PREVALENCE OF PREDIABETES AND ITS ASSOCIATED RISK FACTORS AMONG A SAMPLE OF EMPLOYEES AT FACULTY OF MEDICINE

By

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Abstract

Introduction: Prediabetes is a state of pathological changes that precede diabetes; so early screening and interventions are both cost-saving and feasible to prevent disease progression and complications. **Aim of Work:** To measure the prevalence of prediabetes among a sample of employees at Faculty of Medicine Ain Shams University (ASU), to identify different risk factors associated with prediabetes and to assess risk of having prediabetes. **Materials and Methods:** A cross-sectional study was conducted among a convenience sample of 352 employees at Faculty of Medicine, ASU using self-administered questionnaire. Physical activity assessment by International Physical Activity Questionnaire Short Form (IPAQ-SF), Diet Assessment by Mediterranean Diet Assessment Score (MEDAS), anthropometric measurements, and The American Diabetes Association - Centers for Disease Control and Prevention (ADA- CDC) prediabetes Risk Score. Measurements of glycosylated hemoglobin (HbA1c) were done to employees who were identified as high-risk individuals based on the prediabetes risk score. **Results:** The prevalence of prediabetes was 36.1% by ADA-CDC Prediabetes Risk score and 65.4% of high-risk participants were confirmed to be prediabetic by HbA1c. By Multiple logistic regression analysis, age (OR=1.24, CI=1.18-1.29), gender (OR=5.67, CI=2.36-13.67), positive family history of Diabetes Mellitus (DM) (OR=15.16, CI=6.10-37.67), and having hypertension (OR=8.17, CI=3.29-20.27) affect the occurrence of prediabetes by ADA-CDC prediabetes risk score among studied sample. Being ≥ 40 years old, male, hypertensive and had positive family history of DM increased the risk of prediabetes. Meanwhile, being ≥ 40 years old (OR=1.13, CI=1.07-1.21), with positive family history of DM (OR=2.96,CI=1.01-8.62), and having hypertension (OR=3.41,CI=1.29-9.01) were associated with higher risk of prediabetes by HbA1c. **Conclusion and recommendations:** The prevalence of prediabetes among employees was high. Therefore, screening program with intervention strategy targeting high risk group may contribute to the reduction of the prevalence and further complications of diabetes mellitus.

Keywords: Prediabetes, Glycosylated hemoglobin (HbA1c), Prediabetes risk score, Hypertension and positive family history of Diabetes Mellitus.

Introduction

Prediabetes is increasingly recognized as an important metabolic dysregulation state with a high risk of progression to diabetes mellitus. Typical diabetes mellitus complications associated with chronic hyperglycemia may already be evident among patients with prediabetes (Mutie et al., 2020 and Eleftheriadou et al., 2021).

Prediabetes includes impaired fasting glucose (IFG), impaired glucose tolerance (IGT), and both IFG combined with IGT. According to the World Health Organization (WHO), IFG was defined as fasting plasma glucose (FPG) 100-125 mg/dl. IGT was defined as post-load plasma glucose of 7.8–11.0 mmol/L based on 2-h Oral Glucose Tolerance Test (OGTT) of 140 mg/dl (7.8 mmol/l) to 199 mg/dl (11.0 mmol/l) or a combination of both (ADA, 2020). The American Diabetic Association (ADA) has additionally introduced HbA1c levels of 5.7–6.4% as a new category of high diabetes risk (ADA, 2020 and Goyal et al., 2020).

About 69.2% of the prediabetes population lives in low- or middle-income countries (IDF, 2015 and Sandu et al., 2016). The International Diabetes Federation (IDF) released a comprehensive picture of the current and future trends of prediabetes prevalence based on IGT in individuals aged 20–79 years. By 2045 the prevalence is anticipated to increase to 8.3% of the global adult population, equivalent to an estimated 587 million individuals. It should be noted that these estimates are based on IGT only, so prevalence may be higher if additional criteria were taken into consideration(Hostalek, 2019).

The prevalence of type II DM has increased dramatically in the Arabic-speaking countries; an estimated 9.1% of the populations from the Middle

Eastern/North African region have type II DM in 2015, and 30 million with IGT. Egypt is in the world's top 10 in terms of the highest diabetic prevalence in 2015 (7.8 million) (Salama et al., 2018).

