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Original Article

How Much Excess Body Weight, Blood Pressure, Triglyceride, or Age Can Double the Likelihood of Diabetes Type 2?

Parya Jangipour Afshar [1], ***Hamid Najafipour*** [2], ***Mitra Shadkam Farokhi*** [3], ****Armita Shahesmaeili*** [4]

1. *Department of Biostatistics and Epidemiology, School of Public Health and Physiology Research Center, Institute of Neuropharmacology, Kerman University of Medical Sciences, Kerman, Iran*
2. *Cardiovascular Research Center, Institute of Basic and Clinical Physiology Sciences, Kerman University of Medical Science, Kerman Iran*
3. *Endocrinology and Metabolism Research Center, Institute of Basic and Clinical Physiology Sciences, Kerman University of Medical Sciences, Kerman, Iran*
4. *HIV/STI Surveillance Research Center, and WHO Collaborating Center for HIV Surveillance Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran*

***Corresponding Author:** Email: armita.shahesmaeili@gmail.com

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Abstract

Background: We aimed to identify the level of known risk factors of diabetes associated with doubled likelihood of diabetes type 2.

Methods: In this cross-sectional study, an analysis was performed on the data of 9930 individuals aged 15 yr and older participating from 2014 to 2018 in the second phase of the Kerman coronary artery disease risk factors study (KERCADRS), Kerman, Iran. Data were collected using a standard questionnaire. Multivariable logistic regression was performed to identify factors associated with doubled chance of diabetes.

Results: The mean age of participants was 46.1±15.5 yr from which 59.5% were women. Overall, 1105 (11.1%) individuals had type 2 diabetes. An increase of 13.86 yr in age, an increase of 17.32 kg/m^2 unit in the amount of body mass index, an increase of 0.17 in the waist-to-hip ratio, a 77 mmHg increase in systolic blood pressure and 6.07 unit increase in triglyceride to HDL ratio doubled the chances of developing type 2 diabetes.

Conclusion: Slight changes in the waist-to-hip circumference ratio (0.17), aging (14 yr), and increase in TG/HDL ratio (6.07 unit) were the most important risk factors, while intense physical activity was the most important protective factor associated with doubling of the chances of developing diabetes. Since most of these risk factors are modifiable, increase in physical activity and providing facilities to improve lifestyle in the community seems necessary.

Keywords: Diabetes; Risk factor; Odds ratio

Introduction

Diabetes is a serious and long-term disease that has a great impact on the health of individuals, families, and communities around the world. Just in 2017, diabetes led to 6.7 million deaths

all around. The high rate of mortality from this disease made it as the eighth leading cause of death worldwide (1). The global prevalence of diabetes in 2019 is estimated at 9.3% (463 million people) and is predicted to reach 10.2% (578 million people) in 2030 and 10.9% in 2045 (700 million people) (2). Overweight and obesity along with physical inactivity will account for a large proportion of the global burden of diabetes (3). Increased waist circumference and increased body mass index (BMI) are associated with an increased risk of type 2 diabetes (4,5). In a meta-analysis conducted in 2010, the relative risk of developing diabetes in people with a BMI above 30 was 7.19 fold that of people with a BMI below 25 (6). Other risk factors associated with the disease include obesity, high blood pressure, heart disease, family history, and race (7). Diabetes brings about variety of microvascular and macrovascular complication in different body organs. The risk of premature death increases among people with diabetes compared to non-diabetic individuals. Possible complications include heart attack, stroke, kidney failure, amputation, vision loss, and nerve damage, and uncontrolled diabetes during pregnancy increases the risk of fetal death and other complications (4).

According to the WHO in 2016, the prevalence of diabetes in Iran at the age of 20-74 yr was 9.6% in women, 11.9% in men and 10.3% in the total population (8). Based on a national study conducted in 2016, majority of patient with diabetes who referred to outpatient diabetes clinics suffered from type 2 diabetes (85.5%) followed by diabetes type 1(11.4%) and other types of diabetes (1.3%). Among them, the most prevalent complications reported to be nerve damage (28.0%), ischemic heart disease (23.9%), visual loss (21.9%), renal failure (17.6%) and diabetic foot (6.2%) (9).

