Prevalence of insulin resistance and identifying HOMA1-IR and HOMA2-IR indexes in the Middle Black Sea region of Turkey

Ayşe Kevser Demir[1]; Şafak Şahin[1]; Süheyla Uzun Kaya[1]; İlknur Bütün[2]; Rıza Çıtıl[3]; Yalçın Önder[3]; Türker Taşlıyurt[1], Osman Demir[4]; Köksal Deveci[2]; Faruk Kutlutürk[5]

1. Gaziosmanpaşa University Faculty of Medicine, Department of Internal Medicine.
2. Department of Biochemistry.
3. Department of Public Health.
4. Department of Biostatistics.
5. Department of Endocrinology and Metabolism, Tokat, Turkey.

Abstract

Background: Insulin resistance (IR) is one of the most important etiological risk factors in the development of diabetes. However, there is no clear data regarding the prevalence of IR in the country.

Objective: This study evaluates the prevalence of IR and identifies the optimal threshold values for the HOMA indexes in Turkey.

Methods: This cross-sectional, population-based survey includes 2013 participants aged 20–84 years. The values of the anthropometric measurements and laboratory analysis were recorded. The 90th percentile in the non-obese and non-diabetic population was accepted as cut-off values for IR.

Results: The optimal threshold values for IR were 2.46 in HOMA1-IR and 1.40 in HOMA2-IR. Using the HOMA2-IR method, the overall prevalence of IR was 33.2%. The IR prevalence was higher in women (35.6%) compared to men (30.1%) [p=0.008]. There was a higher IR prevalence in men living in urban areas (p=0.001), not in women. The multivariate logistic regression analysis showed that gender, serum glucose level, serum levels of triglycerides and high-density lipoprotein cholesterol, body-mass index and income status were associated with insulin resistance.

Conclusion: The cut-off values of HOMA1-IR and HOMA2-IR were determined in this study and we believe that these findings will be helpful to clinicians in the fight against health problems such as diabetes.

Keywords: Insulin resistance, HOMA, diabetes mellitus.

DOI: https://dx.doi.org/10.4314/ahs.v20i1.33

Cite as: *Demir AK, Şahin S, Kaya SU, Bütün İ, Çıtıl R, Önder Y; et al. Prevalence of insulin resistance and identifying HOMA1-IR and HOMA2-IR indexes in the Middle Black Sea region of Turkey. Afri Health Sci. 2020;20(1):277-86.https://dx.doi.org/10.4314/ahs.v20i1.33*

Introduction

Insulin resistance (IR) is characterized a diminished physiological response of the tissues to the impact of normal levels of insulin[1]. There is insufficient biological response of cells to circulating insulin. IR is associated with significant comorbidity and increased risk of mortality related illnesses, including diabetes mellitus (DM), metabolic syndrome (MetS), hypertension, and obesity[2]. There is concern that the prevalence of DM is increasing worldwide. In Turkey, the "Turkish Epidemiology Survey of Diabetes, Hypertension, Obesity, and Endocrine Disease (TURDEP)-II"[3] revealed that the prevalence of DM and obesity had increased by 90% and 40%, respectively, in the 12 years since the first survey, TURDEP-I[4]. This rapid increase in DM prevalence indicates an epidemic in Turkey; therefore, learning about the role of insulin resistance and its consequences are gaining prominence in the country.

The most reliable methods available for estimating IR are the hyperinsulinemic-euglycemic clamp and the intravenous glucose tolerance test; however, they are expen-

Corresponding author:
Ayşe Kevser Demir,
Gaziosmanpasa University Faculty of Medicine,
Internal Medicine, Tokat, Turkey
Phone: +90 5558773989
Fax: +90 3562133179
Email: dr.kevserdemir@yahoo.com

sive and time-consuming[5]. For large population studies and clinical tracking, the simplicity of the homeostatic model assessment (HOMA), which measures IR using only fasting glucose and insulin, is very useful[6]. Recently, a computer version (HOMA2) was developed to take into account alterations in peripheral and hepatic glucose resistance[7]. Although studies relying on HOMA use different methods to determine IR, the top quintile or 90th percentile value of the HOMA in non-diabetic and non-obese populations are used most often[8].

IR is one of the most important factors in the development of diabetes; however, there is no credible data about threshold values of insulin resistance in Turkey. This cross-sectional investigation was planned to provide credible data on the prevalence of IR and identify optimal threshold values for HOMA1-IR and HOMA2-IR in the adult population of the middle Black Sea region of Turkey.

