Journal of Health, Medicine and Nursing
ISSN 2422-8419 An International Peer-reviewed Journal
Vol.32, 2016

THE ASSOCIATION BETWEEN CIGARETTE AND WATERPIPE SMOKING WITH GLYCEMIC CONTROL AMONG PATIENTS WITH T2DM ATTENDING AT THE National Center for Diabetes, Endocrinology and Genetics NCDEG

Mohammed Abuwardeh[1*], Manar Al-Nabolsi[2], Yousef Khader[3], Mousa Abu Jbara [4], Yousef Abuwardeh [5], Kamel Ajlouni [6].

1. senior nurse, Cardiac center, governmental hospital at ministry of health in Jordan, PO box 8136, PC : 81482, Hail city, Saudi Arabia
2. Associated Professor, Adult Health Nursing, University of Jordan.
3. Professor of Epidemiology, Medical Education and Biostatistics, Jordan University of Science and Technology
4. Consultant Endocrinologist AT THE National Center for Diabetes, Endocrinology and Genetics
5. School of nursing, University of Hail, PO Box 8136, PC: 81482, Hail city, Saudi Arabia
6. MD, FACP, FACE: professor of endocrinology and diabetes, the national center of diabetes, endocrinology, and genetics. The university of Jordan

Abstract

Objective: Smoking is one of the modifiable risk factors for multiple diseases, such as cardiovascular diseases (CVD), cancer, and diabetes. As smoking aggravates the insulin resistance already presented in T2DM, it contributes to increasing glucose in the bloodstream, thus the risk for developing diabetes complications also rises. The association between tobacco smoking and glycemic control may explain the role of smoking in increasing the risk of diabetes and its complications. The aim of this study is to measure the association between cigarette smoking and waterpipe (WP) smoking on Glycemic control. **Design and Setting**: A descriptive cross-sectional study was conducted in the NCDEG in Amman, Jordan. **Methods:** This study recruited 879 male participants. The target population consisted of all male patients diagnosed with T2DM, who had two or more regular visits to the Diabetes and Endocrinology Clinic. The sample was collected during the period from 15 November 2015 to 15 March 2016. All patients attending the center during the study period were asked to take part in the study. The study subjects were selected using a systematic random sample selection (every two patients) from the nursing room. **Results:** In the study sample, 65.1% of male participants did not achieve the target level of HbA1c with a mean 7.6 (SD±1.21); the age of the participants ranged between 30 and 90 years with a mean of 58 years (SD±11); the mean duration of diabetes was 9.9 (±7.2) years. In the present study, 65.1% participants did not achieve the recommended target level for glycemic control (HbA1c <7). About 43% of the participants were smokers. An overall 32.3% were cigarette smokers, 69.6% of whom were of poor glycemic control; 7.3% were water pipe smokers, 71.4% of whom had poor glycemic control, and the remaining 3.7% were dual (cigarettes and WP) smokers of whom 75% were of poor glycemic control. This study reported, on overall smoking, cigarette smoking and dual smoking were significantly associated with poor glycemic control (p-values were 0.017, 0.032) respectively, after adjustment of other confounders including duration of diabetes, age of patients 65 years old and above, drug adherence, dietary adherence and waist circumference. On the other hand, participants on waterpipe alone were less likely to have good glycemic control compared with non-smokers, although it was a positive association but not a significant one. In our study, the number of cigarettes smoked was not significant at using binary logistic regression analysis. However, the chi-square test indicated that glycemic control differed significantly between participants according to the number of cigarettes smoked. **Conclusion:** Most of diabetic smokers did not achieve the target level of glycemic control. Smoking cigarettes and waterpipe smoking were found to have a significant association with poor glycemic control, after adjustment of other confounders such as duration of DM, age, drug adherence, dietary adherence and waist circumference.

Keywords: Glycemic control, Diabetes, Cigarette smoking, Water pipe smoking, T2D

1. Introduction and research problem

Diabetes mellitus is a chronic metabolic disease with high morbidity and mortality worldwide [1]. Globally, the International Diabetes Federation (IDF) marked that the prevalence of diabetes was estimated to be about 8.3% (387 million people) among adult population worldwide, and the figure will rise up to 10.1% (592 million) in 2035 with the greatest number between 40 and 59 years of age [2]. World Health Organization (WHO) reports that Type 2 diabetes (T2DM) comprises 90% of people with diabetes around the world [3]. The International Diabetes Federation (IDF) reported the prevalence of diabetes in the Arab region to be 16.7% in Saudi Arabia, in United Arabic Emirates, 19.5%, in Bahrain, 15.2%, Kuwait, 14.4%, Oman, 13.1% and in Egypt, 10 % [2]. In Jordan, the study by Ajlouni et al showed that the prevalence of diabetes was estimated to be around 17.1 % [4]. The main goal of diabetes management is to control blood glucose levels in order to prevent the complications associated with diabetes, which are primarily microvascular (such as retinopathy, nephropathy and neuropathy) and macrovascular (such as cardiovascular disease) that result from accelerated atherogenesis [5]. These complications can reduce the quality of life and increase morbidity and mortality rate [6]. Glycemic control is a key element in diabetes treatment, which is indicated by HbA1c level in the bloodstream attached to hemoglobin molecules in the previous two to three months and considered the gold standard for assessing glycemic control. Screening and early detection of blood sugar levels prevents and provides better treatment for these patients [6, 7]. The American Diabetes Association (ADA) guidelines recommended that HbA1c should be below 7% to assess the efficacy of therapy and, if not achieved, to recommend adjustments in diet, exercise and medication in order to improve patients' glycemic control [8]. However, the IDF guidelines have changed the general HbA1c target from 6.5% to 7.0% in 2014[9]. In addition to controlling blood glucose to prevent diabetic complications, it is necessary to control associated modifiable risk factors. The risk factors are classified into two categories: non-modifiable risk factors, such as age and gender, and modifiable risk factors, which include obesity, dyslipidemia, hypertension, physical activity and smoking [10]. Smoking is one of the modifiable risk factors for multiple diseases, such as cardiovascular disease (CVD), cancer, diabetes, chronic obstructive lung disease and asthma. It is associated with insulin resistance, central obesity, dyslipidemia and inflammation [11]. Smoking aggravates the insulin resistance that is already presented in T2DM, and thus contributes to increasing glucose in the bloodstream [12], which in turn, increases the risk for the development of diabetic complications. In addition, smoking-related insulin resistance accelerates atherosclerosis and increases cardiovascular diseases risk and long-term poor metabolic control [13]. The association between tobacco smoking and glycemic control may explain the role of smoking in increasing the risk of diabetes and its complications [14].

Tobacco use currently kills approximately 5.2 million people worldwide each year_ a figure expected to upgrade to more than 8 million a year by 2030. Half of those deaths occur between the ages of 30 and 69, resulting in a loss of 20–25 years of life for smokers versus non-smokers [15]. Globally, tobacco-affiliated epidemics are expected to take their toll of 10 million deaths annually in the next 20 to 30 years due to global tobacco. More than 70 percent of these deaths are in developing countries [16]. The statistics show an increasing number of people in developing countries smoke tobacco using a waterpipe (WP) [17]. Jordanian Ministry of Health reported that the prevalence of smoking increased from 27% to 29% within a period of 2 years after conducting a survey in 2005 and 2007 respectively [18]. WP smoking rates in the Middle East ranged from11.5% to 40.5% compared with cigarette smoking rates of 20.2% to 45.5 % [19]. Cigarette smoking is the inhalation of the smoke of burning tobacco in cigarettes [20], while water pipe is a way of smoking tobacco in which the vapor passes through water before inhalation [21]. There are different terms used to describe WP variations, depending on the region, and they include WP, Pory or Goza in Egypt, Shisha in Saudi Arabia and Pakistan; in Jordan, Lebanon and Syria, it is known as Narghille or Arghila, and Hookah in India. It has variations in size, shape, appearance and the type of tobacco used [22, 23]. According to health experts, smoking is a psychological addiction [24]. Tobacco smoke contains more than 4,000 chemical substances; more than 200 of these chemicals are toxic and cause cancer. Toxic substances enter the circulation in the bloodstream and affect the function of the blood vessels and lead to the development of atherosclerotic lesions in the arterial walls. These lesions cause narrowing of the arteries, which decreases blood flow. Hardening the arterial walls makes them less elastic and more liable to rupture. Additionally, smoking increases platelet adhesions leading to the risk of thrombosis and embolism [24, 25]. WP smoking has harmful effects similar to cigarette smoking, and the Nicotine and Tar contents in WP smoke are more than in cigarette smoke [23]. The World Health Organization estimates that a WP smoker may inhale as much smoke as in cigarettes smoking, calculating the risk during one session of WP to be equivalent to smoking 100 cigarettes [24].

