who were older than 30 years. An oral glucose tolerance test (OGTT) was conducted according to the World Health Organization (WHO) criteria. Of the 1452 subjects, 58 (4%) had diagnosed diabetes, 41 (2.9%) undiagnosed diabetes and 130 (9%) had impaired glucose tolerance. The total glucose intolerance was 15.9%. The prevalences of type 2 diabetes mellitus (9.7%-4.1%) were significantly different in low occupational and high occupational activity groups, respectively ($P<0.0001$). The prevalence of type 2 diabetes mellitus was 17.9% among the hypertensive group ($P<0.0001$). The prevalence of type 2 diabetes mellitus was higher in smokers ($P<0.05$). Patients with diagnosed diabetes, undiagnosed diabetes and IGT were older, more obese and have higher blood glucose values, triglyceride values, systolic and diastolic blood pressures than healthy subjects ($P<0.001$). We conclude that type 2 diabetes mellitus and IGT prevalences are quite high in the urban area of Kayseri, central Anatolia and multivariate analysis indicated that low occupational activity, low leisure activity, family history for diabetes, hypertension and obesity were significant independent risk factors for diabetes mellitus.

Key words Type 2 diabetes mellitus • Prevalence • Turkey • Central Anatolia • Urban population

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Introduction

Type 2 diabetes mellitus occurs predominantly in adults over than 30 years old. Typically it is an asymptomatic disease for many years, which causes neurologic, cardiac, vascular, ocular and renal complications [1]. Because of its slow and sneaky progression, the prevalence of undiagnosed diabetes is almost equal to that of previously diagnosed diabetes. The primary purpose of a screening program is to identify individuals without symptoms who are likely meet the diagnostic criteria for diabetes, identifying the high risk groups in the population and to seek the conditions associated with diabetes [2-6]. World Health Organization (WHO) suggests population-based studies for preventive policies from diseases including diabetes, planning controlling programmes and carrying out the management and educational services [7].

Even though there are no sufficient epidemiological studies, the prevalence of diabetes is estimated 1-1.5% in our country [8-10]. Between 1991 and 1994, we have investigated the prevalence of diabetes among the total of 4000 subjects over than 30 years old and found that 5.6% of the population had diabetes in the rural area of Kayseri [11]. The objective of the present study is to find the prevalence of type 2 diabetes mellitus among Turkish people and associated risk factors in the urban area of Kayseri, which is located in central Anatolia (also called Cappadocia in which diabetes was first described and named by Arateus 2000 years ago) where the risk factors are more prominent, probably because of social and economical reasons.

Subjects and methods

The study population was located in the city of Kayseri in central Anatolia. Besides the modern lifestyle with industrialisation and urbanisation, there was a high caloric nutritional habit of high fat and carbohydrated diets. The total population was about 550000 in 1994 of which 200000 of the people were living in the urban area.

We have used a cluster sampling and four districts out of ten were randomly selected from the city center. The total population, older than 30 years, was 18020 in the selected area, 1774 (approximately 10% of the selected area) individuals were invited and 845 (58%) women and 607 (42%) men, total 1452 continued the screening programme. The mean age was 45.92 ± 11.59 (30-92) years. The participation rates were 91.5% among women and 71.3% among men.

Procedure

The study had been started in June 1994 and finished in 6 months. The study was approved by the ethical committee of Erciyes University Medical School and informed consent was obtained from each subject. The people were informed about the purpose and details of the study by local press, radio and television. Also, invitation cards were sent to selected people. The test subjects were instructed to abstain from food beginning at 20.00 hours on the previous day. An OGTT was conducted according to the WHO criteria for each participitant (except cases diagnosed previously who were on oral-antidiabetic and/or insulin therapy) between 07.30-10.00 hours in the morning. Venous blood samples were obtained just before and after 2 hours of 75 g anhydrous glucose in 250 ml of water [12-14]. Serum glucose levels were measured by the glucose oxidase method (Glucose analyser; R.A.1000/XT Technicon USA). Also triglyceride, total cholesterol, HDL cholesterol and uric acid values were determined from the same samples. Epidemic index, which is a risk factor in the development of type 2 diabetes mellitus from IGT, was calculated by (IGT/TGI [IGT+type 2 diabetes mellitus) [15].

Demographic, social and economical status, smoking, occupational and leisure time activity were recorded; medical history was taken according to the model protocol of WHO and physical examination was performed on each participant [14].

