ejpmr, 2015,2(3), 545-555

SJIF Impact Factor 2.026

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH
www.ejpmr.com

Research Article
ISSN 3294-3211
EJPMR

RELATIONSHIP OF BLOOD GLUCOSE LEVELS WITH ANTHROPOMETRIC INDICES

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Article Received on 28/03/2015 Article Revised on 18/04/2015 Article Accepted on 10/05/2015

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ABSTRACT

Background: Anthropometric measurements such as waist circumference, hip circumference and waist-hip ratio give risk information on diabetes mellitus. However, there are mixed reports on the relationship of these anthropometric indices with the levels of glucose in the blood. **Objective:** The objective of this study was to determine the relationship between random blood glucose levels with BMI, waist circumference, hip circumference, and waist-hip ratio among females. **Methods:** We carried out a cross-sectional descriptive study of 528 subjects aged >18years using random sampling technique. Data were collected with a structured questionnaire. Subjects were measured for waist circumference and hip circumference; the waist-hip ratio was calculated. Estimation of blood glucose concentration was carried out using glucometer. **Statistical Analysis:** SPSS Statistic 17 for statistical processing. Means and standard deviations were calculated for each variable using descriptive statistics. **Results:** Subjects consisted of 528 females, the mean age was 39±5.97yrs, average BMI 25.54 ±6.28kg/m2, mean Random Plasma glucose level (RPGL) was 101.99(±26.87) mg/dl. The range (median) of the visceral fat, hip circumference and waist-hip ratio of the subjects were 97cm±46.5, 97cm±9.76 and 0.8±9.76 respectively. There were positive relationship between blood glucose levels with waist circumference (r=0.1, P=0.004) and waist-hip ratio (r=0.1, P=0.002). There was no relationship between blood glucose levels and hip circumference (r=0.0, P=0.13). **Conclusion:** We found positive relationship between the random blood glucose levels with waist circumference and waist-hip ratio in this study. Therefore, waist circumference and waist-hip ratio would be good predictors of diabetes mellitus among rural adults.

KEYWORDS: Diabetes mellitus, Blood glucose levels(BGL),BMI, Waist-hip ratio, waist circumference, Hip circumference.

INTRODUCTION

Anthropometric indexes such as waist circumference, hip circumference and waist-hip ratio are anthropometric measurements that could give risk information on diabetes mellitus . Waist circumference, hip circumference and waist-hip ratio have been shown to be positively predictive of type 2 diabetes mellitus.[1] Fatty acids which constitutes the body fat contents can be synthesized from simple carbohydrate such as glucose; thus, an increase in blood glucose levels have been associated with increase in lipid biosynthesis (lipogenesis) resulting in changes in anthropometric indexes.[2] Thus, it would be beneficial to assess the relationship of these anthropometric measurements with the levels of glucose in the blood because of its use in the diagnosis of diabetes mellitus. Therefore, the objective of the study was to determine the relationship of blood glucose levels with waist circumference, hip circumference, and waist-hip ratio and BMI among female adults in Ha'il region.

Overview of Anthropometry

Anthropometry involves the external measurement of morphological traits of human beings. It has a widespread and important place in nutritional assessment, and while the literature on anthropometric measurement and its interpretation is enormous, the extent to which measurement error can influence both measurement and interpretation of nutritional status is little considered. [3]

Anthropometric measurements are measurements that measure a person's body fat. To do this, they measure different parts of the body, including height, weight, and skinfold thickness, and the bodily circumference at the waist, hip, and chest. These measurements will give the examiner an accurate assessment of a person's body mass index (BMI).[4]

Obesity is associated with an increased risk of developing insulin resistance and type 2 diabetes. In obese individuals, adipose tissue releases increased amounts of non-esterified fatty acids, glycerol, hormones, pro-inflammatory cytokines and other factors that are involved in the development of insulin resistance.[5]

The term "insulin resistance" usually connotes resistance to the effects of insulin on glucose uptake, metabolism, or storage. Insulin resistance in obesity and type 2 diabetes is manifested by decreased insulin-stimulated glucose transport and metabolism in adipocytes and skeletal muscle and by impaired suppression of hepatic glucose output.[6]

Visceral and central abdominal fat and waist circumference show a strong association with type 2 diabetes.[7] Overweight people with large waists have the same or higher risks of eventually developing type 2 diabetes as obese individuals.[8]

Hip circumference, height and risk of type 2 diabetes relationship between hip circumference and risk of T2DM in men and women. The inverse association between height and risk was significant only in women.[9] links a ate the most sugar did with type 2 diabetes sugar doesn't cause diabetes. But candy and other sugary foods contribute plenty of calories, which can lead to weight gain, and being overweight greatly increases the risk of type 2 diabetes.[10]