1.1. Significance of the Study

The main goal of diabetes management is to control blood glucose levels in order to prevent complications associated with diabetes including microvascular diseases (such as, retinopathy, nephropathy and neuropathy) and macrovascular diseases (such as cardiovascular disease). These complications result from accelerated atherogenesis, and they reduce the quality of life and increase morbidity and mortality rate [(5)]. The association between tobacco smoking and glycemic control may explain the role of smoking in the risk of diabetes and its complications [(14)].The amount of data concerning the effect of tobacco smoking on glycemic control in Jordan and in the surrounding Arab countries is limited. Globally, few researches studied the impact of cigarette smoking on glycemic control, while there are no available data regarding the effect of waterpipe smoking on glycemic control.

2. Aim of the Study

The aims to determine the association between smoking cigarettes and waterpipe smoking with glycemic control and their relationship with other risk factors which include socio-demographic characteristics, anthropometric measurements, and clinical data among male patients with T2DM in the NCDEG.

2.1 Objectives of the Study

1- To examine the relationship between cigarette smoking and WP smoking on glycemic control in male groups with T2DM
2- To determine the prevalence of cigarette smoking and WP smoking among T2DM patients
3- To examine the relationship between glycemic control with demographic and clinical characteristics of T2DM patients
4- To determine the prevalence of poor glycemic control among male patients with T2DM.

3. Research Questions

1- Is there a relationship between cigarette smoking and WP smoking and glycemic control among males with T2DM?

3- Is there a relationship between glycemic control and demographic and clinical characteristics among the participants?

4- What is the prevalence of WP smoking and cigarette smoking among T2DM patients?

5- What is the prevalence of poor glycemic control among male patients with T2DM?

4. Literature Review

Source of data used in this study Started with electronic research and focus on full copies of relevant studies from CINAHL (cumulative index to nursing and allied health lecture), MEDLINE (medical literature on line) and Google search. This chapter presents the literature review regarding glycemic control, diabetes, and smoking. A comprehensive literature search was performed to explore the data available on cigarette smoking and WP smoking and the increased risk of poor glycemic control complications. This chapter also presents the results of the reviewed literature that is related to the study variables.

4.1 Glycemic Control

The success of diabetes management is calculated by controlling blood glucose levels measured by HbA1c, which, according to the American Diabetes Association (ADA) guidelines, should be below 7% [(8)]. A cross-sectional study in the United Kingdom, conducted from 1998 through 2002, recruited 10,663 participants whose age ranged between 17 to 98 years with a mean age of 66 years. This study estimated that about 76% of diabetic patients had their HbA1c over 7%. In 1998 and in 2002, 79% and 76% of the participants, respectively, had poor glycemic control, defined as HbA1c >7.0%. Participants with poor glycemic control were approximately 2 years younger and had been prescribed more oral hypoglycemic agents: 41% received ≥2 oral hypoglycemic agents in 1998 and 52% in 2002 [(27)]. In a 1999-2000 study of 4874 participants with diabetes by the US National Health and Nutrition Examination (NHANES), 37.0% of diabetic patients achieved the target level HbA1c of less than 7%. Patients who were non-Hispanic, white, with high BMI, and had insulin combination with oral agents were found to be significantly associated with poor glycemic control [(28)]. A study, which included 500 patients with

T2DM, was conducted in India over one year period from May 2011 to April 2012. This study showed that in male participants, hypertriglycermia and gender were significantly associated with poor glycemic control. The study illustrated that, though positively correlated but not statistically, elderly age (>50 years), higher BMI, longer duration of DM, being only on oral hypoglycemic agents groups, significantly associated with poor glycemic control in T2DM patients [(29)]. Another study in San Diego, USA, of patients with T2DM included 573 individuals with a mean age of 55 years, 69% of whom were females. Participants' ethnic mix was 53% Hispanic, 18% Asian, 7% black, 20% white, and 2% other. The study concluded that long duration of diabetes; insulin use or different oral agents, young age and high cholesterol were significantly associated with poor glycemic control [(30)]. A study was conducted at the King Khalid University Hospital in Saudi Arabia to evaluate glycemic control of diabetic patients. A total of 20,000 participants were involved in the study. Approximately 90% of the patients were older than 40 years and 90% were obese. In this study, good glycemic control was acceptable in approximately 40% of those participants. Cholesterol level was normal in more than 70% of the patients, while triglyceride was normal in 56% of them. In about half of the participants, systolic blood pressure was not controlled and in about 27%, the diastolic blood pressure was uncontrolled. Good glycemic control was significant in males; BMI<30 and Age<50 were significantly associated [(31)]. In a study conducted at Najran Armed Forces Hospital in Saudi Arabia, 100 diabetic patients, with a mean age of 58 ± 14.52 years, were involved. About 78% of the participants had poor glycemic control regarding their diabetes. Patients younger than age 65, female participants, and high levels of triglyceride were significantly associated with poor Glycemic control [(32)]. Another study was conducted at Al Faisal University in Saudi Arabia. A total number of 778 T2DM patients, with a mean age of 55.03 ± 11.4, participated in the study. Females made up 62.7% of the study sample. This study measured the mean HbA1c levels, LDL levels, blood pressure, BMI and the percentage of glycemic control. The study also monitored changes during a 4-years span. The mean of the HbA1c was 8.7 in 2006 and 8.6 within four years. In 2009, 16.6% of diabetic patients had good glycemic control with HbA1c reading of ≤ 7.0%. While the mean of diabetic patients in the 4 years was 13.55% with good glycemic control (HbA1c goal ≤ 7%), the systolic blood pressure and BMI increased over 4 years of time. Glycemic control showed a significant association with LDL for three years in sequence [(33)].

A study conducted in 2010 to determine the factors associated with poor glycemic control among patients with T2DM in Jordan included 917 people attending in the NCDEG. The attendants aged between 24 and 84 years, with a mean of 57.4 years. Approximately 65.1% of the 917 participants had poor glycemic control (HbA1c ≥ 7%). This study estimated that with long duration of diabetes, participants who did not adhere to eating plans recommended by dietitians, negative attitudes towards diabetes, and increased barriers to adherence were significantly associated with poor Glycemic control [(34)]. In another study in Jordan, which included 337 participants, the mean HbA1c was 7.1%. This study reported that 56.1% participants had poor glycemic control, and about 46.6% achieved the target blood pressure of <130/80. Whereas half of the patients achieved the target levels of TC, TG and HDL, only 10.4% achieved the target level of LDL. Duration of the disease (>5 years) and type of treatment (insulin alone and combination therapy) were significantly associated with poor Glycemic control [(35)]. A further study, also conducted in Jordan, included 1000 T2DM patients attending the NCDEG in Amman. The participants' mean age was 58.1 (SD 9.3) years. The group of participants with HbA1c ≥ 10% decreased from 15.3% to 6.0% after 12 months. Good glycemic control (HbA1c < 7%) increased from 25.4% at the first visit to 27.5% in a 12-month follow-up. Low BMI, shorter duration of diabetes and higher baseline HbA1c had significant associations with good Glycemic control [(36)]. Another cross-sectional design study was conducted between June 2008 and December 2008 at the King Abdullah University Hospital (KAUH) in Jordan. The study included 533 T2DM patients, aged 18 years and above. This study reported that poor glycemic control was prevalent in about 51.6% of the participants. This study, in addition, showed that long duration of diabetes of more than 10 years and decreased family and friend support significantly associated with poor glycemic control [(37)].

Table (2-1): Summary of Studies Reporting on Glycemic Control						
Study Location/ Author(s)	**Year(s)**	**Subjects (No.)**	**HbA1c Cutoff Point**	**Prevalence and Level of Glycemic Control**	**Significant Associated Factor(s)**	**Age**
UK Kathleen et al. (27)	1998	10,663	>7.0%	76% poor	OHA, younger age	mean 66
USA NHANES Sharon et al. (28)	1999, 2000	4,874	>7.0%	37% good	age at diagnosis, insulin in combination with oral, high BMI, non-Hispanic, white ethnicity	20 and older
USA San Diego Benoit et al. (30)	2004	573	>7.0%	-poor	insulin use, different oral agents, younger age, high cholesterol, duration of DM, BMI	mean 55
India Gopinath et al. (29)	2011-2012	500	>7.0%	78.6% poor	male gender, hypertriglycermia	<50 51-59 >60
Saudi Arabia by Al-Rowais (31)	2009	20,000	>7.0%	40% good	male gender, BMI <30, Age <50	older than 40 years
Saudi Arabia NAFH clinics Harrabi et al. (32)	2014	100	>7.0%	22% good	age less than 65 years, high levels of total cholesterol	mean 58
Saudi Arabia by Ferwana et al. (33)	2006 and 2009	778	>7.0%	16.6% good	education level, LDL, age, BMI, systolic blood pressure	mean 55
Jordan at NCDEG by Khattab et al. (34)	2010	917	>7.0%	65.1% poor	long duration of diabetes, not adhering to eating plans, negative attitudes towards diabetes, increased barriers to adherence	mean 57.4
Jordan at JUST A Omari et al. (35)	2009	337	>7.0%	65.1% poor	duration of disease >5 years, type of treatment (insulin alone and combination therapy)	-
Jordan at KAUH Al-Akour (37)	2008	533	>7.0%	51.6% poor	long duration of diabetes of more than 10 years, decreased family and friend support	mean 50.1
Jordan at NCDEG by Adham et al. (36)	2006	1,000	>7.0%	from 25% to 27% at 12 month follow- up	low BMI, shorter duration of diabetes, higher baseline HbA1c	mean 58.1

