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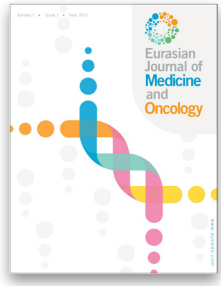


Research Article

# The Prevalence of Insulin Resistance in the Turkish Population: A Study Conducted with 3331 Participants

**Ahmet Kaya,[1] Elif Turan,[2] Mehmet Uyar,[3] Fahri Bayram,[4] Yasar Turan[2]**

[1]Department of Endocrinology, Necmettin Erbakan University, Konya, Turkey
[2]Department of Endocrinology, Bozok University, Yozgat, Turkey
[3]Department of Public Health, Necmettin Erbakan University, Konya, Turkey
[4]Department of Endocrinology, Erciyes University, Kayseri, Turkey

## Abstract

**Objectives:** The aim of this study was to apply the homeostasis model assessment of insulin resistance (HOMA-IR) and examine the relationships between age, sex, and body mass index (BMI) and the prevalence of diabetes mellitus (DM) and insulin resistance (IR) in the Turkish population of different regions of the country.
**Methods:** This was a cross-sectional, observational study designed in the framework of a multicenter study to analyze the Turkish prevalence of insulin resistance. The study sample consisted of volunteers from the 7 different regions of Turkey. Weight, height, and waist circumference were measured. BMI, blood pressure, fasting blood glucose, and fasting blood insulin levels were calculated. IR was determined using the HOMA-IR.
**Results:** The prevalence of DM, impaired fasting glucose, and IR was 11.1%, 21.3%, and 26.2%, respectively, in all 7 regions of Turkey. IR was detected in 28.9% of women and 25.1% of men. The difference between men and women was significant (p=0.04). The prevalence of IR in postmenopausal women (30.8%) was higher than premenopausal women (25.1%) (p<0.04). A comparison of age groups revealed that the prevalence of IR among those aged 50 to 59 (33.8%; p<0.001) was higher than in the other age groups. IR was also more prevalent in those with a BMI >25 kg/m2, those with hypertension, and those living in city centers (p<0.05).
**Conclusion:** The high prevalence of IR and DM in Turkey is an important public health problem. This study provides a large-sample representative study of the Turkish population. The prevalence of IR was highly correlated with central obesity, hypertension, and a more sedentary lifestyle, such as is often seen in city centers. There is an urgent need to institute more aggressive, nationwide public health measures and screening programs regarding obesity.
**Keywords:** Diabetes, hypertension, impaired fasting glucose, insulin resistance, obesity, prevalence

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Insulin resistance (IR) is a pathogenic factor for type 2 diabetes mellitus (DM).[1] Cells in the peripheral tissues (for example, adipose tissue, liver, muscles) develop an insensitivity to insulin. Increased insulin secretion and chronic hyperinsulinemia can develop when pancreatic beta cells can no longer compensate and maintain glucose homeostasis, leading to the development of type 2 DM.[2] A notable proportion of healthy subjects also have IR.[3] IR and related conditions are very common, some 30% to 40% of those who live in affluent countries are affected. IR is also a common finding in developing countries.[4]

Recent studies have demonstrated that the fasting insulin level is a surrogate marker of IR and a predictor of coronary artery disease (CAD).[5] IR has also been shown to be related

**Address for correspondence:** Elif Turan, MD. Necmettin Erbakan Universitesi Meram Tıp Fakultesi Konya, Turkey
**Phone:** +90 332 223 69 52 **E-mail:** drelifturan@hotmail.com
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to most of the cardiovascular risk factors: hypertension, dyslipidemia, obesity, and glucose intolerance, and a combination of these abnormalities could cause CAD.[6]

The hyperinsulinemic-euglycemic clamp technique is the adopted gold standard to calculate insulin sensitivity, but this method is not cost-effective and is therefore typically not suitable for clinical settings.[7] The homeostasis model assessment of insulin resistance (HOMA-IR) is a noninvasive and effective alternative method to evaluate insulin sensitivity based on the glucose level and the level of serum insulin measured in fasting conditions. HOMA-IR is considered a standard method of measuring IR in epidemiological studies.[8]

The present study used the HOMA-IR to estimate the prevalence of IR and DM in all 7 regions of Turkey.

