ARAŞTIRMA MAKALESİ / *RESEARCH ARTICLE*

Anthropometric Measurements and Analysis Results of Metabolic Parameters of Those with Impaired Fasting Glucose and Impaired Glucose Tolerance

Bozulmuş Açlık Glikozu ve Bozulmuş Glikoz Toleransı Olanların Antropometrik Ölçümleri ile Metabolik Parametrelerinin Analiz Sonuçları

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ABSTRACT

Aim: *Prediabetes is when the blood glucose level is between the normal value and the diabetes mellitus (DM) cut-off value. It is a metabolic disorder characterized by insulin resistance due to pancreatic β-cell dysfunction caused by primary or secondary causes. It is important due to the possibility of developing DM.*

Material and Method: *We aimed to compare anthropometric and metabolic parameters in prediabetics and patients who applied to the internal medicine clinic of Kafkas University Health Education and Research Hospital between 01.06.2018–01.09.2018 included. Prediabetic individuals were divided into three as impaired fasting glucose, impaired glucose tolerance, and combined.*

Results: *Of the 64 patients in our study, 35 were female, and 29 were male. While the age, body mass index (BMI), waist circumference, HBA1c, and homeostatic model assessment (HOMA) values did not differ significantly between the two genders, weight, height, hip circumference, waist/hip, and waist/height ratio showed significant difference (respectively p=0.040, p<0.001, p=0.040, p<0.001, p=0.003). When metabolic parameters were analyzed in prediabetic groups, HBA1c and HOMA-IR values showed statistically significant differences (p<0.001, p=0.004, respectively). While there was no difference in BMI and waist circumference from anthropometric parameters, hip circumference, waist/hip values, and Waist/Height ratio differed significantly between the genders (p=0.174, p=0.849, p=0.040, p<0.001, p=0.003 respectively).*

Conclusion: *In comparing anthropometric parameters with metabolic parameters in prediabetics, it is recommended that the waist/height value shows a significant difference between the metabolic parameters and HBA1c, HOMA values in the clinical follow-up and treatment of these prediabetic agents.*

Key words: *prediabetes; impaired fasting glucose; impaired glucose tolerance; anthropometric measurement*

ÖZET

Amaç: *Prediyabet, kan şekeri seviyesinin normal değer ile diabetes mellitus (DM) cut off değeri arasında olması durumudur. Primer ya da sekonder nedenlerle oluşan pankreas β hücre disfonksiyonuna bağlı insülin direnci ile karakterize metabolik bir bozukluk olup DM gelişebilmesi nedeniyle önem arzetmektedir.*

Materyal ve Metot: *Prediyabetiklerde antropometrik parametreler ile metabolik parametrelerin karşılaştırılmasını amaçladığımız çalışmamıza 01.06.2018–01.09.2018 tarihleri arasında Kafkas Üniversitesi Sağlık Eğitim ve Araştırma Hastanesi İç hastalıkları polikliniğine başvuran hastalar içerisinden çalışma kriterlerine uyan hastalar alındı. Prediyabetik bireyler bozulmuş açlık glukozu, bozulmuş glukoz toleransı ve kombine olmak üzere üç gruba ayrıldı.*

Bulgular: *Çalışmamıza dahil edilen 64 hastanın 35'i kadın, 29'u erkek idi. Cinsiyetler arasında yaş, vücut kitle indeksi (BMI), bel çevresi, HBA1c, homeostatik model değerlendirmesi (HOMA) değerleri anlamlı farklılık göstermez iken, kilo, boy, kalça çevresi, bel/kalça ve bel/boy oranı anlamlı fark göstermiştir (sırası ile p=0,040, p<0,001, p=0,040, p<0,001, p=0,003). Prediyabetik gruplarda metabolik parametreler analiz edildiğinde HBA1c ve HOMA-IR değerleri gruplar arasında istatistiksel olarak anlamlı farklılık gösterdi (sırası ile p<0,001, p=0,004). Antropometrik parametrelerden BMI ve bel çevresi açısından fark yok iken kalça çevresi, bel/kalça ve bel/boy oranı cinsiyetler arasında anlamlı farklılık gösterdi (sırası ile p=0,174, p=0,849, p=0,040, p<0,001, p=0,003).*

Sonuç: *Prediyabetiklerde antropometrik parametrelerin metabolik parametreler ile karşılaştırılmasında bel/boy değerinin, metabolik parametrelerden ise HBA1c, HOMA-IR değerlerinin gruplar arasında istatiksel olarak anlamlı bir farklılık göstermesi bu parametrelerin prediyabetiklerin klinik izleminde ve tedavisinde göz önünde bulundurulması önerilir.*