Material and Methods

The study was carried out using collected samples from "Prevalence of Chronic Diseases in Adults in Tokat Province" (TEKHAP) study. The study was approved by the Gaziosmanpaşa University Faculty of Medicine Ethical Committee (Approval number: 13-KAEK-024). Our study was also approved by the Gaziosmanpaşa University Faculty of Medicine Ethical Committee (Approval number: 14-KAEK-043). Detailed information about the study was made each participant and written informed consent was also provided. This study was conducted in accordance with the Helsinki declaration.

Study centers and case selection

The TEKHAP study was carry out in the city of Tokat, which is located in the northern Anatolian region. According to the report of Turkish Statistical Institute, the population of Tokat was 598,708 in 2013; 59% of the population lived in urban areas and 41% in rural areas. The adult population of Tokat, defined as those aged 20 or older, was 412,653 and they were selected as the target population of the study. At least 2635 people were selected as a number of people to represent the population with using the PASS 11.0.8 package program, when the estimated prevalence rate for chronic illnesses were 50%, confidence level was 97%, deviation was 0.05, and effect size was 2%. When the estimated prevalence for IR was 30%, at least 790 people were found to be sufficient to include in the study in this population.

Because of the Republic of Turkey is registered in the Family Medicine Program (FMP), free-of-charge and offering each Turkish people to find a specific family physician, this units were used to recruit the study participants. There were a total of 170 units of FMP in the city of Tokat and 85 (50%, 52 urban and 33 rural) were selected in a manner that reflects the population pyramid and demographic characteristics of the city. The number of FMPs to be included in the survey and the number of people to be taken from each FMP were determined by multi-layer proportional cluster sampling method in accordance with Tokat provincial population pyramid considering the size of urban and rural settlements, gender and age groups. The number of clusters was proportional to the size of urban and rural settlements of provincial centers and districts. Using the quota sampling method in the intracluster sample, the number of individuals corresponding to the determined gender and age groups was provided for the study. Therefore, the number of people to include the study were planned as 2635 (1345 women and 1290 men; 1515 in urban area and 1120 in rural area; 1123 in 20-39 age, 1104 in 40-64 age and 408 65 years and over). The participants were randomly chosen men and women, aged 20 or older, who were being participants of the FMP units. A 10% substitute group was also recruited from each FMP units for to complete the missing number of individuals due to refusing to participate in the survey, not being able to find at the address, and not meeting the criteria. Blood samples obtained from the TEKHAP trial, those with insufficient quantities, impaired blood samples, and those with insufficient test reliability were removed from our study and remaining 2013 individuals were included in the study. The removed samples were found to be scattered throughout the population and the number of cases included the study was well beyond the required number for this study.

Study protocol

The selected individuals were seen at the units of FMP early in the morning after an overnight fast. The participants' examinations were performed by two internal medicine specialists. At least 10h of fasting was provided and the others were excluded from the analysis. Peripheral blood samples were obtained from all participants. Plasma was separated by centrifugation (1500g for 10 minutes at 4°C). The plasma was transferred to clean test tubes and stored at +4°C, then transferred to a −70°C unit at the end of the day until further analysis could be performed.

Laboratory analysis was performed for plasma glucose (FPG), creatinine, lipid profile (LDL-cholesterol, HDL-cholesterol, and triglycerides), insulin, C-peptides, HbA1c, hepatic markers such as AST and ALT, vitamin B12, and folic acid values. Fasting capillary blood glucose was also measured.

Anthropometric measurements

Experienced health technicians measured the anthropometrical characteristics of the subjects. Body weight was measured in kilograms and height was measured in meters. Waist circumference was assessed at the midpoint between the lowest rib and the iliac crest at the end of a normal expiration. The World Health Organization (WHO) recommendation was used for calculation and classification of body-mass index (BMI)9. Blood pressure measurements were performed after at least five minutes rest of the participants on the upper left arm via an indirect method, using a manual cuff and sphygmomanometer. Systolic blood pressure (sBP) >140 mmHg and diastolic blood pressure (dBP) >90 mmHg and/or the current intake of antihypertensive drugs were accepted as hypertension. Previously known DM was accepted as a diagnosis if self-reported or if the patient was on regular anti-diabetic medication. In cases in which participants self-reported DM, but denied regular anti-diabetic treatments, diagnosis was confirmed through further tests. Expert committee recommendations were used in classification of DM[10]. The MetS was defined using the International Diabetes Federation criteria[11].

