Original Article

Association of BMI with Blood Glucose Levels in Type 2 Diabetes Mellitus

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ABSTRACT

Objective: To study the association of BMI with blood glucose levels (FPG) and (RPG) in type 2 diabetes mellitus.
Study Design: Cross-sectional study
Place and Duration of Study: This study was conducted at the Ayub Medical Complex, Abbottabad. It was conducted from June 2014 to Feb 2015.
Materials and Methods: The study involved 200 known type-2 diabetics, aged between 20 to 70 years. Both males and females were selected randomly. Questionnaire method was used to collect demographic and clinical data of participants. The fasting blood glucose profile was determined followed by two hours post-prandial blood glucose levels of each diabetic.
Results: Statistical analysis was done using SPSS version 21. Mean ±SD, CV% were determined for BMI, fasting plasma glucose, random plasma glucose. Frequency distribution of above control measures was determined. Pearson's correlation coefficient(r) was used to assess the association between above mentioned variables with Fasting plasma glucose and Random plasma glucose. Positive associations ($p<0.005$) were found for BMI. Non significant ($p>0.005$) association was seen in case of age; gender, for FPG. Poor glycemic levels were observed in case of our study subjects for FPG (139.3mg/dl) and RPG (207.6mg/dl).
Conclusion: Poor glycemic control was observed incase of our study subjects, predisposing them to develop complications of diabetes. These associations can be used to effectively control diabetes and to implement their role in preventing complications of diabetes.

Key Words: Diabetes mellitus, glycemic control, fasting plasma glucose, random plasma glucose.

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INTRODUCTION

Diabetes Mellitus is a group of diseases associated with high blood glucose either due to deficient production of insulin or due to inability of the body to utilize its own insulin effectively causing serious health complications and even death[1]. Diabetes mellitus is classified on the basis of etiology into following types: Type 1 diabetes, Type 2 diabetes and other specific types. Type 1 diabetes also called (IDDM) is a form of diabetes in which pancreatic β-cells are mostly destroyed due to autoimmune process[2].

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Type 2 diabetes is by far the most common and predominant type of diabetes. It is characterized by variable levels of insulin and insulin resistance, starting with optimal or high circulating insulin[3]. Many patients of type 2 diabetes exhibit β-cells dysfunction over time and ultimately need insulin for glycemic control, the relation between β-cells damage and resistance to the insulin is not established fully[4]. Diabetes mellitus type 2 previously known as Non–insulin–dependent diabetes mellitus (NIDDM) or Adult–onset diabetes involves persons who have relative (rather than absolute) insulin deficiency and it mostly remain undetected for many years because glucose level is not high enough to initiate noticeable symptoms of diabetes[5]. Diabetics are at increased risk of having macro-vascular and micro-vascular complications[6].

Type 2 diabetes involves 90% of cases globally. According to a study conducted in year 2000, about 150 million people were affected by diabetes and it is estimated to become double till 2025[7]. Diabetes has reached epidemic level in developing and newly developed countries. The minimum numbers of cases of diabetes are mostly seen in rural population where people follow healthy life patterns[8]. Presently prevalence of diabetes mellitus in Pakistan is about 12% and particularly in KPK, it is on the rise in both the sexes especially in the rural regions[9].

Increasing age, not sufficient energy intake, alcohol drinking, smoking are indirect risk factors in the pathogenesis of type 2 diabetes. In diabetics with obesity (especially visceral fat obesity) in the absence of exercise, less muscle mass, insulin resistance increases more rapidly in middle-aged and elderly diabetics[10].Unhealthy dietary habits such as more fats in diet and more intake of simple sugars as an energy source and minimum fiber intake are related to obesity and cause poor glucose tolerance. Nutrition and lifestyle intervention in type 2 diabetes[11].Following factors have been evaluated in an attempt to prevent type 2 diabetes: diet, physical activity, weight reduction and drug therapy. Smoking cessation may also be important[12]. Intensive lifestyle intervention provides the greatest benefit in prevention of diabetes. Most type 2 diabetics are obese, and obesity itself causes an increase in insulin resistance[13]. If obesity is not present by specific weight criteria then an increased percentage of body fat distribution mostly in the abdominal region is responsible. WHO recognized the BMI (18.5-24.9 kg/m^2), as a normal range for all populations[14].There are significant variations in age-specific incidence regarding BMI in Pima Indians[15]. Nurse's Health study data confirmed that there is minimum risk of diabetes occurrence in persons whose body mass index was (BMI) < 21[16].As there is strong association between body weight (adiposity) and insulin resistance, weight reduction is favorable life style pattern[17].Various factors cause increase in adiposity in diabetics such as reduced glycosuria, resulting in retention of calories, changes in food intake and energy expenditure[18].The aim of the current study was to find out the association of blood glucose levels (FPG) and (RPG) with BMI and the role of above-mentioned control measures in effective control of diabetes to prevent diabetes related complications in the study population.

