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Biochemistry Section

Waist Circumference, Body Mass Index, Hip Circumference and Waist-To-Hip Ratio in type 2 diabetes patients in Gorgan, Iran

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ABSTRACT

The present study was aimed to assess the anthropometric parameters of type 2 diabetic patients.

The anthropometric parameters were determined. The data were collected from the subjects with type 2 diabetes mellitus in Gorgan, Iran.

Insulin sensitivity, waist circumference, waist to hip ratio, fasting insulin and beta cell function were higher in males than in females, but the females had a higher body fat percent and hip circumference than the males. The waist circumference was found to correlate positively and significantly with BMI, the waist to hip ratio and body fat percentage in diabetic females and males. There was a correlation between the waist circumference and hip circumference in diabetic females. The waist circumference very highly correlated with the body fat percent and the waist to hip ratio was likely to behave similarly in diabetes prediction.

The body mass index, despite having a lower correlation with waist circumference, appears to have the same ability to predict diabetes as do both the body fat percentage and the waist to hip ratio. Waist circumference appears to be a better predictor for diabetes risk than other parameters.

Key Word: Waist Circumference, BMI, Hip Circumference, Waist-To-Hip Ratio, type 2 diabetes, Gorgan

INTRODUCTION

Diabetes is a major public health problem that is approaching epidemic proportions in the whole world. This metabolic disease is one of the most common endocrine disorders affecting a nearly 6% of the world's population [1].

The prevalence of type 2 diabetes mellitus varies from 1.2% to 14.6% in Asia, 4.6% to 40% in the Middle East, and 1.3% to 14.5 % in Iran [2], [3].

The overweight condition and obesity are frequently confirmed by calculating the body mass index (BMI). Higher BMI is collaborated with a higher risk of death by cardiovascular disease [4].

This risk elevates with additional abdominal adiposity, which is measured by the waist circumference (WC) [5].

Furthermore, some researchers reported that WC was strongly collaborated with the risk factors for the insulin-resistance syndrome in women [6].

A study found that a WC of 80 cm was a simpler logical choice to BMI for health promotion [7].

The expert panels at the National Institutes of Health (NIH), in recent times, suggested a WC≥88 cm in women and a WC≥102 cm in men with BMI≥25 kg/m2, to identify the increased relative risks for obesity unhealthiness [8].

However, other researchers reported that the effects of anthropometric variables on obesity unhealthiness were also different in Whites and Blacks, and that they depended on the studied risk factors [9], [10].

They have highlighted the need to evaluate these effects in different population groups [10]. Although the dramatic worldwide increase in the incidence of obesity, and consequently, in the incidence of type 2 diabetes, has been recognized, the exact aetiological link between these remains unclear. In a study on Chinese men and women, the hip circumference was found to positively collaborate with the incidence of type 2 diabetes [11].

In that study, however, neither the waist circumference nor BMI was considered. The prevalence of obesity has increased dramatically in industrialized and developing countries [12], [13].

The world Health Organization (WHO) has recently defined obesity as a disease [14].

Abdominal or central adiposity is considered to be the most important determinant of cardiovascular disease (CVD) and type 2 diabetes mellitus (DM) [15], [16].

Body mass index (BMI), which relates weight to height, is the most widely used and simple measure of body size, and is frequently used to estimate the prevalence of obesity within a population [17], [18].

A BMI ≥ 25 Kg/m2 is associated with increased morbidity, primarily from DM and CVD, while a BMI >30 Kg/m2 is collaborated with an elevated risk for both unhealthiness and mortality, the latter resulting mainly from diabetes, coronary heart disease, and stroke [19].

BMI does not express the body fat distribution, whereas the intra abdominal deposition of adipose tissue is a major contributor to the development of abnormally high blood pressure, insulin resistance, DM and dyslipidaemia [20].

Therefore, other anthropometric indices such as waist circumference (WC) have been used as options to determine the BMI. Waist circumference is increasingly being accepted as the best anthropometric indicator of abdominal adiposity and metabolic risk [21-23].

The identification of WC to discriminate the individuals who are at a significantly elevated risk for obesity-associated risk factors, is a

valuable tool in clinical care and public health research. There are however, racial and ethnic effects on the relationship between the visceral adipose tissue and the metabolic risk factors [24], [25].

