Palestinian Medical and Pharmaceutical Journal

Factors Associated with Diabetes Mellitus Control Among Palestinian Diabetic Patients Visiting Specialized Center

Ali Shakhshir[1], Ola Anabtawi[2], Shatha Ardah[2], Tasneem Smerat[3] & Manal Badrasawi[4,*]

Received 17th Nov. 2024, Accepted 12nd Mar. 2025, Published: ××××, 202X, DOI: https://doi.org/10.xxxx

Received Accepted, In Press

Abstract: Poor glycemic control increases the risk of various complications in diabetic patients. Therefore, this study investigated the factors influencing glycemic control among diabetic patients in Palestine. In this cross-sectional study, diabetic patients who regularly attended the Palestine Diabetes Institutes were recruited. Data on demographics, clinical characteristics, Mediterranean diet adherence, and quality of life (QOL) were collected. Descriptive analysis and binary logistic regression were employed to determine the associations among the selected variables, using the SPSS software. The study included 199 participants, 54.8% of them were females and 83.4% had poor glycemic control, while 22.1% had strong adherence to the Mediterranean diet. Patients with poor glycemic control were more likely to be obese, non-smokers, and who engaged less walking. Additionally, these patients were more frequently prescribed a combination of metformin and Dipeptidyl Peptidase-4 (DPP-4) inhibitors, as well as mixed insulin. glycemic control was significantly associated with all QOL domains except for energy., with patients with poor glycemic control presenting lower scores across all QoL domains, except for emotional well-being. Binary regression analysis showed that increasing the amount of time spent walking per week, having role limitations due to physical health, and better general health were significant predictors of poor glycemic control. Poor glycemic control is significantly associated with lifestyle factors, medication use, and QoL domains. These findings underscore the need for targeted interventions to improve glycemic control and to explore effective strategies for optimizing glycemic control.

Keywords: diabetes, glycemic control, quality of life, obesity, Palestine.

Introduction

Diabetes mellitus (DM) is a chronic disease that results from defects in insulin secretion, insulin action, or both, which ultimately results in a hyperglycemic state (1,2). Worldwide, the number of patients diagnosed with diabetes was estimated to be 415 million in 2015, with expectations to reach 642 million by 2040 (3). In the Arab countries, the total prevalence of DM in the Kingdom of Saudi Arabia is 23.7% among adults aged 30 to 70 years old. The estimated prevalence in the United Arab Emirates is 20.1%. While the prevalence in Bahrain and Kuwait is 12.8% and 14.9%, respectively (4). In Palestine, the prevalence of diabetes was estimated at 15.3%, with a prediction to increase to 23.4% by the end of 2030 (5). In the long term, associated insulin resistance and glucose intolerance primarily lead to hyperglycemia and alterations in lipid and protein metabolism (6), consequently, increasing the risk of diabetes complications (7,8). Microvascular complications like chronic kidney disease, retinopathy, and neuropathy, as well as lower-extremity amputations (LEA), and macrovascular complications like peripheral vascular disease, stroke, and coronary heart disease, account for the majority of the burden associated with diabetes (9).

Glycemic control (GC) is recognized as a public health concern for being the optimal therapeutic target to prevent DM complications (10). For the best glucose management, the American Diabetes Association (ADA) recommends an HbA1c level of less than 7%, while the American Association of Clinical Endocrinologists (AACE) recommended a level of less than 6.5% (4). However, if it can be accomplished safely without causing frequent or severe hypoglycemia or other negative treatment side effects, achieving lower A1C levels than the target of 7% (53 mmol/mol) may be acceptable and even advantageous, depending on the judgment of medical professionals and the preferences of the diabetic patient. However, people with a short life expectancy or those for whom the negative effects of treatment outweigh the positive effects might benefit from less strict glycemic targets (11).

Several risk factors are associated with diabetes mellitus, specifically type II, including being overweight or obese, consuming alcohol, smoking, or other behavioral dietary factors like consuming refined carbohydrates and high sugar and highly saturated fat (HSHF) foods (12). Additionally, factors such as physical inactivity and a sedentary lifestyle, early diagnosis, and self-care, including non-adherence to health promotion and maintenance actions, play a significant negative role in glycemic control (12).

Previous literature has investigated the potential factors that could lead to either optimal or poor glycemic control for patients with diabetes (13–15). In a recent meta-analysis (13), Bitew and colleagues revealed that being a male provides protection against inadequate glycemic control. However, decreased

1 Department of Medicine, Faculty of Medicine and Health Sciences, Arab American University, Jenin, Palestine
2 Department of Nutrition and Food Technology, Faculty of Agriculture and Veterinary Medicine, An-Najah National University, Nablus, Palestine.
3 Department of Medicine and Health Sciences, Faculty of Medicine and Health Sciences, Palestine Polytechnic University, Hebron, Palestine.
4 Department of Nutrition and Food Technology, Faculty of Medicine and Health Sciences, An-Najah National University, Nablus, Palestine.
*Corresponding author: m.badrasawi@najah.edu

exercise, poor diet adherence, poor adherence to anti-diabetic medications, and being a smoker increased the risk of poor glycemic control (13). Additional aspects, such as limited access to formal education, the unavailability of a glucometer for blood glucose monitoring, the absence of a family history of diabetes, the existence of comorbidities, obesity, and a prolonged duration of diabetes contribute to poor glycemic control (13). Espinosa and colleagues discovered that inadequate glycemic control was substantially associated with insulin use, reduced or no physical activity, age of 59 years or older, a diagnosis of the disease beyond 10 years, and high blood pressure (14). Moreover, Babaniamansour and his colleagues found that glycemic control has a significant relationship with educational and occupational levels (16). Additionally, they reported that patients with optimal glycemic control had considerably lower levels of total cholesterol and fasting plasma glucose (FPG), while an increase of one standard deviation in FPG can raise HbA1c by 0.014 (16).

