Original Article

The Relationship between Body Mass Index and Pre-Diabetes In Teachers Residing in Shiraz-Iran 2009

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Background: Diabetes and cardiovascular diseases often go hand in hand and conversely, many patients with established coronary heart disease suffer from diabetes or its pre-states. Thus, it is high time that diabetologists and cardiologists join their forces to improve the quality management in diagnosis and care for the millions of patients who have both cardiovascular and metabolic diseases in common. The cardio-diabetological approach not only is of utmost importance for the sake of those patients, but also instrumental for further progress in the fields of cardiology and diabetology and prevention.

Methods: This descriptive cross- sectional study was conducted February to December 2009. A total of 3115 teachers residing in Shiraz aged 21- 73 years, were enrolled. Questionnaires were applied to collect information including demographic data, physical activity, history of CAD, hypertension, dyslipidemia,and smoking. In addition, waist circumference, height, weight, body mass index (BMI), and hip circumference (HC) were measured and serum biochemistry profiles were determined on venous blood samples. The prevalence of diabetes, hypercholesterolemia,hypertriglyceridemia, hypertension, overweight, obesity, central obesity, and smoking were identified based on the above mentioned data.

Results: Total prevalence of impaired fasting glucose and diabetes were 47.2% and 6.2% and the prevalence of impaired fasting glucose and diabetes were 44.3% and 5.3% among men and 49.2% and 6.6% among women respectively**.** Thus the association of sex with prevalent impaired fasting glucose and diabetes was significant and greater among women. Diabetes and prediabetes are more prevalent in men and women who are considered as obese in regard to waist circumference and waist/hip ratio scales. This study showed a relationship between higher range of BMI and prevalence of diabetes and prediabetes.

Conclusion: Obesity is a preventable risk factor for diabetes mellitus and preventive measures taken to control obesity are effective means of reducing the risk of diabetes mellitus and also cardiovascular disease.

Key words: Diabetes Mellitus, Cardiovascular Disease, Cardiovascular Disease Risk Factors, Body Mass Index, Waist Circumference

Introduction

According to the World Health Organization (WHO) estimates, chronic diseases will account for approximately three-quarters of all the deaths in the developing world by the year 2020.[1] In this regard, the increasing incidence of overweight and obesity could be an emerging public health problem in the low and middle-income communities.[2]

In countries undergoing epidemiological transition, a complex picture relating to increased food consumption and concomitant changes towards sedentary lifestyles is frequently found.[3] Similarly, Iran as many other developing countries, has been experiencing a rapid phase of urbanization and industrialization in recent decade.[2] The prevalence of obesity varies significantly across the world[4] and it is an undesirable outcome of changing lifestyle and behavior.

Large prospective studies such as Framingham Heart Study, Nurses Health Study, Buffalo Heart Study and Second Cancer Prevention Study provided compelling evidence for inclusion of obesity as a major modifiable cardiovascular risk factor by American Heart Association and other organizations.[5] It is also a major risk factor for development of diabetes, hyperlipidemia, cardiovascular disease,[6] stroke, sleep apnea, and certain cancers.[7]

Obesity is also strongly associated with an increased risk of diabetes.[8] Body-mass index (BMI), waist-size or waist/hip ratios (WHR) are indicators of obesity. It has been recognized that prediabetic

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hyperglycemia (fasting plasma glucose (FPG) of 110 to 125 mg/dl (6.1 to 6.9 mmol/l)) confers an increased risk for cardiovascular disease.[9] Individuals with impaired fasting glucose (IFG) have a 20–30% chance of developing diabetes over the next 5–10 years.[10] The risk is even greater if they have combined IFG and impaired glucose tolerance (IGT).[5] Thus, great emphasis has recently been placed on the early detection of glucose intolerance in adults.