After resting, blood pressure was measured two times by a standard mercury sphygmomanometer (cuff= 69 x 17 cm, bladder= 42 x15 cm) from the right arm. The arithmetical mean was recorded. A third blood pressure measurement was performed whenever more than 20% difference was noted between the two measurements.

Activity

Physical activity was assessed based on the type of occupation and time spent on leisure-time physical activities as noted in the literature. All subjects were finally divided into four categories of physical activity based on occupation and leisure time activities [14-16].

Occupational activity: (1) sedentary; working at a table or not working etc, (2) light; housewife, seller, servant etc, (3) moderate; tradesman, craftsman etc, (4) heavy; manual labourers and agricultural workers.

Leisure time activity: (1) sedentary; living at home and taking no regular exercise (2) light; walking but no regular exercise (3) moderate; sport or aerobic once or twice a week (4) heavy; those engaged in a strenuous exercise programme. In each activity period, it was considered low and high activity if the activity degree was < 2 or > 3, respectively. Weight, height and waist and hip measurements were recorded. The waist and hip measurements were made with subjects standing and wearing thin clothes. The waist was defined as the smallest girth between the costal margin and iliac crests and hip as the circumference at the level of the greater trochanters [17, 18]. Body mass index (BMI) and the waist: hip ratio (WHR) were calculated. BMI > 25 kg/m^2 and > 27 kg/m^2 were considered as obesity in men and women, respectively [19].

OGTT

The recommended criteria by WHO were used (1). Diabetes mellitus; fasting plasma glucose value > 7.8 mmol/l and/or plasma glucose value >11.1 mmol/l 2 h after 75 g oral glucose loading. (2) IGT; fasting plasma glucose value < 7.8 mmol/l and plasma glucose value ≥ 7.8 mmol/l but < 11.1 mmol/l 2 h after 75 g oral glucose loading [12, 13].

Statistical analysis

Type 2 diabetes mellitus and IGT prevalences according to the age and sex were estimated by chi-square test. Multivariate analysis was performed to assess various risk factors for diabetes mellitus. Student's *t*-test was performed to evaluate the variation of the risk factors. We used analysis of covariance and relative risk estimation to evaluate the age-adjusted prevalence of diabetes mellitus according to risk factors. The values were expressed as mean ± SD. Procedures were done by epi-info program and SPSS for Windows 7.0.

Results

Type 2 diabetes mellitus and IGT prevalences

Of the 1452 subjects, 58 (4%) had diagnosed diabetes, 41 (2.9%) had undiagnosed diabetes and 130 (9%) had IGT. The prevalences of type 2 diabetes mellitus and total glucose intolerance were 6.9 and 15.9%, respectively. The mean ages of patients with diagnosed diabetes, undiagnosed diabetes and IGT were 54.98 ± 9.53, 51.27 ± 12.78 and 51.45 ± 11.94 years, and female/male ratio was 60.3/39.7%, 56.1/43.9% and 64.6/35.4%, respectively.

Risk factors

The prevalence of undiagnosed diabetes was significantly higher than diagnosed diabetes ($P<0.001$) in the 30-39 years age group. In the 40-49 years age group no difference was noted ($P>0.05$). Between ages 50-59 years, the prevalence of diagnosed diabetes was higher than undiagnosed diabetes ($P<0.001$). Remarkable increment was noted in diagnosed diabetic cases and IGT prevalences between 60-69 years of age. Four to sixfold increase in the prevalence of type 2 diabetes mellitus and threefold increase in the prevalence of IGT were noted in 50- (70+) age group compared to 30-49 years age group (*P*<0.001).

The prevalences of diagnosed diabetes, undiagnosed diabetes and IGT were 4.2%, 2.7% and 9.9% among women and 3.8%, 3.0% and 7.6% among men, respectively. There was no sex related dominance of IGT (*P*>0.05). The age and sex related type 2 diabetes mellitus and IGT prevalences are shown in Table 1. Table 2 shows demographic and socio-cultural risk factors.

Although multivariate analysis has shown that formal education was not an independent risk factor for type 2 diabetes mellitus (Table 3), age-adjusted comparisons have shown that it was an important risk factor. The prevalence of type 2 diabetes mellitus was higher in poorly educated [people who never had school education] individuals (RR: 2.2, *P*<0.0001) (Table 4). The family income of participants were classified as "good" or "better" by their descriptions. The family income was not an important risk (RR:1.0, *P*>0.05). The prevalences of type 2 diabetes mellitus and IGT were 9.7% and 10.7% in low occupational activity group and 4.1 and 7.3% in high occupational activity group, respectively. Occupational activity was an important risk factor for the prevalence of type 2 diabetes mellitus (RR:2.4, *P*<0.0001). Leisure activity was also an important risk factor (RR:3.2, *P*<0.0001).