In the Arab region, specifically in Jordan, a study revealed that longer duration of diabetes (>7 years), failure to follow the dietary plan advised by dietitians, a negative attitude towards diabetes, and higher scores on the barriers to adherence scale were significantly linked to higher odds of poor glycemic control (4). Nevertheless, few studies were done to assess the factors associated with glycemic control in Palestine. Radwan et al. (2018) (17), for instance, who conducted a study in the Gaza Strip, found that good glycemic control, which was shown in one fifth of the 369 included patients, was associated with older age, good adherence to medications, and higher health awareness. However, longer disease duration (DM > 7 years) was negatively associated with good glycemic control. Another study by Mosleh et al. (2017). found that 16.7% of 271 participants had good glycemic control, along with a significant correlation between unemployment and lower likelihood of having good glycemic control (18). Samara et al. (19) concluded in their study that age, total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), healthcare index (HIC), and the type of management plan had a strong relationship with HbA1c. A large percentage of the patients had poor glycemic control, and multivariate analysis showed that lower HDL values, younger age, and combination therapy with insulin were significantly associated with increased HbA1c levels.

Overall, this study was conducted to investigate the prevalence of poor glycemic control and its relationship with physical activity, quality of life, and adherence to a Mediterranean diet among diabetic patients who visit a diabetes-specific primary health care center.

Materials and Methods

Study design

This cross-sectional study recruited Type II DM patients, who are currently being followed up at the Palestinian Diabetes Institute (PDI), located in Nablus City, Palestine. The Palestinian Diabetes Institute is a primary health care institute that offers health care services to patients with diabetes through several specialized clinics, with branches in three major Palestinian cities in the occupied West Bank–Hebron, Nablus, and Al-Bireh. The PDI is strategically located to reach and serve a broad spectrum of the Palestinian population suffering from diabetes. These clinics include diabetes follow-up, ophthalmology, nutrition, and endocrinology for children. Additionally, the institute offers a wide range of laboratory analyses related to the diabetes management status (20).

Inclusion criteria included adults with diabetes, aged at least 18 years, being diagnosed with diabetes for a period of 6 months or longer, and receiving treatment at the aforementioned institute. Informed written consent was obtained from participants. Data collection began in August 2022 and continued until March 2023.

At the start of data collection, we gave the participants a validated and pre-tested structured open-response interview-type questionnaire. To ensure confidentiality for the participants, the dietitian conducted the data collection at her office. G-Power v.3 was used for calculating the sample size for the independent samples t-test, with an alpha level of 0.05, a power of 0.8, and a medium effect size of 0.5. Based on these factors, the required sample size was 175 patients; however, with dropouts or missing data, it scaled to 190 participants.

Data collection and research tools

Participants' sociodemographic details (gender, age, marital status, educational attainment, monthly income, employment status, and residence area), lifestyle behaviors (such as smoking, physical activity, and daily sleep and wake times), and diabetes mellitus-related data were among the data collected, which included questions related to home test monitoring and disease duration. Several laboratory biomarkers were investigated, such as fasting blood glucose, lipid profile, including low-density lipoprotein (LDL), high-density lipoprotein (HDL), triglycerides (TG), and cholesterol. Clinical characteristics related to the medical and surgical histories and associated comorbidities were evaluated like the presence or absence of nephropathy, dyslipidemia, retinopathy, ischemic heart disease in addition to the number of previous surgeries (if any) along with the anti-diabetic medications used among the targeted patients such as the use of either metformin, long-acting insulin, short-acting insulin, DDP Inhibitor, sulfonylurea glinides, combined metformin plus DDP-I, mixed insulin or sodium-glucose cotransporter-2 (SGLT2) inhibitors. Anthropometric measurements such as weight, height, and waist-hip ratio were also measured. Lifestyle habits related to smoking, including smoking duration and years since cessation, as well as sleep disturbances and time spent playing sports (in minutes) at the gym or home. Lastly, adherence to the Mediterranean diet and quality of life were assessed using the Mediterranean Diet Adherence Screener (MEDAS) and the 36-Item Short Form Survey Instrument (SF-36), respectively.

Adherence to Mediterranean diet

The Mediterranean Diet Adherence Screener (MEDAS) tool was used to measure participants' Mediterranean diet adherence. This 14-item questionnaire was developed as a self-reported and valid tool to determine adherence to the Mediterranean diet (MD). The final score ranged from 0 to 14, where low adherence was any score below 5, moderate adherence ranged between 6 and 9, and high adherence was ≥ 10 (21).

Quality of life assessment

The quality of life of the respondents was assessed using the validated Arabic version of the RAND 36-item health survey (22). Thirty-six multiple-choice questions make up the 36-Item Short Form Health Survey questionnaire (SF-36), which assesses eight different aspects of current quality of life: physical function, role limitations due to physical health problems, bodily pain, general health perception, emotional well-being, role limitations due to emotional problems, social function, and energy or fatigue. Higher scores indicate higher levels of functioning or well-being. Each scale has a score between 0 and 100.