The present study was aimed to assess the anthropometric parameters of the male and female patients who were diagnosed with type 2 diabetes in Gorgan (South East of Caspian Sea), Iran.

MATERIALS AND METHODS

This study was performed in the Biochemistry and Metabolic Disorder Research Center of Gorgan (South East of Caspian Sea), Iran in 2009. We had a study group which included 200 patients of type-2 diabetes mellitus who were referred to the Department of Diabetes Center at the 5th Azar Hospital in the Golestan University of Medical Sciences. There were 122 women and 78 men. At the point of entry into the study, all the diabetic patients underwent a clinical and biochemical investigation. The data were collected by trained interviewers. The exclusion criterion was the coexistence of any other serious illness.

Type-2 diabetes mellitus was defined as nonketosis diabetes by assessing the medical history of the patient and current treatment with oral agent. None of the patients had micro vascular complications (diabetic nephropathy or retinopathy). The administration of insulin for glycaemic control was considered as an exclusion criterion. Venous blood samples were collected from all the subjects who came after a 12-h overnight fast. The samples were centrifuged for 10 minutes at 3000rpm. The serum was used for the analysis of fasting blood sugar in those who had type-2 diabetes mellitus. Fasting blood sugar levels were measured by a biochemical kit by using spectrophotometric techniques (Model JENWAY 6105 UV / VIS) at the Biochemistry and Metabolic Disorder Research Center (Faculty of Medicine).Weight was then measured, while the subjects were minimally clothed, without shoes, by using digital scales and this was recorded to the accuracy of 100g. Height was measured in the standing position without shoes by using a tape meter, while the shoulder was in a normal position. BMI was calculated as weight in kilograms, divided by height in squared meters. Those with a BMI of 25.0-29.9 Kg/m2 were classified as overweight, whilst those with a BMI ≥30 Kg/m2 were defined as obese. Subjects with a BMI greater than 45 Kg/m2 were considered as very obese [14].

Waist circumference was measured at the point halfway between the lower border of the ribs and the iliac crest in a horizontal plane [26], and hip circumference was measured at the widest level over the greater trochanters. The waist to hip ratio was calculated as the waist circumference divided by the hip circumference. Body fat content was calculated according to the method of Lean et al.[27] by using the following formula:

Body fat % for men = [(0.567 × waist circumference in cm) + (0.101 × age in years)] – 31.8

Body fat % for women = [(0.438 × waist circumference in cm) + (0.221 × age in years)] – 9.4

Insulin resistance and β cell function were derived by using the HOMA method [28] by using the following formula:

Insulin resistance (HOMA-IR) = fasting insulin (μ/ml) × fasting glucose (mmol/l) / 22.5

Beta cell function (HOMA-BF) = 20 × fasting insulin (μ/ml) / fasting glucose (mmol/l) – 3.5

The results were reported as mean± SD. The statistical analysis was done by using the SPSS- version 11.5 software. The results were evaluated by using the Independentsample 't' test and the Pearson's correlation coefficient test. Statistical significance was considered at P values <0.05.

RESULTS

The study sample consisted of 122 females and 78 males. The mean duration of diabetes mellitus in the type-2 diabetes mellitus patients was 1.5 years (range 1-3 years). The baseline characteristics of the type-2 diabetic patients by sex are shown in [Table/Fig 1]. The mean ages of the femaleand male patients among the type-2 diabetics was 53.74±9.54 and 53.51±9.49 years, respectively. A number of differences were found between the two subjects. The indices of insulin sensitivity (HOMA-IR), waist circumference, the waist to hip ratio, fasting insulin and HOMA-beta cell function were higher in males than in the female subjects (p<0.05), but the females had a higher body fat percent (p<0.05) and hip circumference than the male subjects. The males and females were of the same age, BMI and HOMA-IR (p>0.05) [Table/Fig 1].