In the present study, the prevalence of type 2 diabetes mellitus was 17.9% and the prevalence of IGT was 14.1% among the hypertensive group. The risk of diabetes mellitus in hypertensive group was higher than the normotensive group (RR:2.9, *P*<0.0001). The prevalence of type 2 diabetes mellitus was two times more common in cases with family history of diabetes (RR:2.3, *P*<0.0001). Although multivariate analysis has shown that smoking was not an important risk factor for type 2 diabetes mellitus, age-adjusted comparisons have shown that it was an important risk factor (RR:1.7, *P*<0.05).

Of the study population, 70.5% was obese and 29.5% was non-obese. Of the 1223 subjects with normal glucose tolerance, 68.4% was obese and 31.6 was non-obese. The prevalences of obesity among the patients with diabetes and IGT were 87.9 and 76.9%, respectively. Obesity was found to be an important risk factor for type 2 diabetes mellitus (RR:3.0, *P*<0.0001). Tables 3 and 4 show multivariate analyses and age-adjusted comparisons, respectively. As shown in Tables 2 and 5, the cases with diagnosed diabetes, undiag-

Table 1 Age and sex-specific prevalence of diabetes and IGT

Age (years)	*n*	Diabetes		Total prevalence (%)	Cases	IGT prevalence (%)
		Diagnosed cases	Undiagnosed cases			
30–39						
Male	164	1	3	2.4	5	3.0
Female	336	3	5	2.3	18	5.3
Total	500	4	8	2.4	23	4.4
40–49						
Male	206	3	4	3.3	15	7.3
Female	240	8	6	5.8	27	11.2
Total	446	11	10	4.7	4.2	9.6
50–59						
Male	126	11	5	12.0	9	7.1
Female	151	14	6	13.2	18	11.9
Total	277	25	11	13.0	27	9.7
60–69						
Male	88	6	4	11.3	16	18.1
Female	88	8	3	12.5	13	14.7
Total	176	14	7	12.0	29	16.5
≥ 70						
Male	23	2	2	17.4	1	4.3
Female	30	2	3	16.6	8	26.6
Total	53	4	5	16.9	9	17.0
TOTAL						
Male	607	23	18	6.8	46	7.6
Female	845	35	23	6.9	84	9.9
Total	1452	58	41	6.9	130	9.0

Table 2 Prevalence of diabetes and IGT, and risk factors

	Diagnosed diabetes (*n* = 58) %	Undiagnosed diabetes (*n* = 41) %	Total diabetes (*n* = 99) %	IGT (*n* = 130) %
Total	4.0	2.9	6.9	9.0
Age - Group				
30-39	0.8	1.6	2.4	4.4
40-49	2.5	2.2	4.7	9.6
50-59	9.0	4.0	13.0	9.7
60-69	8.0	4.0	12.0	16.5
70 +	7.5	9.4	16.9	17.0
Sex				
Male	3.8	3.0	6.8	7.6
Female	4.2	2.7	6.9	9.9
Formal education				
None	6.8	5.9	12.7	14.0
Yes	3.5	2.3	5.8	8.1
Family income				
High	4.3	2.6	6.9	6.0
Moderate	3.9	2.9	6.8	10.3
Occupational activity				
Light	6.3	3.4	9.7	10.7
Heavy	1.8	2.3	4.1	7.3
Leisure activity				
Light	5.5	3.4	8.9	10.2
Heavy	1.0	1.8	2.8	6.7
Diabetes in family				
Yes	11.0	2.6	13.6	10.7
No	2.2	3.7	5.9	8.5
Hypertension				
Yes	6.4	11.5	17.9	14.1
No	2.6	3.6	6.2	8.7
Smoking				
Yes	3.3	4.5	7.8	10.2
No	1.8	2.5	4.7	6.3
Obesity				
Yes	4.8	3.7	8.5	9.7
No	2.1	0.7	2.8	7.0

Table 3 Multivariate analysis of risk factors by diabetes mellitus prevalence*

	P-value
Sex	>0.05
Formal education	>0.05
Family income	>0.05
Occupational activity	<0.005
Leisure activity	<0.0001
Diabetes in family	<0.0001
Hypertension	<0.05
Smoking	>0.05
Obesity	<0.05