MATERIALS AND METHODS

A cross sectional study was done. This study was undertaken with objective to look for an effective control of diabetes in study population in order to prevent complications and to analyze the association of blood glucose levels with various demographic, clinical and nutritional parameters. The sample size consisted of 200 individuals, all of them were known type 2 diabetics. Convenient sampling technique was used.200 known diabetics satisfying the American Diabetes Association Criteria for diabetes mellitus(American Diabetes Association, 2013) were selected for the study. Previously registered two hundred known type 2diabetic patients of both sexes admitted in medical wards and those visiting the outpatient department of Ayub Medical Complex, Abbottabad, were selected for the study. Informed consent was taken and obtained from each study subject. The age of the patients was in the range of 20-80 years.Individuals with age less than 20 years, pregnant and lactating diabetic women, patients having any mental or hormonal disorder, those who did not consent to participate in the study were excluded. A questionnaire was used as a tool for collection of useful data. A specially designed bio-data form was developed which contained questions regarding demographic informationwhich included name, age, gender, weight, height, BMI.

Clinical data consisting of family history of diabetes (Yes/No), symptoms of diabetes, medical history, use of medication (Oral/Insulin/Nil) was also recorded in the same questionnaire. Record of fasting plasma glucose and random plasma glucose was also kept in same questionnaire.After taking informed consent, whole questionnaire was explained to the study subjects and data was documented in the bio-data form.The height of each participant was recorded without shoes in centimeters using a stadiometer.The weight of each participant was recorded in kilograms while wearing normal clothes and without shoes. The standard platform scale was used for recording weight with calibration to zero before each new measurement.From height and weight recorded for each participant, Body Mass Index(BMI) was calculated using standard formula kg/m^2 where kg is unit of mass & m is the unit of height.BMI=WEIGHT/(HEIGHT)^2. Following criteria recommended by WHO for BMI was considered as standard[19]. BMI<18.5: underweight, BMI 18.5-24.9: normal, BMI 25.0-30.0: overweight and BMI > 30.0 obese. Following criteria of FPG(80-120mg/dl) and RPG(100-140mg/dl) as recommended by ADA for the control of diabetes mellitus was considered. After an overnight fast of 8-10 hours, blood samples were collected while in a seated position.2ml of blood was collected from each participant using a disposable syringe under strict aseptic conditions. The patients were then asked to take breakfast andreport for sample collection for 2hrs postprandial blood glucose estimation as well. Blood glucose fasting was immediately measured. Plasma Glucose levels of all the study subjects were estimated by the enzymatic colorimetric method. The data was analyzed by using statistical program SPSS 21. The numeric variables were described in terms of Mean,$\pm$S.D, CV% was calculated and frequency distribution of different parameters was determined.Pearson's correlation coefficient was used to determine association between various parameters and fasting plasma glucose and random plasma glucose.

RESULTS

A total of 200 subjects were investigated. All the patients were known type 2diabetics.The mean age of study population was 41.89± 14.87. Maximum frequency was 75 and minimum frequency was 20. The co-efficient of variability CV% was 35.49% as shown in Table1.The Pearson's co-efficient for correlation

with FPG for age was (r= 0.66) as shown in table 2. The p value was 0.35 which was found to be not significant (Table3).There was no linear association between the age and FPG.(Table 2) . Pearson's coefficient of correlation of RPG for age(r= 0.089) and p value was 0.002 as shown in Table 3.

Gender is a categorical variable .It is expressed as Percentage. In our study population, there were 71%men and 29%women.The mean weight of diabetics was 69.05± 9.02. Their coefficient of variability CV % was 13.06%. The maximum frequency was 92 while the minimum frequency was 45 as shown in Table 1.