In adults, type 2 diabetes develops over a long period, and most, if not all, patients initially have impaired glucose tolerance, which is an intermediate stage in the natural history of type 2 diabetes and predicts the risk for the development of diabetes and cardiovascular disease.[5]

Evidently most studies paid attention to obesity and diabetes and correlation between body-mass index (BMI) and other markers of obesity. However, prediabetes as a cardiovascular risk factor has not been well studied. As appropriate changes in lifestyle arise, progression from impaired glucose tolerance to frank diabetes can be delayed or prevented.[5] Planning health programmers and preventive projects on cardiovascular risk factors require adequate information about obesity, diabetes and prediabetes. In the present study we describe the relationship between BMI and obesity in regard to the prevalence of prediabetes in teachers of Shiraz as a sample of such population in southern Iran.

Patients and Methods

This descriptive cross-sectional study, which comprised 3115 Shiraz teachers, aged 21-73 years was conducted from February to December 2009 in collaboration with Ministry of education, Shiraz branch, and cardiovascular research center of Shiraz University of Medical Sciences.

There were 1842 (%59.1) females and 1273 (%40.9) males. Mean age of females was 41.5 and that of males 42.7 years. All eligible participants gave verbal informed consent.

The participants were visited and interviewed at Shiraz healthy heart house, by a nurse who had received adequate training on short-term workshop in cardiovascular research center of Shiraz University of medical sciences prior to initiation of study. Interviewer- administered questionnaires were used to collect data of participants including details concerning demographic records, and information about physical activity, tobacco use or any kinds of addictions, and history of hypertension, DM, CAD, and dyslipidemia or receiving any treatments for such entities.

Demographic information comprised of sex, age, race, second occupation, postal address and telephone number. CAD was defined as history of angiographically documented CAD, history of Percutaneous coronary intervention or CABG. History of DM and/or hypertension was considered positive only if a physician had ever told the subjects that either they had DM or hypertension or were treated accordingly.

The participants were examined by interviewer under surveillance of a cardiology resident. Anthropometric features including weight, height, BMI, waist circumference (WC), hip circumference (HC) were measured by standard method. Height and weight of participants were determined without shoes and with light clothing using portable weight scale and measuring inflexible bars with high accuracy.

Waist circumference was measured using tape in a horizontal plane around abdomen at the end of a normal expiration and the midpoint between highest point of hip and lower part of the lowest rib.

Hip circumference were also measured and recorded.

Blood pressures (BP) in both arms were measured with a digital sphygmanometer. The average of three measurements, at five minutes intervals was used for final blood pressure analysis. After physical examination, biochemistry measurements including fasting Blood sugar (FBS), serum total cholesterol (TC), triglyceride (TG), high density lipoprotein (HDL), and low density lipoprotein (LDL) was done after fasting for 10-12 hours.

Participants were instructed to maintain their usual physical activity and diet for at least 3 days before the oral glucose-tolerance test. After at least 10 hours of ovenight fasting, a venous blood specimen was collected from antecubital vein and immediately transferred to reference laboratory of Fars province health center. FBS was measured by enzymatic colorimetric method using glucose oxidize test. Also serum TC, LDL-c, HDC-c, and TG were measured by enzymatic method.

Variable and measurements

In participants without known history of DM, FBS≥126 mg/dl was considered as newly diagnosed DM, while FBS between 100 to 125 mg/dl was defined as impaired fasting glucose or prediabetes.

Criteria for glucometabolic disturbances as established by the World Health Organization (WHO) and the American Diabetes Association (ADA)[11] are

Table 1. Criteria used for glucometabolic. Classification according to the WHO(1999) and ADA (1997, 2003).