Statistical analysis

The statistical analysis was done using version 21 of the Statistical Package for the Social Sciences (SPSS) software. Descriptive analysis using means and standard deviations was used for the continuous variables, while number and frequency were used for categorical variables. For inferential statistical analysis, the independent samples t-test, Pearson correlation, and the Chi-square test were used to determine the associations among the selected variables. Further analysis was done using a binary logistic regression test; the logistic regression assumptions were examined. Collinearity diagnostic tests were used to evaluate multicollinearity. The Hosmer-Lemeshow goodness of fit test was used to assess how well the model fitted the data. All of the variables included showed a significant association with DM control in the univariate analysis.

Results and Discussion

Demographic and lifestyle variables of the participants

There were 199 participants in the final analysis, 90 of whom were male (45.2%) and 109 of them were female (54.8%), with an average age of 52.8±14.22 years. Table 1 presents the sociodemographic and lifestyle characteristics of the participants. Most of the participants were married (81.4%), 35.7% had primary education, almost 60% of them were unemployed, half lived in villages or camps, and 52.3% had a family mean income of 1500-3000 new Israeli Shekel (NIS).

The majority of participants (64.3%) were non-smokers, while 11.1% were ex-smokers. Among the smokers, the majority used cigarettes. The average number of years of smoking was 6.55±11.39, whereas ex-smokers had an average of 15.43±13.88 years since quitting. Most participants (85.9%) indicated that they do not experience sleep disturbances. Among those who do any kind of sports, the average weekly duration of walking was 188.58±145.06 (40–840) minutes, the average weekly duration of gym-based sports was 341.25±64.08 (270–420) minutes, and the average weekly duration of home-based sports was 198±126.57 (120–420) minutes.

Table (1): Sociodemographic characteristics of the participant presented in (N) and (%) and (mean±SD)

Variable		**N**	**%**
Gender	Male	90	45.2
	Female	109	54.8
Marital Status	Married	162	81.4
	Single	21	10.6
	Others (e.g.: Divorced, widowed)	16	8
Educational degree	No formal education	6	3
	Primary education	71	35.7
	Secondary education	53	26.6
	University	63	31.7
	Postgraduate	6	3
Employment Status	Employed	80	40.2
	Unemployed	119	59.8
Living area	City	95	47.7
	Village or camp	104	52.3
Family income	Less than 1500 NIS[1]	8	4
	1500-3000 NIS	104	52.3
	3000-5000 NIS	49	24.6
	More than 5000 NIS	38	19.1
Lifestyle habits			
Smoking	Yes	49	24.6
	No	128	64.3
	Ex-smoker	22	11.1
Smoking years (mean± SD)		6.55±11.39	
Stop smoking years (mean± SD)		15.43±13.88	
Smoking type	Cigarette	32	16.1
	Shisha	17	8.5
	None	150	75.4
Sleep disturbance	Yes	28	14.1
	No	171	85.9
Walking in mins per week (mean± SD)		188.58±145.06	
Sport at gym in mins per week (mean± SD)		341.25±64.08	
Sport at home in mins per week (mean± SD)		198±126.57	

[1] New Israeli Shekel (1 NIS = 0.28 US dollar).

Disease related data of the participant

The mean disease duration was 9.29±7.51 (0.42–38) years. Among them, 120 individuals (60.3%) had comorbidities associated with DM, including hypertension (45.2%), dyslipidemia (10.1%), ischemic heart disease (7%), nephropathy (3.5%), and retinopathy (0.5%). Additionally, 54.8% of the participants had surgery, with a median of one surgery and a range of 0 to 8. The patients in the study used a range of drugs to manage their condition. Among them, 69.8% used metformin, 24.1% used long-acting insulin, 12.6% used short-acting insulin, 5.5% used DDP inhibitor (Dipeptidyl Peptidase Inhibitor), 9% used sulfonylurea glinides, and 3.5% used SGC-I (Guanylate Cyclase Inhibitor). Furthermore, Table 2 indicates that drug combinations were also used; almost half of participants used a mix of Metformin and DDP, and 21.1% used mixed insulin.

The average and variability of the outcomes from the laboratory test conducted on certain participants were as follows: The blood sugar level is 186.4±74.51 mg/dL, the LDL level is 115.6±37.09 mg/dL, the HDL level is 49.2±14.99 mg/dL, the TG level is 179.8±144.11 mg/dL, and the cholesterol level is 177.4±42.13 mg/dL.

Table (2): Disease related data of the participant presented in (N) and (%) and (mean±SD).