The Pearson's coefficient of correlation of FPG and RPG was(r= 0.140 &r=0.187) and (p= 0.04 and p= 0.003) respectively which was found to be statistically not significant for FPG but was found significant for RPG as shown in Table 2 and 3 respectively. The mean height was 2.69± 0.34. The maximum to minimum frequency range was 3.53 to 1.61. The coefficient of variability, CV% was 12.6% as shown in 1. The Table 2 and 3 show the Pearson's correlation coefficient of FPG and RPG respectively which was(r= 0.37 and r=0.123) respectively. The p value was (p= 0.059 and p= 0.03) respectively and was not significant. The mean BMI of the study subjects was 25.9 ± 3.7. Their maximum frequency was 38.51 and minimum frequency was 18.35. The coefficient of variability was 14.5% as shown in Table 1. Pearson's Coefficient of correlation for FPG was r= .199and positive association was found and r=.055 for RPG, significant positive association p<0.005 was present as shown in Table 2 and 3 respectively.

Table No.1: Descriptive Statistics(Demographic Variables)

	Frequency	Minimum	Maximum	CV%	Mean	Std. Error	Std Deviation	P-Value
Age(yrs)	200	20.00	75.00	35.4	41.89	1.05	14.87	0.005
Gender	200	1.00	2.00	34.8	1.29	0.03	0.454	
Weight(kg)	200	45.00	92.00	13.0	69.05	0.63	9.02	
Height(m)	200	1.61	3.53	12.6	2.69	0.02	0.340	
BMI(kg/m²)	200	18.35	38.51	14.5	26.0	0.26	3.78	0.005

The mean FPG of diabetics was 139.3 ±23.9. Their coefficient of variability CV% was 17.23%. The frequency range was from 220 to 76.00. The frequency distribution of Fasting Plasma Glucose which depicts that most of the study population had poor control of diabetes.The mean random plasma glucose of study subjects was 207.6 ± 28.5. The coefficient of variability CV% was 13.76. The frequency range was from 402 to 129.0.Most of the diabetics had raised RPG.Family history was a categorical variable, expressed as percentage. Among study subjects 68% diabetics had positive family history while 32% had no family history of diabetes. The coefficient of variability was 14.59%.The mean medication was 0.91 ± 0.49. The CV% was 54.53. Pearson's coefficient (r=-0.325)for FPG which show highly significant inverse association p<0.005 and (r=-0.319) for RPG which were found to be significant and inversely associated p<0.005.

Table:1 shows the Mean ±S.D,CV%, minimum and maximum frequency of age, weight, height and BMI. The Co-efficient of variation shows the variation in each variable. Here in this analysis the CV for age is very high as compare with other demographic variable. The most reliable variable inthis statisticsis height.

Table No.2:Pearson Correlation Co-efficient of FPG with Demographic Variables.

S. No	Variables	Pearson Correlation Co-efficient	P-Values
1	Age(years)	.066	.035
2	Gender	-.057	.042
3	Weight(kg)	.140	.049
4	Height(m)	.037	.059
5	BMI(kg/m²)	.199	.002

Table:2 shows association between demographic variables and Fasting Plasma Glucose. Statistically non-significant association was found in case of demographic parameters.P≤0.005 was considered as significant.

Table No.3: Pearson correlation coefficient of RPGwith demographic variables.

S. No	Variables	Pearson Correlation Co-efficient	P-Values
1	Age(years)	-.089	.002
2	Gender	-.054	.003
3	Weight(Kg)	0.187	.003
4	Height(m)	0.123	.003
5	BMI(Kg/m²)	.055	.003

Table:3 shows association of age,gender,weight and height with random plasma glucose. P≤0.005 was taken as significant.

DISCUSSION

Type 2 diabetes has reached epidemic proportions worldwide and in Pakistan. It carries with it an increased mortality risk, multiple co-morbidities, decreased quality of life and a significant economic burden. Much evidence suggests that many of the long-term complications of diabetes, especially the micro-vascular complications(retinopathy and nephropathy), result from many years of hyperglycemia[20].Effective glycemic control has become an important goal of diabetes care. Present study was conducted on a sample size of 200 diabetic patients in the age group ranging

between 20-80 years, both male and female subjects, selected randomly. The primary objective of the study was to study the roleof different control measures in effective control of diabetes in order to delay or prevent diabetes related out comesand to study the association of various demographic, clinical and nutritional parameters with fasting plasma glucose(FPG) and random plasma glucose(RPG).

