Diabetes & Metabolic Syndrome: Clinical Research & Reviews 13 (2019) 1437–1441

Contents lists available at ScienceDirect

Diabetes & Metabolic Syndrome: Clinical Research & Reviews

journal homepage: www.elsevier.com/locate/dsx

Original Article

The incidence rate of diabetes mellitus (type II) and its related risk factors: A 10-year longitudinal study of Yazd Healthy Heart Cohort (YHHC), Iran

Seyedeh Mahdieh Namayandeh [a], Ahmad Karimi [b, c, *], Hossein Fallahzadeh [b], Masoud Rahmanian [d], Seyed Mahmood Sadr Bafghi [a], Mohammadhosein Soltani [a], Leila Hadiani [a]

[a] Yazd Cardiovascular Research Center, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[b] Research Center of Prevention and Epidemiology of Non-Communicable Disease, Departments of Biostatistics and Epidemiology, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[c] Department of Communicable Disease Surveillance, Abadeh Health Center, Shiraz University of Medical Sciences, Shiraz, Iran
[d] Diabetes Research Center, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

ARTICLE INFO

Article history:
Received 23 January 2019
Accepted 4 February 2019

Keywords:
Diabetes mellitus
Incidence
Risk factors
Longitudinal cohort study

ABSTRACT

Background and objectives: Diabetes Mellitus (DM) is a metabolic disease characterized by chronic hyperglycemia, which occurs due to insufficient production of insulin by the pancreas or resistance to insulin produced by the body. The most dangerous and Long-term complications of diabetes include renal failure, heart failure, cardiovascular disease, stroke, diabetic foot ulcers, and diabetic neuropathy.
Materials and methods: This longitudinal cohort study was conducted on 1641 non-diabetic people of 2000 participants enrolled in phase I of Yazd Healthy Heart project (YHHP) aged 20-74 year-old resident of the city of Yazd. They were selected randomly through cluster sampling method and included in follow up a project for ten years (2004–2014). In order to analyze the data, Chi-Square, independent *t*-test and logistic regression statistical models were used through the SPSS Ver_{20}.
Results: The incidence rate of DM type II among the people aged 20–74 years in Yazd was 21.4 per 1000 of a population-year. Univariate analysis revealed that the relative risk of DM incidence increased by smoking, increasing BMI, abdominal obesity, hypertension, and increased cholesterol, triglyceride and uric acid levels ($p < 0.0001$). Variables with a significant p-value < 0.05 using the univariate analysis were included in the logistic regression model. Age, family history of diabetes mellitus in relatives, abdominal obesity, triglyceride values greater than 150 and uric acid more than the 75th percentile were recognized as independent risk factors of diabetes.
Conclusion: In the present study, Age, family history of DM, abdominal obesity, high triglycerides, and high uric acid are the most important risk factors for diabetes.

1. Introduction

Diabetes mellitus (DM) is one of the metabolic diseases characterized by chronic hyperglycemia [1].

Diabetes mellitus is due to insufficient production of insulin by the pancreas or resistance to the body's produced insulin, which leads to symptoms such as polyuria and polydipsia, weight gain or weight loss, diabetic ketoacidosis and hyperosmolar coma [2].

Long-term complications of diabetes include macro-vascular complications such as renal failure, heart disease, stroke, diabetic foot ulcers, and microvascular complications; including retinopathy and neuropathy [3,4].

Diabetes mellitus epidemiologic studies showed that, as an emerging global epidemic, is one of the leading causes of mortality worldwide [5], accounting for the direct cause of 1.6 million deaths in the world in 2015 [6]. It is among the most common non-communicable diseases that affect populations in developing and developed countries [7].

* Corresponding author. Department of Communicable Disease Surveillance & control, Abadeh Health Center, Iran.
E-mail address: elsavan97@gmail.com (A. Karimi).

https://doi.org/10.1016/j.dsx.2019.02.012
1871-4021/

Given more than two-fold increase in the incidence of type 2 diabetes over the past 20 years worldwide, the diabetes mellitus not only is a medical and health problem but also is a socioeconomic phenomenon [8,9].