Variable		N	%
Comorbidities	Yes	120	60.3
	No	79	39.7
Nephropathy	Yes	7	3.5
	No	192	96.5
Hypertension	Yes	90	45.2
	No	109	54.8
Dyslipidemia[1]	Yes	20	10.1
	No	179	89.9
Retinopathy	Yes	1	0.5
	No	198	99.5
Ischemic heart disease	Yes	14	7
	No	185	93
Previous surgeries	Yes	109	54.8
	No	90	45.2
How many operation (mean±SD)		1.16±1.52	
Medication			
Metformin	Yes	139	69.8
	No	60	30.2
Long-acting Insulin	Yes	48	24.1
	No	151	75.9
Short-acting Insulin	Yes	25	12.6
	No	174	87.4
DDP Inhibitor	Yes	11	5.5
	No	188	94.5
Sulfonylurea Glinides	Yes	18	9
	No	181	91
Combined Met plus DDP-I	Yes	93	46.7
	No	106	53.3
Mixed insulin	Yes	42	21.1
	No	157	78.9
SGC.I	Yes	7	3.5
	No	192	96.5
Lab test			
FBG (mean±SD)		186.4±74.51	
LDL (mean±SD)		115.6±37.09	
HDL (mean±SD)		49.2±14.99	
TG (mean±SD)		179.8±144.11	
Cholesterol (mean±SD)		177.4±42.13	

[1] Diabetics were considered to have dyslipidemia if they had LDL-C ≥100 mg/dL (moderate risk), LDL ≥70 mg/dL (high risk), and LDL ≥55 mg/dL (very high risk) (23).

Nutritional status of the participant

Table 3 presents the nutritional status of the participant. The findings indicated that 43.7% of the participants were obese, 39.7% were overweight, 15.1% had a normal weight, and 1.5% were underweight, while 93.5% of the participants had abdominal obesity. Regarding adherence to the Mediterranean diet, 22.1% of participants showed high adherence, with 68.8% showing moderate adherence to the Mediterranean diet

Table (3): Nutritional status of the participant presented in (N) and (%).

Variable		N	%
MEDAS	High	44	22.1
	Moderate	137	68.8
	Low	18	9
BMI	Underweight	3	1.5
	Normal	30	15.1
	Overweight	79	39.7
	Obese	87	43.7
Abdominal obesity	Abdominal obesity	186	93.5
	No Abdominal obesity	13	6.5

The participants DM related data

Out of the participants, 181 (91%) had type II diabetes mellitus, while 9% had type I diabetes. The participants were categorized into two groups based on their HbA1c laboratory results: those with good glycemic control (less than 7%), which accounted for 16.6% of the study participants, and those with poor glycemic control (greater than 7%), which accounted for 83.4%, as shown in Figure 1.

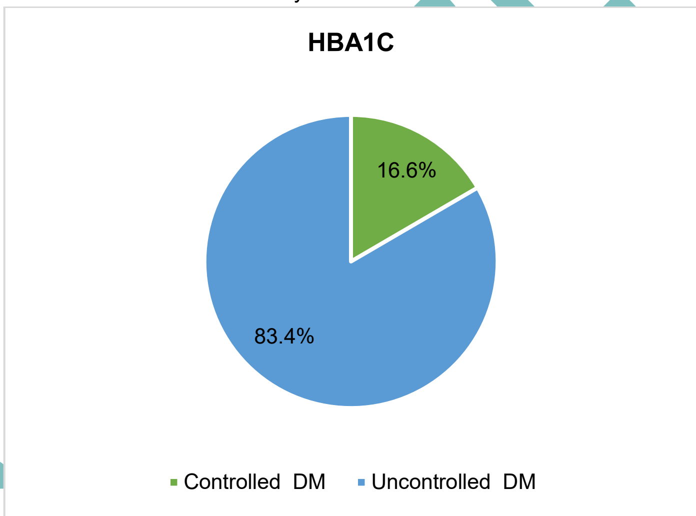

Figure (1): The percentages of patients with controlled and uncontrolled diabetes as determined by HbA1c laboratory results.

Glycemic control association with sociodemographic and lifestyle factors

According to the information presented in Table 4, the analysis revealed that there was no significant correlation between any of the sociodemographic characteristics and glycemic control. The results indicate a significant positive correlation between good glycemic control and smokers, type of smoking, and increased walking duration per week, with p-values of 0.011, 0.012, and <0.001, respectively.

Table (4): Glycemic control association with sociodemographic and lifestyle factors.

Variable		Good GC (33, 16.6%)	Poor GC (166, 83.4%)	P-value
Age (mean±SD)		50.6±15.55	53.3±13.95	[b]0.333
Gender	Male	16 (48.5)	74 (44.6)	[a]0.411
	Female	17 (51.5)	92 (55.4)	
Marital Status	Married	23 (69.7)	139 (83.7)	[a]0.139
	Single	5 (15.2)	16 (9.6)	
	Others	5 (15.2)	11 (6.6)	
Educational degree	No formal education & Primary education	7 (21.2)	70 (42.2)	[a]0.064
	Secondary education	10 (30.3)	43 (25.9)	
	University & postgraduate	16 (48.5)	53 (31.9)	
Employment Status	Employed	12 (36.3)	68 (40.9)	[a]0.386
	Unemployed	21 (63.6)	98 (59.0)	
Living area	City	18 (54.5)	77 (46.4)	[a]0.252
	Village or camp	15 (45.5)	89 (53.6)	
Family income	Less than 3000 NIS	20 (60.6)	92 (55.4)	[a]0.845
	3000-5000 NIS	7 (21.2)	42 (25.3)	
	More than 5000 NIS	6 (18.2)	32 (19.3)	
Lifestyle				
Smoking	Yes	14 (42.4)	35 (21.1)	[a]0.011*
	No and Ex-smoker	19 (57.6)	131 (78.9)	
Smoking years (mean±SD)		10.1±12.69	5.8±11.03	[b]0.052
Stop smoking years (mean±SD)		3.5±2.52	17.9±14.01	[b]0.056
Smoking type	Cigarette	10 (30.3)	22 (13.3)	[a]0.012*
	Shisha	5 (15.2)	13 (7.8)	
	None	18 (54.5)	131 (78.9)	
Sleep disturbance	Yes	2 (6.1)	26 (15.7)	[c]0.180
	No	31 (93.9)	140 (84.3)	
Walking in mins/week (mean±SD)		270.34±189.86	152.81±103.31	[b]<0.001*
Sport at home in mins/week (mean±SD)		230±165.22	150±42.42	[b]0.568

[a]Chi-square test, [b]t-test, [c]Fisher Exact Test.