## Methods

### Study Plan

This study was a cross-sectional research project carried out in Turkey to assess the prevalence of IR in different Turkish populations. The sampling design was based upon multistage probability sampling. Approval was granted by the ethics committee of the ministry of health and household identification form data were obtained from primary health care centers of the provincial health directorates affiliated with the ministry of health. Using the results of the 2000 national Turkish census, a stratum of the 7 regions of Turkey was created with at least 3 provinces from every region selected using a simple random sampling method. A total of 23 provinces were regarded as clusters. These 23 provinces were Ankara, Antalya, Bursa, Canakkale, Denizli, Diyarbakir, Edirne, Erzurum, Eskisehir, Gaziantep, Giresun, Hatay, Istanbul, Izmir, Kars, Kayseri, Konya, Mersin, Samsun, Sivas, Sanliurfa, Van, and Zonguldak. They represent all 7 regions of Turkey (Fig. 1). The population of villages, towns, and city centers were classified using the stratified sampling method. Males and non-pregnant females between 20 and 83 years of age were included in the study. Blood sampling was performed after fasting for 10 to 12 hours.

**Figure 1.** Map of the 7 regions of Turkey.

### Study Protocol

Medical history, age, and gender data were recorded by nurses and specialist physicians. Family and personal history of hypertension, cardiovascular disease, DM, and other chronic diseases were also recorded. The weight, height, and waist circumference of the participants were measured, and body mass index (BMI) was calculated as (weight in kg)/(height in meters)2. Blood samples were centrifuged at room temperature for 5 minutes at 3000 RPM. The extracted serum was kept in ice bags and put in deep freezers at -80°C on the same day. IR was calculated using the HOMA-IR formula of fasting insulin (uU/mL) x fasting glucose (mmol/L) / 22.5.[9] The cut-off value was 3. DM was diagnosed according to the American Diabetes Association criteria. Single fasting glucose (FG) of 126 mg/dL was considered diagnostic of DM. Previous DM diagnosis or the use of oral antidiabetic agents and/or insulin therapy was also classified as diabetic. Impaired fasting glucose (IFG) was defined as FG level between 100 and 126 mg/dL. A coastal area was defined as elevation between 0 and 300 m, medium altitude as elevation between 300 and 1000 m, and high altitude as elevation above 1000 m.

### Statistical Analysis

Unstable sampling selections were made during the multistage sampling process. To make this calculation, we used the SPSS for Windows, Version 15.0 (SPSS Inc., Chicago, IL, USA) statistical package Syntax Editor and wrote syntax codes to calculate post-stratification weights. A chi-square test was used to determine significant differences in proportions between categorical variables. The Student's t-test and Mann-Whitney U test were used to compare differences between continuous variables. A p value ≤0.05 was considered statistically significant.

## Results

A total of 3331 adults participated in this study (2059 females, 61.6%; 1282 males, 38.4%) from 7 regions: Marmara, 716 (21.0%); Central Anatolia, 504 (15.4%); Aegean, 404 (12.1%); Mediterranean, 801 (24.0%); Black Sea, 482 (14.0%); Southeastern Anatolia, 265 (7.09%); and Eastern Anatolia, 279 (8.4%). Demographic features are shown in Table 1. The mean age of the participants was 48.7±14.0 years (range: 20-83 years); the male mean was 49.9±14.45 years and the female mean age was 45.5±14.7 years. Among the participants, 35.1% (n=1166) lived in city centers, 39% (n=1318) in districts, and 24.9% (n=847) in villages.

The prevalence of DM, IFG, and IR in all 7 regions of Turkey was 11.1%, 21.3%, and 26.2%, respectively. DM was present in 118 (9.2%) men and in 252 (12.3%) women. The preva-

**Table 1.** Demographic features of the study participants

| | Total n=3331 | Males n=1282 | Females n=2049 |
|---|---|---|---|
| | Mean±SD | Mean±SD | Mean±SD |
| Age (years) | 48.7 ±14.0 | 49.9±14.45 | 48.04±13.80 |
| SBP (mmHg) | 133.5±27.2 | 133.0±26.6 | 133.9±27.7 |
| DBP (mmHg) | 81.4±16.0 | 81.2±15.3 | 81.5±14.9 |
| BMI (kg/m2) | 30.06±5.7 | 27.71±4.44 | 31.52±6.05 |
| WC (cm) | 95.50±12.9 | 96.19±12.03 | 95.02±13.34 |
| FBG (mg/dL) | 105.62±46.8 | 103.10±40.70 | 107.19±50.32 |
| Insulin (µU/mL) | 12.07±20.06 | 11.51±18.70 | 12.42±21.77 |

BMI: Body mass index; DBP: Diastolic blood pressure; FBG: Fasting blood glucose; SBP: Systolic blood pressure; WC: Waist circumference.