4.2. Smoking

Smoking is a risk factor for several diseases such as cardiovascular diseases. Several studies agreed that WP is as harmful to the body as cigarette smoking, if not more damaging. A laboratory-based study compared exposure to WP toxicants with cigarette smoking among 54 participants. Each participant completed two 45-minute sessions, one in which they smoked tobacco using a single cigarette and a WP. Carbon Oxide (CO) increased by 23.9 ppm for WP and 2.7 ppm for cigarette smoking. Peak WP Carboxyhemoglobin (COHB) levels were three times more than those observed in cigarette smoking. Peak nicotine levels did not differ, however. Significant

heart-rate increases relative to pre-smoking were observed at 5, 10, 15, 20, 25, and 35 minutes during the cigarette session and in 5-minute intervals during the WP session. The single cigarette and the WP used were associated with similar peak plasma nicotine concentrations. The study findings support that WP smoking presents a risk to non-smokers via secondhand smoke exposure [38]. The prevalence of cigarette smoking and WP smoking in several countries is increasing. A cross-sectional study conducted in the UK, which included 12,436 participants in 2012 and another 12,171 participants in 2013, reported that the prevalence of WP use among adults was about 12%. Frequent WP use was found to be statistically significant as water pipe was more common among adult males than among females, in higher social grades, in younger people and in white ethnicity [39]. A study conducted in Nablus, Palestine, in 2015, which included 336 individuals estimated that 22.8% of the participants were WP smokers, and that this rate was higher among males (35.5%) than among females (11.5%). In logistic regression analysis, male gender, type of college, older age, negative social norms and negative beliefs towards WP smoking contributed to this habit [40]. As many as 38 cohort and cross sectional studies were conducted to establish an assessment of the prevalence of the use of WP. Those studies reported that the prevalence of WP smoking among adults was as follows: Pakistan, 6%, Arab Gulf region, 4% - 12%, Australia, 11%, Syria, 9% - 12%, and Lebanon, 15%. Group WP smoking was high in Lebanon (5%), and in Egypt (11% - 15) [41]. A Cohort study, which included 287 individuals, divided the participants into four groups, according to the smoking pattern. The groups were WP smokers, cigarette smokers, dual (cigarettes and WP) smokers, and non-smokers. The study established that coronary artery disease (CAD) risk was worse among WP smokers than among cigarette smokers, and this may be due to increased tobacco nicotine content. The study also found that there was a positive significant association between the severity of CAD and the duration of smoking per year amongst both WP and cigarette smokers and between the number of cigarette and WP sessions per day [42].

4.3. Smoking and Diabetes

A relationship does exist between smoking and diabetes. In Italy, a study performed to evaluate the effects of cigarette smoking on insulin sensitivity enrolled participants with T2DM and included 28 smokers and 12 non-smokers. The study found a statistically significant association between cigarette smoking and insulin sensitivity after adjustment of potential confounders such as BMI, systolic blood pressure, triglyceride, and HbA1c. The number of cigarettes smoked per day had a significant relationship with the insulin-mediated rate of total glucose disposal [12]. A cross-sectional study in UK, done by European Prospective Investigation into Cancer (EPIC-Norfolk), examined the association between cigarette smoking and HbA1C. Included in the study were 2,704 men and 3,385 women. The participants' age ranged between 45 to 74 years. This study concluded that the mean HbA1c among smokers was greater than that of non-smokers after adjustment of dietary intake. There was also a relationship between HbA1c levels and the number of cigarettes smoked per day. The prevalence of current smoking among men was 14.8% in the age group (45 - 54), 11.0% and 9.8% in the age groups (55 – 64) and (65 – 74) respectively; 12% of men reported being current smokers [14]. A prospective cohort study conducted in Australia included 34 diabetic patients whose smoking average number was 24 cigarettes/ day. The participants were followed for one year of quitting smoking. The mean age of the group who stopped smoking was 60 years. Seven subjects had T1DM and 27 had T2DM. Their mean of HbA1c was 7.7%, which decreased to 7.0 % after smoking cessation. This study reported improvement in HbA1c with smoking cessation [43]. A cross-sectional study, conducted in Pakistan, enrolled 2,032 participants to determine the association between WP smoking and metabolic syndrome (MS) which involves central obesity plus any two of the three factors: dyslipidemia, hypertension, and diabetes. Among the study sample, 16.0% were current WP smokers. Prevalence of MS was significantly higher among current WP smokers (33.1%) as compared to non-smokers (14.8%). WP smokers were three times more likely to have MS compared to non-smokers after adjustment of age, sex and social class. In addition, WP smokers were significantly more likely to have hypertriglyceridemia, hyperglycemia, hypertension and abdominal obesity [44]. The National Diabetes Register in Sweden conducted two smoking-related studies in 1996 and in 2001. Participants with diabetes were 392 in 1996 and 579 in 2001. The studies concluded that the rates of smokers with T1DM were 12% in 1996 and 15% in 2001. The rates were great in females less than 30 years (12% in 1996 and 16% in 2001) and yet greater in the age group 30 – 59 years (13% in 1996 and 17% in 2001) than in older age groups (6% in 1996 and 9% in 2001). The rates of smoking in T2DM patients were 10% in 1996 and 12% in 2001. The rates were greater in patients <60 years of age (17% in 1996 and 22% in 2001) than in older age groups (7% in 1996 and 9% in 2001). Smoker participants with T1DM and T2DM had a greater mean of HbA1c but a lower mean of BMI than non-smokers. This study determined that smoking significantly associated with increased HbA1c levels but the association decreased with BMI, in

both T1DM and T2DM patients [45]. Another study of 204 patients with T2DM was conducted in Turkey. The mean age of the participants was 34.84 years. The mean age for ex-smokers was 35.83 years and for non-smokers 41.75 years. This study showed that HbA1c levels were higher in males, but the levels increased further with age in smokers compared with non-smokers [46]. A study conducted in Nigeria recruited 97 diabetic patients visiting Federal Medical Centre. This study reported that 80.4% participants were non-smokers, 8.2% individuals were current smokers, and 11.3% were past smokers. The study stated that smokers with T2DM were more likely to an increased risk of ischemic heart disease, peripheral vascular disease and stroke [20]. A cross-sectional study in Libya enrolled 242 participants who were WP smokers. This study reported that health problems, such as chronic cough, hypertension, diabetes, breathlessness, acid peptic disorders, recurrent respiratory infections, and ischemic heart disease, were significantly higher among those who had been smoking for the duration of 20 years or above, and those who smoked more than 3 times per week and aged above 35 years [47].

Table (2-2): Summary of Studies Reporting on Smoking and Diabetes

Study Location/ Author(s)/ Year(s)	Sample Size	Result(s)
Italy Benoit et al., 2005 [12]	28 smokers and 12 non-smokers	Diabetic smokers had higher HbA1c concentrations compared to non-smokers.
Australia Gunton et al., 2002 [43]	34 diabetic smokers	There was a significant improvement in HbA1c with smoking cessation.
Turkey Fidancı et al., 2015 [46]	204	HbA1c levels were higher in males and in smokers compared to females and to non-smokers.
UK Sargeant et al., 2001 European Prospective Investigation into Cancer (the EPIC-Norfolk Study) [14]	2,704 men and 3,385 women	Mean HbA1c among smokers was greater than that of non-smokers and was significant after adjustment of dietary intake. There was a relationship between HbA1c levels and the number of cigarettes smoked per day.
Sweden Nilsson et al., 2004 [45]	314 and 439	Diabetic smoker patients had a higher HbA1c mean but a lower BMI mean compared to non-smokers. Smoking was associated with HbA1c elevation, independently of other risk factors such as, age, sex, diabetes duration, use of antihypertensive and anti-lipid drugs.

4.4. Summary

The review of the literature showed that patients with diabetes have poor glycemic control. Several studies showed that smoking cigarettes and WP smoking are risk factors to diseases such as cardiovascular diseases and diabetes. Smoking increases insulin resistance. Hence the prevalence of poor glycemic control among patients with diabetes, which increases their risk of developing microvascular and macrovascular complications.

5. Methods

This chapter discusses the research design, setting, sample, ethical considerations, and operational definitions of variables and statistical analysis plan. The aim of this study is to determine the effect of cigarette and water pipe smoking on glycemic control and the relationship with other risk factors that include socio-demographic characteristics, anthropometric measurements, and clinical data among male patients with T2DM in the NCDEG.

5.1. Study Design

A comparative cross-sectional study was conducted in the National Center for Diabetes, Endocrinology and 6.2Genetics (NCDEG).

5.2. Setting

The NCDEG was established in Amman, Jordan, in 1996 as one of the centers affiliated with the Higher Council for Science and Technology. The main goal of this center is to provide quality health care, education and training in the fields of diabetes, endocrinology and genetics.