* $P<0.0001$

Table 4 Age-adjusted comparison of risk factors for diabetes mellitus prevalence

	Prevalence of diabetes	Odds ratio	*P*-value
Sex			
Male	6.8		
Female	6.9	0.99	>0.05
Formal education			
None	12.7		
Yes	5.8	2.20	<0.0001
Family income			
High	6.9		
Moderate	6.8	1.01	>0.05
Occupational activity			
Light	9.7		
Heavy	4.1	2.37	<0.0001
Leisure activity			
Light	8.9		
Heavy	2.8	3.18	<0.0001
Diabetes in family			
Yes	13.6		
No	5.9	2.31	<0.0001
Hypertension			
Yes	17.9		
No	6.2	2.89	<0.0001
Smoking			
Yes	7.8		
No	4.7	1.66	<0.05
Obesity			
Yes	8.5		
No	2.8	3.04	<0.0001

nosed diabetes and IGT were older, more obese and have higher blood glucose values, triglyceride values, systolic and diastolic blood pressures than healthy subjects ($P<0.001$). There were no differences of body height, total cholesterol, HDL cholesterol and uric acid values ($P>0.05$).

WHR ratio, which was an indicator of android type fat deposition, was significantly higher in the abnormal glucose tolerance group and it was estimated as a risk factor for cardiovascular disease and diabetes ($P<0.001$).

Discussion

Because of the geographical settling, Turkey is influenced by near-east Asia and European civilization for social, economic and socio-cultural views. By the 20th century, economical development and urbanization caused radical changes in the lifestyle. While the incidence of nutritional deficiencies and infectious diseases was decreasing, morbidity and mortality due to noninfectious causes such as diabetes and cardiac diseases increased.

In some of the Middle East and African countries like Egypt, Saudi Arabia, Omen and Tunisia, the prevalences of type 2 diabetes mellitus in urban areas were reported as 5.7%, 4.9%, 9.8%, 4.1%, respectively [20]. The prevalence of type 2 diabetes mellitus is at an epidemic level in South Pacific communities, Bangladeshian immigrants in England, Chinese in Mauritius Islands, in American indigenous, in Mexican and American blacks [3]. The prevalences of type 2 diabetes mellitus and IGT among urban Africans were found to be 8 and 7%, respectively [21].

Already, there is not enough knowledge about the prevalence of type 2 diabetes mellitus in Turkey. In 1966, Öker and co-workers reported 1.98% glucosuria incidence in Silivri and its villages [8], Akıncı and co-workers reported 1.53% postprandial glucosuria in the villages of Silivri-Catalca [9]. In 1973, 23243 individuals were screened and 1.7% glucosuria was found in Kayseri [22]. Between 1991-1994, Öztürk and co-workers reported that the prevalence of diabetes was 5.6% in the rural area of Kayseri [11]. In the present study, the prevalences of type 2 diabetes mellitus and IGT were 6.9 and 9% in the urban area of the same region where the population have more risk factors. In our country, low diabetes prevalences (1-2%) were reported from the studies mainly by examining urinary glucose which cannot be accepted as a reliable marker. In order to estimate type 2 diabetes mellitus prevalence in Turkey, it is necessary to have a multi-center, population-based diabetes screening programme according to the model protocol suggested by WHO [13].

The prevalence of undiagnosed diabetes has been shown to be about equal to that of diagnosed diabetes in population-based studies [4, 5, 23]. In the present study, the prevalence of diagnosed diabetes (4.0%) was higher than undiagnosed diabetes (2.9%). It is mentioned that by social interest and early studies, undiagnosed diabetes prevalence can be less than 1% [2]. According to us, a high prevalence of diagnosed diabetes depends on the interest of participitants.

In several studies a close relationship between IGT and type 2 diabetes mellitus was reported and claimed that the risk of developing diabetes was two to eight times more common in cases with IGT compared with normal persons during the following 2-10 years [3, 24, 25]. Among Australian indigenous living in the rural areas, while they have high diabetes prevalence [14.6% in women and 16.7% in men], IGT prevalences were 4.2% in women and 0.7% in men [25]. On the contrary, in urban Polynesian communities, IGT prevalence was three to four times higher than type 2 diabetes mellitus prevalence in Tuvalu. So, the likelihood of developing type 2 diabetes mellitus from IGT mainly depends on the relative risk factors rather than prevalence [15]. It is claimed that beta cell decompensation and presumably insulin resistance leads to the developing diabetes by the contribution of risk factors such as obesity and physical inactivity [3, 26]. In fact the development of type 2 diabetes mellitus was prevented or delayed by dietetic regulation or tolbutamide therapy with diet in cases with IGT during 10 years [27]. It has been suggested that a decrease in epidemic index is an increased risk factor for type 2 diabetes mellitus [15]. We found that epidemic index was 56.9% in our region. This ratio was 100% in Papua New Guinea where IGT was 4.7% but type 2 diabetes mellitus was 0% and 37.7% in Nauru where IGT was 17.4% and type 2 diabetes mellitus was 24.7%. In our region, epidemic index seems to be an important risk factor for developing type 2 diabetes mellitus from IGT.