Calculation of HOMA1-IR and HOMA2-IR

HOMA1 values were calculated using the following formula first described by Matthews et al.12: HOMA1 = fasting plasma insulin (μU/ml) x fasting plasma glucose (mmol/L)/22.5. HOMA2 values were obtained by the program HOMA Calculator v2.2.3. The 90th percentile value of the non-diabetic and non-obese participants was used as threshold values for HOMA1-IR and HOMA2-IR. Because the HOMA2-IR models the feedback relationship between insulin and glucose in the various organs in the body[13], it is considered a more accurate representation of the metabolic process and so was used in further analysis for determining IR prevalence in the region.

Statistical analysis

Definitive statistics were expressed as percentage and mean ± standard deviation (minimum-maximum); the Chi-square and Fisher's exact tests were used in the comparison of the data obtained with counting; and the Student's t-test was used for the comparison of data obtained by measurements. The values of $p<0.01$ were considered as statistically significant. Statistical analysis was performed using SPSS v. 19, SPSS Inc., Somers, NY). A multivariate logistic regression model was implemented to determine risk factors associated with insulin resistance.

The HOMA1-IR and HOMA2-IR were determined from the 90th percentiles of non-obese and non-diabetic population. Therefore, 749 (38.7%) obese participants and 708 (36.6%) overweight participants were excluded. Forty five diabetic patients of remaining 479 participants were also excluded. Of the remaining 448 participants, age-matched 197 participants included the analysis to identify optimal threshold values for HOMA1-IR and HOMA2-IR (table 1). Selection was made randomly in accordance with the general population age distribution percentages. There was no difference between selected group (197 people) and others (1816 people) in terms of age (46.4±14.9 vs. 47.3±15.2 respectively, $p=0.454$).

Table 1. Determination of optimal threshold values of HOMA1-IR and HOMA2-IR

Percentiles	HOMA1	HOMA2
10	0.4701	0.3700
20	0.6135	0.4200
25	0.7017	0.4400
30	0.7464	0.4700
40	0.8766	0.5520
50	1.1013	0.6400
60	1.2447	0.7280
70	1.4736	0.8760
75	1.6189	0.9750
80	1.7581	1.1000
90*	2.4593	1.4020

* The values of 90^{th} percentile of non-obese and non-diabetic population were chosen.

Results

In total, 2013 subjects aged 20–84 years were enrolled in this study; 1180 (58.6%) participants lived in urban areas and 833 (41.4%) in rural areas. The mean age of the participants was 47.2±15.2 years and 56.6% were female. Obesity was higher in women (47.4%) compared to men (28.5%). Nearly one-quarter (23.5%) of the population had a high school education or above, but 17.6% had no formal education. Over half (51.8%) had an income below USD 500. A more detailed presentation of the main characteristics of the studied population is shown in table 2.

Table 2. General features of the studied population by gender

	Women *n:1139 (56.6%)*	Men *n:874 (43.4%)*	Total *n:2013 (100%)*
Age (year)	46.7±15.1	47.9±15.4	47.2±15.2
Height (cm)	156.5±6.6	169±7.2	162.3±9.5
Weight (kg)	73.4±14.9	79.6±14.4	76.1±15.0
Waist (cm)	93.4±13.7	95.4±12.3	94.2±13.1
WHR	109.2±12.4	102.9±8.7	106.5±11.4
BMI (kg/m^2)	30.0±6.1	27.5±4.5	28.9±5.6
sBP (mmHg)	124.7±23.1	123.3±22.5	124.1±22.9
dBP (mmHg)	77.3±13.1	77.0±13.0	77.2±13.0
DM	220 (19.3)	127 (14.5)	347 (17.2)
HT	490 843.4)	293 (34.0)	783 (39.3)
MetS	337 (32.8)	194 (22.3)	567 (28.3)
Smoking			
Current user	94 (8.3)	304 (34.8)	398 (19.8)
Ex-smoker	64 (5.6)	271 (31.0)	335 (16.6)
Alcohol			
Current user	22 (1.9)	156 (17.8)	178 (8.8)
No-user	1117 (98.1)	718 (82.2)	1835 (91.2)
Settlements			
Rural	484 (42.5)	349 (39.9)	833 (41.4)
Urban	655 (57.5)	525 (60.1)	1180 (58.6)
Marital status			
Married	979 (86.0)	770 (88.1)	1749 (86.9)
Single or widowed	160 (14.0)	104 (11.9)	264 (13.1)
BMI categories			
Lean	11 (1.0)	8 (0.9)	19 (0.9)
Normal	230 (20.2)	244 (27.9)	474 (23.5)
Over weight	358 (31.4)	373 (42.7)	731 (36.3)
Obese	540 (47.4)	249 (28.5)	789 (39.2)
Education			
Illiterate or literate, but no formal education	301 (26.4)	53 (6.1)	354 (17.6)
Formal education under high school	674 (59.2)	512 (58.6)	1186 (58.9)
High school or above	164 (14.4)	309 (35.4)	473 (23.5)
Income status			
<500 $	634 (55.7)	409 (46.8)	1043 (51.8)
500-1000 $	333 (29.2)	284 (32.5)	617 (30.7)
>1000 $	172 (15.1)	181 (20.7)	353 (17.5)