In Iran, the mortality rates due to diabetes were high in the most provinces of the country. However, the age-standardized mortality rate per 100000 was 18.8% (16.6-21.3) in Golestan, 21.3% (18.8-24.2) in Hormozgan, and 20.5% (17.8-23.5) in Tehran, showing higher rate of mortality in the southern, central and northern provinces than other provinces like Zanjan (7.0-9.4) and Kordestan (10.9-14.0) (10).

Due to the complications and high burden of diabetes, prevention of diabetes risk factors is the most important strategy to control this disease. In this regard, knowing how much an increase or decrease in the level of exposure to risk factors is associated with a certain amount of risk of diabetes, is important in policy-making and prioritization of prevention and treatment services. For instance, in the case of ischemic heart disease, our knowledge about the facts that every 20 mm Hg increase in systolic blood pressure and 10 mm Hg in diastolic blood pressure doubles the risk of cardiovascular disease or that 150 min of moderate physical activity per week reduces the risk of ischemic heart disease by about 30% (11), can play an important role in providing preventive advice to the public.

Despite identifying the role of various risk factors associated with type 2 diabetes, the level of exposure to these factors associated with a doubling of the risk of the disease has not been identified. Therefore, in the present study, we examined how much exposure to any of the known risk factors for coronary heart disease was associated with doubling of the likelihood of diabetes.

Methods

In this cross-sectional study, an analysis was performed on the data of 9930 individuals aged 15 yr and older participating in the second phase of the of Kerman coronary artery disease risk factors study (KERCADRS) who entered the study by one-step random cluster sampling from 20014 to 2018. Overall, 420 zip codes were randomly selected. Each of zip codes represented a house. Then, from houses nearby every selected house, 24 eligible people selected to reach the total target sample size of 10,000.

Information about blood pressure (systolic, diastolic), fasting blood sugar (FBS), body mass index (BMI), waist to hip ratio, triglyceride to HDL cholesterol ratio, sleep duration, physical activity

and family history of diabetes as well as demographic characteristics (age and gender) were assessed. Weight was measured with light clothing and height without shoes. Body mass index (BMI) was obtained by dividing weight in kilograms by height squared in meters (kg/m^2).

To measure waist circumference, measurements were taken with light clothing at the end of a gentle expiration (at the level of the midpoint between the iliac crest and lower border of the tenth rib). The hip circumference was measured using an inelastic tape measure without any pressure at the level of the widest circumference over the great trochanters. Waist to hip ratio was calculated by dividing the waist to hip circumference in centimeters. Ranges above 0.90 in men and above 0.85 in women were considered as abdominal obesity.

To measure blood pressure a standard mercury sphygmomanometer was used, so that after sitting on a chair for 5 min and resting, the blood pressure was taken twice at least 30 min apart. The average of these two values was considered as blood pressure.

Daily physical activity at home and at work was assessed by the WHO Physical Activity Questionnaire. The metabolic equivalent of the task (MET) was used to assess the intensity of physical activity. MET is the use of energy in an adult while sitting (equivalent to 3.5 ml of oxygen per kilogram of body weight per minute). Moderate physical activity was considered as energy consumption 4 to 8 times and intense physical activity more than 8 times compared to the sitting position. In other words, a combination of walking and physical activity with at least 3,000 MET per week was considered as intense, between 1,500-3,000 as moderate and less than 1,500 as low levels of physical activity.

FBS as well as lipids were measured using a blood test after 10-12 h of fasting. According to the American Diabetes Association, people with a fasting glucose cut point of ≥126 mg/dL as well as people on diabetes medication, were considered diabetics. To measure the ratio of triglycerides to HDL cholesterol, the amount of triglycerides measured in the blood test was divided by the amount of HDL cholesterol.

Ethics approval

This study has been registered in the ethics committee of Kerman University of Medical Sciences (IR.KMU.REC.1393.310). Written informed consent was obtained from all study participants.