5.3. Sample and Sampling

The target population consisted of all male patients diagnosed with T2DM, who had two or more regular visits to Diabetes and Endocrinology Clinic. The sample was collected during the period from 15 November 2015 to 15 March 2016. All patients attending the center during the study period were requested to take part in the study. The study subjects were recruited using a systematic random sample selection (every two patients) from the nursing room. Patients were excluded if there were no previous HbA1c measurements in their files to compare with.

There is evidence in the literature that poor glycemic control remains high (>60%) in patients with type 2 diabetes, so the sample size was defined by calculating sample size equation:

Sample size = $(Z_{1-\alpha/2})^2 * P(P-1)/(d)^2$, by calculation $(1.96)2 * 0.6(1-0.6)/(0.04)^2$ = (577 total sample). For the purpose of providing broader, clearer and more liable results, the researcher had to increase the number of the sample to 879 participants, thus compensating for the missing data.

5.4. The Inclusion Criteria includes Male patients with T2DM, All patients aged over 18 years and Presence of a previous chemical laboratory (HbA1c) study in the patient's medical file record. The **Exclusion Criteria includes** all male and female patients, Patients with T1DM and Ex-smokers.

6. Ethical Considerations

The following principles of ethics in research were ensured before data collection and during the course of the study.

First, the researcher sought approval of NCDEG to conduct the study at the center. Approval of the development of the research instrument to use it as the main data collection tool in the present study was also obtained. **Second,** beneficence was achieved by explaining to the participants the aim of the study and the benefits of taking part in the study. The participants were ensured that they would not be exposed to any harm physically, socially or mentally. **Third**, data were collected from the participants who gave a verbal approval 1- to participate in this study after explaining to the participants that their participation involved voluntary acceptance of answering the questionnaire without any pressure, and 2- to collect data from their medical files without mentioning the national number, name or family name of the participant to keep their anonymity. All participants were informed that they had the right to ask any questions and to withdraw from the study at any time and this would not affect their treatment or the care they received at the center. The researcher conducted the interviews with the participants in a private room to ensure privacy. **Fourth,** the participants were ensured of guaranteed anonymity. The participant could fill the questionnaire without a name, and no name would be used to identify the participant and each participant would have a code number. In addition, it was emphasized that the information provided by the participants would be used for scientific aims only.

7. Data Collection

7.1. Socio-demographic and Clinical Characteristics Questionnaire

A semi-structured questionnaire consisting of sociodemographic data, anthropometric measurements and a clinical data sheet was developed. The questionnaire included the following items: information about age, occupation (employed, non-employed, or retired), level of education, and income. The clinical characteristics and anthropometric data included type of medication used for diabetes, other investigations, duration of diabetes and the last three readings of HBA1c, height, weight, BMI, lipid profile, and blood pressure (Appendix A). Information regarding patients' self-monitoring to glucose levels, dietary adherence and compliance to physical activity and Morisky Medication Adherence Scale were collected (Appendix B). A package including a questionnaire instrument consisting of the smoking status was developed (Appendix C).

7.2. Medication Adherence Questionnaire

This tool was developed by Morisky [48]. Medication Adherence Scale (MMAS-8) is an 8-item questionnaire. The first seven questions are Yes/ No questions, while the eighth question is a multiple-choice question with the answers being (Rarely, Once in a while, Sometimes, Usually, All the time). Each No answer was scored with 0 point except for the fifth question where the Yes answer was scored with 1 point. The eighth question was scored 0 for Never, whereas any other answer was scored with 1 point. According to the scores adherence is classified into 3 categories scores: >2 = low adherence 1 or 2 = adherence 0 = high adherence. The tool was translated into Arabic and tested for validity and reliability by Prof. Waleed Saweileh. Permission was obtained from the author of the Arabic version of MMAS-8 to be used in this study by e-mail (Appendix B).

7.3. Smoking Status Questionnaire

Smoking questionnaire in Arabic language for WP smoking was developed by Prof. Omar F. Khabour [49]. WP tobacco defined as subjects who were current and regular smokers for more than one year. We also asked the participants to estimate the age at which they began using cigarettes and/ or water pipes, with the response categories of (1) Less than 11; (2) 11 – 14; (3) 15 – 17; (4) 18 – 21; and (5) More than 21 years (Appendix C).

8. Operational Definitions of Variables

Diagnosis of Diabetes Mellitus, according to the American Diabetes Association criteria for DM, was adopted (ADA, 2014) [8].

1- Diabetes Mellitus, characterized by insulin resistance in peripheral tissue and defect of the beta cell to insulin secretion, is defined as:

- Level of HbA1c ≥ 6.5
- Fasting plasma glucose ≥ 126 mg/dl after 8 hours of fasting
- Glucose level of ≥ 200 mg/ dl in a two-hour oral glucose tolerance test
- Random plasma glucose ≥ 200 mg/ dl.

2- Participants were eligible for this study if they were diagnosed by a physician as having T2DM.

Duration of Diabetes in years since diagnosis of diabetes was categorized into less than7 years and more than or equal 7 years.

Blood Pressure: People with systolic / diastolic levels ≥140 / 90 mmHg or people, who were on antihypertensive medication, were defined as having hypertension [50].

BMI was categorized into normal if BMI was below 25 kg/ m^2, overweight if BMI was 25 – 29.9 kg/ m^2, and obese if BMI was ≥30 kg/ m^2 [51].

Waist Circumference was considered normal if the value of male WC was <102cm and the value of female WC was <88cm, and if more than or equal to these values, obese (American Diabetes Association, 2014) [51].

Glycemic Status was considered controlled when HbA1c level ≤7% and poor if HbA1c more than 7% (American Diabetes Association, 2014) [6].

Dyslipidemia: Criteria for abnormal lipid profile levels were based on the ADA criteria (American Diabetes Association, 2014) [6]. HDL was considered low when the level was below 40 mg/ dl in males and below 50 mg/ dl in females. LDL was considered high when the level was ≥100 mg/ dl. Dyslipidemia was defined as the presence of one or more of the previous abnormalities in serum lipids or patients receiving medications or any of the above conditions were classified achieving the condition [6].

Type of Treatment was categorized into insulin treatment, oral agent treatment alone and mixed insulin and oral agents.

Diabetes Self-management Behavior

Self monitoring of Blood Glucose: If patients performed at home frequencies of glucose monitoring for 3 days or more in the previous 7 days, patients were classified as highly adherent.

Eating Adherences Recommended by Dietitians: if a patient's eating frequencies were 3 days and more in the previous 7 days, the patient was considered adherent, and if a patient's eating plan was less than 3 days in the previous 7 days, the patient was considered non-adherent.

Physical Activity Questionnaire [52]: The National Institute of Diabetes, Digestive, and Kidney Diseases (2014) recommended that a total amount of 150 minutes a week of moderate-intensity aerobics, such as brisk walking, should be spent. Physical activity for 3 days or more each week consistently reduced the risk of many chronic diseases and other adverse health outcomes. The patients were asked to provide information as follows. Doing Physical Activity: Yes if the patient did a physical activity or No if the patient did not; Type of Physical Activity: Light, Moderate, Vigorous; Group of Physical Activity: Aerobic, Strength, Stretching; Duration of Physical Activity; and Number of Days for Physical Activity per Week. Additionally, the participants were requested to give further elaboration in terms of physical activity. In Light Physical Activity, the patients were asked to tell if Light Physical Activity was easy, Patients were breathing normally, Patients were not sweating, and Patients could talk normally or even sing. In Moderate Physical Activity, we sought to determine if Patients felt the activity to be somewhat hard, Patients were breathing quickly, Patients were lightly sweating after about 10 minutes of activity, and Patients could talk normally but could not sing. In Vigorous Physical Activity, we sought to find out if Patients felt the activity to be hard, Patients were breathing deeply and quickly, Patients were sweating after a few minutes of activity, and Patients could not talk normally without stopping for a breath.

Groups of Physical Activity

- Aerobic exercise uses large muscles, makes your heart beat faster, and makes you breathe harder. Doing moderate to vigorous aerobic exercises 30 to 60 minutes a day most days of the week provides many benefits.

- Strength training to build muscles is a light to moderate physical activity that builds muscles and keeps your bones healthy. When you have more muscle and less fat, you will burn more calories because muscle burns more calories than fat, even between exercise sessions.

- Stretching exercises are a light to moderate physical activity that both men and women can do. For example, yoga is a type of stretching that focuses on your breathing and helps you relax.

Smoking

In this study, respondents who reported smoking at the time of the survey_ current smokers_ were categorized into daily smokers or occasional smokers according to the WHO (1998) guidelines. Daily smokers are defined as individuals who smoke any tobacco product at least once a day, including those who smoke every day except days of religious fasting. Occasional smokers are individuals who smoke any tobacco product, but not every day [46]. Cigarette-smokers were asked about the duration and frequency of smoking (the average number of cigarettes smoked per day or week). Smoking definition was based on its active presence in the last one year [20].