Glycemic control association with disease related data

There was no observed association between glycemic control and participants'' reported comorbidities, diabetes type, selected laboratory tests (except for FBG), and the number of operations. However, certain medications, specifically combined metformin and DDP-I, and mixed insulin, demonstrated a significant outcome with a p-value < 0.005. These findings are presented in Table 5.

Table (5): Glycemic control association with disease-related data

Variable		Good GC	Poor GC	P-value
Comorbidities	Yes	21 (63.6)	99 (59.6)	[a]0.411
	No	12 (36.4)	67 (40.4)	
Nephropathy	Yes	31 (93.9)	161 (97.0)	[c]0.328
	No	2 (6.1)	5 (3.0)	
Hypertension	Yes	16 (48.5)	74 (44.6)	[a]0.411
	No	17 (51.5)	92 (55.4)	
Dyslipidemia	Yes	6 (18.2)	14 (8.4)	[a]0.089
	No	27 (81.8)	152 (91.6)	
Ischemic heart disease	Yes	2 (6.1)	12 (7.2)	[c]0.581
	No	31 (93.9)	154 (92.8)	
Diabetes type	Diabetes type I	3 (9.1)	15 (9.0)	[c]0.603
	Diabetes type II	30 (90.9)	151 (91.0)	
Operation	Yes	19 (57.6)	90 (54.2)	[a]0.849
	No	14 (42.4)	76 (45.8)	
How many operation (mean±SD)		1.0±1.29	1.2±1.56	[b]0.590
Medication				
Metformin	Yes	24 (72.7)	115 (69.3)	[a]0.433
	No	9 (27.3)	51 (30.7)	
Long-acting Insulin	Yes	4 (12.1)	44 (26.5)	[c]0.117
	No	29 (87.9)	122 (73.5)	
Short-acting Insulin	Yes	4 (12.1)	21 (12.7)	[c]0.59
	No	29 (87.9)	145 (87.3)	
DDP Inhibitor	Yes	1 (3.0)	10 (6.0)	[c]0.695
	No	32 (97.0)	156 (94.0)	
Sulfonylurea Glinides	Yes	2 (6.1)	16 (9.6)	[c]0.743
	No	31 (93.9)	150 (90.4)	
Combined Met plus DDP.I	Yes	8 (24.2)	85 (51.2)	[a]0.004*
	No	25 (75.7)	81 (48.8)	
Mixed insulin	Yes	2 (6.1)	40 (24.1)	[c]0.019*
	No	31 (93.9)	126 (75.9)	
SGC.I	Yes	1 (3.0)	6 (3.6)	[c]0.672
	No	32 (97.0)	160 (96.4)	
Laboratory test				
FBG (mean±SD)		116.3±35.17	200.3±72.43	[b]0.000
LDL (mean±SD)		120.2±37.37	114.6±37.13	[b]0.501
HDL (mean±SD)		49.8±14.93	49.1±15.07	[b]0.811
TG (mean±SD)		141.8±51.15	187.7±155.65	[b]0.113
Cholesterol (mean±SD)		180.1±43.79	176.8±41.92	[b]0.699

[a]Chi-square test, [b]t-test, [c]Fisher Exact Test.

Glycemic control association with Nutritional status

Table 6 demonstrates a clear positive significant association between glycemic control and body mass index (BMI). Overweight and obese participants exhibit poor glycemic control, with a p-value of 0.038. However, no correlation was observed between glycemic control and abdominal obesity or adherence to the Mediterranean diet.

Table (6): Glycemic control association with Nutritional status.

Variable		Good GC	Poor GC	P-value
MEDAS	High	5 (15.2)	39 (23.5)	[a]0.565
	Moderate	25 (75.7)	112 (67.5)	
	Low	3 (9.1)	15 (9.0)	
BMI	Underweight	1 (3.0)	2 (1.2)	[c]0.034*
	Normal	10 (30.3)	20 (12.0)	
	Overweight	9 (27.3)	70 (42.2)	
	Obesity	13 (39.4)	74 (44.6)	
Abdominal obesity	Abdominal obesity	32 (97.0)	154 (92.8)	[c]0.699
	No Abdominal obesity	1 (3.0)	12 (7.2)	

[a]Chi-square test, [c]Fisher Exact Test.

Glycemic control association with QOL questionnaire

Table 7 shows the correlation between glycemic control and different domains of the QOL questionnaire. It shows that there was a significant relationship between glycemic control and physical functioning, as well as role limitations due to physical health, role limitations due to emotional problems, emotional well-being, social functioning, pain, and general health. The p-values for these relationships were all less than 0.001, except for the relationship with emotional well-being, which had a p-value of 0.003.

Table (7): Glycemic control association with QOL questionnaire domains.