Our study showed statistically significant positive associations for parameters, like BMI and medication were inversely associated with glucose levels. The results of our study showed poor control of diabetes FPG(139.3± 23.9) and RPG (207.6± 28)predisposing the study population to multiple complications like retinopathy, nephropathy, CVD, nephropathy and diabetic foot.The results of the present study showed no significant correlation with age (r=0.06, p>0.35) for FPG (Table 2) and significant inverse association(r=-0.08,p=0.002) for RPG(Table3) which is consistent with the study of Tasnimet al[21]who reported the negative association of age with FPG (p>0.005) andRPG(p>0.005)[21],Mean FPG(184±3.26) was observed also,reported poor glycemic control in diabetics which was consistent with our results FPG(139.3±23.9).The data was further analyzed on the basis of age groups to find the percentage frequency of age in diabetic population. The highest frequency was observed between the age groups of 20-40 years while it was lowest between 60-80 years and it was in contrast to the results of Tasnimet al[21],who found maximum frequency of poorly controlled diabetes in the age between 40-60 years and lowest between 27-40 years. Gopinath et al[22] observed (HbA1c>6.5%) suggesting poor control of diabetes in elderly >50 years but association between age and glucose was statistically not significant(p=0.382).Both studies reaffirm our findings of poor control of diabetes predisposing diabetics to various complications. The CURES study conducted to determine the prevalence and risk factors for neuropathy in South Indian diabetic subjects, age,glycatedhemoglobin were significantly associated with neuropathy.The CURES study showed that diabetes related outcomes were associated with poor glycemic control[22].

Present study has shown significant positive association(r=0.199, p < 0.005) between BMI and fasting plasma glucose (Table 2) and positive correlation(r= 0.55, p < 0.005) with random plasma glucose e(Table3) which is consistent with study of Innocent[23]etal(2012) which showed that BMI and blood glucose levels were positively correlated among 253 study subjects. The association for FPG was positively present among total participants(r=0.38,p≤0.005).Our results showed FPG(139.3±23.9) and RPG (207.6±28.5), reflecting poor control of diabetes in study population, who were found to be overweight with BMI(26.0±3.78) which was found consistent with the study of Gopinathet al[22]who observed that majority of diabetics with higher BMI(>25) had poor glycemic control but results were not found statistically significant(P=0.382).In accordance to our study Fawwadet al.[23],(2006)observed strong association (r=0.121,p<0.005) of BMI(28.3±5.2)in female subjects and (27.3±4.5)in male subjects with their fasting blood glucose(FPG≥126mg/dl) in type 2 diabetic patients suggesting poor control of diabetes in overweight diabetics. Several studies consider waist circumference or waist-to-hip ratios as a better anthropometric measure while in Japanese American population, intra-abdominal fat, is measured as predictor of diabetes mellitus[24,25,26]. According to a study, three out of every four diabetics are overweight[27] and almost half diabetics are obese[28]. Our results were found inconsistent with the results ofTasnimet al[21]who observed no association (r=-0.093, p>0.005) between BMI (27.97±0.24) and fasting plasma glucose FPG(164.0±2.92) showing overweight diabetics had poor control of diabetes, increasing the risk of CVD. Bakariet al[29]reported a non-significant association between BMI and RPG(p>0.005) among female diabetics while associated significantlyin case of male subjects(p<0.005). The findings showed a significantly higher BMI in females as compared to male population[29]. Studies have shown that lowering BMI improves the glycemic control and with increasing BMI, poor glycemic control is observed. Nurses's Health study confirmed that a BMI of 21 g/m² is most suitable for consideration because in European population there is greater risk of developing diabetes mellitus type 2 even with normal BMI but in Asian population,who have increased body fat as compared to Europeans, a lower BMI is more acceptable[30]. In case of Polynesians who have high lean body mass proportions in comparison to Europeans the higher BMI value is suitable.Habib and Aslma[31]observed higher prevalence among obese BMI(33.8±2.36) females as compared to male diabetics(FPG>126mg/dl).In another prospective study involving Caucasians and African American women conducted by Dowlings and Pisunyer[32](1993) suggested BMI had no significant relationship with random plasma glucose(p>0.005).

CONCLUSION

Our study has established the significant role of associations of BMI and medication with glycemic levels. It is clear from our discussion that effective glycemic control cannot be achieved by adopting any single control measure, diabetes related knowledge, awareness and compliance regarding management of diabetes are the first step towards better control of diabetes,in-order to achieve an effective glycemic control in diabetics,diabetics should be more active, should use proper combination of medications, be more aware of dietary changes needed to be incorporated in

their daily diet. Our study population consisted of mostly young males, who reported themselves as sedentary, most of them were on oral anti-diabeticdrugs as a result our study population showed uncontrolled diabetes mellitus predisposing themselves to various complications.

Author's Contribution:

Concept & Design of Study:	Sofia Shoukat
Drafting:	Madeeha Jadoon, Saadia Sadiq
Data Analysis:	Uzma Faryal, Javeria Saqib, Bibi Hajira
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