Glucometabolic category	Source	Classification criteria [mmol/L (mg/dL)]
Normal glucose regulation (NGR)	WHO	FPG<6.1 (110)+2 h PG<7.8 (140)
	ADA (1997)	FPG<6.1 (110)
	ADA (2003)	FPG<5.6 (100)
Impaired fasting glucose (IFG)	WHO	FPG≥6.1 (110) and<7.0 (126)+2 h PG<7.8 (140)
	ADA (1997)	FPG≥6.1 (110) and<7.0 (126)
	ADA (2003)	FPG≥5.6 (100) and <7.0 (126)
Impaired glucose tolerance (IGT)	WHO	FPG<7.0 (126)+2 h PG≥7.8 and<11.1 (200)
Impaired glucose homeostasis (IGH)	WHO	IFG or IGT
Diabetes mellitus (DM)	WHO	FPG≥7.0 (126) or 2 h PG≥11.1 (200)
	ADA (1997)	FPG≥7.0 (126)
	ADA (2003)	FPG≥7.0 (126)

outlined in Table 1.

BMI (weight in Kg)/(height in meters) was calculated and overweight and obesity defined as BMI ≥ 25 kg/m2 and BMI was classified into various groups: Group I<18.5, Group II 18.5-25, Group III 25-30 and Group IV>30 Kg/m^2.

Truncal obesity was diagnosed when WHR was >0.90 in men and >0.80 in women according to second report of National Cholesterol Education Program (ATP-2).[12] Abdominal obesity was diagnosed when waist size was more than 102 cm in men and > 88 cm in women according to the third report of National Cholesterol Education Program (ATP-3).[1,12]

Statistical analysis

The data were processed using the method of mathematics. All the calculations were performed using Statistical Package for Social version SPSS 15. A P value of less than 0.05 was considered statistically significant.

Table 2. Age-related fasting blood sugar

Age	FBS		
	Normal FBS<100	Pre diabetic FBS 100-126	Diabetic FBS>126
<40 years	58.7%	38.3%	3%
40-60 years	53.2%	42.5%	4.3%
>60 years	45.6%	47.8%	6.6%

Results

Total prevalence of impaired fasting glucose and diabetes in our population were 10.2% and 4% and the prevalence of impaired fasting glucose and diabetes were 11.6% and 4.2%among men and 9.2% and 3.8% among women respectively. Thus the relationship of sex with prevalently impaired fasting glucose and diabetes were greater in males (13).

The peak prevalence of diabetes was found among individuals aged 59-63 years. Age-related increases in diabetes and pre diabetes prevalence were significant. (Table 2)

The population was divided into four groups in regard to marital status as single ,married, divorced and lone with respective prevalence of diabetes of 6.4%, 7.1%, 6.1% and 1% which was greater among married persons. In respect of impaired fasting glucose the corresponding prevalence were 48.1%, 50.4%, 55.1% and 50.2% which was

Table 3. Waist circumference, Waist/Hip ratio obesity and diabetes and prediabetes

Obesity status	Total prevalence	Women	Men	Obese				Non obese			
				Diabetic		Pre diabetic		Diabetic		Pre diabetic	
				Women	Men	Women	Men	Women	Men	Women	Men
Waist circumference	45.9	56.7	30.1	6.8	4.9	50.8	52.8	5.0	4.9	40.2	25.2
Waist/Hip ratio	76.3	89.2	57.2	6.7	6.1	49.9	50.3	4.6%	4.3	44.6	38.2

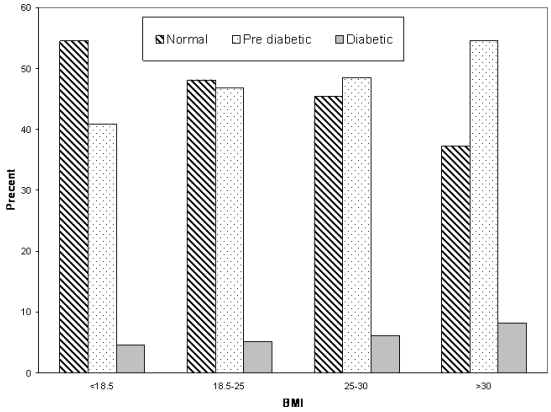

Fig 1. Fasting blood sugar and Body mass index

greater in divorcees.