According to figures from the International Federation of Diabetes, the disease has been diagnosed in 151 million in 2000, 194 million in 2003, 246 million in 2006, 286 million in 2009, 366 million in 2011, and 415 million in 2015, as well as the world's diabetic population is projected to reach 642 million by 2040 [10].

In the world, the Middle East and North Africa (MENA) region with the prevalence of 10.9% has the highest global prevalence of diabetes in the population aged 20–79 years. The highest prevalence of diabetes in the MENA region in 2013 was reported in Saudi Arabia (20.2%), Egypt (15.6%), the United Arab Emirates (10%), and Tunisia (9.2%) in the population aged 20–79 years, respectively [11].

According to the World Health Organization, the prevalence of diabetes in Iran in the age group of 20–74 years old was 9.6% in men and 11.1% in women, and 10.3% of the adult population in Iran suffered from diabetes in general [12].

According to recent studies, the prevalence rate of diabetes and impaired glucose tolerance was 16.3% and 11.9%, respectively, in Yazd, indicating a double prevalence rate of diabetes in Yazd compared with other cities of Iran[13]. Despite the numerous statistics on the prevalence of diabetes in Iran and Yazd, the incidence rate of this disease and its determinants have not been determined in a cohort study on the population representative of the community. Hence, the aim of this study was to determine the incidence rate of diabetes and determination of its predictors in Yazd.

2. Materials and methods

This is a historical cohort study conducted in a longitudinal design based on a Yazd Healthy Heart Cohort (YHHC) [14].

In this research project, 2000 people from the age range of 20–74 years old in Yazd were selected randomly as multistage cluster were divided into five age groups of 20–34, 35–44, 45–54, 55–64, and 65–74 years old.

By examining the selected subjects, people with a history of diabetes or overt diabetes mellitus under drug therapy at the baseline were excluded from the study population, and finally collected data of the 1641 final population.

The study period was 10 years. Mean duration of follow up was 7.5 years During the study, a demographic questionnaire, risk factors for heart disease such as obesity, waist, family history of diabetes, hypertension, and lifestyle data such as dietary habits, physical activity and smoking and laboratory data, including fasting blood sugar and blood lipid profile (LDL, HDL, TG and Cholesterol) and the level of blood uric acid were collected and recorded in the case file [15].

The participants were evaluated annually for the study parameters in the first five years of the research, but only two times in the second five years of their study in the eighth year and the last year of the study.

The International Physical Activity Questionnaires (IPAQ) was used to determine the physical activity of individuals.

The DM defined according to the American Diabetes Association criteria for the diagnosis of DM type II. The individuals taking anti-diabetic drugs and having fasting blood glucose levels $\geq$126 mg/dl were defined as DM and fasting glucose levels between 100 and 125 mg/dl as impaired glucose tolerance (pre-diabetic state), and <100 mg/dl as healthy persons [16].

The patients taking anti-diabetic drugs during follow up period and having fasting blood glucose levels $\geq$126 mg/dl in the last year were categorized as diabetics and included in the analysis.

2.1. Body mass index

BMI below 18.5 was considered as underweight, 18.5–24.9 as normal, 25.0–29.9 as overweight and 30.0 and over as obese.

2.2. Inclusion and exclusion criteria

The inclusion criteria were the residence of the participants in Yazd in a year before the study began and age range of 20–74 years old. The exclusion criteria were people with a history of diabetes and diabetics diagnosed at the baseline.

2.3. Ethical considerations

In different study phases of the healthy heart of Yazd, the measurements of variables were performed with informed consent of individuals. There was no need for a specific ethical consideration in the present study, as the information was extracted from the research database of the healthy heart of Yazd in coordination between the project executive of YHHP and the Yazd Heart Research center.

Meanwhile, the study was approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences and Health Services in Yazd (code of ethics: IR.SSU.SPH.REC.1396.37).