The optimal threshold value for IR was 2.46 for HOMA1-IR and 1.40 for HOMA2-IR. The IR prevalence was 34.5% and 33.2% according to HOMA1-IR and HOMA2-IR methods, respectively. The comparison of demographic and biochemical parameters of cases with respect to insulin resistance is presented in table 3. The IR prevalence was higher in women (35.6%) compared with men (30.1%) [p=0.009]. The average BMI was higher in the IR+ group (31.8) than the IR- group (27.5) [p<0.001]. Figure 1 shows a weak positive correlation between IR and BMI (r=0.210; p<0.001). The prevalence of IR in comparisons age groups with geographic localizations is shown in figure 2 for women and figure 3 for men. A larger IR prevalence was found in participants in urban areas compared with those in rural areas (p=0.011). Further analyses determined that the difference was significant only in the men (p=0.001), not in the women (p=0.489).

Table 3. General features of the studied population by insulin resistance situation calculated by HOMA2-IR.

	Insulin resistance (+) *n:669 (33.2%)*	Insulin resistance (-) *n:1344 (66.8%)*	p
Age (year)	49.7±14.2	45.9 ±15.6	<0.001
Gender			
Female	406 (35.6)	733 (64.4)	0.009
Male	263 (30.1)	611 (69.9)	
DM , n (%)	200 (57.6)	147 (42.4)	<0.001
HT, n (%)	338 (43.2)	445 (56.8)	<0.001
MetS, n (%)	332 (58.6)	235 (41.4)	<0.001
Glucose (mg/dl)	114.2±51.5	91.1±25.6	<0.001
Insulin (µU/ml)	20.2±19.1	6.3±2.4	<0.001
C-peptide (ng/ml)	3.6±1.6	1.9±0.6	<0.001
HDL-C (mg/dl)	46.9±11.6	52.3±13.6	<0.001
LDL-C (mg/dl)	130.0±36.4	121.4±35.3	<0.001
TG (mg/dl)	167.3±97.7	117.8±75.0	<0.001
Hemoglobin (mg/dl)	13.5±1.5	13.4±1.7	0.586
sBP (mmHg)	129.0±23.1	121.7±22.4	<0.001
dBP (mmHg)	79.9±13.1	75.8±12.8	<0.001
Height (cm)	162.0±9.6	162.5±9.5	0.221
Weight (kg)	83.3±14.6	72.6±13.9	<0.001
Waist (cm)	100.6±11.8	91.1±12.5	<0.001
WHR	0.90±0.08	0.88±0.08	<0.001
BMI (kg/m^2)	31.8±5.5	27.5±5.1	<0.001
Alcohol, n (%)	49 (28)	129 (72)	0.096
Smoking, n (%)			
Non-smoker	446 (67)	834 (62)	0.323
Current	107 (16)	291 (22)	
Ex-smoker	116 (17)	219 (16)	
Education, n (%)			
Illiterate or literate, but no formal education	141 (21)	213 (16)	0.069
Formal education under high school	372 (56)	814 (61)	
High school or above	156 (23)	317 (24)	
Income status, n (%)			
<500 $	308 (46)	735 (55)	<0.001
500-1000$	224 (34)	393 (30)	
>1000$	137 (21)	216 (16)	
Marital status, n (%)			
Married	587 (88)	1162 (87)	0.769
Single or widowed	82 (12)	182 (13)	

HT, hypertension; DM, diabetes mellitus; MetS, metabolic syndrome; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglycerides; sBP, systolic blood pressure; dBP, diastolic blood pressure; WHR, Waist-hip ratio; BMI, body mass index.
The HOMA2-IR was used to determine insulin resistance rate.