Using standard waist measuring, 45.9% of subjects under study were obese (waist circumference >88cm for women and >102cm for men). Sex-specific prevalence of obesity, according to waist circumference scale, was 56.7% for females and 30.1% for males and the corresponding difference was statistically significant (Table 3). Reports of FBS were analyzed for persons that were marked as obese according to waist circumference scale. (Table3)

Another scale for evaluation of obesity is waist/hip ratio. Based on this ratio, 76.3% of our population was considered as obese (WHR >0.8 for men and >0.9 for women) and sex specific prevalence of obesity with respect to waist/hip ratio was 89.2% for females and 57.2% for males (Table 3).

The population was grouped in respect of BMI and the prevalence of diabetes and prediabetes are shown in Table 4 which were higher among obese who had greater BMI values.

Table 4. Body mass index and fasting blood sugar

BMI	FBS		
	Normal	Pre diabetic	Diabetic
	FBS<100	FBS 100-126	FBS>126
<18.5	54.5	40.9	4.5
18.5-25	48.1	46.8	5.1
25-30	45.4	48.5	6.1
>30	37.2	54.6	8.2

Discussion

Diabetes mellitus is one of the major cardio vascular disease risk factors worldwide and a large number of epidemiologic studies have been performed in Iran and other countries, most of which targeting type 2 diabetes and factors that influence the prevalence of diabetes.

As mentioned above we used criteria for definition of diabetes mellitus and prediabetes established by the WHO and the American Diabetes Association (ADA). This study showed the total prevalence of impaired fasting glucose and diabetes to be 10.2% and 4% which are close to WHO prediction. According to WHO forecast, the prevalence of diabetes mellitus in year 2025 in Iran will be 6.8% which would comprise 15.1 millions of Iran's population.[14] Also the prevalence of diabetes and prediabetes rise with increasing age and higher range of waist circumference, waist /hip ratio and BMI in our population.

The first study that applied WHO criteria in Iran was conducted in 1993 by endocrine research center of Shahid Beheshti University of Medical Sciences in Islamshahr among people aged 30 years or older. The study reported that the prevalence of type 2 diabetes mellitus was 7.4% (7.1% in men and 7.6% in women). The study showed that, 12.4% of population had impaired glucose tolerance. The prevalence of diabetes and impaired glucose tolerance test spectively. This was 10.4% in individuals aged 30- 39 years and 31.3% in those aged 70-79 years.[15]

The last study performed by Endocrine Research Center of Tehran University of Medical Sciences during 2007 found that 7.7% of adults aged 25–64 years, including 2 millions adults, had diabetes, of which one-half were undiagnosed. An additional 16.8%, or 4.4 millions of Iranian adults had impaired fasting glucose.[16]

During aging process several types of health problems and abnormalities such as irregularity in controlling blood sugar emerge[11] and aging is one of the risk factors for diabetes. Wenying and col-

leagues found that the aging of the population, and other risk factors had probably contributed to the rapid increase in diabetes among Chinese[17] and our findings showed that diabetes and prediabetes have an ascending pattern of prevalence during aging.

In this study we concluded that diabetes mellitus and prediabetes were more prevalent in men. A national study carried out during 2006 in China, indicated that the prevalence of isolated impaired fasting glucose, previously undiagnosed diabetes, and previously diagnosed diabetes were 3.2%, 6.5%, and 4.1% among men and 2.2%, 5.2%, and 3.5% in women.[17] In the multivariable, multinomial, logic models, male sex, older age, a family history of diabetes, overweight , obesity, central obesity, increased heart rate, elevated systolic blood pressure, elevated serum triglyceride level, education below college level, and urban residence were all significantly associated with an increased risk of diabetes.[17,18] A main pathophysiological road from obesity and adverse body fat distribution passes insulin resistance and type 2 diabetes mellitus to cardiovascular disease. A known major sex difference is that men have unfavorable body fat distribution and higher vulnerability to cardiovascular disease.[19] However, in our study we found that diabetes and prediabetes were more prevalent among women and thus they are more vulnerable for cardio vascular disease.