	Females (n=122)	Males (n=78)
Age (years)	53.74±9.54	53.51±9.49
BMI (kg/m²)	32.90±3.27	32.22±2.62
Waist Circumference (cm)	93.20±10.60	102.39±10.70*
Hip Circumference (cm)	107.33±9.45	104.83±12.14
Waist to Hip ratio	0.86±0.09	0.98±0.12*
Fasting glucose (mmol/l)	10.51±6.54	9.82±2.09
Fasting insulin (μU/ml)	15.33±6.89	17.07±6.66*
Body fat (%)	43.21± 5.31	31.55±6.00*
HOMA-IR	7.01±2.99	7.47±3.49
HOMA-beta cell function (%)	50.32±27.24	60.01±33.06*
All	122	78

[Table/Fig 1]: Anthropometric and laboratory parameters of male and female type 2 diabetes mellitus subjects

*P<0.05, statistically significant

The waist circumference correlated positively and significantly with BMI, the waist to hip ratio and body fat percent in diabetic females (r=0.233, r=0.696 and r=0.892, p<0.05) and males (r=0.280, r=0.756 and r=0.931, p<0.05) (Table 2). There was a correlation between the waist circumference and the hip circumference in the diabetic females also (r=0.449, p<0.05) (Table 2).There was no correlation between the waist circumference and other parameters in diabetic males and females [insulin sensitivity (HOMA-IR), fasting insulin, fasting glucose and HOMA-beta cell function] (Table 2).There was no correlation between the waist circumference and the hip circumference in the diabetic males [Table/Fig 2].

Parameters	Male	Female
Age (years)	0.179	0.124
BMI (kg/m²)	0.280*	0.233*
Hip Circumference (cm)	0.101	0.449*
Waist to Hip ratio	0.756*	0.696*
Fasting glucose (mmol/l)	-0.039	-0.068
Fasting insulin (μU/ml)	-0.081	-0.035
Body fat (%)	0.931*	0.892*
HOMA-IR	-0.073	-0.080
HOMA-beta cell function (%)	-0.069	-0.013

[Table/Fig 2]: Correlations of waist circumference with BMI, Hip Circumference, Waist to Hip ratio, Fasting glucose, Fasting insulin, body fat percent, HOMA-IR and HOMA-beta cell function in male and female type 2 diabetes mellitus patients

*P<0.05, statistically significant

DISCUSSION

Obesity is associated with many metabolic risks; however, only few studies on obesity-related disorders have been conducted in Asia as compared to the western countries [29]. Studies in Iran have shown an increasing prevalence of obesity, which is expected to rise in the future due to increasing urbanization [30]. Most studies examining the risk of adverse health conditions which are associated with fat location have been based on data from Europe or the United States, and only little information on the lesser developed-countries are available. A recent consultation by a World Health

Organization (WHO) expert group suggested that Asians have different associations between body mass indexes, the percentage of body fat and the health risk of type 2 diabetes as compared to the European populations [31].

On the other hand, studies among other populations showed waist circumference alone [32], or together with body mass index [33], to be good predictors of type 2 diabetes mellitus. The World Health Organization [21] has explained that waist circumference is the easiest and most efficient anthropometric index to be used in many studies because it measures fatness and fat location.

In the present study, we determined waist circumference, body mass index, body fat percent, hip circumference, fasting glucose, fasting insulin, insulin resistance (HOMA-IR), HOMA-beta cell function and waist to hip ratio in males and females among the type 2 diabetic patients.

The main findings of this study are:

1. Type 2 diabetic patients had significantly increased waist circumference, body mass index, HOMA-beta cell function and fasting insulin among the males when compared to the diabetic females; but, body fat percent was significantly increased only in the diabetic females. The data on the diabetic subjects showed that the body fat percent was higher in females than in males, thus suggesting the increased adiposity of females which overrode the effect of metabolism alterations.

2. In the present study, we investigated the relationships between waist circumference and some anthropometric indices in males and females among the type 2 diabetic patients in Gorgan. Our results showed that there was a correlation between waist circumference and some of these indices. Among the anthropometric indices, waist circumference had a correlation with body mass index, body fat percent and the waist to hip ratio in both the sexes. There was also a correlation between the waist circumference and the hip circumference among the female type 2 diabetic patients. The correlation between waist circumference and body mass index, body fat percent and the waist to hip ratio were almost similar in both the sexes. None of the other indices showed any relationship with the waist circumference.