Data analysis

Blood pressure (systolic, diastolic), FBS, BMI, waist to hip ratio, triglyceride to HDL cholesterol ratio, sleep duration, physical activity and family history of diabetes mellitus as predictor variables and diabetes mellitus as response variable were entered into multivariable logistic regression. After determining the variables significantly associated with diabetes, for each variable, the level of exposure associated with a doubling of the odds ratio of diabetes was determined using the equation1. For instance, in this equation that considers the odds ratio= 2, the amount of exposure level was calculated for the body mass index.

Equation

$$\frac{\frac{p_1}{1-p_1}}{\frac{p_0}{1-p_0}} = e^{B(x_1-x_0)} \quad \rightarrow \quad \frac{\frac{p_1}{1-p_1}}{\frac{p_0}{1-p_0}} = e^{B(X)}$$

$$OR = e^{B(X)} \quad \rightarrow \quad 2 = e^{0.040X}$$

$$\rightarrow X = 17.32$$

Where p_0 and p_1 are the estimated probability of outcome at low and high risk categories of exposure. This was repeated for each of the variables and the values obtained were reported. (Table 1). Data analysis was performed using SPSS software version 24 (IBM Corp., Armonk, NY, USA). *P*-values less than 0.05 were considered significant.

Table 1: Estimated level exposure associated with doubled chance of diabetes type 2 using multivariable logistic regression model among a sample of adult population living in Kerman, Iran (n=9930)

Variable	*Coef*	*Std.Err*	*Z*	*P-value*	*(95% CI)*	*Exposure level*
Age (yr)	0.050	0.003	299.344	<0.001	(0.044,0.055)	13.86
BMI (Kg/m2)	0.040	0.007	28.075	<0.001	(0.025,0.054)	17.32
Waist-to-hip ratio	4.026	0.430	88.124	<0.001	(3.185,4.866)	0.172
SBP (mmHg)	0.009	0.002	19.470	<0.001	(0.004,0.012)	77
TG-to-HDL ratio	0.114	0.011	101.965	<0.001	(0.091,0.136)	6.07
Constant	-10.960	0.426	661.117			

The estimates were adjusted for age, BMI, and other risk factors presented in the table. BMI: body mass index. SBP and DBP: systolic and diastolic blood pressure HDL**:** high-density lipoproteins; TG: triglyceride

Results

Out of 9930 participants, 5904 (59.5%) were female and 4026 (40.5%) were male. The mean age of the subjects was 46.1±15.5 yr and the age range was between 15 and 80 yr. Overall, 1105 patients (11.1%) had type 2 diabetes. According to the multivariable regression model being in higher age category, having abdominal obesity, family history of diabetes, high systolic blood pressure, increased body mass index and increase in triglyceride to HDL ratio significantly increased the chances of developing diabetes while diastolic blood pressure and intense physical activities were associated with decreased chance of diabetes (Table 2).

Table 2: Logistic regression analysis of factors associated with diabetes type 2 among a sample of adult population living in Kerman, Iran (n=9930)

Subgroup	*Non-diabetes n=8825*	*Diabetes type 2 n=1105*	*Odds ratio (95% CI)*	*P-value*
Gender				
Male	3591	435	1	
Female	5234	670	1.05 (0.92,1.21)	0.461
Age group (year)				
≤45	4682	144	1	
46-55	1784	276	3.74(2.99,4.66)	<0.001
56-65	1508	435	6.35 (5.10,7.91)	<0.001
>65	851	250	6.62(5.14,8.53)	<0.001
Waist-to-hip ratio				
Normal	4239	198	1	
Abdominal obesity	4565	907	2.12 (1.77,2.53)	<0.001
Family history of diabetes				
No	5650	483	1	
Yes	3019	592	2.43 (2.11,2.79)	<0.001
Physical activity				
Low	4170	571	1	
Moderate	3279	423	0.99 (0.86,1.15)	0.95
Intense	1375	111	0.67 (0.53,0.84)	0.004
Body mass index (kg/m2)	8801	1100	1.03(1.01,1.04)	0.004
SBP	8821	1105	1.02 (1.02,1.03)	<0.001
DBP	8818	1104	0.97 (0.96,0.98)	<0.001
TG-to-HDL ratio	8825	1102	1.13(1.10,1.15)	<0.001
Sleep hours	8790	1105	0.97(0.93,1.01)	0.289