In our region the most important independent risk factors leading to high prevalence of type 2 diabetes mellitus are physical inactivity, family history of diabetes and hypertension. Occupational and physical inactivity was 79.2% in the study group. BMI and WHR ratio indicated an android of type fat deposition. Android type fat deposition is primarily a hypertrophic pattern and is reported that it causes insulin resistance and is also a specific risk factor for type 2 of diabetes mellitus [26, 28]. We have found that the prevalence of type 2 diabetes mellitus was higher in poorly educated individuals. This difference may be due to the fact that educated people are more aware of the symptoms and complications of diabetes and therefore seek medical advice at an earlier stage of the disease.

75-80% of adult patients with diabetes die because of coronary heart diseases, cerebrovascular diseases and/or peripheral vascular diseases. Abnormal metabolic process due to insulin resistance and/or insufficiency are responsible high triglyceride and low HDL cholesterol levels in for diabetic and prediabetic individuals. Finally, they have four to five times more risk of cardiovascular diseases (compared with nondiabetic subjects) than persons of similiar age without diabetes [29]. Cholesterol and triglyceride values were found as high in the diabetic and nondiabetic individuals of the urban area of Kayseri. Triglyceride levels were significantly higher in diabetic cases (P<0.001). It is certain that macrovascular diseases, due to abnormal lipid profile, will increase morbidity and mortality. For management of abnormal lipid profile of diabetic individuals, the American Diabetes Association and National Cholesterol Education programme advises; (1) weight loss (2) increasing physical activity (3) diet; 10% < saturated fat, 30% < fat for total calories. In this way, it leads to decrease in triglyceride, total cholesterol, LDL cholesterol and increase in HDL cholesterol,

Table 5 Baseline anthropometric, biochemical and hemodynamic data

Variables	Total diabetes (n=99)	IGT (n=130)	Normal (n=1223)
Age (years)	53.49 ± 11.21[c]	51.32 ± 11.97[c]	44.74 ± 11.14
Height (cm)	158.08 ± 9.39	157.98 ± 12.12	160.22 ± 8.65
Weight (kg)	71.22 ± 11.99[a]	75.52 ± 1.87	74.63 ± 12.93
Body mass index (kg/m^{-2})	30.97 ± 4.52[b]	30.02 ± 4.86[a]	29.030 ± 5.05
Waist-hip ratio	0.90 ± 0.07[c]	0.90 ± 0.05[c]	0.87 ± 0.08
Fasting plasma glucose (mg/dl)	176.48 ± 81.29[c]	94.75 ± 16.59[c]	81.47 ± 12.17
2hPG (mg/dl)	156.07 ± 14.73[c]	88.16 ± 17.96	
Triglyceride (mg/dl)	185.36 ± 110.48[c]	157.47 ± 126.95[a]	134.87 ± 82.99
Total cholesterol (mg/dl)	199.73 ± 37.66	193.94 ± 38.58	192.26 ± 37.0
HDL cholesterol (mg/dl)	43.78 ± 8.93	44.0 ± 8.79	44.72 ± 8.98
Uric acid (mg/dl)	3.63 ± 1.44	3.52 ± 1.33	3.57 ± 1.25
sBP (mmHg)	138.64 ± 24.55[c]	134.92 ± 25.89[b]	124.83 ± 20.87
dBP (mmHg)	86.62 ± 14.07[b]	84.11 ± 14.91[a]	80.93 ± 12.03

Results are expressed as mean ± SD for all variables. The significance levels indicates the comparisons between the groups with total diabetes or IGT and normal subjects. [a] $P < 0.05$, [b] $P < 0.01$, [c] $P < 0.001$

insulin sensitivity and better regulation of blood glucose [29, 30]. It is certain that by weight loss, exercise and diet, abnormal lipid profiles will be normalized and morbidity and mortality of macrovascular diseases will be decreased.

In conclusion, type 2 diabetes mellitus and IGT prevalences are quite high in the urban area of Kayseri, central Anatolia with abnormal lipid profiles, obesity and nutritional mistakes.

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