Our data showed that waist circumference would be a good predictor of diabetes in the future. The reasons for the correlation of the waist circumference with body mass index, the waist to hip ratio and body fat percent in our diabetic male and female patients and the hip circumference in the females and not in the males; were of interest. The diabetic patients in our study were obese. In the patients with type 2 diabetes in Gorgan, who were also obese, the waist circumference was not correlated with age, fasting glucose, fasting insulin, insulin secretion and insulin resistance. Several publications on the relationship between the anthropometric markers and type 2 diabetes mellitus, but with the best anthropometric index of fat location remains controversial. These controversies may be explained in part by the differences in the body composition and fat distribution among the different racial groups [10], [21], [34] and sexes [35-39]; such as, the Japanese women have a higher abnormal waist circumference than the men [40]. Many studies have found that waist circumference is strongly correlated with BMI [37], [38], [41], [44] and the percentage of body fat [42], [43].

In a study, when hip circumference was modeled alone, no significant association was found with diabetes in both men or women; after adjustment for age, body mass index, and waist circumference, a greater hip circumference was found to be associated with the reduced odds of developing diabetes [44], but this was not in agreement with our results when compared to the diabetic females. Some researchers have suggested that the abdominal fat localization is more important than the total amount of body fat or subcutaneous adipose tissue in the prediction of type 2 diabetes. They also reported that the predictive effect of the waist circumference was equal to the combined effect of the waist circumference and the body mass index [45]. Ford et al.[46] showed the role of waist circumference as a measure of obesity to predict health risk. Their arguments were that waist circumference has been shown to be a good or better predictor than the body mass index of the metabolic syndrome, diabetes, cardiovascular disease, and all-cause mortality; it provides information about the health risk. However, others have noted that the substitution of body mass index by waist circumference as an indicator of the risk for diabetes may be an oversimplification [47], [48].

Many counterarguments which exist are that, waist circumference is strongly correlated to body mass index [45], [46], [50], [51]; waist circumference does not differentiate between subcutaneous fat and visceral fat; it has not been shown that a consistent association exists between waist circumference and visceral fat after the adjustment for body mass index; and that the body fat distribution was different across different races and sexes [47], [49], [52-54].

In the present study, the waist circumference was found to have a weaker correlation with the body mass index than the body fat percent and the waist to hip ratio in the male and female diabetic patients. Stevens et al. [55] showed that the waist circumference had a better discriminatory performance for diabetes than did the body mass index or the waist to hip ratio. However, more recently, the waist circumference alone has been suggested as being a more practical measure of intra-abdominal fat mass and the total body fat. Indeed, waist circumference had been found in some studies to be more closely correlated with the level of abdominal visceral adipose tissue than was the waist to hip ratio [56-58].

The Framingham study suggested that the waist predicted mortality better than other anthropometric measures [59]. Waist circumference was also found to be associated with diabetes, stroke and coronary heart disease [60].

It is reported that waist circumference is the best anthropometric correlate of the amount of visceral adipose tissue [56]. A longitudinal study revealed that the change in waist was a better predictor of the change in the visceral adipose tissue [61].

Waist circumference captures information on the general as well as the abdominal obesities, including both the abdominal subcutaneous fat and the visceral adipose tissue [62].

The measure of obesity that takes into account the increased risk of obesity related illnesses because of the accumulation of abdominal fat is desirable. An increased waist circumference is most likely to be associated with elevated risk factors because of its relationship with visceral fat accumulation, and the mechanism may involve an excessive exposure of the liver to fatty acids [63].The abdominal visceral adipose tissue deposition is associated with an increase in the portal free fatty acid concentration, which leads to plasma disturbances such as hyperinsulinaemia [56, 64].

Thus, waist circumference reflects total body fat (BMI) and abdominal fat distribution [65-66]. In conclusion, the present study demonstrated consistently strong associations of the waist circumference, body mass index and the waist to hip ratio in both the sexes (and hip circumference in females) with type 2 diabetes. Waist circumference was very highly correlated with body fat percent and the waist to hip ratio likely to behave similarly in diabetes prediction. The body mass index, despite a lower correlation with the waist circumference, appears to have the same ability to predict diabetes as do both the body fat percent and the waist to hip ratio. Waist circumference appears to be a better predictor for diabetes risk than other parameters.

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