Variable	Good GC	Poor GC	P-value
Physical functioning	96.1±9.16	81.4±20.79	0.000*
Role limitations due physical health	95.5±13.19	59.9±39.12	0.000*
Role limitations due emotional problems	91.9±23.61	71.1±38.58	0.003*
Energy/fatigue	58.6±6.87	58.1±7.48	0.721
Emotional well being	40.0±8.94	52.3±12.13	0.000*
Social functioning	88.0±11.68	71.9±22.40	0.001*
Pain	94.3±10.99	79.9±24.04	0.001*
General health	65.2±13.08	44.6±14.09	0.000*

* p<0.05 using t-test.

The binary logistic model included all the significant predictors of poor glycemic control found in the univariate analysis. These were smoking, the type of smoking, the amount of time spent walking each week, using combined insulin, BMI, and all domains of QoL except for the domain of fatigue and loss of energy. It also included factors that were close to significant (p<0.1), such as educational level. The results showed that this model fulfilled the analysis's assumption; the multicollinearity was violated, as indicated by the correlation coefficients being <0.7 for all of the variables in the model. The Hosmer and Lemeshow test revealed that the model's goodness of fit was acceptable (p = 0.415); the Cox & Snell R square was 0.340; and the Nagelkerke R square was 0.572. It was found that walking at home, role limitation due to physical health, and general health variables are all significant predictors of DM control (p<0.01) (Table 8).

Table (8): Poor glycemic control predictors.

Factors	P-value	Exp (B)	95% CI	P-value for the model
Educational level	0.791	0.918	(0.489-1.723)	0.000*
Being smoker	0.525	1.602	(0.374-6.857)	
Smoking type (Ref: none)	0.817	0.858	(0.234-3.142)	
Walking time/ per week	<0.001*	0.991	(0.986-0.995)	
Mixed Insulin	0.101	5.561	(0.715-43.273)	
BMI (Ref: obese)	0.735	0.890	(0.453-1.749)	
Physical functioning	0.875	1.217	(0.105-14.144)	
Role limitation due to physical health	0.019*	0.003	(0.000-0.384)	
Role limitation due to emotional problems	0.313	0.279	(0.023-3.332)	
Emotional wellbeing	0.904	0.920	(0.235-3.600)	
Social Functioning	0.081	0.322	(0.091-1.149)	
Pain	0.368	0.581	(0.178-1.896)	
General health	0.007*	6.663	(1.672-26.548)	

* p<0.05 using binary logistic regression test.

The primary aim of this study was to investigate the factors correlated with glycemic control among patients with diabetes. The analysis revealed a significant correlation between glycemic control and various variables, such as smoking, the type of smoking, the amount of time spent walking or participating in home sports each week, being overweight or obese, and the combination of metformin and DDP-I, and mixed insulin. Furthermore, a significant correlation was observed with the majority of QoL domains.

While previous studies conducted in Palestine have adopted a similar approach (15,17,19,24), this study stands out by combining the assessment of new variables such as patients' compliance with the Mediterranean diet and physical activity and nutritional assessment. When examining several factors, it is well established that tobacco smoking has become more prevalent among patients with diabetes (25). In Europe, 12.5% of the diabetics are found to be smokers (25). Several studies have confirmed the association between smoking and poor glycemic control, in addition to the increased morbidity and mortality among diabetics of either type (26). However, cessation has been proven to decrease the mortality risk among patients several years after quitting smoking (27). In contrast with previous findings, our study has unexpectedly found a significant association between smokers and good glycemic control. This does not imply that smoking is beneficial for glycemic control but might be attributed to several factors, including physical activity and dietary differences, selection bias or sample characteristics, as well as confounding variables like age and disease duration.

In the current study, increased weekly walking minutes were found to be significantly associated with better glycemic control among diabetes patients when compared to their counterparts. This aligns with previous findings that evaluated the influence of walking training programs in type II diabetes patients (28). For instance, high-intensity interval training protocols in patients with metabolic syndrome and type II diabetes have shown significant improvements in glycemic control and cardiovascular risk factors (29). A meta-analysis conducted by Qiu et al. (2014) showed that supervised walking at a moderate intensity 3–5 times/week, 120–150 minutes/week, can gain benefits on glycemic control, with a significant decrease in HbA1c by 0.58%. Moreover, they concluded that it is advisable to recommend supervision or the implementation of motivational techniques while prescribing walking in order to achieve the best possible glycemic control (29). In addition, Van Dijk et al. (2016) showed that engaging in extended walking exercise results in significant decreases in daily insulin use among individuals diagnosed with type I diabetes, even when they increase their caloric and carbohydrate consumption (30). Generally, glycemic control in type II diabetes patients is a well-known benefit of exercise. Minuto et al. have confirmed, based on the experience of Covid-19 lockdowns, that healthy lifestyle adjustments and household physical activity significantly improved glucose control by an age-proportional amount (31), each of which reinforces the importance of structured movement in diabetes management, particularly reducing the odds of poor glycemic control.

In the present study, the majority of patients who had poor glycemic control were more likely to require mixed insulin or combined metformin and DDP-I therapies to manage their condition. This is consistent with a study conducted in Palestine, which showed that patients who had poor glycemic control were more likely to receive insulin and oral treatment (18). Similarly, several studies have established that insulin therapy is commonly required for patients with poor glycemic control (32,33). Furthermore, another study revealed that intensive insulin treatment among patients with type **II** DM can negatively impact quality of life compared to those using oral medications (34). In line with our findings as well, it was reported that the use of DDP.I as monotherapy and in combination with metformin is effective among diabetics, especially patients with HbA1c between 7.6% and 9% (35). However, it is important to recognize that this association between these medications and glycemic control reflects the need for intensified therapy, reinforcing the need for early intervention and restricted management.