Prediabetes will progress to overt type II diabetes in approximately 25% of subjects within 3–5 years, and as many as 70% of individuals with prediabetes will develop overt diabetes within their lifetime. Since pre-diabetes is a transitional stage between normal and DM, and it is a reversible process through the implementation of lifestyle modification programs (ADA, 2019).

Previous cross-sectional studies have reported multiple risk factors related to prediabetes, such as increased age, overweight and obesity, blood pressure, sedentary habits and smoking (Sandu et al., 2016).

The prevalence of prediabetes is increasing rapidly in all parts of the world; so early screening is of great importance for early detection and reducing the incidence of diabetes.

Aim of Work

To measure the prevalence of prediabetes among a sample of employees at Faculty of Medicine Ain Shams University (ASU), to identify the different risk factors associated with prediabetes and to assess the risk of having prediabetes.

Materials and Methods

Study Design: A cross-sectional study was conducted to achieve the objective of work.

Study place and duration: The study was conducted among employees at Faculty of Medicine, Ain Shams University, Cairo, Egypt from July to October 2020.

Study Sample: A convenience sampling technique was used to collect data from faculty employees. All employees aged 20 years, or more were eligible to be included in the study with exclusion of Diabetic and illiterate employees. According to step wise survey, the expected prevalence of IFG=6%. Assuming that the expected prevalence of prediabetes in the study population =6%± 1.6%, and at a 95% confidence level, total population size =600, a sample size of 352 persons was calculated using Epi Info 7 program (WHO, 2017).

Study methods:

Data Collection tool: Arabic structured self- administered questionnaire was used to collect data;

the questionnaire was composed of:

Section 1: Socio-demographic characteristics and special habits of the studied employees including age, education, marital status, smoking habit, and occupation (which was categorized according to the Standard Occupational Classification System, 2018 into administrative, worker and technicians).

Section 2: History of diseases including: present history of hypertension, family history of diabetes and history of medication intake. ***Section 3: Assessment of physical activity:*** Regular exercise is defined according to WHO as "any physical activity performed to increase physical fitness. Such activity should be performed 3 to 5 times per week for 20–60 minutes per session." Answer choices were categorized as a binary variable: Yes or NO. Also, ***Arabic version of Physical activity assessment by (IPAQ-SF)*** was used (Helou et al., 2018). The validated Arabic version of the questionnaire was designed specifically for adults (18–65 years old). It collected information on the time spent being physically active (i.e., number of days and average time per day) and classified into vigorous-intensity activity, moderate-intensity activity, walking activity, and sitting (sedentary life) in the last seven consecutive day period.

Section 4: Diet assessment by Mediterranean Diet Assessment Score: This "Mediterranean" dietary pattern is typically based on none or minimally processed foods and incorporated most of the protective factors (fruits and vegetables, legumes, whole grains, dietary fiber, fish, vegetable, protein, and vegetable fat from olive oil). Adherence to the Mediterranean diet was measured by a 14-points MEDAS. Each question was scored 0 or 1. Based on the MEDAS values, participants were divided into three classes: (1) Low adherence (score 0–5),(2) Medium adherence (score 6–9), and (3) High adherence(score10-14) (Haidar et al., 2016)a better quality of the diet (for example, conformity to the Mediterranean diet.

Section 5: Anthropometric parameters were measured for each participant using standardized techniques and calibrated equipment (WHO, 2011).

-Body Mass Index (BMI) was calculated for each participant according to the formula: weight (kg) / [height (m)] ^{2}. BMI was graded to

Obese, Overweight, and Normal weight which defined as a BMI of 30 kg/m^2 and higher, between ٢٥ and ٢٩,٩ kg/m^2, and 18.5–24.9 kg/m^2 respectively.

-Waist Circumference (WC) was measured at the midpoint between the anterior superior iliac crest and the lowest rib. The WC values of >102 and >88 cm for males and females respectively were considered to be high.

-Hip circumference (HC) was measured by measuring tape to the nearest 0.1 cm around the thighs, at the height of the greater trochanter, in the standing position.

-Waist hip ratio (WHR) was calculated as hip circumference (cm) divided by waist circumference (cm). It was classified as Low risk (lower than 0.80 and 0.95), Moderate risk (0.81-0.85 and 0.96-1.0), and High risk (0.86 or higher and 1. or higher) for female and male respectively.