**Table 2.** The prevalence of diabetes mellitus by region in Turkey

| Regions | DM absent | | DM present | |
|---|---|---|---|---|
| | N | % | N | % |
| Mediterranean | 736 | 91.9 | 65 | 8.1 |
| Central Anatolia | 420 | 83.3 | 84 | 16.7 |
| Southeastern Anatolia | 227 | 89 | 28 | 11 |
| Aegean | 354 | 87.6 | 50 | 12.4 |
| Marmara | 521 | 86 | 85 | 14 |
| Black Sea | 441 | 91.5 | 41 | 8.5 |
| Eastern Anatolia | 262 | 93.9 | 17 | 6.1 |

DM: Diabetes mellitus.

lence of DM in women was significantly higher than in men (p<0.05). The prevalence of DM in postmenopausal women (17.5%) was higher than in premenopausal women (5.9%) (p<0.05). The prevalence of DM was higher in the Aegean (12.4%), Marmara (14%), and Central Anatolia (16.7%) regions compared with the other regions (p<0.05) (Table 2). DM prevalence was 10.8% among those living in city centers, 11.9% in districts, and 11.1% in the villages. There was no significant difference in DM prevalence according to altitude of residence.

IR was detected in 28.9% of the women and 25.1% of the men. The difference between IR prevalence in men and women was significant (p=0.04). The prevalence of IR in postmenopausal women (30.8%) was higher than in premenopausal women (25.1%) (p<0.04). When age groups were compared, IR was observed most in the age group of 50 to 59 years (33.8%; p<0.00) (Table 3). IR was higher in the Mediterranean (30.1%), Marmara (34.2%), and Southeastern Anatolia (31.4%) regions than the other regions (p<0.05). The prevalence of IR in city centers (29.7%) was higher than in districts (26.4%) or villages (24.4%) (p<0.02).

In this study population, 30.2% (1006) of the participants were overweight and 50.2% (1673) were obese. When BMI >25 kg/m2, IR prevalence increased significantly (p<0.05). In all, 36% of participants had central obesity (male >102 cm, female >88 cm). The prevalence of IR was higher in participants with central obesity (35%) than in the other participants (20%) (p<0.05).

**Table 3.** The prevalence of insulin resistance by age group

| Age groups (years) | IR absent | | IR present | | $X^2$ | P |
|---|---|---|---|---|---|---|
| | N | % | N | % | | |
| 20-29 | 231 | 81.3 | 53 | 18.7 | 33.91 | 0.000 |
| 30-39 | 462 | 74.9 | 155 | 25.1 | | |
| 40-49 | 646 | 73.8 | 229 | 26.2 | | |
| 50-59 | 500 | 66.2 | 255 | 33.8 | | |
| 60-69 | 355 | 71.4 | 142 | 28.6 | | |
| 70-79 | 236 | 77.9 | 67 | 22.1 | | |

IR: Insulin resistance.

IFG was present in 711 (21.3%) participants. The plasma FG levels were: 64.6% <100 mg/dL, 22.1% 100-125 mg/dL, and 12% ≥126 mg/dL. Of the participants with plasma FG <100 mg/dL, IR was present in 17.1% (368), among those with FG 100-125 mg/dL, IR was determined in 36.2% (274), and in those with FG ≥126 mg/dL, 61.4% (259) had IR. Significantly less IR was found among those living at high altitude (21.3%) compared with those living at medium altitude (26.3%) and coastal regions (29.3%) (p<0.05).

The prevalence of hypertension was 22.8% (760) in all 7 regions of Turkey. Of those, 37.4% (284) participants had IR. IR was also present in 24% of the participants without hypertension. There was a significant difference between participants who had hypertension with IR and no hypertension with IR (p<0.05).

## Discussion

The results of this study indicated that there was a significant prevalence of DM, IFG, and IR in the 7 regions of Turkey and the HOMA-IR revealed that IR was significantly higher in obese study participants compared with those of normal weight. In this study of 3331 subjects, 21.3% had IFG, 26.2% had IR, and 11.1% had DM. The second Turkish Diabetes Epidemiology Study (TURDEP)[10], which investigated the prevalence of DM and prediabetes, included 26,499 randomly sampled adults aged were >20 years. The general prevalence of DM was 13.7% (12.4% in men, 14.6% in women), and the prevalence of IFG was 14.5%. In this study, IFG was higher than that observed in TURDEP-II.[10] The prevalence of DM and IFG were 6.8% and 8.6%, respectively, in the Brunneck study conducted in Italy.[11] The Indian prevalence of DM has been reported to be 9.3% in men and 8.1% in women, and IFG was present in 5.3% of men and in 4.1%

lence of DM has been reported to be 9.3% in men and 8.1% in women, and IFG was present in 5.3% of men and in 4.1% of women.[12]