Current WP Smokers are defined as subjects who were current and regular smokers for more than one year.

The participants were compared at two different levels:

1. Smokers vs non-smokers

2. Patients were first divided, according to their smoking habits, into four groups: Group 1: WP smokers only, Group 2: Cigarette smokers only, Group 3: Dual smokers (cigarette and WP smokers), and Group 4: Non-smokers.

Anthropometric Measurement

Body Mass Index [51] is weight in kilograms divided by square of the height in meters, measured by electrical and non-electrical L-shape digital weight scales to the nearest 0.5 cm. Measures in centimeter and meter units should be to the nearest 0.5 kg without shoe use and with minimal clothing.

Waist Circumference is a measurement in centimeters at midpoint between the lower border of the ribs and the upper border of the pelvis.

Hypertension (Blood Pressure) operational definition: the pressure applied by blood on the blood vessels during heart contraction and heart relaxation. Heart contraction is called systolic blood pressure and heart relaxation is called diastolic blood pressure. Blood pressure measurement is usually done by nurses, using electronic sphygmomanometers. NCDEG uses (RIESTAR sphygmomanometers, model number EN 1060). Nurses should focus, before measuring blood pressure, on the size of the cuff and bladder in the sphygmomanometers. If the patient's body weight is normal, a nurse should use a normal adult blood pressure cuff (sized 24cm x 32cm) with a bladder (sized 12cm wide and 23cm long). If the patient is obese, a larger blood pressure cuff (35 - 44 cm circumference) should be used. The patient should be in sitting position and the hand on the heart level. The patient should take a rest before the nurse measures BP.

Biochemical Data

We used the BIO RAD Variant II TURBO high-performance liquid chromatography method to measure HBA1c percentage. Lipid profiles were assayed by the automated spectrophotometer, which uses the enzymatic colorimetric method. Kits from Roche Diagnostics were implemented.

9. Statistical Analysis Plan

We used the Statistical Package for Social Science (SPSS version 20), Data were examined for data entry errors and corrected appropriately.Univariate analysis: Descriptive statistics were obtained for continuous analysis of variables as means ± SD, and categorical variables as frequencies and percentages. Bivariate analysis: the chi-square test was used to assess the significance for the differences of categorical variables and the associations between dependent and independent variables. Multivariate analysis: using binary logistic regression analysis was conducted to determine the factors associated with Glycemic control. The association of a particular variable was expressed as odds ratio (OR) with a 95% confidence level (CL). And Results were considered significant at a P-value of <0.05.

Results

This study aims to determine the association between smoking cigarettes and water pipe smoking with glycemic control, and to determine the prevalence of glycemic control and associated risk factors among male patients with T2DM in the NCDEG. This chapter describes the results to accomplish the purpose of the study. It includes a description of the participants' socio-demographic characteristics and clinical and laboratory data. The associations between cigarette-smoking, water pipe smoking, socio-demographic characteristics, clinical and laboratory data with glycemic control are presented as well.

Participants' Characteristics

The study recruited 879 male participants with T2DM. The socio-demographic and anthropometric characteristics of the study participants are shown in Table (4-1). The age of participants ranged from 30 to 90 years with a mean of 58 years (SD±11.0). Most of the participants (43.2%) were in the age group 51 - 64 years. More than half of the participants (53.2%) had diabetes for more than 7 years, while 46.8 % of them had diabetes for less or equal to 7 years, with a mean duration of 10 years (SD ±7.2). As for the level of education, 61.1% of the participants received a higher level of education, while 38.9% of them received secondary education or less. About half of the participants had income equal to 500 JDs or more per month, while 49.7% of them were having monthly income less than 500 JDs per month. More than half (56.5%) of participant were of high waist circumference and described as obese. The clinical characteristics of the study participant are presented in table (4-2). About 65% participants did not achieve the target level of HbA1C with a mean of 7.6% (SD±1.21). Most participants (73.5%) were performing glucose self-monitoring regularly, 77.2% were adherent to treatment of diabetes, 65% were non-adherent to regular diet, and the majority of the participants (78.7%) were non-compliant to physical activity. Regarding medical history, seventy-three percent of our study participants had HTN, with a mean systolic blood pressure of 136 (SD±14.3) and a mean diastolic blood pressure of 77 (SD±8.6), 16.4% participants had IHD, 3.9% had CVA and 80% had dyslipidemia. With concern to the type of treatment used for the management of diabetes, patients who were on oral hypoglycemic agents (OHA) made up 54.6 % of the sample, while 41.7% were on a combination of OHA and insulin therapy; only 3.8% of the patients were on insulin therapy alone.

Table (4-2): Clinical Characteristics of the Study Participants (n=879)

Variable	Number (%)
Glycemic Control mean=7.6, (SD ±1.21)	
Uncontrolled	566 (65.1)
Controlled	303 (34.9)
Dyslipidemia	
No	175 (20)
Yes	699 (80)
Physical Activity	
Non-compliant	685 (78.7)
Compliant	185 (21.3)
Type of Treatment	
Insulin	32 (3.7)
Oral Hypoglycemic Agents	473 (54.6)
Insulin and Oral Hypoglycemic Agents	361 (41.7)
Ischemic Heart Disease	143 (16.4)
Hypertension	632 (73)
CVA	34 (3.9)
Drug Adherence	
Non-adherent	199 (22.8)
Adherent	675 (77.2)
Self-monitoring	
Non-adherent	231 (26.5)
Adherent	642 (73.5)
Dietary Adherence	
Non-adherent	562 (64.4)
Adherent	310 (35.6)

Smoking Status

As shown in table (4-3), 56.8 % of the study participants were non-smokers, while 43.2% of the participants were smokers. Of all participants, 32.2% were cigarette smokers alone, 7.3% were waterpipe smokers alone, and the remaining 3.7% were dual (cigarettes and WP) smokers.

Table (4-3): Characteristics of Smoking Habits among the Study Participants (n=879)

Variable	Number (%)
Smoking	
Yes	375 (43.2)
No	494 (56.8)
Type of Smoking	
Cigarettes alone	280 (32.3)
Waterpipe alone	63 (7.3)
Cigarettes and water pipe	32 (3.7)
Non-smoker	493 (56.8)
Number of Cigarettes Smoked/ Day	
Less than 10 cig/ day	9 (3.2)
10 to 20 cig/ day	21 (7.4)
1-2 packs/ day	149 (52.3)
More than 2 packs/ day	106 (37.2)
Frequency of Waterpipe Smoking	
At least once/ day	43 (45.7)
At least once/ week	49 (52.2)
At least once/ month	2 (2.1)

Glycemic Control

About sixty-five percent of the participants did not achieve the target level of HbA1C with a mean HbA1C 7.6% (SD±1.21). Glycemic control, according to participants' characteristics, is shown in tables (4-4, 4-5, and 4-5). Glycemic control differed significantly between participants according to duration of diabetes, waist circumference, smoking status, type of diabetes treatment, dyslipidemia, dietary adherence, physical activity, self-monitoring of diabetes and adherence to medications. As shown in table (4-5) and Figure (4-1), most diabetic smokers did not achieve the target level of glycemic control.

Table (4-4): Relationship between Glycemic Control and Sociodemographic and Anthropometric Characteristics among the Study Participants (n=879)

Variable	Uncontrolled N (%)	Controlled N (%)	P-value
Age (years)			0.386
≤50	165 (68.2%)	77 (31.8%)	
51-64	245 (65%)	132 (35%)	
≥65	155 (62.2%)	37 (37.8%)	
Duration of DM			**0.000**
≤7	205 (50.6%)	200 (49.4%)	
>7	358 (77.7%)	103 (22.3%)	
Waist Circumference			**0.000**
High	215 (57.2%)	161 (42.8%)	
Normal	348 (71.5%)	139 (28.5%)	
Education			0.216
Secondary or less	230 (67.6%)	110 (32.4%)	
Higher education	336 (63.5%)	193 (36.5%)	
Occupation			0.521
Employed	283 (66.1%)	145 (33.9%)	
Unemployed or Retired	279 (64%)	157 (36%)	
Monthly Income (JDs)			1.000
<500	275 (65%)	148 (35%)	
≥500	279 (64.9%)	151 (35.1%)	

Table (4-5): Relationship between Glycemic Control and Clinical Characteristics among the Study Participants (n=879)

Variable	Uncontrolled N (%)	Controlled N (%)	P-value
Dyslipidemia			**0.041**
No	101 (58.4%)	72 (41.6%)	
Yes	465 (66.8%)	231 (33.2%)	
Type of Treatment			**0.000**
Insulin	26 (81.2%)	6 (18.8%)	
Oral Hypoglycemic Agents	221 (46.9%)	250 (53.1%)	
Insulin and Oral Hypoglycemic Agents	314 (87.7%)	44 (12.3%)	
Ischemic Heart Disease			0.563
No	468 (64.7%)	255 (35.3%)	
Yes	96 (67.6%)	46 (32.4%)	
Hypertension			0.076
No	140 (60.3%)	92 (39.7%)	
Yes	422 (67.1%)	207 (32.9%)	
CVA			0.584
No	539 (64.8%)	293 (35.2%)	
Yes	24 (70.6%)	10 (29.4%)	
Physical Activity			**0.000**
Non-compliant	472 (69.4%)	208 (30.6%)	
Compliant	93 (50.3%)	92 (49.7%	