Anahtar kelimeler: *prediyabet; bozulmuş açlık glukozu; bozulmuş glukoz toleransı; antropometrik ölçüm*

Introduction

In the development of Diabetes Mellitus (DM), several pathogenic processes may result in insulin deficiency and resistance to insulin action, which occurs with autoimmune destruction of β cells. Prediabetes is a metabolic disorder characterized by insulin resistance due to β-cell dysfunction caused by primary or secondary causes. It is important because of the possibility of DM

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development. It is divided into three isolated impaired fasting glucose (IFG), isolated impaired glucose tolerance (IGT), and combined type (IFG + IGT)[1].

While insulin resistance is within normal limits in muscle tissue in IFG, hepatic insulin resistance starts, whereas, in IGT, insulin resistance is mainly in the muscles. Although the rate of progression of prediabetes to DM varies according to the population's characteristics and the prediabetic, DM develops in approximately 5–10% of prediabetic patients every year[2].

β-cell dysfunction is found in both isolated IFG and isolated IGT. In IFG, the early insulin response is severely impaired during the OGTT. The correlation between prediabetes and nephropathy, neuropathy, retinopathy, cognitive dysfunction, and macrovascular disease has been demonstrated in many studies[3,4].

Diabetic retinopathy (DR) is characterized by progressive vision loss, causes damage to retinal microvasculature, deterioration of the blood-retina barrier, and neovascularization, leading to vision loss[5].

In previous studies, the prevalence of chronic kidney disease (CKD) was found to be 17.7% in prediabetic individuals, 10.6% in those with normal blood glucose levels, independent of body mass index (BMI), and rate of stage 3 or stage 4 nephropathy among prediabetic patients with CKD was 56.2%[6]. Diabetic neuropathy develops in approximately 50% of DM patients, and the risk of neuropathic complications is similarly high in the presence of prediabetes[7].

In clinical practice, anthropometric measurements are often accepted as a practical and valuable approach in prediabetics and DM: Waist and hip circumference, body mass index (BMI), waist/hip, and waist/height ratios.

When insulin resistance increases, β cells increase insulin production to keep blood glucose levels within normal limits. If insulin resistance continues or increases, β cells will begin to be affected, and DM will develop by decreasing insulin secretion[8]. Although parameters predicting the development of DM in prediabetics were investigated in previous studies, it was tried to determine whether there was a difference between anthropometric and metabolic parameters in patients with IFG, IGT, and IFG+ IGT, rather than determining a predictive parameter in this study.

Material and Method

Thirty-five women who applied to the internal medicine outpatient clinic and met the determined study criteria, 64 patients, including 29 men, were recruited: those with fasting blood glucose of 100–125 mg/dl, those with an HBA1c value of 5.7–6.4%, those with a positive family history, those with BMI ≥30 were taken. Sufficient carbohydrates for a 75 g glucose load at least three days before the test (≥150 g/day), taking and maintaining daily routine physical activity, patients were included in the study with the recommendation of at least 8 hours of fasting. The time when glucose was started to be drunk in 250–300 ml of water was considered the beginning of the test.

Serum samples were obtained by centrifuging blood samples at 3000 rpm for 10 minutes. Serum glucose, lipid profile, HBA1c, and C-reactive protein (CRP) levels by Cobas c501 (Roche Diagnostics, Germany) autoanalyzer, insulin, ferritin, and vitamin D, parathormone, folic acid levels were studied with Unixel DXI 600 (Beckman Coulter Diagnostics, France). Complete blood counts were taken into tubes containing ethylenediaminetetraacetic acid (EDTA) and were performed with ABXPentra DX 120 device (Horiba, France). Waist circumference was 102 cm for men and 88 cm for women between the lower edges of the ribs and the iliac crest on a horizontal plane. Hip circumference was measured over the anterior superior spine iliaca. For BMI, it was taken by dividing the weight by the square meter of height (according to the Quetelet index). Normal weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2) and obese (≥30 kg/m^2) were taken.

IFG: plasma glucose was taken as 100–125 mg/dL.

IGT: After 75 g glucose load, 2nd-hour plasma glucose is 140–199 mg/dL.

Combined: IFG+ IGT

HBA1c values: 5.7–6.4% were taken as prediabetic.