Body weight is determined by many factors, such as genetic, behavioral, cultural, socio-economic, psychosocial and psychological mechanisms. Many of these factors influence health independently or roughly, mechanisms other than body weight. Excess body weight is a risk factor for a variety of health hazards, but it is also a marker of other factors that are directly or indirectly related to health, such as physical activity, diet, socio-economic status and smoking.[12] Evaluation of obesity and rang of body weight are necessary for evaluation of cardiovascular disease risk factors and in this study we did this with different scales for population and we found that the prevalence of diabetes and prediabetes are increased with higher ranger of waist circumference, waist /hip ratio and body mass index and obesity will be presented as a risk factor for diabetes and prediabetes and also cardiovascular disease and details will be presented.

According to waist circumference scale 45.9% of population is obese and this type of obesity is more prevalent between women. The prevalence of diabetes and prediabetes between obese women with this scale are greater than non-obese ones but the prevalence of prediabetes is similar between obese and non-obese men and diabetes is more prevalent between obese men.

Another scale for obesity is waist/hip ratio and the prevalence of this type of obesity is 76.3% in this population and the difference of prevalence between men and women is significant. Diabetes and prediabetes are more prevalent between obese men and women.

Azizi et al. showed that in overweight and obese women, chances of having cardiovascular risk factors increased with WHR>0.78 for premenopausal and with WHR>0.84 for postmenopausal women.[20]

According to this scale it's possible to conclude that the obesity can be one of the risk factors for developing diabetes and prediabetes and also a significant risk factor for cardiovascular disease.

Another important index that was calculated in this study is body mass index. BMI was studied in previous studies as a risk factor for diabetes only.[6,2,20] It was a risk factor for diabetes mellitus and we wanted to evaluate the relationship between BMI and prevalence of prediabetes. We concluded that diabetes and prediabetes are more frequent between persons with higher rang of BMI and people with lower BMI are less susceptible to developing diabetes and prediabetes. These results were presents in most previous study for only diabetes.

Jousilhati et al reported that among Finnish men obesity, as determined by BMI, was an independent risk factor for coronary heart disease mortality in men and was an important contributor for mortality in women.[21,22] In Framingham Study, Hubert et al.[21] and Garrison et al.[22] reported that obesity as determined by body-weight>20% of desirable was an independent risk factor for cardiovascular disease.

Obesity is closely related to several known cardiovascular risk factors, lipid abnormalities and impaired glucose metabolism and it has a complicated association with smoking. Obese subjects on average have higher BP, higher serum total cholesterol, lower HDL cholesterol, higher serum triglycerides, higher blood glucose and a higher plasma insulin levels than lean persons.[12,23] The present study also shows that increasing obesity measured by BMI, waist or WHR is associated with grater prevalence of abnormal FBS and diabetes and prediabetes.

Diabetes increases the risk of microvascular and macrovascular complications and premature death in the general population and results in a huge economic burden for society[24] and the concept that diabetes is a cardiovascular disease is

gradually being accepted; diabetes is often referred to as a coronary-disease equivalent it is not possible for cardiologists and cardiovascular surgeons to avoid treating patients with diabetes. However, the fragmentation of patient care has reached such proportions that cardiologists and cardiovascular surgeons often do not manage the diabetic component of a patient's illness nearly to the extent that would be of greatest benefit to the patient.[25]

Nearly half of the Iranians diabetics are not aware of their problem; this signifies the role of screening programs. Change in lifestyle, especially high fat diet and decreased physical activities, is a major contributor to the increasing occurrence of diabetes in Iran. Large-scale programs should be conducted to promote the knowledge of lay public and modify their lifestyles (especially among populations at risk). Such programs along with establishment of directions to prevent complications of the disease are major steps towards the control of diabetes.

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