The regions of the Middle East and the Eastern Mediterranean are considered to be on the border of an emerging diabetes epidemic. The region of Central Anatolia had the greatest prevalence of DM compared with the other regions in this study. Our results were similar to the prevalence of DM reported in Qatar (16.1%) [13] and Syria (15.6%) [14], but lower than that seen in Bahrain (25.7%) [15] and Saudi Arabia (23.7%).[16] In contrast, the prevalence of IR was higher in the Mediterranean (30.1%), Marmara (34.2%), and Southeastern Anatolia (31.4%) regions. In this study, no significant difference was found in the prevalence of DM based on urban or rural residence, but the same was not true for IR. The prevalence of IR in city centers was significantly higher than that observed in districts and villages. Those living at high altitude had significantly less IR than those living at medium altitude and in coastal regions. Dietary changes and less physical activity resulting from rapid development and other changes in living conditions may be an etiological factor in the higher IR prevalence in coastal areas.

Obesity is always associated with IR. Our results similarly found that the mean HOMA-IR results were significantly higher in obese individuals compared with the non-obese. Although the precise mechanism by which adipose tissue affects insulin sensitivity is still unclear, it is thought that adipokines secreted by adipose tissue could modulate insulin action and affect glucose disposal.[17] We found a mean BMI of 30.06 kg/m$^2$. In the TURDEP-I and TURDEP-II studies, the mean age-standardized BMI was 26.6 kg/m$^2$ and 28.6 kg/m$^2$, respectively. In the present study, the percentage of those who were obese and overweight was 50.2% and 30.2%, respectively. IR prevalence increased with an increase in BMI.

Our results also indicated that the prevalence of IR increased until 60 years of age. This finding is supported in previous studies. Oya et al. [18] reported that age had a positive and independent impact on HOMA-IR values in both men and postmenopausal women in 3908 non-diabetic study participants. There are several possible explanations. Men tend to have higher visceral/peripheral fat ratio than women.[19] Central adiposity, particularly the presence of visceral fat, is believed to play a key role in the development of IR.[19, 20] Estrogen may also play an important role in maintaining insulin sensitivity in premenopausal women [21], whereas the level of androgens increases with age, which results in increases in adipose tissue, particularly visceral fat, and skeletal muscle IR in women, particularly postmenopausal women.[18] BMI values increase with age in women. Therefore, changes in sex hormones and body composition due to aging may more strongly affect IR for women than age, whereas men do not experience similar dramatic changes in the levels of sex hormones.

In this study, the prevalence of hypertension was 22.8%. The Turkey Prevalence, Awareness, Treatment and Control of Hypertension (PatenT) study of 2003 was a population-based, cross-sectional, epidemiological survey. There was a total of 4910 participants aged over >18 years included. The overall prevalence of hypertension was 31.8% [22], which is greater than our present results. The prevalence of IR in hypertension that we found in this study was 37.8%. The Brunneck study[11] found quite similar values (~30%). However, Mohteshamzadeh et al. [23] reported estimates of an IR prevalence in patients with pharmacologically treated hypertension of ~20% in non-diabetic participants, which was quite a different result.

The potential limitations of this study include a large number of female and elderly participants. These factors might reduce the ability to generalize our findings. The lack of information about dietary variation across the country, socioeconomic status and physical activity of the participants, as well urbanization, are also limitations of the present work.

In conclusion, this research offers a large-sample representative study of the Turkish population. The prevalence of IR is highly correlated with central obesity, hypertension, and a sedentary lifestyle in a city center. There is an urgent need to institute more aggressive, nationwide, public health measures and screening programs about obesity.

### Disclosures

**Ethics Committee Approval:** Approval was obtained from the Ethical Committee of the Ministry of Health.

**Peer-review:** Externally peer-reviewed.

**Conflict of Interest:** The authors have no conflicts of interest. The authors alone are responsible for the content and writing of the article.

**Authorship contributions:** Concept – Y.T.; Design – E.T.; Supervision – A.K., F.B., Y.T.; Materials – F.B.; Data collection &/or processing – A.K., F.B.; Analysis and/or interpretation – M.U.; Literature search – M.U.; Writing – E.T., A.K.; Critical review – F.B.

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