For the diagnosis of DM: Fasting plasma glucose >125 mg/dL, 2nd hour after glucose load ≥200 mg/dL or HBA1c ≥6.5%.

HOMA (homeostasis model assessment)=[fasting insulin (μu/mL) × fasting plasma glucose (mg/dL)]/405 equation[1,9]. Pregnant women, those younger than 18 years of age, those with existing diagnoses of type 1 and type 2 DM, those who refused to drink 75 grams of glucose, and those who could not tolerate 75 grams of glucose solution were not included in the study.

Statistical analysis SPSS 20.0 package program was used (SPSS Inc. Chicago, USA). Mean ± standard deviation calculated for continuous variables. Homogeneity among the four defined groups was assessed using the one-way-ANOVA test and Levene statistic. Tamhane's T2 determined significance between non-homogeneous groups, Significance between homogeneously distributed groups was investigated using the Bonferroni test. For all statistical data, $p<0.05$ was considered significant.

Ethics committee approval numbered 80576354-050-99/115 was obtained by the Ethics Committee of the Medicine faculty, Kafkas University, in the session numbered 09, dated 26.06.2018.

Results

A total of 64 patients were included in our study. Of these, 54.6% were women (n=35). The mean age of our patients was 46 in women, 48 in men, the youngest age was 20, and the highest was 77. Age, and waist circumference between men and women, There was no significant difference between BMI, HBA1c, and HOMA values. However, there were statistically significant differences in weight, height, waist/hip, waist/height ratio, and hip circumference (Table 1, $p<0.05$).

Although age, weight, height, waist circumference, hip circumference, and BMI did not differ significantly between prediabetic groups, HBA1c and HOMA values showed a significant difference (Tables 2 and 3, $p<0.05$).

The mean values of waist/height and waist/hip among the groups and statistical analysis of the groups are shown in Table 4.

The distribution of anthropometric parameters according to Hb A1 c values is shown in Table 5, and in Table 6, the measurements of anthropometric parameters according to HOMA values are compared.

Discussion

Studies show that insulin secretion is continuous during the progression from normal glucose tolerance level to DM. Although an increase in glucose levels is pursued in the first years in those who develop DM, there is an increase in blood glucose levels up to 13 years before the diagnosis [10–12].

Studies have demonstrated that insulin resistance is present in the first stage of DM and that β-cell mass and insulin secretion is increased; in the next stage, following the compensatory period, the stable adaptation process begins, in which the β-cells cannot fully compensate for the increased insulin resistance. During this period, fasting and postprandial glucose levels cannot be kept at normal levels[2,13]. This stage is attended by a decrease in acute insulin secretion when fasting, postprandial glucose levels are within the normal range, and IFG levels are around 100 mg/dL[13,14]. In the last stage of DM development, that is, glucose levels begin to increase rapidly in the decompensation period as insulin resistance cannot be compensated by β-cells[13].

Endogenous glucose production products and fasting insulin are used as markers of hepatic insulin resistance and show a strong association with fasting glycemia[11,12,15].

During glucose absorption, the blood glucose level is determined by intestinal absorption, inhibition of endogenous glucose production, and total body glucose uptake. Endogenous glucose is markedly depressed in normal glucose-tolerant humans after glucose ingestion. This suppression is less in prediabetic and diabetic individuals[11,12].

Insulin resistance and impaired β-cell function are the major defects in type 2 DM and are detectable in both IGT and IFG patients. Although investigations show that insulin resistance differs between these two diseases, those with IGT have only mild hepatic insulin resistance and significant muscle insulin resistance. At the same time, those with IFG have serious hepatic insulin resistance

Table 1. *Comparison of patients' biodemographic and anthropometric measurements by gender*

	Mean ± Std.		
	Female (N: 35)	Man (N: 29)	P
Age	46±12	48±12	0.388
Weight	76±12	87±15	0.040
Height	158±4	174±6	<0.001
Waist circumference	101±11	101±12	0.849
Hip circumference	110±11	102±10	0.040
BMI	30±4	28±5	0.174
Waist/Hip	0.91±0.05	0.99±0.38	<0.001
Waist/Height	0.63±0.06	0.58±0.07	0.003
HBA1c	5.8±1.5	6.3±1.8	0.278
HOMA	2.7±1.5	2.6±1.3	0.689

HBA1 c: Hemoglobin A1C; HOMA: Homeostatic Model Assessment.