2.4. Statistical analysis

At the end of the study, the required data were extracted from the archives of the participant record data forms and questionnaires according to the study. In order to analyze the data, Chi-Square, independent *t*-test and logistic regression statistical models were used through the SPSS Version 20. The univariate analysis was performed for all variables to assess the relationship between potential risk factors and diabetes, and variables having a significant association with diabetes were included in the logistic regression backward likelihood model used for evaluation of risk factors changes effect on DM incidences. A type I error of 0.05 was considered.

3. Results

In this study, 1641 people were enrolled and followed up for 12226 person-years over a period of 10 years. Of these, 219 people (13.34%) used the drug in the last year of the study or had fasting blood glucose levels $\geq$126 mg/dl, 327 people (19.92%) had impaired glucose tolerance, 530 people (32.3%) were healthy and 565 people (34.43%) were unwillingness to continue collaboration at the start of the study or were inaccessible.

The results of the cumulative incidence rate of diabetes for 1641 non-diabetic patients who were followed for 10 years, according to Table 1, were significantly increased in both genders with increasing age at baseline, as the incidence rate in men from 6.6% in the age group of 20–34 to 32.1% in the age group of 55–64 years old ($p < 0.0001$) and in women from 4.4% in the age group of 20–34 years to 39.6% in the age group of 65–74 years ($p < 0.0001$).

First, the variables of age, gender, smoking, BMI, waist, systolic and diastolic blood pressure, blood cholesterol and triglyceride levels, obesity, family history of DM and uric acid levels were tested as the univariate analysis with the incidence of diabetes (Tables 2 and 3). The Logistic regression model with backward methods showed the DM increases significantly with age, smoking, increased body mass index, family history of diabetes, increased waist circumference, hypertension, hyperuricemia, and increased cholesterol and triglyceride levels.

Table 1
10- year Cumulative incidence rate in different age groups.

Gender	Age groups	Cumulative Incidence, frequency (percentage)
Male	20–34	9 (6.6)
	35–44	37 (25.3)
	45–54	27 (21.3)
	55–64	34 (32.1)
	65–74	14 (20.3)
	Total	121 (20.7)*
Female	20–34	5 (4.4)
	35–44	21 (15.3)
	45–54	31 (27.7)
	55–64	22 (27.8)
	65–74	19 (39.6)
	Total	98 [20] **

Table 1 shows DM incidence increases in participants with older age in the baseline.*: $p < 0.0001$ **: $p < 0.0001$.

According to Table 4, all variables with a significant correlation in the univariate analysis were included in the logistic regression model backward methods in order to eliminate their confounding effect. The age, increased waist circumference, triglyceride values greater than 150 and uric acid more than the 75th percentile were recognized as independent risk factors of diabetes.

The age and sex-adjusted incidence rate in the age groups of 20–34, 35–44, 45–54, 55–64 and 65–74 years was 4.6, 9.22, 20.2, 28.9 and 23.43 per 1000 of a population in a year, respectively. After age matching in society, the incidence rate in the population aged 20–74 in Yazd during the ten years was calculated as 21.4 per 1000 of a population-year. For participants who have been diagnosed with diabetes during the study, the average age of diagnosing diabetes for participants in the study was 5 years.

4. Discussion

In the present study, the incidence of type 2 diabetes in the population aged 20–74 years in Yazd was 21.4 per 1000 of a population-year. The incidence rate in the age groups of 20–34, 35–44, 45–54, 55–64 and 65–74 years was 4.6, 9.22, 20.2, 28.9 and 23.43 per 1000 of a population-year, respectively. With significantly increased in both genders with increasing age at baseline, as the incidence rate in men from 6.6% in the age group of 20–34 to 32.1% in the age group of 55–64 years old and in women from 4.4% in the age group of 20–34 years to 39.6% in the age group of 65–74 years. The DM increases significantly with age, smoking, increased body mass index, increased waist circumference, hypertension, increased cholesterol and triglyceride levels, and family history of DM were recognized as independent risk factors of diabetes.

Table 3
Unvariate analysis of demographic and cardiovascular risk factors measures of people with diabetes and healthy people.