Self-mentoring Adherent Non-adherent	 181 (79.4%) 385 (60.2%)	 47 (20.6%) 255 (39.8%)	**0.000**
Dietary Adherence Adherent Non-adherent	 433 (77.5%) 133 (43.2%)	 126 (22.5%) 175 (56.8%)	**0.000**
Drug Adherence Adherent Non-adherent	 174 (87.9%) 392 (58.4%)	 24 (12.1%) 279 (41.6%)	**0.000**

Table (4-6): Relationship between Glycemic Control and Smoking Habits among the Study Participants (n=879)

Variable	Uncontrolled N (%)	Controlled N (%)	P-value
Type of Smoking Cigarettes alone Waterpipe alone Cigarettes and Water pipe Non-smoker	 195 (69.6%) 45 (71.4%) 24 (75%) 302 (61.1)	 85 (30.4%) 18 (28.6%) 8 (25%) 192 (38.9)	**0.037**
Number of Cigarettes/ Day 10 to 20 cig/ day 1-2 packs/ day More than 2 packs/ day	 13 (44.8%) 115 (68%) 91 (79.8%)	 16 (55.2%) 54 (32%) 23 (20.2%)	**0.001**
Frequency of Waterpipe Smoking At least once/ day At least once/ week At least once/ month	 34 (79.1%) 33 (67.3%) 1 (50%)	 9 (20.9%) 16 (32.7%) 1 (50%)	0.353
Health Team Support No Yes	 9 (69.2%) 553 (65%)	 4 (30.8%) 298 (35%)	0.502

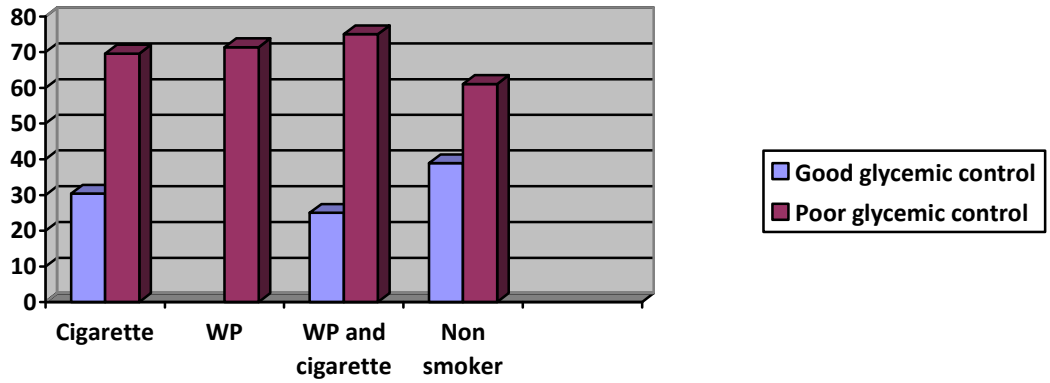

Figure (4-1): The Association between Glycemic Control and Smoking Status

Multivariate Analysis of Factors Associated with Glycemic Control

Multivariable logistic regression analysis was performed to examine the net effect of certain variables on glycemic control after adjustment of the effects of other variables in the model. As shown in table (4-7), the only factors that associated with glycemic control were duration of DM, age, drug adherence, dietary adherence, type of smoking habits, and waist circumference, all of which were significant to the model. Participants with short duration of diabetes less than or equal 7 years were 2.9 times more likely to have good glycemic control compared to participants with long duration of diabetes (more than 7 years). Participants with age group more than 64 years old were 2 times more likely to have good glycemic control compared to participants less than 51 years old (p-value was 0.008). Participants with positive adherence to treatment were 4 times more likely to have

good glycemic control compared to participants were non-adherent to diabetes treatment (p-value 0.000). Participants adherent to diet were 3 times more likely to have good glycemic control compared with participants who were non-adherent to their diet as recommended by dietitians (p-value was 0.000).

In addition, subjects who were cigarette smokers and dual (cigarettes and WP) smokers were (0.62, 0.35) times, respectively, less likely to have good glycemic control compared with non-smokers, with p-values being 0.017 for cigarette smokers and 0.032 for cigarette and WP smokers, respectively. It was noticed that more than half of the participants had high waist circumference and were (0.049) times lower likely to have good glycemic control compared to patients of normal waist circumference (p-value 0.017). On the other hand, participants who were WP alone users were 0.52 time less likely to have good glycemic control compared with non-smokers. WP alone smokers had a positive but not significant association (p-value 0.072). As for patients who were on a combination of insulin and OHA, they were 0.39 time less likely to have good glycemic control compared to participants on insulin alone. Their association was positive but not significant (p-value 0.072).

Table (4-7): Logistic Regression Analysis of the Factors Associated with Glycemic Control among Participants with Type 2 Diabetes

Variable	OR (95% CI)	P-value
Duration of Diabetes (years)		
≤7	2.94 (2.01-4.30)	**0.000**
>7	1 (reference)	
Age (years)		
≤50	1 (reference)	
51-64	1.54 (.99-2.38)	0.053
≥65	1.98 (1.19-3.28)	**0.008**
Type of Treatment		
Insulin	1 (reference)	
Oral Hypoglycemic Agents	1.80 (.7-4.9)	0.237
Insulin and Oral Hypoglycemic Agents	0.39 (.14-1.1)	0.072
Drug Adherence		
Non-adherent	1 (reference)	
Adherent	3.84 (2.2-6.6)	**0.000**
Dietary Adherence		
Non-adherent	1 (reference)	
Adherent	2.66 (1.9-3.8)	**0.000**
Type of Smoking		
Cigarettes alone	0.619 (.41-.91)	**0.017**
Waterpipe alone	0.52 (.26-1.06)	0.072
Cigarettes and Water Pipe	0.35 (.14-.92)	0.032
Non-smoker	1 (reference)	
Waist Circumference		
Normal	1 (reference)	
High	0.65 (.46-.93)	**0.017**

Summary

In the present study, it was established that 65.1% of the participants did not achieve the recommended target level for glycemic control (HbA1c <7). About 43% of the participants were smokers. An overall 32.3% were cigarette smokers of whom 69.6% had poor glycemic control. Another 7.3% were waterpipe smokers of whom 71.4% were of poor glycemic control. The remaining 3.7% were dual smokers, 75% of them had poor glycemic control.

10. DISCUSSION

This study aims to determine the association between smoking cigarettes and waterpipe smoking with glycemic control, and to determine the prevalence of glycemic control and associated risk factors among male patients with T2DM in the NCDEG. The study enrolled 879 male participants with T2DM receiving treatment at the NCDEG. Smoking was found to be associated with poor glycemic control among T2DM patients. As for the

prevalence of smoking, this study showed that about 43% of the participants were smokers. Our results are consistent with a recent study for the Middle East region, which set the rates of smoking 20.2% to 45.5% [53]. In our study, we determined that 32.3% of our participants were cigarette smokers, 69.6% of them were of poor glycemic control. Our study also pointed out that 7.3% participants were water pipe smokers, 71.4% of them had poor glycemic control, and that the remaining 3.7% were dual smokers, 75% of whom with poor glycemic control. Moreover, our study confirmed that participants less than 50 years were more likely to smoke than participants 65-years old and older. Similar to our finding are the results of the *American Lung Association*, which stated in 2007 that patients of younger ages were more than three time likely to smoke than people 65 years and older [54].

Smoking induces the insulin resistance existent in T2DM. This leads to increased glucose in the bloodstream. Smoking-related insulin resistance accelerates atherosclerosis and increases cardiovascular risk and long-term poor metabolic control [12]. This finding supports the association between tobacco smoking and poor glycemic control and concludes that smoking increases the risk of diabetes and its complications [14]. Most diabetic smokers adhered to eating recommendations of dietitians and most of them had normal waist circumference. The explanation for this is that nicotine increases energy expenditure and could also decrease appetite. Smoking cessation is frequently followed by weight gain [18]. Most diabetic smokers were non-compliant to physical activity, which was possibly, because smoke decreased their pulmonary function [55].

This study reported that smoking cigarettes and dual smoking (cigarettes and WP) were significantly associated with poor glycemic control. However, participants who were on waterpipe alone were less likely to have good glycemic control compared with non-smoking patients; the association was positive, but not significant. Additionally, most diabetic smokers did not achieve the target level of glycemic control. This finding is similar to other studies which support that cigarette smoking is significantly associated with elevated HbA1c concentrations [12, 43, 14, and 46]. Also, our study established (by using binary logistic regression analysis) that the number of cigarettes smoked was not significant. The chi-square test, nevertheless, indicated that glycemic control differed significantly between participants according to the number of cigarettes smoked. This finding is contrary to another study that reported the number of cigarettes smoked to be statistically significant with the level of HbA1c [14]. In addition Our study found significant association between smoking and target level of HbA1c after adjusting age, duration of diabetes, waist circumference and diet adherence variables. This finding is similar to studies which concluded that the association between smoking and the level of HbA1c was independent of BMI, age, duration of diabetes [45] and diet [14].but, not similar to a study with blood pressure and patients who used lipid lowering medication [45].