Table 2. *Distribution of variables by disease groups*

	Groups	n:	Mean ± Std.	P
Age	IFG	24	42.63±11.32	0.052
	IGT	8	45.38±14.10	
	IFG + IGT	18	51.83±13.18	
	DM	14	51.43±9.68	
Weight	IFG	24	79.38±12.76	0.451
	IGT	8	81.38±25.00	
	IFG + IGT	18	80.50±13.25	
	DM	14	87.50±15.09	
Height	IFG	24	167.29±9.24	0.267
	IGT	8	166.63±10.83	
	IFG + IGT	18	161.67±8.81	
	DM	14	167.00±11.01	
Waist circumference	IFG	24	98.46±9.20	0.096
	IGT	8	96.38±17.98	
	IFG + IGT	18	104.22±10.90	
	DM	14	106.21±11.36	
Hip circumference	IFG	24	103.13±11.22	0.246
	IGT	8	105.63±14.77	
	IFG + IGT	18	110.28±12.07	
	DM	14	108.64±10.91	
BMI	IFG	24	28.42±4.44	0.217
	IGT	8	28.89±6.39	
	IFG + IGT	18	30.74±3.86	
	DM	14	31.58±6.02	
HBA1c	IFG	24	5.42±0.41	<0.001[a]
	IGT	8	5.46±0.57	
	IFG + IGT	18	5.60±0.56	
	DM	14	8.07±2.66	
HOMA	IFG	24	2.38±0.99	0.004[a]
	IGT	8	1.76±0.72	
	IFG + IGT	18	2.62±1.33	
	DM	14	3.79±1.96	

BMI: Body mass index, HBA1 c: Hemoglobin A1C, HOMA: Homeostatic Model Assessment, IFG: Impaired Fasting Glucose, IGT: Impaired Glucose Tolerance, DM: Diabetes Mellitus.
[a]ANOVA (Analysis of Variance) was performed to determine from which groups the p values were obtained in comparing HBA1 c and HOMA levels with four different groups. Post Hoc analysis (Tamhane's T2) was performed in this test. Differences in HBA1 c were determined between DM and IFG (p=0.016), DM and IGT (p=0.018), and DM and (IFG + IGT) (p=0.026) groups.

Table 3. *Comparison of those diagnosed with prediabetes and diabetes in terms of HBA1 c and mean HOMA values (with student's T test)*

Parameter	Diagnosis	Compared diagnosis	P
Comparison in terms of HBA1c levels	IFG (HBA1 c: 5.4%)	IGT	1.000
		IFG + IGT	0.971
		DM	<0.001
	IGT (HBA1 c: 5.4%)	IFG	1.000
		IFG + IGT	0.994
		DM	<0.001
	IFG + IGT (HBA1 c: 5.6%)	IFG	0.971
		IGT	0.994
		DM	<0.001
	DM (HBA1 c: 8.0%)	IFG	<0.001
		IGT	<0.001
		IFG + IGT	<0.001
Comparison in terms of HOMA levels	IFG (HOMA: 2.3)	IGT	0.669
		IFG + IGT	0.940
		DM	0.014
	IGT (HOMA: 1.7)	IFG	0.669
		IFG + IGT	0.437
		DM	0.006
	IFG + IGT (HOMA: 2.6)	IFG	0.940
		IGT	0.437
		DM	0.077
	DM (HOMA: 3.7)	IFG	0.014
		IGT	0.006
		IFG + IGT	0.077

HOMA: Homeostatic Model Assessment – Insulin Resistance, IFG: Impaired Fasting Glucose, IGT: Impaired Glucose Tolerance, DM: Diabetes Mellitus.

Table 4. *Waist/hip and waist/height average values by disease groups*

				95% confidence interval		
Parameter	Groups	n:	Mean ± Std.	Lower limit	Upper limit	P
Waist/hip	IFG	24	0.957±0.05	0.93	0.98	0.111
	IGT	8	0.91±0.09	0.83	0.99	
	IFG+IGT	18	0.94±0.04	0.92	0.97	
	DM	14	0.97±0.06	0.94	1.01	
Waist/height	IFG	24	0.59±0.06	0.56	0.61	0.027
	IGT	8	0.57±0.08	0.50	0.65	
	IFG+IGT	18	0.64±0.06	0.61	0.68	
	DM	14	0.63±0.07	0.59	0.68	

IFG: Impaired Fasting Glucose, IGT: Impaired Glucose Tolerance, DM: Diabetes Mellitus.