Section 6**: **The ADA- CDC prediabetes Risk Score: It consists of 7 questions including gender (Male/Female), age category (4 subgroups: < 40, 40-49, 50-59, and ≥ 60 years), family history of diabetes, hypertension, BMI, regular physical activity and gestational diabetes with total score from 0–10, whereas risk factors were binary (0 or 1) except age with a score (0-3) and BMI (score 1-3) to capture the risk gradient (Prabhu et al., 2019). Based on the ADA-CDC values, participants were divided into two classes: (1) Low risk (score 0–4), and (2) High risk (score 5-10).

Section 7: Measurements of Glycosylated hemoglobin (HbA1c) for employees who were identified as high risk based on the prediabetes risk score. The American Diabetes Association defines prediabetes as a HbA1c of 5.7–6.4% (ADA, 2020).

Pilot study: The designed questionnaires were pilot tested on 10% of the sample size before data collection. Results of the pilot study were assessed, some questions needed re-wording. Data obtained from the pilot study were excluded from the analysis.

Consent

The informed consent was appended to the questionnaire. Each questionnaire contained the informed consent in its first part and participants had to check "I agree" to start.

Ethical Approval

The Ethical Committee of the Faculty of Medicine, ASU approved the research, and administrative approval was obtained.

Data Management

Data were revised, coded, entered into the personal computer. Collected data were analyzed using the SPSS program (Statistical Package for Social Science) for windows version 20. Quantitative data were expressed as mean and standard deviation. Independent t-test was used to assess the difference between the two-study group means. Qualitative data were expressed as number and percentage, Chi-square and Fisher's exact tests were used to examine the relationship between two qualitative variables. A logistic regression model was constructed to estimate odds ratio (Confidence Interval 95%) for risk factors of prediabetes. P-value ≤ 0.05 was considered significant.

Results

Table (1): Sociodemographic data and medical history among the studied participants (No=352):

Characters		**Female=195 No (%)**	**Male=157 No (%)**	**Total=352 No(%)**	**p value**
Age/ years	20- 30- 40- 50- >60	38.5))75 22))43 18.5))36 19.5))38 1.5))3	26.8))42 35))55 19.1))30 16.6))26 2.5))4	33.2))117 27.8))98 18.8))66 18.2))64 2.0))7	**0.04#***
Age in years	***(Mean ± SD)***	37.14±11.33	38±10.71	37.69±10.97	**0.00$***
Marital status	Single Married Divorced/ Widow	28.7))56 66.6))130 4.7))9	26.8))42 71.3))112 1.9))3	27.8))98 68.8))242 3.4))12	0.49##
Educational level	Read& write /primary/ Preparatory. Secondary/vocational University	7.7))15 29(14.9) 77.4))151	18.5))29 35(22.3) 59.2))93	12.5))44 18.2))64 69.3))244	**0.00# ***
Residence	Urban Rural & Slum area	92.3))180 7.7))15	84.7))133 15.3))24	313 (88.9) 39 (11.1)	**0.03#***
Job category	Administrative Workers Technicians	89.7))175 9.7))19 0.6))1	75.8))119 17.8))28 6.4))10	83.5))294 47 (13.4) 11 (3.1)	**0.00#***
Smoking	Current smokers Nonsmokers	0.0))0 100))194	19 (28.8) 76 (43.9)	14.8))52 85.2))300	0.05#
FH of DM	Yes NO	51.3))100 48.7))95	44.6))70 55.4))87	48.3))170 51.7))182	0.24#
Hypertension	Yes NO	21.5))42 78.5))153	17.8))28 82.2))129	19.9))70 80.1))282	0.42#
PCO	Yes NO	24(12.3) 87.7))171	----	----	----
Gestational Diabetes (N=139)	Yes NO	6(4.3) 95.7))133	-----	----	----
Contraception use (No=139)	Yes NO	43.2))60 56.8))79	----	----	----
Medications	Yes NO	24.1))47 75.9))148	18.5))29 81.5))128	21.6))76 78.4))276	0.20#
Type of medication	Cardiovascular$$ Steroid Psychiatric	20.5))40 3.1))6 0.5))1	16.6))26 0.6))1 1.3))2	18.8))66 2))7 0.9))3	0.14##

#: χ2 test, ##:Fisher exact, $: Independent t test, $$:Cardiovascular medicine include antihypertensive and diuretics
FH: Family history
DM: Diabetes mellitus
PCO: Polycystic ovary syndrome
*: Statistically significant

Table 1 showed that the mean age of the studied participant was 37.69±10.97. Most of the employees aged between 20 to 40 years (61%), married (68.8%), completed university education (69.3%), most of them worked in administrative jobs (83.5%), and lived in urban areas (88.9%). Concerning special habits, 85.2% were non-smokers. Males differed significantly from females in their age, education level, tobacco use, residence, physical exercise and job ($p < 0.05$). Concerning family and present histories there was no statistically significant difference between males and females.