A multivariate logistic regression analysis was also conducted using insulin resistance as the independent variable, and age, gender, settlements, DM, HT, MetS, glucose, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglycerides, sBP, dBP, weight, waist, WHR, BMI, alcohol consumption, educational status, and income status associated with insulin resistance. After adjusting the related factors, female gender, increased level of serum glucose, decreased level of high-density lipoprotein cholesterol, increased level of triglycerides, increased BMI, and high income status had statistically significant increased risk of IR. The results of the multivariate logistic regression analysis are presented in Table 4.

Table 4. Results of multivariate logistic regression analysis for Insulin resistance

	β	S.E.	p	Odds ratio	95% CI for Odds ratio	
					Lower	Upper
Age	-0.003	0.005	0.599	0.997	0.987	1.008
Gender	-0.579	0.201	**0.004**	0.560	0.378	0.831
Settlements (urban vs. rural)	-0.131	0.116	0.259	0.877	0.698	1.102
DM	-0.105	0.187	0.575	0.901	0.624	1.299
HT	-0.121	0.186	0.515	0.886	0.616	1.275
MetS	0.264	0.160	0.100	1.302	0.951	1.782
Glucose (mg/dl)	0.015	0.002	**<0.001**	1.015	1.010	1.019
HDL-C (mg/dl)	-0.017	0.006	**0.002**	0.983	0.972	0.994
LDL-C (mg/dl)	0.000	0.002	0.992	1.000	0.997	1.003
TG (mg/dl)	0.003	0.001	**0.002**	1.003	1.001	1.004
sBP (mmHg)	-0.007	0.200	0.971	0.993	0.671	1.468
dBP (mmHg)	0.074	0.062	0.236	1.077	0.953	1.217
Weight (kg)	0.017	0.010	0.084	1.017	0.998	1.038
Waist (cm)	0.015	0.011	0.192	1.015	0.993	1.038
WHR	1.034	1.162	0.373	2.813	0.289	27.411
BMI (kg/m^2)	0.057	0.026	**0.026**	1.059	1.007	1.113
Alcohol consumption	-0.223	0.207	0.281	0.800	0.534	1.200
Education			0.457			
Formal education under high school	0.036	0.167	0.827	1.037	0.748	1.438
High school or above	0.241	0.237	0.310	1.272	0.800	2.024
Income status			**0.001**			
500-1000$	0.254	0.132	0.055	1.289	0.994	1.671
>1000$	0.634	0.177	**<0.001**	1.885	1.332	2.668

Reference status of categorical variables: female for gender; normal for DM; normal for HT; normal for MetS; non-user for alcohol consumption; illiterate or literate, but no formal education for education; <500 $ for income status. P< 0.05 was considered statistically significant and marked as bold.

Discussion

The present study shows that, for the Turkish population, the optimal cut-off values for HOMA1-IR and HOMA2-IR were 2.46 and 1.40, respectively. Using the HOMA2-IR methods, the IR prevalence in the middle Black Sea region of Turkey was 33.2%. The IR prevalence was higher in women and geographic localization has no significant effect on this population. There was a lower rate of insulin resistance in males living in rural areas. Overall, there was a weak positive correlation between BMI and IR prevalence. There was also a higher prevalence of IR in those with better income, increased serum level of triglycerides, and decreased serum level of high-density lipoprotein cholesterol.

Poor people are expected to work in jobs that require more physical activity for their nutritional expenditure.

On the contrary, rich people work in jobs that require less physical power and reach more daily calories easily. As a result, the body mass rate can increase as the income level increases. We found in our study that higher BMI and income status significantly related with increased IR. Over the past two decades, the prevalence of diabetes has increased dramatically in Turkey. The TURDEP-I and TURDEP-II studies, which surveyed the same population, clearly document that diabetes prevalence rose from 7.2% to 13.7% in 12 years. TURDEP-II shows that, in 2013, the crude prevalence of diabetes was 16.5%[3]. The main difference in the two studies was that the obesity rate had increased by 40%. The present study is not a part of TURDEP-I and also not follow-through study of TURDEP-II. These studies are conducted in all over the country and we gained data about the changes in the metabolic profile of population within a decade. However, this epidemiologic study was conducted only in a city of Tokat with reflects the population pyramid and demographic characteristics of the city and aiming the evaluate HOMA1-IR and HOMA2-IR values of the population. Our study also confirmed the finding that the rate of obesity in the middle Black Sea region of Turkey was 39.2%. BMI averages in TURDEP-I, TURDEP-II, and our study were 25.5, 27.4, and 27.5 in men and 27.5, 29.2, and 30.0 in women, respectively. Therefore, our study also confirms an increase in BMI in both women and men in the country.