There was a strong association between all of the QoL questionnaire domains except for energy and fatigue in the univariate analysis of the current study. While the multivariate analysis identified walking time and role limitations due to physical health and general health as predictors of poor glycemic control, suggesting that increased walking time reduced the risk of poor glycemic control by 0.9%, while role limitations due to physical activity unexpectedly lowered the odds of poor glycemic control. In addition, participants with poorer general health are 6.6 times more likely to have poor glycemic control. This aligns with the findings of other studies, particularly when the analysis is adjusted for factors such as age and the duration of diabetes (34). A study revealed an association between the quality of life and glycemic control. It showed that after 12 months of treatment, patients with good glycemic control have been noticed to have improvement in their health functional status according to RAND-36 scores. These were related almost to all aspects of quality of life, although some domains did not show any statistical significance (36). Similarly, in another study, enhanced glycemic control was associated with improvements in all QoL domains except two, mental and emotional health, which did not quite reach statistical significance (37). A study done in 2010 showed lower scores of physical and mental health in those with poor glycemic control, and the other domains were not statistically significant. It suggested poorer quality of life in some aspects (34). However, previous studies highlighted the link between quality of life and glycemic control (34,36,37), but fewer studies have explored how physical limitations predict glycemic control, which might be attributed to several factors, including medication adherence, better healthcare access, and disease monitoring among this group. On the other hand, this could be related to confounding variables or the small sample size. Further research is recommended in this regard.

The study's strengths lie in its comprehensive assessment of a wide range of influencing factors that are proven to play a significant role in glycemic control and its relatively large sample size. Furthermore, this study is the first one that was conducted among specialized center in Palestine compared to other related studies. However, its cross-sectional design restricted the study to determine the causality relationship. Furthermore, recall bias could not be avoided in this investigation because some of the obtained data was self-reported. This is evident from the frequency of diabetes complications reported in our study, such as nephropathy and retinopathy, which are clearly more common among diabetic patients than our findings.

Conclusion

This study provided insight into the significant factors influencing glycemic control among diabetic patients. A significant association was observed between glycemic control and lifestyle factors, including smoking, physical activity, and adherence to treatment regimens, particularly the use of mixed insulin and combined metformin with DDP-I. In addition, a significant correlation was found between quality-of-life domains and glycemic control, emphasizing the impact of diabetes on overall well-being. Walking emerged as a protective factor as well in our findings. This could significantly affect the established factors and indicators related to glycemic management.

Future research should also explore the various approaches that can be implemented to optimize treatment outcomes and assess their long-term sustainability in diverse populations.

Ethics approval and consent to participate

The study protocol was approved by the internal review board at the An-Najah National University ethical committee. Prior to any communication with patients, permission and approval were obtained from the PDI administration. Patients were adequately briefed about the study's design and objectives. All participants were given a consent to sign, and they were properly informed that their involvement was voluntary, and that the data would be handled with academic integrity and maintained in a completely confidential manner.

Consent for publication

Not applicable

Availability of data and materials

Data are available Upon reasonable request from the corresponding author.

Author's contribution

The authors confirm contribution to the paper as follows: principal investigation and proposal writing: Badrasawi, M; data collection and data entry: Ardah, S; data analysis and validation, Smerat, T; draft manuscript preparation: Shakhshir, A, Anabtawi, O. All authors reviewed the results and approved the final version of the manuscript.

Funding

This work has not received any financial support.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Acknowledgements

The authors are grateful to all patients participated in this study and to the Palestinian diabetes institute.