Table (2): Nutritional status, anthropometric characteristics and physical activity among the studied participants (No=352):

Variables		Female=195 No (%)	Male=157 No(%)	Total=352 No(%)	p value
Diet according to the 14-items of Mediterranean Diet Adherence Assessment (MEDAS)					
Total score ***Mean ± SD*** **(min-max)**		5.58±1.67 (2-11)	6.11±1.55(1-10)	5.82±1.64(1-11)	**0.00$^{\$*}$**
Adherence					0.16$^{\#\#}$
Low	0-5	88(45.1)	57(36.3)	145(41.2)	
Moderate	6-9	106(54.4)	99(63.1)	205(58.2)	
High	≥10	1(0.5)	1(0.6)	2(0.6)	
Anthropometric measurements					
Waist circumference ***(Mean ± SD)***		88.03±19.80	93.4±18.11	90.45±19.23	**0.01$^{\$*}$**
Normal		103(52.8)	110(70.1)	213(60.5)	
High risk		92(47.2)	47(29.9)	139(39.5)	**0.00$^{\#*}$**
Hip circumference ***(Mean ± SD)***		100.55±21.41	105.94±19.43	102.95±20.69	**0.02$^{\$*}$**
Waist/Hip ratio *(Mean ± SD)*		0.88±0.09	0.88±0.08	0.88±0.09	**0.589$^{\$}$**
Low risk		22(11.3)	151(96.2)	173(49.1)	
Moderate risk		45(23.1)	1(0.6)	46(13.1)	**0.00$^{\#*}$**
High risk		128(65.6)	5(3.2)	133(37.8)	
BMI ***(Mean ± SD)***		30.08±5.54	28.44±5.49	29.35±5.57	**0.01$^{\$*}$**
Normal		28(14.4)	48(30.6)	76(21.6)	
Overweight		88(45.1)	55(35.0)	143(40.6)	**0.00$^{\#*}$**
Obese		79(40.5)	54(34.4)	133(37.8)	
Physical activity					
Regular exercise					
Yes		56(28.7)	71(45.2)	127(36.1)	**0.00$^{\#*}$**
NO		139(71.3)	86(54.8)	225(63.9)	
Activity by IPAQ					
Inactive		139(71.3)	86(54.8)	225(63.9)	**0.00$^{\#*}$**
Minimally active		56(28.7)	71(45.2)	127(36.1)	

#: $\chi 2$ test, ##:Fisher exact, $:Independent t test

IPAQ: International Physical Activity Questionnaire *: Statistically significant

Based on the Mediterranean Diet Assessment Score, males and females differed in their adherence to Mediterranean diet with mean score of 5.58 ±1.67 and 6.11±1.55

for females and males respectively. About 58% of the studied participants were moderately adherent to the Mediterranean diet compared to 0.6% among high adherence group. There was statistically significant difference between males and females regarding waist circumference, hip circumference, waist/hip ratio and BMI; female participants had higher BMI and waist/hip ratio compared to males. As regard physical activity, 36.1% of the studied sample practiced regular physical activity and they are classified as minimally active based on IPAQ-SF. Males practiced exercise in higher rates compared to females (45.2% versus 28.7%) and the difference was statistically significant (Table 2).