Insulin resistance is the first step on the path toward non-insulin-dependent diabetes mellitus (type 2 DM). To the best of our knowledge, this study was the first to evaluate the prevalence of IR in Turkey. We have found that the crude prevalence of IR was 33.2% in adult participants. A cut-off value of 1.40 for HOMA2-IR, determined from the 90th percentile of the non-obese and non-diabetic population, was used to find the IR prevalence. Because the HOMA2-IR is a newer method of calculation, most of the data on the IR rates of many countries is based on HOMA1-IR values. Our study found an IR rate of 34.5% using HOMA1-IR methods, with a threshold of 2.46. This value is compatible with literature data. Evaluating non-obese and non-diabetic patients, the optimal cut-off values for HOMA1-IR, determined from the 90th percentile criteria, were 2.7 in Brazil 14, 2.77 in Italy[15], 2.33 in Portugal[16], and 2.48 in Iran[17]. In contrast, the threshold was 1.55 in Thailand[18] and 3.8 in France[19] and Spain[20]. The lowest prevalence of IR was 17%, in Denmark[21], and one of the highest IR prevalence rates in the literature, 51%, was in Iran[17]. Arbitrary cut-offs or the utilization of IR-assessing methods different from HOMA2-IR may contribute to these disparities.

Socio-demographic factors have an effect on IR. Indeed, differing genetic, epigenetic, and sociocultural factors are important determinants of insulin sensitivity[22]. Dietary differences also have an effect on IR; a plant-based, low-fat dietary pattern has a protective effect against its development[23]. It is interesting that family income and parental education are inversely associated with insulin resistance in Danish children but are positively associated with insulin resistance in Estonian and Portuguese children[24]. This shows that increasing income and educational levels produce different changes in personal health across various cultures. In our study, increased income status was inversely associated with the prevalence of IR, but there was no significant association between education and IR. This may be because low-income people in Turkey live primarily in rural areas, and these people usually work in jobs that require physical strength. Our study also showed that IR prevalence was lower in men who live in rural areas compared to their counterparts in urban areas.

Habits such as smoking and alcohol consumption have an effect on type 2 DM[25-26]. The results of a European meta-analysis showed that moderate alcohol consumption is associated with a lower risk of type 2 diabetes amongst women only[27]. The study suggests this risk reduction may be related to fat distribution. Although there are conflicting results in the literature regarding the effects of smoking on insulin resistance[28-30], a recent multicenter study concluded that smoking habits were not independently associated with insulin sensitivity in a healthy middle-aged European population[31]. Although our study showed that the proportion of individuals who smoke and use alcohol was higher in the group with IR, there was no statistically significant difference between these habits and IR.

A lack of awareness about diabetes is one of the reasons that the fight against the disease has been unsuccessful[32]. A recent report suggests that the reason for the sharp increase of diabetes in Turkey is related to lifestyle changes and rapid industrialization[33]. There is increasing evidence to show that lifestyle changes such as modern eating habits and lack of activity can cause increased prevalence of both IR and type 2 D[34-36]. Our results are similar to those found by the TURDEP-II study 3; the prevalence of DM in the middle Black Sea region of Turkey was 17.2%, and the rate was higher in women (19.3%) compared with men (14.5%). While our study did not survey participants' food choices or activity levels, these might be topics to be addressed in a future study on IR.

Conclusion

This article outlines the results of a population-based study in which the prevalence of IR and its relation to social and demographic variables were analyzed for the first time in the middle Black Sea region of Turkey. Moreover, this study is the first attempt in Turkey to identify the optimal threshold values for insulin resistance in both HOMA1-IR and HOMA2-IR. Increasing community and individual awareness about insulin resistance will help Turkey combat its rising prevalence of DM.

Acknowledgements

The study was approved by the Gaziosmanpaşa University Faculty of Medicine Ethical Committee (approval number: 14-KAEK-043) and it was supported by Gaziosmanpaşa University Scientific Research Projects Commission (Project No: 2014/17).

Funding source

This work was supported by Gaziosmanpaşa University Scientific Research Projects Commission (Project No: 2014/17).