Variables	Diabetic	Non-diabetic	P-value
Age	53.8 ± 16	43.7 ± 14	<0.0001
BMI	28.3 ± 5.8	26 ± 8.9	<0.0001
waist	98.6 ± 10.5	91.1 ± 12	0.001
SBP	130 ± 15	124 ± 14	<0.0001
DBP	83.5 ± 9	81.3 ± 8.8	<0.0001
Cholesterol	204 ± 41	191.6 ± 42	<0.0001
TG	200 ± 108	159 ± 97	<0.0001
Uric acid	4.9 ± 1.2	4.3 ± 1.2	<0.0001

Table 4
Results of fitting the logistic regression model.

Variable	B	SE	RR	95%CI	P-value
Age	0.039	0.007	1.018	1.02–1.05	<0.0001
Uric Acid	0.843	0.402	1.691	1.05–5.10	0.036
Waist	0.653	0.176	1.274	1.36–2.71	<0.0001
TG	0.751	0.178	1.883	1.49–3.00	<0.0001
Smoking	1.190	0.573	3.098	1.06–10.11	0.038
Family History of Diabetes	1.413	0.466	3.315	1.64–10.23	0.002

The results of this study indicate that the odds ratio of diabetes is higher in older people, more body mass index. Oba S. et al., in 2014 examined the active and passive exposure to smoking and its association with insulin sensitivity and pancreatic function. The female smokers were more likely to suffer from glucose tolerance than non-smokers and the prevalence of diabetes and impaired glucose tolerance was higher in men with 25 cigarettes and more in smokers than in non-smokers [17]. The results of the present study confirm the association between smoking and increasing odds ratio of diabetes and impaired glucose tolerance.

In a study by the American Diabetes Association in 2014 to diagnose and classify diabetes, variables such as abdominal obesity, triglycerides, cholesterol, blood pressure, physical activity, and lifestyle have been identified as risk factors associated with type 2 diabetes [18].

A study in Denmark found that those who were overweight (20 years or older) were more likely to develop diabetes (1.1% per unit of increase in the BMI). The study also revealed that the odds ratio of diabetes increases with weight gain and obesity [19].

Shakeri et al. in Mashhad, Iran, investigated the relationship between anthropometric indices and diabetes. There was a significant relationship between BMI in three groups of patients, at risk and healthy subjects. They reported that the odds ratio of diabetes

Table 2
Demographic information of people with diabetes and healthy people based on qualitative variables.

Variables	Diabetic	Non-diabetic	P-value
Gender	Male (n = 121, 55.3%)	Male (n = 465, 54.3%)	0.043
	Female (n = 98, 44.7%)	Female (n = 391, 45.7%)	
Smoking	(32) 14.6%	(111) 13%	0.029
Obesity	(64) 29.4%	(126) 14.8%	<0.0001
food habitation	Poor (n = 75, 34.2%)	Poor (n = 150, 28.3%)	0.262
	Moderate (n = 75, 34.2%)	Moderate (n = 203, 38.3%)	
	Good (n = 69, 31.5%)	Good (n = 177, 33.4%)	
Physical activity	Low (n = 103, 66.9%)	Low (n = 221, 62.8%)	0.662
	Moderate (n = 44, 28.6%)	Moderate (n = 115, 32.7%)	
	Vigorous (n = 7, 4.5%)	Vigorous (n = 16, 4.5%)	
Family history of diabetes	Mother (51) 23.3%	Mother (88) 16.6%	0.02
	Father (25) 11.4%	Father (60) 11.3%	0.5
	Sister (49) 22.4%	Sister (42) 7.9%	<0.0001
	Brother (41) 18.7	Brother (43) 8.1%	<0.0001

can elevate with increasing BMI [20].

In a study by Zand-Karimi et al., in 2013 in Kermanshah, Iran, it has been reported that age, physical activity, and body mass index are known as determinants of diabetes [21], the results of which are consistent with the findings of this study.