In this study, 65.1% participants did not achieve the recommended target level for glycemic control (HbA1c <7). The level of glycemic control found in this study is similar to the findings of other studies that were reported by Sharon et al. [28], Khattab et al. [34], Al-Omari et al. [35] and Al-Rowais [31], in which HbA1c ≥7% was achieved in 68%, 65.1%, 65.1% and 60% respectively. However, the level of poor glycemic control found in this study is lower than other studies reported by Kathleen et al. [27], Gopinath et al. [29], Harrabi et al. [32] and Ferwana et al. [33], in which HbA1c ≥7% was achieved in 76%, 78.6%, 78% and 84.4% respectively. A higher prevalence of good glycemic control was not achieved in the NCDEG, possibly because around two thirds of the participants were non-adherent to regular diet plans by dietitians, and the majority of the participants (78.5%) were non-compliant to physical activity. Factors found to be correlated with good glycemic control were duration of DM, age older than 65, positive drug adherence, positive dietary adherence and normal waist circumference.

This study showed that short duration of diabetes was significantly associated with good glycemic control (less than or equal 7 years). This finding is consistent with that reported by other studies [37], [34], [30], [35]. It is explained by the fact that progressive impairment of insulin secretion and decrease in beta-cell function with longer duration of diabetes, makes the response to diet alone or oral agent, unattainable. The United Kingdom prospective diabetes study showed that beta cell function decreased during five to ten years [56]. In this study, participants with poor glycemic control prescribed a combination of insulin and oral hypoglycemic agents were compared with participants on insulin alone. This finding is explained by health care providers attempting to provide better glycemic control by giving additional different types of medication to treat diabetes and the need for higher doses of medication that increases over time. This finding is consistent with other studies [33, 28, and 26]. The results of this study showed a significant relationship between good glycemic control and normal waist circumference. Obesity is progressively worsening among participants with T2DM which may be due to insulin and other OHA used [36, 30, 28, 31, and 33]. Younger age less than 65 years old was associated with poor glycemic control. This finding is consistent with studies reporting that old age more than 65 years old was associated with good glycemic control [27, 30, 32, and 31]. Positive adherence to medication was more common among participants

above 50 years with good glycemic control. The possible explanation for this finding is that most participants in this age are afraid of aging and death. Only a small percentage of participants was adherent to dietitian-recommended regular diet and continued education is important to encourage diet-regime adherence. This finding is similar to the finding of another study [34].

11. Conclusion

Most diabetic smokers did not achieve the target level of glycemic control. Smoking cigarettes and waterpipe smoking were found to have a significant association with poor glycemic control, after adjustment of other confounders, such as duration of DM, age, drug adherence, dietary adherence and waist circumference.

12. Recommendations

Smoking increases the risk of diabetic complications. Therefore, it is recommended that

- A comprehensive strategy should be initiated to assist patients to quit smoking.
- Health promotion activities such as smoking cessation should be implemented at outpatient clinics, schools, mosques, universities and different community settings.
- Further studies with large cohort should be conducted to give better understanding of the relationship between tobacco smoking and glycemic control.

Strengths of the Study

- This is the first study in Jordan that reports on the effects of cigarette and waterpipe smoking on glycemic control.
- The large sample size.

Limitations of the Study

- Glycemic control may be affected by confounders other than smoking
- Numbers of waterpipe smokers were small in our study
- The questionnaire which was used to assess the WP smoking was adapted from a study which was conducted on a sample population taken from one center, without checking for the validity and reliability of this particular questionnaire.
- Our results cannot be generalized on the whole community (Jordanian), since the sample which we use was taken from one health center (NCDEG).

List of Abbreviations

ADA: American Diabetes Association

BP: Blood Pressure

BMI: Body Mass Index

CVA: Cardiovascular Disease

HbA1c: Glycosylated Hemoglobin

HTN: Hypertension

NCDEG: National Center for Diabetes, Endocrinology and Genetics

OHA: Oral Hypoglycemic Agent(s)

OR: Odd Ratio

SD: Standard Deviation

SPSS: Statistical Package for Social Science

T2DM: Type 2 Diabetes

TG: Triglyceride

WHO: World Health Organization

WP: Waterpipe (Arghila)

References

[1] Azevedo, M. and Alla, S., 2008. Diabetes in sub-saharan Africa: kenya, mali, mozambique, Nigeria, South Africa and zambia. *International journal of diabetes in developing countries*, *28*(4), p.101.
[2] Edition, I. D. A. S. (2014). International Diabetes Federation 2013. Update.
[3] Alberti, K.G.M.M. and Zimmet, P.F., 1998. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus. Provisional report of a WHO consultation. *Diabetic medicine*, *15*(7), pp.539-553.
[4] Ajlouni, K., Khader, Y.S., Batieha, A., Ajlouni, H. and El-Khateeb, M., 2008. An increase in prevalence of diabetes mellitus in Jordan over 10 years. *Journal of Diabetes and its Complications*, *22*(5), pp.317-324.
[5] Stumvoll, M., Goldstein, B.J. and van Haeften, T.W., 2005. Type 2 diabetes: principles of pathogenesis and therapy. *The Lancet*, *365*(9467), pp.1333-1346.
[6] LeRoith, D. and Smith, D.O., 2005. Monitoring glycemic control: The cornerstone ofdiabetes care. *Clinical therapeutics*, *27*(10), pp.1489-1499.
[7] Delamater, A.M., 2006. Clinical use of hemoglobin A1c to improve diabetes management. *Clinical Diabetes*, *24*(1), pp.6-8.
[8] American Diabetes Association. Standards of Medical Care in Diabetes-2014. *Diabetes Care*, 37, S14.
[9] International Diabetes Federation Guideline Development Group, 2014. Global guideline for type 2 diabetes. *Diabetes research and clinical practice*, *104*(1), p.1.
[10] Murad, M.A., Abdulmageed, S.S., Iftikhar, R. and Sagga, B.K., 2014. Assessment of the common risk factors associated with type 2 diabetes mellitus in Jeddah. *International journal of endocrinology*, *2014*.
[11] Chang, S.A., 2012. Smoking and type 2 diabetes mellitus. *Diabetes & metabolism journal*, *36*(6), pp.399-403.
[12] Targher, G., Alberiche, M., Zenere, M.B., Bonadonna, R.C., Muggeo, M. and Bonora, E., 1997. Cigarette Smoking and Insulin Resistance in Patients with Noninsulin-Dependent Diabetes Mellitus 1. *The Journal of Clinical Endocrinology & Metabolism*, *82*(11), pp.3619-3624.
[13] Després, J.P., Lamarche, B., Mauriège, P., Cantin, B., Dagenais, G.R., Moorjani, S. and Lupien, P.J., 1996. Hyperinsulinemia as an independent risk factor for ischemic heart disease. *New England Journal of Medicine*, *334*(15), pp.952-958.
[14] Després, J.P., Lamarche, B., Mauriège, P., Cantin, B., Dagenais, G.R., Moorjani, S. and Lupien, P.J., 1996. Hyperinsulinemia as an independent risk factor for ischemic heart disease. *New England Journal of Medicine*, *334*(15), pp.952-958.
[15] World Health Organization, 2009. *Global Adult Tobacco Survey (GATS): Thailand country report, 2009 (# 080072)*.
[16] Global Youth Tobacco Survey Collaborating Group, 2003. Differences in worldwide tobacco use by gender: findings from the Global Youth Tobacco Survey. *The Journal of school health*, *73*(6), p.207.
[17] Maziak, W., Ward, K.D., Soweid, R.A. and Eissenberg, T., 2004. Tobacco smoking using a waterpipe: a re-emerging strain in a global epidemic. *Tobacco control*, *13*(4), pp.327-333.
[18] Gavlak, D., 2008. Smoke alarm from Afghanistan to Morocco. *Bulletin of the World Health Organization*, *86*(2), pp.89-90.
[19] Fadhil, I., 2007. Tobacco control in Bahrain: an overview.
[20] Nwaokoro, J.C., Okorie, E.A., Chima, O.E., Sally, N.I., Amadi, A.N., Dozie, I.N.S., Iwuji, S.C. and Nwaokoro, A.A., 2014. Study on the effect of smoking on Type 2 Diabetic Patients in Federal Medical Center Owerri, Southeastern Nigeria. *Asian Journal of Medical Sciences*, *5*(3), pp.63-71.
[21] Sadiq, M.A., Parekh, M.A., Zubairi, A.B.S., Frossard, P.M. and Khan, J.A., 2012. Cross-sectional study identifying forms of tobacco used by Shisha smokers in Pakistan. *Journal of the Pakistan Medical Association*, *62*(2), p.192.
[22] Aslam, H.M., Saleem, S., German, S. and Qureshi, W.A., 2014. Harmful effects of shisha: literature review. *International archives of medicine*, *7*(1), p.1.
[23] Watad, W., Sukhera, J., Shushan, S., Kazlak, M., Skinner, H.A., Alnueirat, A.A. and Roth, Y., 2009. Water pipe smoking: Effects, attitudes and directions. *Journal of Smoking Cessation*, *4*(01), pp.18-25.
[24] US Department of Health and Human Services, 2004. The health consequences of smoking: a report of the Surgeon General. *Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health*, *62*.
[25] Doll, R., Peto, R., Boreham, J. and Sutherland, I., 2004. Mortality in relation to smoking: 50 years' observations on male British doctors. *Bmj*, *328*(7455), p.1519.
[26] World Health Organization, 2005. Waterpipe tobacco smoking: health effects, research needs and recommended actions by regulators. *Geneva, Switzerland: World Health Organization*.