The sum of subgroups may be less than total because of missing data. SBP and DBP: systolic and diastolic blood pressure SBP and DBP: systolic and diastolic blood pressure. HDL**:** high-density lipoproteins; TG: triglyceride

Based on the equation 1, an increase of 13.86 yr in age, an increase of 17.32 kg/m^2 in the body mass index, an increase of 0.17 in the waist-to-hip ratio, a 77 mmHg increase in systolic blood pressure and 6.07 unit increase in triglyceride to HDL ratio doubled the chances of developing type 2 diabetes (Table 1).

Discussion

In this study, the relation of risk factors of age, body mass index (BMI), waist to hip ratio, systolic blood pressure, and TG/HDL-C ratio with type 2 diabetes was confirmed and the level of exposure to each of these risk factors when diabetes likelihood doubled was expressed.

Our results showed that for every 13.86 yr increase of age, the chance of developing type 2 diabetes doubled. The prevalence of diabetes increased with age. Aging, through various mechanisms, predisposes diabetes. With increasing age, obesity, inactivity and the ratio of adipose tissue to the muscle are increased, considered risk factors for diabetes (12-14). Furthermore, aging has been contributed to diabetes through impaired β-cell function and impaired β-cell adaptation to insulin resistance and consequently impairs insulin secretion (15).

The chance of type 2 diabetes doubled by 17.3 kg/m^2 increase in BMI and 0.17 increase in waist to hip ratio. Weight gain and obesity are known risk factors of diabetes (16-20). Obesity and overweight, especially central obesity can lead to diabetes through various mechanisms. Two main pathophysiologic mechanisms that link diabetes and obesity to each other are insulin resistance and insulin deficiency. Previous studies confirmed the intensification of both mechanisms among obese individuals (21,22). The increase in obesity and high weight in today's societies are due to the high consumption of foods rich in carbohydrates, reduced physical activity and mechanization of lifestyle, highlighting the need to change in public health behaviors.

In addition, we showed that a 77 mm Hg increase in systolic blood pressure was associated with a doubling of the likelihood of developing diabetes. Hypertension and diabetes shared common pathways. Genetics, obesity, inflammation and oxidative stress, insulin resistance, mental stress and stimulation of sympathetic nervous system, and low physical activity are thought to be the common pathways (23).

The observed reverse association between diastolic blood pressure and increased likelihood of diabetes was an unexpected finding unknown for us at present and needs more investigation to be clarified.

Another finding of this study indicates that a 6.07-fold increase in triglyceride to HDL ratio is associated with a 2-fold increase in the chance of type 2 diabetes. TG/HDL ratio is independently related to an increased risk of diabetes. Dyslipidemia may cause a series of metabolic disorders related to abnormal insulin resistance and glucose metabolism (24-26). Furthermore, TG/LDL could be a predictor of β-cell function and future diabetes risk in African -American women (27). The potential mechanisms suggested TG/HDL-C ratio as a marker of lipo-toxicity in β-cells that decreases the insulin secretion and increases β- cell apoptosis mediated by increase in TG concentration (28).

The main limitation of our study was that it was cross-sectional and therefore causality cannot be inferred.

Conclusion

Among the risk factors associated with diabetes, aging, having a family history of diabetes and abdominal obesity were the most important risk factors, while intense physical activity was the most important protective factor. Slight change in the waist-to-hip circumference ratio (0.17) was associated with a doubling of the chance of diabetes. In addition, approximately every 14 yr increase in age, 17 units in BMI, 80 mm Hg in systolic blood pressure, and 6.7 units in TG/HDL

ratio was associated with a doubling of the chances of developing diabetes. Since most of the mentioned factors are modifiable risk factors, increase in physical activity and providing facilities to improve lifestyle in the community seems necessary.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interests.

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