Harati et al. studied the incidence rate of type 2 diabetes and concluded that the incidence rate of diabetes in the female population was 1.4 times more than that of the male. The incidence rate of diabetes increased gradually with age. Family history of diabetes, general and abdominal obesity, hypertension and high triglyceride level were significant predictive variables of diabetes [22]. In the present study, it was found that the odds ratio of diabetes increases with age, as well as high triglyceride level and hypertension, are the effective factors in increasing the odds ratio.

Ahmadi et al., in 2013 found a positive association of age, female gender, blood pressure, and triglyceride with diabetes, in line with the present study [23].

In a study by Navipor et al., in 2017, the prevalence of type 2 diabetes in the population aged 35–65 years was reported to be 14.4% in Mashhad, Iran [24]. Hadaegh et al. showed a 13% of prevalence for diabetes among a population over the age of 20 years in Tehran, Iran [25], while according to studies conducted over the past 30 years, the prevalence of diabetes in Yazd was 16.3% in a people aged over 30 years [13].

In a study conducted in China, After adjustment for age, gender, BMI, and the waist-to-hip ratio A significant correlation was found between parental history of diabetes and onset of diabetes type II (adjusted OR:3.58 95% CI 3.08–4.17 $P < 0.001$), this study supported our finding [26].

5. Conclusion

Age, abdominal obesity, high triglycerides, positive DM family history, and high uric acid are the most important risk factors for diabetes. All of these factors, except for age, can be controlled and prevented. Given the rapid growth of the number of people with diabetes, it seems that a large epidemic of diabetes is forming in Iran, which is affected by altering in the lifestyle of communities and turning people into an inappropriate diet.

6. Study limitations

The present historical cohort study was conducted on the incidence of diabetes and related risk factors and the cumulative incidence of diabetes. Some of the weaknesses in the study were irregular referral and poor collaboration among subjects. Missing data was tried to be minimized by calling and encouraging people to continue to participate in the study.

7. Suggestions

It is recommended to be conducted further studies to compare the risk factors and the incidence of diabetes between the suburb, rural and urban populations, while this study only examined the urban population of Yazd and also to evaluate a genetic aspect of diabetes in Yazd.

Conflicts of interest

The authors declare no competing interests.

Funding

This study was approved, supported and performed in the Yazd Cardiovascular Research Center.

Acknowledgment

We would like to thank and appreciate the Cardiology Center staff and physicians Mrs. Reyhani, Atashkuh, Bagheri and Abedini, who collaborated perfectly in the implementation of the study and the extraction of data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dsx.2019.02.012.