Declaration of interest

None.

Conflict of interest

The authors state that there is no conflict of interest.

References

1. Martin BC, Warram JH, Krolewski AS, Bergman RN, Soeldner JS, Kahn CR. Role of glucose and insulin resistance in development of type 2 diabetes mellitus: results of a 25-year follow-up study. *Lancet* 1992;340(8825):925-9.
2. Bermudez V, Salazar J, Martinez MS, Chavez-Castillo M, Olivar LC, Calvo MJ, et al. Prevalence and Associated Factors of Insulin Resistance in Adults from Maracaibo City, Venezuela. *Adv Prev Med* 2016;2016:9405105.
3. Satman I, Omer B, Tutuncu Y, Kalaca S, Gedik S, Dinccag N, et al. Twelve-year trends in the prevalence and risk factors of diabetes and prediabetes in Turkish adults. *Eur J Epidemiol* 2013;28(2):169-80.
4. Satman I, Yilmaz T, Sengul A, Salman S, Salman F, Uygur S, et al. Population-based study of diabetes and risk characteristics in Turkey: results of the turkish diabetes epidemiology study (TURDEP). *Diabetes Care* 2002;25(9):1551-6.
5. Gutch M, Kumar S, Razi SM, Gupta KK, Gupta A. Assessment of insulin sensitivity/resistance. *Indian J Endocrinol Metab* 2015;19(1):160-4.
6. Radziuk J. Homeostastic model assessment and insulin sensitivity/resistance. *Diabetes* 2014;63(6):1850-4.
7. Levy JC, Matthews DR, Hermans MP. Correct homeostasis model assessment (HOMA) evaluation uses the computer program. *Diabetes Care* 1998;21(12):2191-2.
8. Tang Q, Li X, Song P, Xu L. Optimal cut-off values for the homeostasis model assessment of insulin resistance (HOMA-IR) and pre-diabetes screening: Developments in research and prospects for the future. *Drug Discov Ther* 2015;9(6):380-5.
9. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ *Tech Rep Ser* 2000;894:i-xii, 1-253.
10. Genuth S, Alberti KG, Bennett P, Buse J, Defronzo R, Kahn R, et al. Follow-up report on the diagnosis of diabetes mellitus. *Diabetes Care* 2003;26(11):3160-7.
11. Alberti KG, Zimmet P, Shaw J. Metabolic syndrome--a new world-wide definition. A Consensus Statement from the International Diabetes Federation. *Diabet Med* 2006;23(5):469-80.
12. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. *Diabetologia* 1985;28(7):412-9.
13. Wallace TM, Levy JC, Matthews DR. Use and abuse of HOMA modeling. *Diabetes Care* 2004;27(6):1487-95.
14. Geloneze B, Vasques AC, Stabe CF, Pareja JC, Rosado LE, Queiroz EC, et al. HOMA1-IR and HOMA2-IR indexes in identifying insulin resistance and metabolic syndrome: Brazilian Metabolic Syndrome Study (BRAMS). *Arq Bras Endocrinol Metabol* 2009;53(2):281-7.
15. Bonora E, Kiechl S, Willeit J, Oberhollenzer F, Egger G, Targher G, et al. Prevalence of insulin resistance in metabolic disorders: the Bruneck Study. *Diabetes* 1998;47(10):1643-9.
16. Timoteo AT, Miranda F, Carmo MM, Ferreira RC.