Visceral fat area was associated with elevated concentrations of insulin and C-peptide and with glucose intolerance before and after the oral glucose load. Concentrations of sex-hormone-binding glubolin (SHBG), as well as total and free testosterone, were negatively correlated with waist/hip circumference ratio and visceral fat area and also negatively associated with increased glucose, insulin, and C-peptide concentrations. In multiple linear regression, adjusting for age, body mass index, and visceral fat area, serum concentrations of free testosterone were still negatively correlated with glucose, insulin, and C-peptide levels.[11]

In Saudi population, there is an increased risk of diabetes and hypertension relative to BMI, starting at a BMI as low as 21 but overall there is no cutoff BMI level with high predictive value for the development of these chronic diseases, including the WHO definition of obesity at BMI of 30.[12]

It has been demonstrated that Asians have a higher percentage of body fat than Caucasians at the same BMI cut-off levels and the health risks associated with obesity occur at a lower BMI cut-off level than Caucasians.[5-12] There have been a few attempts to investigate the applicability of the WHO BMI cut-offs in Asian and Pacific populations.[12-18]

MATERIALS AND METHODS

This descriptive analytical study performed with random cluster sampling method in hail region. 528 adult females were randomly selected. After obtaining informed consent by volunteers, they were invited to participate in this study.

Questionnaire

A questionnaire included: age, sex, marital status, ethnicity, education level, family history of diabetes (DM), Hypertension (HTN) and obesity, smoking and parity and previous history of gestational diabetes Mellitus in women were filled for each person. Fasting Blood glucose level, Blood pressure, weight, height, body mass index (BMI) [Weigh(kg)/Height(m)^2], abdominal and waist circumference were measured in each participant.

Blood Pressure Assessment

Blood pressure was measured by a standard sphygmomanometer, after 15 minutes rest in a sitting position. It measured twice at least 30 minutes interval between two measurement and mean of these two measurements, was taken as blood pressure. Blood pressure was measured two times while the subject was at rest in a sitting position. The average of the two measurements was accepted if the difference between the values was less than 5 mm Hg. Measurement was taken using standardized digital sphygmomanometers with an appropriate cuff inflated to a pressure approximately 30 mm Hg greater than systolic and with the subject's arm at the level of the heart. The screening test for hypertension was considered positive if the systolic and diastolic blood pressure was ≥140 and/or ≥90 mm Hg, respectively.

Anthropometric Analysis

Anthropometric measurements were taken after removing shoes and wearing a light dress. Weight and height were measured according to the standard program. Weight was measured to the nearest 0.5 kg using standardize digital weight scales and recorded to the lowest unit without footwear and with only light clothes on. Height was measured to the nearest centimeter with the subjects barefoot and standing with the feet together, ensuring the nape, back, calves and with the ankles pressed against the measuring tape, which is part of weighing scale. Waist circumference was measured in standing position at the midpoint between the lowest rib and the upper lateral border of the right iliac crest and hip circumference at the point of maximum hip diameter, to the nearest 0.1 cm using a measuring tape.

Body Mass Index Calculation

BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2), and standard WHO cut-off values of a BMI ≥25.0 as overweight and a BMI ≥30.0 as obesity were used to define the prevalence. Using these measurements and the new WHO growth reference, the weight status of each subject was categorized: obese (z-score > +2SD, equivalent to BMI > 30 kg/m² at 19 years), overweight (z-scores > +1SD, equivalent to BMI > 25 kg/m² at 19 years), and normal weight (−2SD ≤ z-scores ≤ +1SD, equivalent to 18 ≤ 25 kg/m² < BMI ≤ 25 kg/m² at 19 years).

Blood Glucose level Assessment

After 12 h of fasting, blood samples were taken in the morning, and checked for glucose levels using a standard glucometer. Whole blood glucose concentration was measured for all participants using uniform portable glucometer machines based on reflectance photometry, where the glucose was catalytically oxidized by the glucose oxidase and peroxides enzymes with a color change reaction. A screening test was considered to be positive for hyperglycemia if Fasting Blood Glucose (FBG) was ≥100 mg/dL (≥5.6 mmol/L) after at least 8 hours of fasting or the Random Blood Glucose (RBG) was ≥140 mg/dL (≥7.8 mmol/L) taken without consideration of the time of the last meal.A FBG of 100-125 mg/dl (5.6-6.9 mmol/l) and a CRBG of 140-199 mg/dl (7.8-11 mmol/l) were considered to be consistent with impaired fasting glucose (IFG) and impaired glucose tolerance (IGT), respectively. Initial screening test was considered to be consistent with the diagnosis of diabetes if the CFBG was ≥126 mg/dl (≥7.0 mmol/l) or the CRBG was ≥200 mg/dl (≥11.0 mmol/l). Diabetes mellitus was diagnosed either by a positive history of diabetes or through the screening test.