References

[1] Federation ID. what is diabetes? 2017 [cited 2017 4.20]. Available from: https://www.idf.org/about-diabetes/what-is-diabetes.html.
[2] WHO. What is diabetes 2017 [cited 2017 12.4]. Available from: http://www.who.int/diabetes/en/.
[3] Nathan DM, Group DER. The diabetes control and complications trial/epidemiology of diabetes interventions and complications study at 30 years: overview. Diabetes Care 2014;37(1):9–16.
[4] Tao Z, Shi A, Zhao J. Epidemiological perspectives of diabetes. Cell Biochem Biophys 2015;73(1):181–5.
[5] Papatheodorou K, Banach M, Edmonds M, Papanas N, Papazoglou D. Complications of diabetes. J Diabetes Res 2015;2015.
[6] WHO. Diabetes 2017 [cited 2017 4.12]. Available from: http://www.who.int/mediacentre/factsheets/fs312/en/.
[7] Chang C-H, Shau W, Jiang Y, Li H-Y, Chang T, H-H Sheu W, et al. Type 2 diabetes prevalence and incidence among adults in Taiwan during 1999–2004: a national health insurance data set study. Diabet Med 2010;27(6):636–43.
[8] Zimmet P, Alberti KG, Magliano DJ, Bennett PH. Diabetes mellitus statistics on prevalence and mortality: facts and fallacies. Nat Rev Endocrinol 2016;12(10):616.
[9] Jiang Y-D, Chang C-H, Tai T-Y, Chen J-F, Chuang L-M. Incidence and prevalence rates of diabetes mellitus in Taiwan: analysis of the 2000–2009 Nationwide Health Insurance database. J Formos Med Assoc 2012;111(11):599–604.
[10] Federation iD. FACTS AND FIGURES 2017 [cited 2017 4.12]. Available from: http://www.idf.org/about-diabetes/what-is-diabetes.html.
[11] Javanbakht M, Mashayekhi A, Baradaran HR, Haghdoost A, Afshin A. Projection of diabetes population size and associated economic burden through 2030 in Iran: evidence from micro-simulation Markov model and Bayesian meta-analysis. PLoS One 2015;10(7):e0132505.
[12] WHO. Diabetes country profiles 2017 [cited 2017 10.10]. Available from: http://www.who.int/diabetes/country-profiles/en/#I.
[13] Lotfi MH, Saadati H, Afzali M. Prevalence of diabetes in people aged≥ 30 years: the results of screening program of Yazd Province, Iran. J Res Health Sci 2013;14(1):88–92. 2012.
[14] Benfer KA, Weir KA, Bell KL, Ware RS, Davies PS, Boyd RN. Longitudinal cohort protocol study of oropharyngeal dysphagia: relationships to gross motor attainment, growth and nutritional status in preschool children with cerebral palsy. BMJ open 2012;2(4):e001460.
[15] Mirzaei M, Soltani M, Namayandeh M, GharahiGhehi N. Sodium and potassium intake of urban dwellers: nothing changed in Yazd, Iran. J Health Popul Nutr 2014;32(1):111.
[16] Association AD. Diagnosing diabetes and learning about prediabetes. 2015 [updated June 1, 2015; cited 2018 March 30, 2018]. Available from: http://www.diabetes.org/diabetes-basics/diagnosis/?loc=db-slabnav.
[17] Oba S, Suzuki E, Yamamoto M, Horikawa Y, Nagata C, Takeda J. Active and passive exposure to tobacco smoke in relation to insulin sensitivity and pancreatic β-cell function in Japanese subjects. Diabetes Metab 2015;41(2):160–7.
[18] Association AD. Diagnosis and classification of diabetes mellitus. Diabetes Care 2010;33(Suppl 1):S62.
[19] Black E, Holst C, Astrup A, Toubro S, Echwald S, Pedersen O, et al. Long-term influences of body-weight changes, independent of the attained weight, on risk of impaired glucose tolerance and Type 2 diabetes. Diabet Med 2005;22(9):1199–205.
[20] Shakeri M, rasoolian A, Erfanian M. Investigating the relationship between anthropometric indices and diabetes. J Mashhad Univ Med Sci 2015;58(7):390–6.
[21] Zandkarimi E, Safavi AA, Rezaei M, Rajabi G. Comparison logistic regression and discriminant analysis in identifying the determinants of type 2 diabetes among prediabetes of Kermanshah rural areas. J Kerman Univ Med Sci 2013;17(5):300–8.
[22] Harati H, Hadaegh F, Saadati H, Azizi F. Incidence rate based on type 2 diabetes and its associated risk factors: Tehran Lipid and Glucose Study. J Diabetes Metabol of Iran 2009;8(4):347–56.
[23] Aram-Ahmadi M. Predicting type two diabetes and determination of the effectiveness of risk factors applying logistic regression. J Kerman Univ Med Sci 2014;21(2).

[24] Navipour E, Esmaily H, Doosti H, Ghayour-Mobarhan M, Yosefi R. Anticipating factors associated with type 2 diabetes using logistic regression. J Sci Health 2017;12(2):59–65.
[25] Hadaegh F, Bozorgmanesh MR, Ghasemi A, Harati H, Saadat N, Azizi F. High prevalence of undiagnosed diabetes and abnormal glucose tolerance in the Iranian urban population: Tehran Lipid and Glucose Study. BMC Public Health 2008;8(1):176.
[26] Zhao Y, Song C, Ma X, Ma X, Wang Q, Ji H, et al. Synergistic effect of family history of diabetes and dietary habits on the risk of type 2 diabetes in Central China. Int J Endocrinol 2017;2017.