Table 3: Characteristics of the studied participants according to ADA-CDC Prediabetes risk score:

Characters	No (%)
1. How old are you?	
<40 (0 point)	215(61)
40- (1 point)	66(18.8)
50-(2 points)	64(18.2)
≥60 (3 points)	7(2.0)
2.Are you a male or a female?	
Male (1 point)	157(44.6)
Female (0 point)	195 (55.4)
3.If you are a female, have you ever been diagnosed with gestational diabetes?	
NO (0 point)	124(95.4)
Yes (1 point)	6(4.6)
4.Do you have a mother, father, sister, or brother with diabetes?	
NO (0 point)	182(51.7)
Yes (1 point)	170(48.3)
5. Do you have ever diagnosed with high blood pressure?	
NO (0 point)	282 (80.1)
Yes (1 point)	70(19.9)
6. Are you physically active?	
NO (1 point)	225(63.9)
Yes (0 point)	127(36.1)
7. What is weight category?	
Normal (1 point)	76(21.6)
Overweight (2 points)	143(40.6)
Obese (3 points)	133(37.8)
Total Prediabetes score ***Mean ± SD (min-max)***	3.8 ±1.67 (0-8)
Classification of participants according to prediabetes risk score:	
Low risk 0-4	225(63.9)
High risk 5-10	127(36.1)

Table 3 showed that the mean of ADA-CDC prediabetes risk score of the studied participants was 3.8 ±1.67 and 63.9% of the participants were classified as low risk for having prediabetes. High-risk participants 83 (65.4%) based on the ADA-CDC Prediabetes risk score were pre-diabetics using HbA1c. The mean HbA1c level among the studied sample was 5.67 ± 0.37 (5.1-6.4) (Results are not tabulated).

Table 4: Comparison between low and high-risk groups as categorized by ADA-CDC pre-diabetes risk score according to sociodemographic characteristics and other variables:

Variables		**Low risk (No=225) N (%)**	**High risk (No=127) N (%)**	**p value**
Age category	<40	190(84.5)	25(19.7)	**0.00[##*]**
	40-	30(13.3)	36(28.3)	
	50-	5(2.2)	59(46.5)	
	≥60	0(0)	7(5.6)	
Gender	Male	90(40)	67(52.8)	**0.03[#*]**
	Female	135(60)	60(47.2)	
Marital status	Single	85(37.8)	13(10.2)	**0.00[##*]**
	Married	135(60)	107(84.3)	
	Divorced/widow	5(2.2)	7(5.5)	
Educational level	Read and Write/primary/Preparatory	20(8.9)	24(18.9)	**0.00[#*]**
	Secondary/Vocational/Institute	37(16)	28(22)	
	University	169(75.1)	75(59.1)	
Residence	Urban	199(88.4)	114(89.8)	0.73[#]
	Rural	26(11.6)	13(10.2)	
Job category	Administrative	197(87.6)	97(76.4)	**0.02[#*]**
	Workers	23(10.2)	24(18.9)	
	Technicians	5(2.2)	6(4.7)	
Smoking	Nonsmoker	199(88.4)	101(79.5)	**0.03[#*]**
	Current smoker	26(11.6)	26(20.5)	
Physical activity				
Regular physical activity	Yes	59(26.2)	68(53.5)	0.76[#]
	NO	166(73.8)	59(46.5)	

Activity by (IPAQ)	Inactive	166(73.8)	59(46.5)	0.46#
	Minimally active	59(26.2)	68(53.5)	
Sedentary lifestyle hours/day	<3	26(18.7)	6(11.1)	0.37#
	3-6	57(41)	22(40.7)	
	>6	56(40.3)	26(48.1)	
Histories				
Family history of DM	Yes	91(40.4)	79(62.2)	**0.00#***
	NO	134(59.6)	48(37.8)	
Hypertension	Yes	19(8.4)	51(40.2)	**0.00#***
	NO	206(91.6)	76(80.1)	
PCO	Yes	12(8.9)	12(20)	**0.04#***
	NO	123(91.1)	48(80)	
Gestational diabetes (No=139)	Yes	2(2.5)	4(6.8)	0.40##
	NO	78(97.5)	55(93.2)	
Use of contraception (No=139)	Yes	22(26.6)	38(64.4)	**0.00#***
	NO	58(73.4)	21(35.6)	
Medications	Yes	25(11.1)	51(40.2)	**0.00#***
	NO	200(88.9)	76(59.8)	
Type of medication	Psychiatric	3(1.4)	0(0)	**0.00##***
	Steroids	5(2.3)	2(1.7)	
	Cardiovascular $	17(7.9)	49(40.5)	
Anthropometric measurements:				
Waist/Hip ratio	Low risk	101(44.8)	72(56.7)	0.06#
	Moderate risk	35(15.6)	11(8.7)	
	High risk	89(39.6)	44(34.6)	
BMI	Normal	71(31.5)	5(3.9)	**0.00#***
	Overweight	116(51.6)	27(21.3)	
	Obese	38(16.9)	95(74.8)	
Diet score by (MEDAS)				
Degree of diet adherence	Low adherence	98(43.6)	47(37)	0.26#
	Moderate/High adherence$$	127(56.4)	80(63)	