Statistical Analysis

Data entry and analysis were done with SPSS 17(Chicago, IL, USA). The frequencies of categorical variables and means of continuous variables were determined. Cross tabulation analysis was carried out to determine the relationship blood glucose levels with waist circumference, hip circumference and waist-hip ratio. All P-values less than 0.05 were considered significant. All results are presented as mean (SD) or percentage, where applicable.

RESULTS

528 subjects were recruited for the study by the investigators. From total 528 (P = 0. participant, all were women. The mean age of all participants was 42.27 ± 14 years..Our study revealed the following findings, presented in the form of tables and figures.

Table-1 Distribution of Subjects according to Age

Age groups (years)	Frequency	Percent
18-20	216	41.0
21-24	235	44.6
25-28	22	4.2
29-32	14	2.7
33+	40	7.6

Table-1 represents the distribution of subjects according to age groups. It was found that majority of the subjects (44.6%) belonged to 21-24 years and the least (2.7%) to 29-32 years.

Table-2 Demographic and Anthropometric Profile of the Study Population

Variables	Minimum	Maximum	Mean	Std. Deviation
Age (years)	18	60	39	5.97
Height (cm)	145	176	158	5.1
Weight (kg)	35	119	63.9	16.3
BMI (kg/m^2)	14.79	50.33	25.54	6.28

Table 1 depicts the distribution of subjects according to age, height, weight and BMI. Average age of participants was 39±5.97yrs. Average height was 158 ±5.1cm; average weight was 63.9 ±16.3kg; average BMI 25.54 ±6.28kg/m2.

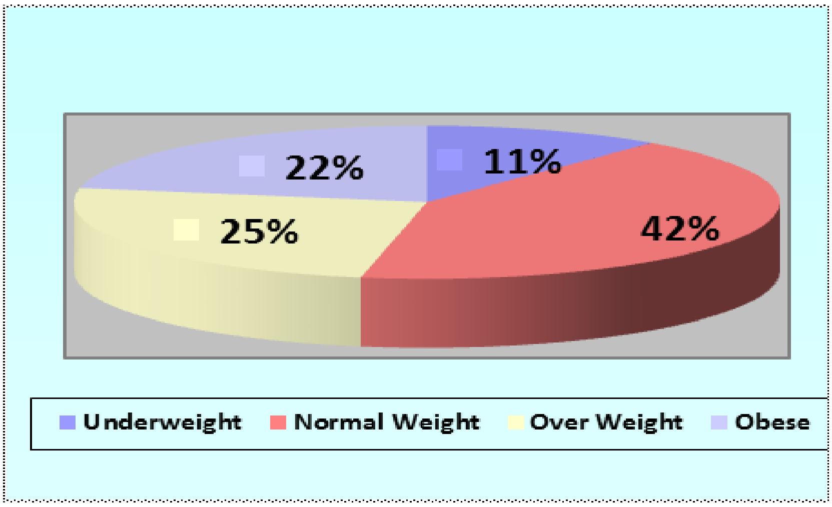

Figure. 1: Prevalence of BMI categories in the study population

Our findings suggest that out of 528 subjects, 11% are underweight; 42% normal weight; 25% overweight and 22% obese.

Table-3 Mean Values of RBGL, BMI, WHR and HC in the study population

Values	RBGL(mg/dl)	BMI(kg/m^2)	WHR(inches)	HC(inches)
Mean	101.99	25.5459	.8887	97.0939
Minimum	26.877	14.79	.73	78.30
Maximum	388	50.3	1.12	136.00
Std.Deviation	63	6.28563	.069	9.76146

The mean (±SD) Random Blood glucose level (RBGL) in the study subjects was 101.99(±63) mg/dL; Mean BMI was 25.54(±6.28)kg/m$^{2;}$ Mean WHR was 0.88(±0.06)inches; Mean Hip Circumference was 97(±9.76) inches.

Table-4: Relation between Waist/Hip Ratio and RBGL of subjects

Correlation Between WHR & RBGL				
	RBGL			Significance
Waist/hip ratio	hypoglycemia	normal	hyperglycemia	
low risk	1	44	1	
mod risk	1	87	2	0.042*
high risk	0	247	14	

Table2 represents a positive correlation between WHR and RBGL. It was found that as WHR increased the RBGL also increased with a significant impact. There was positive relationship of RPGL with WHR of study subjects(P=0.042)

Table-5 Relationship between BMI and RBGL of the subjects

Relationship between BMI & Blood Glucose Level of the Subjects				
	BGL range			Significance
BMI	Hypoglycemia	Normal	Hyperglycemia	
underweight	0	37	1	
normal	2	172	5	0.078
overweight	0	96	5	
obese	0	73	6	

Table3 represents the relationship between BMI and RBGL. Subjects with normal BMI were found to have highest percentage of normal BGL levels. However no significance could be established.