[27] Fox, K.M., Bolinder, B., Chen, J. and Kumar, S., 2006. Prevalence of inadequate glycemic control among patients with type 2 diabetes in the United Kingdom general practice research database: a series of retrospective analyses of data from 1998 through 2002. *Clinical therapeutics*, *28*(3), pp.388-395.
[28] Saydah, S.H., Fradkin, J. and Cowie, C.C., 2004. Poor control of risk factors for vascular disease among adults with previously diagnosed diabetes. *Jama*, *291*(3), pp.335-342.
[29] Gopinath, B., 2013. Sri Sai Prasd M, Jayarama N, Prabhakara K. *Study of factors associated with poor glycemic control in Type-2 Diabetic patients. GJMEDPH*, *2*, p.2.
[30] Benoit, S.R., Fleming, R., Philis-Tsimikas, A. and Ji, M., 2005. Predictors of glycemic control among patients with Type 2 diabetes: a longitudinal study. *BMC Public Health*, *5*(1), p.1.
[31] Al-Rowais, N.A., 2014. Glycemic control in diabetic patients in King Khalid University Hospital (KKUH)–Riyadh–Saudi Arabia. *Saudi Pharmaceutical Journal*, *22*(3), pp.203-206.
[32] Harrabi, I., Al Harbi, F. and Al Ghamdi, S., 2014. Predictors of glycemic control among patients with type 2 diabetes in Najran Armed Forces Hospital: A pilot study. *Journal of Diabetes Mellitus*, *4*(02), p.141.
[33] Ferwana, M., Abdulmajeed, I., Al Madani, W., AlDughaither, A., Alrowaily, M.A., Al Bader, B., Al Owayyed, A., Firwana, M. and Al Farhan, A., 2015. Glycemic Control and Accompanying Risk Factors: 4-Year Primary Care Study. *Journal of Diabetes & Metabolism*, *2015*.
[34] Khattab M, Khader YS, Al-Khawaldeh A, Ajlouni K. Factors Associated with Poor Glycemic Control among Patients with Type 2 Diabetes. *Journal of Diabetes and its Complications*. 2010 Apr 30; 24 (2): 84-9.
[35] Al Omari, M., Khader, Y., Dauod, A.S., Al-Akour, N., Khassawneh, A.H., Al-Ashker, E. and Al-shdifat, A., 2009. Glycaemic control among patients with type 2 diabetes mellitus treated in primary care setting in Jordan. *Primary care diabetes*, *3*(3), pp.173-179.
[36] Adham, M., Froelicher, E.S., Batieha, A. and Ajlouni, K., 2010. Glycaemic control and its associated factors in type 2 diabetic patients in Amman, Jordan. *Eastern Mediterranean Health Journal*, *16*(7), p.732.
[37] Al-Akour, N., 2011. Glycemic control and its determinants among patients with type 2 diabetes mellitus attending a teaching hospital. *Journal of Diabetes & Metabolism*.
[38] Cobb, C.O., Shihadeh, A., Weaver, M.F. and Eissenberg, T., 2011. Waterpipe tobacco smoking and cigarette smoking: a direct comparison of toxicant exposure and subjective effects. *Nicotine & Tobacco Research*, *13*(2), pp.78-87.
[39] Grant, A., Morrison, R. and Dockrell, M.J., 2014. Prevalence of waterpipe (Shisha, Narghille, Hookah) use among adults in Great Britain and factors associated with waterpipe use: data from cross-sectional Online Surveys in 2012 and 2013. *nicotine & tobacco research*, *16*(7), pp.931-938.
[40] Al-Halaweh, M.A., 2015. *Water-Pipe Smoking and Associated Factors among An-Najah National University Students* (Doctoral dissertation, Faculty of Graduate Studies Water-Pipe Smoking and Associated Factors among An-Najah National University Students By Mai Abu Al-Halaweh Supervisor Dr. Samar Musmar Co-supervisor Dr. Zaher Nazzal This Thesis is Submitted in Partial Fulfillment of the Requirements for the Degree of Master in Public Health Program, Faculty of Graduate studies, An-Najah National University).
[41] Akl, E.A., Gunukula, S.K., Aleem, S., Obeid, R., Jaoude, P.A., Honeine, R. and Irani, J., 2011. The prevalence of waterpipe tobacco smoking among the general and specific populations: a systematic review. *BMC public health*, *11*(1), p.1.
[42] Selim, G.M., Fouad, H. and Ezzat, S., 2013. Impact of shisha smoking on the extent of coronary artery disease in patients referred for coronary angiography/Koroner anjiyografi önerilen hastalarda nargile içiminin koroner arter hastaliginin yayginligina etkisi. *Anadulu Kardiyoloji Dergisi: AKD*, *13*(7), p.647.
[43] Gunton, J.E., Davies, L., Wilmshurst, E., Fulcher, G. and McElduff, A., 2002. Cigarette smoking affects glycemic control in diabetes. *Diabetes Care*, *25*(4), pp.796-797.
[44] Shafique, K., Mirza, S.S., Mughal, M.K., Arain, Z.I., Khan, N.A., Tareen, M.F. and Ahmad, I., 2012. Water-pipe smoking and metabolic syndrome: a population-based study. *PloS one*, *7*(7), p.e39734.
[45] Nilsson, P.M., Gudbjörnsdottir, S., Eliasson, B., Cederholm, J. and Steering Committee of the Swedish National Diabetes Register, 2004. Smoking is associated with increased HbA 1c values and microalbuminuria in patients with diabetes—data from the National Diabetes Register in Sweden. *Diabetes & metabolism*, *30*(3), pp.261-268.
[46] Fidancı, İ., Tekin, O., Arslan, İ., Eren, Ş.Ü., Dinçer, G. and Kızıltaş, Ö., 2015. The Evaluation of the Effect of Smoking Habit on HbA1c. *Ankara Medical Journal*, *15*(3).
[47] Sugathan, S. and Swaysi, M., 2014. Reported Health Problems among Shisha or Waterpipe smokers in Misurata, Libya. *International Journal of Preventive and Therapeutic Medicine*, *2*(2).
[48] Morisky, D.E., Green, L.W. and Levine, D.M., 1986. Concurrent and predictive validity of a self-reported measure of medication adherence. *Medical care*, *24*(1), pp.67-74.
[49] Khabour, O.F., Alzoubi, K.H., Eissenberg, T., Mehrotra, P., Azab, M., Carroll, M.V., Afifi, R.A. and Primack, B.A., 2012. Waterpipe tobacco and cigarette smoking among university students in Jordan. *The International Journal of Tuberculosis and Lung Disease*, *16*(7), pp.986-992.

[50] James, P.A., Oparil, S., Carter, B.L., Cushman, W.C., Dennison-Himmelfarb, C., Handler, J., Lackland, D.T., LeFevre, M.L., MacKenzie, T.D., Ogedegbe, O. and Smith, S.C., 2014. 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). *Jama*, *311*(5), pp.507-520.

[51] Panel NO. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults. *NOEIE Panel* - 1998 - ncbi.nlm.nih.gov

[52] The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), What I Need to Know about Physical Activity and Diabetes, *NIH Publication* No. 14–5180 May 2014.

[53] Shafey, O. and Guindon, G.E., 2003. Monitoring the tobacco epidemic: Past, present, and future. *Tobacco control country profiles. Atlanta, GA: American Cancer Society*, *2*.

[54] American Lung Association. An Emerging Deadly Trend: Water Pipe Tobacco Use. PDF–222 KB) Washington: *American Lung Association*. 2007.

[55] Hughes, J.R., Crow, R.S., Jacobs Jr, D.R., Mittelmark, M.B. and Leon, A.S., 1984. Physical activity, smoking, and exercise-induced fatigue. *Journal of behavioral medicine*, *7*(2), pp.217-230.

[56] Diabetes, U.P., 1995. Group S Perspectives in Diabetes UK. Prospective diabetes study 16 overview of 6 Years 'Therapy of type II diabetes: a progressive disease. *Diabetes*, *44*, pp.1249-1258.