#: χ^2 test, ##: Fisher exact test, $: Cardiovascular medicine include antihypertensive and diuretics, $$: high added to moderate IPAQ: International Physical Activity Questionnaire BMI: Body Mass Index DM: Diabetes mellitus MEDAS: Mediterranean Diet Assessment Score *: Statistically significant

Table 4 showed that the high-risk groups were 50 years old and above, most of them were males (52.8%), 59.1% attained university education and 76.4% worked in administrative job. There was a statistically significant positive correlation between positive family history to DM, being hypertensive and those taking antihypertensive medicine, current user of contraceptives and having PCO and being at high risk to diabetes. Concerning the difference in anthropometric measurements between low and high-risk participants; there was a statistically significant difference between the two groups regarding BMI; 74.8% of high-risk participants were obese.

Table 5: Factors associated with pre-diabetes as detected by ADA-CDC prediabetes risk score and HbA1C in logistic regression analysis:

Characteristics		B	Sig.	Adjusted OR Lower	95% C.I. OR	
					Upper	
ADA-CDC prediabetes risk score						
Constant		-8.68	0.00	----	----	----
Age	≥40#	0.21	0.00	1.24	1.18	1.29
Gender	Male#	1.74	0.00	5.67	2.36	13.67
Marital status	Married #	0.34	0.44	1.40	0.59	3.31
Educational level	University education#	-0.33	0.47	0.72	0.29	1.76
Smoking	Current smoker	-0.94	0.10	0.39	0.13	1.21
FH of DM	Yes#	2.72	0.00	15.16	6.10	37.67
Being Hypertensive	Yes#	2.11	0.00	8.17	3.29	20.27
BMI	Underweight and normal##	----	**0.06***	----	----	----
	Overweight	0.14	0.76	1.15	0.45	2.92
	Obese	-0.84	0.08	0.43	0.17	1.12

Job category	Technician/ Worker	0.27	0.64	1.31	0.42	4.05
HbA1C						
Constant		-5.089	0.00	----	----	----
Age	≥40#	0.13	0.03	1.13	1.07	1.21
Gender	Male #	0.11	0.82	1.11	0.43	2.86
Marital status	Married#	-0.45	0.50	0.63	0.16	2.42
HTN	Yes #	1.22	0.01	3.41	1.29	9.01
FH of DM	Yes #	1.08	0.04	2.96	1.01	8.62
BMI	Underweight and normal##	---	----	0.38	----	----
	Overweight	-0.45	0.39	0.63	0.22	1.80
	Obese	0.26	0.66	1.30	0.38	4.39

##: Reference group, #: Reference groups are <40 years old, females, unmarried, low educational level, not having FH of DM, not having hypertension, work in administrative job.
*: Statistically significant; p-value ≤ 0.05.
OR: Odds Ratio CI: Confidence Interval FH: Family history DM: Diabetes mellitus
BMI: Body Mass Index HTN: Hypertension HbA1C: Glycosylated Hemoglobin.

Multiple logistic regression analysis was done to identify different factors that affect the occurrence of prediabetes by ADA-CDC prediabetes risk score; age (OR=1.24, CI=1.18-1.29), gender (OR=5.67, CI=2.36-13.67), positive family history for DM (OR=15.16, CI=6.10-37.67), and having hypertension (OR=8.17, CI=3.29-20.27) affect the occurrence of prediabetes among the studied participants. Being ≥ 40 years old, male, hypertensive and had positive family history for DM increased the risk for prediabetes. Meanwhile, being ≥ 40 years old (OR=1.13, CI=1.07-1.21), with positive family history of DM (OR=2.96, CI=1.01-8.62), and having hypertension (OR=3.41,CI=1.29-9.01) were associated with higher risk for prediabetes by HbA1C (Table 5).