Table 5. *Comparison of anthropometric parameters according to HBA1c values*

	HBA1c	n:	Mean ± Std.	P
BMI	≥6.50	12	32.2±6.6	0.058
	<6.50	52	29.2±4.4	
Waist circumference	≥6.50	12	104.3±14.1	0.363
	<6.50	52	100.8±11.2	
Hip circumference	≥6.50	12	107.0±13.9	0.913
	<6.50	52	106.5±11.6	
Waist/hip	≥6.50	12	0.9±0.06	0.170
	<6.50	52	0.9±0.06	
Waist/height	≥6.50	12	0.6±0.09	0.329
	<6.50	52	0.6±0.07	

BMI: Body Mass index.

Table 6. *Comparison of anthropometric parameters according to HOMA values*

	HOMA	n:	Mean ± Std.	P
BMI	≥2.50	30	30.7±4.6	0.177
	<2.50	34	29.0±4.6	
Waist circumference	≥2.50	30	105.1±9.3	0.020
	<2.50	34	98.3±12.9	
Hip circumference	≥2.50	30	109.3±10.8	0.093
	<2.50	34	104.2±12.6	
Waist/hip	≥2.50	30	0.96±0.05	0.218
	<2.50	34	0.94±0.07	
Waist/height	≥2.50	30	0.63±0.06	0.020
	<2.50	34	0.59±0.07	

BMI: Body mass index.

with almost normal muscle insulin sensitivity. While both IFG and IGT decrease the first phase of insulin secretion, Studies have shown that there is deterioration in late phase insulin secretion when IGT develops[16,17].

In our study, when the waist/height and waist/hip ratios were evaluated according to gender, they were statistically significantly different ($p<0.001$ and $p=0.003$). When the waist/height ratio was analyzed regardless of gender, it was found to be statistically different between IFG, IGT, and IFG+IGT groups and those with DM ($p=0.027$).

The waist/height ratio is a sensitive, inexpensive, and non-invasive measurement and can be used to predict insulin resistance[18,19]. In the study we presented, there was no significant difference between the groups when waist circumference was evaluated. And waist/height ratio with HBA1c. The small number of cases showed a positive correlation between mean BMI and insulin level in the correlation analysis performed without any group discrimination ($r^2=0.146$). In other words, the contribution of BMI to insulin elevation was found to be 14.6%.

Abdominal fat mass causes insulin resistance and pancreatic cell damage by initiating chronic inflammation in fat tissue with the extrication of cytokines like tumor necrosis factor, IL-6, and resistin, which secrete adipokines that are thought to be hormonally active and thus affect glucose tolerance[20].

The first-line treatment for prediabetics is diet and exercise. It has been shown that the risk of DM in 3 years decreases by 58% with lifestyle changes, including diet and exercise, in individuals with IGT. It has been shown that the cumulative incidence of pathologies such as blindness (39%), end-stage kidney disease (38%), amputation (35%), stroke (9%), and coronary heart disease (8%) decrease with lifestyle changes. Pharmacological treatments are only recommended for patients who cannot reach target glucose levels with lifestyle changes[21,22].

In studies, acarbose, metformin, pioglitazone, glucagon-like peptide (GLP-1), glucosidase inhibitors, and

antiobesity that orlistat, etc., drugs have been shown to reduce the risk of developing DM in prediabetic individuals[23].

Although only lifestyle change is recommended initially in individuals diagnosed as prediabetic, if IFG + IGT coexistence with a high risk of developing DM, gestational DM history, BMI ≥35, HBA1c ≥6% are present, pharmacological treatment with lifestyle changes can be considered from the beginning[21].

The association between congestive heart failure, myocardial infarction, and coronary artery disease in prediabetics has been announced in recently reported studies[24]. Parameters of metabolic syndrome can often be identified in prediabetics a few years before the diagnosis of type 2 DM. These features can transform into advanced atherosclerotic vascular changes, usually due to impaired endothelium-dependent vasodilation, vascular smooth muscle dysfunction, and increased arterial stiffness[25].

Abdominal obesity is a risk factor for heart disease, DM, hypertension, dyslipidemia, and non-alcoholic fatty liver disease, and mortality rates are higher in individuals with abdominal obesity[15].

As a result, the study found a significant difference between the waist/height ratio, HBA1c, and HOMA groups of individuals with prediabetes. In the diagnosis and follow-up of prediabetes, where insulin resistance is thought to play a primary role, the use of central obesity associated with insulin resistance and its related anthropometric parameters in the clinical follow-up of patients will be very beneficial, and it is important to delay and prevent the progression to DM.

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