Optimal cut-off value for homeostasis model assessment (HOMA) index of insulin-resistance in a population of patients admitted electively in a Portuguese cardiology ward. *Acta Med Port* 2014;27(4):473-9.
17. Ziaee A, Esmailzadehha N, Oveisi S, Ghorbani A, Ghanei L. The threshold value of homeostasis model assessment for insulin resistance in Qazvin Metabolic Diseases Study (QMDS): assessment of metabolic syndrome. *J Res Health Sci* 2015;15(2):94-100.
18. Do HD, Lohsoonthorn V, Jiamjarasrangsi W, Lertmaharit S, Williams MA. Prevalence of insulin resistance and its relationship with cardiovascular disease risk factors among Thai adults over 35 years old. *Diabetes Res Clin Pract* 2010;89(3):303-8.
19. Marques-Vidal P, Mazoyer E, Bongard V, Gourdy P, Ruidavets JB, Drouet L, et al. Prevalence of insulin resistance syndrome in southwestern France and its relationship with inflammatory and hemostatic markers. *Diabetes Care* 2002;25(8):1371-7.
20. Ascaso JF, Romero P, Real JT, Lorente RI, Martinez-Valls J, Carmena R. Abdominal obesity, insulin resistance, and metabolic syndrome in a southern European population. *Eur J Intern Med* 2003;14(2):101-6.
21. Friedrich N, Thuesen B, Jorgensen T, Juul A, Spielhagen C, Wallaschofksi H, et al. The association between IGF-I and insulin resistance: a general population study in Danish adults. *Diabetes Care* 2012;35(4):768-73.
22. Hasson BR, Apovian C, Istfan N. Racial/Ethnic Differences in Insulin Resistance and Beta Cell Function: Relationship to Racial Disparities in Type 2 Diabetes among African Americans versus Caucasians. *Curr Obes Rep* 2015;4(2):241-9.
23. Doostvandi T, Bahadoran Z, Mozaffari-Khosravi H, Tahmasebinejad Z, Mirmiran P, Azizi F. The association of dietary patterns and the incidence of insulin resistance after a 3-year follow-up: Tehran Lipid and Glucose Study. *Asia Pac J Clin Nutr* 2017;26(3):531-8.
24. Lawlor DA, Harro M, Wedderkopp N, Andersen LB, Sardinha LB, Riddoch CJ, et al. Association of socioeconomic position with insulin resistance among children from Denmark, Estonia, and Portugal: cross sectional study. *BMJ* 2005;331(7510):183.
25. Willi C, Bodenmann P, Ghali WA, Faris PD, Cornuz J. Active smoking and the risk of type 2 diabetes: a systematic review and meta-analysis. *JAMA* 2007;298(22):2654-64.
26. Li XH, Yu FF, Zhou YH, He J. Association between alcohol consumption and the risk of incident type 2 diabetes: a systematic review and dose-response meta-analysis. *Am J Clin Nutr* 2016;103(3):818-29.
27. Beulens JW, van der Schouw YT, Bergmann MM, Rohrmann S, Schulze MB, Buijsse B, et al. Alcohol consumption and risk of type 2 diabetes in European men and women: influence of beverage type and body size The EPIC-InterAct study. *J Intern Med* 2012;272(4):358-70.
28. Haj Mouhamed D, Ezzaher A, Neffati F, Douki W, Gaha L, Najjar MF. Effect of cigarette smoking on insulin resistance risk. *Ann Cardiol Angeiol* (Paris) 2016;65(1):21-5.
29. Henkin L, Zaccaro D, Haffner S, Karter A, Rewers M, Sholinsky P, et al. Cigarette smoking, environmental tobacco smoke exposure and insulin sensitivity: the Insulin Resistance Atherosclerosis Study. *Ann Epidemiol* 1999;9(5):290-6.
30. Wareham NJ, Ness EM, Byrne CD, Cox BD, Day NE, Hales CN. Cigarette smoking is not associated with hyperinsulinemia: evidence against a causal relationship between smoking and insulin resistance. *Metabolism* 1996;45(12):1551-6.
31. Gottsater M, Balkau B, Hatunic M, Gabriel R, Anderwald CH, Dekker J, et al. Insulin resistance and beta-cell function in smokers: results from the EGIR-RISC European multicentre study. *Diabet Med* 2017;34(2):223-8.
32. Buyukkaya Besen D, Arda Surucu H, Kosar C. Self-reported frequency, severity of, and awareness of hypoglycemia in type 2 diabetes patients in Turkey. *Peer J* 2016;4:e2700.
33. Burki T. Country in Focus: diabetes prevalence on the rise in Turkey. *Lancet Diabetes Endocrinol* 2016;4(5):391-2.
34. Corpeleijn E, Saris WH, Blaak EE. Metabolic flexibility in the development of insulin resistance and type 2 diabetes: effects of lifestyle. *Obes Rev* 2009;10(2):178-93.
35. Hivert MF, Christophi CA, Franks PW, Jablonski KA, Ehrmann DA, Kahn SE, et al. Lifestyle and Metformin Ameliorate Insulin Sensitivity Independently of the Genetic Burden of Established Insulin Resistance Variants in Diabetes Prevention Program Participants. *Diabetes* 2016;65(2):520-6.
36. Henning CH, Zarnekow N, Hedtrich J, Stark S, Turk K, Laudes M. Identification of direct and indirect social network effects in the pathophysiology of insulin resistance in obese human subjects. *PLoS One* 2014;9(4):e93860.