Discussion

The current work studied the risk of developing prediabetes based on the ADA-CDC risk score among 352 employees.The studied participants revealed that 36% were at high risk (Table 3). This result nearly agreed with that reported in Qatar by Abbas et al., 2020 using the same tool; the detected prevalence was 32.6%. A slightly higher prevalence of prediabetes (41%) was noted by Fujiati et al., 2017 in Indonesia using an Indonesian Prediabetes Risk Score. Also, a cross-sectional study was done in Houtang Village, China among residents aged 18 to 70 years, which revealed that 40.9% of the participants were at high risk of prediabetes (Yu et al., 2020). However, a lower rate (28.52%) was reported in a study conducted in Ningbo, China (Zhao et al., 2016). Differences in prediabetes rates could be attributed to the difference in the population characteristics and the type of the risk score used.

HbA1c was used to assess participants who were identified as high-risk based on the Prediabetes risk score; 83 (65.4%) of them were pre-diabetics (Results are not tabulated).Similar to a cross-sectional study that was done in USA; all the enrolled patients (No=70) were diagnosed as «high risk» based on risk score and 75% of them were diagnosed as prediabetic based on HbA1c levels. The predictability of simple screening abilities can reinforce the ease in assessing and increasing awareness of prediabetes risk in adults (James et al., 2016).

Studying different socio-demographic variables that may be associated with the high risk of prediabetes by ADA-CDC prediabetes risk score revealed that advancement of age was associated with increased risk for prediabetes; being ≥ 40 years old (OR=1.24, CI=1.18-1.29) was associated with higher risk compared to <40 years with peaked risk at 40-60 years (74.8%) (Table 4) . Similarly, Salama et al., 2018 found that among the attendants of family health units in Menoufia, Egypt, 55.5% of participants aged > 45 years old had a higher risk of developing prediabetes. In the contrary; another study was done in China by Zhao et al., 2016, revealed that the risk of having pre-diabetes peaked in the younger age group (20–40 years) (34.53%) .While a study in Bangladesh found that older-aged participants (≥ 60 years) had a higher risk for prediabetes than the younger age group (Akter et al., 2014). The disagreement might be due to the difference in the study population and their national habits that may affect the age of development of prediabetes. Aging is often accompanied by an increase in body fat, which may contribute to the development of insulin resistance (Sandu et al., 2016).

In the current study, males were at significant higher risk compared to females of developing prediabetes by ADA-CDC prediabetes risk score (Table 4). The present work was in harmony with that which was done by Fujiati et al., 2017 that predicted prediabetes among Indonesian adults, but disagreed with that of Ez–Elarab et al., 2020 to identify associated risk factors among Ain-Shams and Suez-Canal University students; who found that the female gender was accompanied by a high risk of pre-diabetes. Zhao et al., 2016, and Salama et al, 2018 reported that gender had no significant association with the risk of prediabetes.

The present study findings documented that the prevalence of prediabetes was higher among married participants (84.3%) by univariate analysis (Table 4). However, the marital status was not detected as a predictor of prediabetes by multivariate logistic analysis (Table 5). This was in line with a study conducted in Bangladesh, 2011 using the Bangladesh demographic survey (BDHS) data (Akter et al., 2014).

Contradictory, Okwechime et al., 2016 in the USA demonstrated a significant relationship between marital status and prediabetes; married participants were more likely to be pre-diabetic. The relation between marital status and prediabetes can be explained by increased responsibility after marriage so people usually do not have enough time for their physical activity and personal attention (Kposowa et al., 2021). In contrast, Endris et al., 2019 in Ethiopia found that single participants were 3.1 times more likely to have prediabetes than the married ones.

Although 59.1% of the high-risk groups were high educational levels by univariate analysis (Table4), educational attainment was not detected as a predictor of high risk of prediabetes by multivariate analysis (Table5). This was in line with Okwechime et al., 2016 but disagreed with (Yu et al., 2020) in China.

On studying the relation between participants' residence and prediabetes, it was detected there was no association

(Table 4).This finding agreed with Díaz-Redondo et al., 2015, who conducted Primary Health Care on the evolution of patients with a cohort study in prediabetes in Spain and found no association between residence and occurrence of prediabetes.

Although 76.4% of high-risk participants work in administrative job, there was no significant association between job category and prediabetes risk. This finding agrees with Hilawe et al., 2016 and Salama et al, 2018.