DISCUSSION

Body mass index (BMI) is the most widely used measure to define obesity and predict its complications, such as diabetes and hypertension, but its accuracy and usefulness in Saudi subjects is unknown. This study aimed to assess the validity of standard RBGL, BMI and anthropometric measurements cut-point values in the Saudi population.

Normal blood glucose level in humans is about 4 mM (4 mmol/L or 72 mg/dL) When operating normally the body restores blood sugar levels to a range of 4.4 to 6.1mmol/d (82 to 110 mg/dL).

Shortly after a meal the blood glucose level may rise temporarily up to 7.8 mmol/L (140 mg/dL) There were positive relationship of blood glucose levels with waist circumference and waist-hip ratio in this study. These results were in agreement with similar studies.[16-17] These findings strengthen the current use of anthropometric measurements as predictors for the presence of diabetes mellitus in different populations in the world. The simplicity in the measurement of waist circumference with a dressmaker tape makes it an easy tool for obtaining risk information of diabetes mellitus among the rural populace as seen in this study. The results of our study are not surprising since several studies have supported the use of waist circumference and the waist to hip ratio rather than body mass index as important independent predictors of diabetes mellitus.[18]

However, waist to hip ratio requires calculation and this makes it complicated in practice especially in rural setting. There was no relationship of blood glucose levels with hip circumference in this study in contrast to a similar study. In the Horn study, hip circumference was negatively associated with glucose levels.[16] There are limited studies to allow for proper comparison and conclusion on the relationship of blood glucose levels with hip circumference; however, hip circumference contributes to the waist-hip ratio used in the studies of the ratio's relationship with glucose level. Simple random sampling of a defined population would have been ideal for this study but this was not possible because of the large size of the population used. However, a systematic sampling technique was employed for this study.

Waist to Hip Ratio Std values		
Male	Female	Health Risk Based Solely on WHR
0.95 or below	0.80 or below	Low Risk
0.96 to 1.0	0.81 to 0.85	Moderate Risk
1.0+	0.85+	High Risk

Although several epidemiological studies have investigated the relationship between type 2 diabetes mellitus (T2DM) and hip circumference or height, the results are inconsistent. An inverse association between height and T2DM was observed in women only (summary RR [95% CI] 0.83 [0.73, 0.95]). Our meta-analysis strongly supports an inverse relationship between hip circumference and risk of T2DM in women. The inverse association between height and risk was significant only in women. [2]

Age standardized mean waist circumference range between populations from 83-98 cm in men and from 78-91cm in women. Mean hip circumference ranged from 97-108cm in women, and mean WHR from 0.76-0.84, respectively. Together, height, body mass index (BMI), age group and population explained about 80% of the variance in waist circumference. BMI was the predominant determinant (75% women). Similar results were obtained for hip circumference. However, height, BMI, age group and population, accounted only for 30% (women) the variation in WHR.

CONCLUSION

We established a positive relationship of blood glucose levels with waist circumference and waist-hip ratio among the adult females in Ha'il region of Saudi Arabia. These would serve as better predictors of diabetes mellitus than hip circumference among female adults. Considerable variation in waist and hip circumferences and WHR were observed among the study populations. Waist circumference and WHR, both of which are used as indicators of abdominal obesity, seem to measure different aspects of the human body: waist circumference reflects mainly the degree of overweight whereas WHR does not.

Strengths and limitations of this study should be recognized. The very large number of participants provided sufficient cases at each single unit of BMI to assess the significance of association between each BMI unit and the presence of diabetes or hypertension. In contrast, the cross-sectional nature of the survey and the absence of measurements of other relevant obesity-related co-morbidities, such as hypercholesterolemia and hypertriglyceridemia, could be considered as limitations in this study. The sample was a convenience non-random sample. However, it is fairly representative of the target population. When we compared the sub-classification of respondents with the latest census done in Saudi Arabia regarding to age and sex, the characteristics of the study sample were similar.

In conclusion, the diagnostic usefulness of BMI alone in defining obesity is limited in this large population of Saudi adults, for women. Future studies incorporating other measures such as lipid profile, body fat composition, or a combination of tools, need to be conducted to determine the best method to classify obesity accurately in the Saudi population. It seems likely however that limiting management of obesity to those individuals with a BMI>30 may mean that many Saudis at risk of serious co-morbidities could be missing necessary interventions.

ABBREVIATIONS

ADA: American diabetes association

BMI: Body mass index

BGL: Random Blood glucose Level

WC: Waist Circumference

WHR: Waist to Hip Ratio

HDL: High density lipoprotein

LDL: Low density lipoprotein

SPSS: Statistical package for the social sciences

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