As regards the relation between smoking and the risk of prediabetes; the present study results revealed that there was significant association between smoking status and the risk of prediabetes (Table 4), however by multivariate analysis smoking was not detected as a predictor of high risk of prediabetes (Table 5). A similar finding was found in China (Zhao et al., 2016). However, these results disagreed with that of Aynalem and Zeleke , 2018 in their study on the prevalence of diabetes mellitus and its risk factors among individuals aged 15 years and above in Mizan-Aman Town, Southwest Ethiopia. The available evidence showed that smoking habit increases insulin resistance (Sandu et al., 2016).

Multiple logistic regression analyses revealed that employees with a positive family history of DM (OR=15.16, CI=6.10-37.67) and having hypertension (OR=8.17, CI=3.29-20.27) were at higher risk for prediabetes (Table 5). This finding was supported by Fujiati et al., 2017 and Basit et al., 2018.

Abdullah et al., 2019 performed a study among nurses in Dubai using The Finnish Diabetes Risk Score and concluded that taking antihypertensive and positive family history of diabetes had a significant relationship with prediabetes ($p < 0.01$). The association between the risk of developing prediabetes and antihypertensives may be attributed to the use of thiazide diuretics, which could increase insulin resistance, and worsen diabetes control (Liu et al., 2005).

An Egyptian study reported that no difference was found between low-risk and high-risk groups to family history of DM, but a positive association was detected as regard hypertension and receiving antihypertensives medicine (Salama et al., 2018). Underestimation of positive family history of diabetes in the study was attributed to the deficiency of information about diagnosed diabetes cases among the first-degree relatives, who were not exposed to medical diagnosis before. A possible mechanism that can explain the effect of hypertension on the development of prediabetes is that the activity of angiotensin II increased in hypertension; affects the function of the pancreatic islets, resulting in fibrosis and reduced insulin synthesis, leading to insulin resistance (Liu et al., 2005).

The current work revealed that there was no association between history of previous Gestational diabetes mellitus (GDM) and the risk of developing prediabetes (Table 4). Unlikely, Gunderson et al., 2021, found that gestational diabetes leads to an earlier onset and higher risk of prediabetes in young adults in the USA.

Practicing regular physical activity and its degree as measured by International Physical Activity Questionnaire (IPAQ) didn›t differ between low-risk and high-risk participants (Table4). This result was in line with a previous Egyptian study (Salama et al., 2018). In contrast with Fujiati et al., 2017, in an Indonesian study who found a significant difference between high and low-risk groups as regards physical activity.

The present study revealed that obese are at high risk for prediabetes (Table4).This finding agreed with that of Lotfy et al., 2020, who conducted a cross-sectional study in Cairo and found that 40.5% of high-risk groups were obese but disagreed with the results of logistic regression who detected that there was no association between obesity and the risk of prediabetes (Table5). The relation between obesity and diabetes was explained in literature as the excess body fat might lead to increased degradation of fat into Free Fatty Acids (FFAs) that lead to lower the capacity of liver tissue for insulin-mediated glucose uptake (Hilawe et al., 2016).

The risk of prediabetes was not associated to waist/hip ratio in the current study (Table4) which in contrast with the results detected by Muthunarayanan et al., 2015 in India and Abdullah et al., 2019 in Dubai.

The proportions of the different levels of adherence to Mediterranean Diet Assessment Score (MEDAS) were 41.2%, and 58.8% for low, and medium-high adherence, respectively, but no association was found with the risk of prediabetes (Table4). These results agreed with Haidar et al., 2016, who found no difference between low and high adherence to the Mediterranean diet and the risk of prediabetes in Lebanon.

Study limitations: There is a limited power of cross-sectional design to determine the causal effect. Furthermore, the data of smoking and physical activity were self-reported so may be affected by recall bias.

Conclusion: The prevalence of prediabetes among the participants was high; it was 36.1% by ADA-CDC prediabetes risk score and 65.4% of high-risk participants were confirmed to be prediabetic by HbA1c. Multiple logistic regression analysis for both ADA-CDC prediabetes risk score and HbA1C revealed that being ≥ 40 years old, male, hypertensive and with positive family history of DM increased the risk of prediabetes.

Recommendations: Screening program aiming to identify high risk groups become an urgent issue especially for males, older than 40 years, hypertensive, with positive family history of DM and confirmation can be done using HbA1c. Intervention program targeting high risk group may contribute to the reduction of the prevalence of DM and further complications. Furthermore, pharmacologic approaches to glucose management can be part of management plan.

Conflict of interest

The authors declared that there was no conflict of interest.

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