References

1. Association AD. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2013;36(Supplement_1):S67–74.
2. Nolan CJ, Ruderman NB, Kahn SE, Pedersen O, Prentki M. Insulin resistance as a physiological defense against metabolic stress: implications for the management of subsets of type 2 diabetes. Diabetes. 2015;64(3):673–86.
3. Federation ID. IDF diabetes atlas. ed. IDF Dunia. 2019;
4. Khattab M, Khader YS, Al-Khawaldeh A, Ajlouni K. Factors associated with poor glycemic control among patients with Type 2 diabetes. J Diabetes Complications. 2010;24(2):84–9.
5. Shawahna R, Samaro S, Ahmad Z. Knowledge, attitude, and practice of patients with type 2 diabetes mellitus with regard to their disease: a cross-sectional study among Palestinians of the West Bank. BMC Public Health. 2021;21(1):1–13.
6. Samuel VT, Shulman GI. The pathogenesis of insulin resistance: integrating signaling pathways and substrate flux. J Clin Invest. 2016;126(1):12–22.
7. Aiello LM. Perspectives on diabetic retinopathy. Am J Ophthalmol. 2003;136(1):122–35.
8. Boulton AJM, Malik RA, Arezzo JC, Sosenko JM. Diabetic somatic neuropathies. Diabetes Care. 2004;27(6):1458–86.
9. Harding JL, Pavkov ME, Magliano DJ, Shaw JE, Gregg EW. Global trends in diabetes complications: a review of current evidence. Diabetologia. 2019;62(1):3–16.
10. Koro CE, Bowlin SJ, Bourgeois N, Fedder DO. Glycemic control from 1988 to 2000 among US adults diagnosed with type 2 diabetes: a preliminary report. Diabetes Care. 2004;27(1):17–20.
11. Committee ADAPP. 6. Glycemic Goals and Hypoglycemia: Standards of Care in Diabetes—2025. Diabetes Care [Internet]. 2024 Dec 9;48(Supplement_1):S128–45. Available from: https://doi.org/10.2337/dc25-S006
12. Souza CL, Oliveira MV. Fatores associados ao descontrole glicêmico de diabetes mellitus em pacientes atendidos no Sistema Único de Saúde no Sudoeste da Bahia. Cad Saúde Coletiva. 2020;28:153–64.
13. Bitew ZW, Alemu A, Jember DA, Tadesse E, Getaneh FB, Seid A, et al. Prevalence of Glycemic Control and Factors Associated With Poor Glycemic Control: A Systematic Review and Meta-analysis. Inq J Heal Care Organ Provision, Financ. 2023 Jan;60:00469580231155716.
14. Martínez Espinosa M, dos Santos Almeida VR, Ferreira do Nascimento V. Poor glycemic control and associated factors in diabetic people attending a reference outpatient clinic in Mato Grosso, Brazil. Investig y Educ en Enfermería. 2021;39(3).
15. Ali D, Abduelkarem A, Shahwan M, Shahwan M. Evaluation of factors associated with inadequate glycemic control and some other health care indicators among patients with type 2 diabetes in Ramallah, Palestine. 2013;445–451.
16. Babaniamansour S, Aliniagerdroudbari E, Niroomand M. Glycemic control and associated factors among Iranian population with type 2 diabetes mellitus: a cross-sectional study. J Diabetes Metab Disord. 2020;19(2):933–40.
17. Radwan M, Elsous A, Al-Sharif H, Abu Mustafa A. Glycemic control among primary care patients with type 2 diabetes mellitus in the Gaza Strip, Palestine. Ther Adv Endocrinol Metab. 2018;9(1):3–14.
18. Mosleh RS, Abd Aziz N, Ali SM, Manan MM, Zyoud S, Shah IM, et al. Predictors of good glycemic control among type II diabetes patients in Palestine. Asian J Pharm Clin Res. 2017;10(9):341–7.
19. Samara M, Horoub A, Ibaidi N, Sweileh WM. Prevalence of Glycemic Control and Factors Associated With Increasing Levels of Hba1c Among A Sample of Palestinian Patients With Type 2 Diabetes Mellitus. Palest Med Pharm J. 2017;2(2).
20. The Jerusalem Fund for Education and Community Development. Diabetes is Rising, the PDI is Responding: Be the Urgent Help We Need! Available from:

https://thejerusalemfund.org/2023/08/diabetes-is-rising-the-pdi-is-responding-be-the-urgent-help-we-need/

21. García-Conesa MT, Philippou E, Pafilas C, Massaro M, Quarta S, Andrade V, et al. Exploring the Validity of the 14-Item Mediterranean Diet Adherence Screener (MEDAS): A Cross-National Study in Seven European Countries around the Mediterranean Region. Nutrients. 2020 Sep;12(10).
22. Al Abdulmohsin SA, Draugalis JR, Hays RD, Coons S. Translation of the RAND 36-item health survey 1.0 (aka SF-36) into Arabic. 1997.
23. Rhee EJ. Recent dyslipidemia guidelines for patients with diabetes mellitus. Precis Futur Med. 2020;4(4):133–40.
24. Mosleh RS, Abd Aziz N, Ali SM, Manan MM, Zyoud S, Shah IM, et al. Predictors of good glycemic control among type II diabetes patients in Palestine. Asian J Pharm Clin Res. 2017;10(9):341–7.
25. MALINOVSKA J, LUSTIGOVA M, URBANOVA J, KROLLOVÁ P, MICHALEC J, BROZ JAN. 1439-P: Smoking Prevalence in Diabetes Population in Europe. Diabetes. 2023;72(Supplement_1).
26. Pan A, Wang Y, Talaei M, Hu FB. Relation of smoking with total mortality and cardiovascular events among patients with diabetes mellitus: a meta-analysis and systematic review. Circulation. 2015;132(19):1795–804.
27. Chaturvedi N, Stevens L, Fuller JH, Group WHOMS. Which features of smoking determine mortality risk in former cigarette smokers with diabetes? The World Health Organization Multinational Study Group. Diabetes Care. 1997;20(8):1266–72.
28. Negri C, Bacchi E, Morgante S, Soave D, Marques A, Menghini E, et al. Supervised walking groups to increase physical activity in type 2 diabetic patients. Diabetes Care. 2010;33(11):2333–5.
29. Qiu S, Cai X, Schumann U, Velders M, Sun Z, Steinacker JM. Impact of walking on glycemic control and other cardiovascular risk factors in type 2 diabetes: a meta-analysis. PLoS One. 2014;9(10):e109767.
30. van Dijk JW, Eijsvogels TM, Nyakayiru J, Schreuder THA, Hopman MT, Thijssen DH, et al. Glycemic control during consecutive days with prolonged walking exercise in individuals with type 1 diabetes mellitus. Diabetes Res Clin Pract [Internet]. 2016;117:74–81. Available from: https://www.sciencedirect.com/science/article/pii/S0168822716301188
31. Minuto N, Bassi M, Montobbio C, Vinci F, Mercuri C, Perri FN, et al. The effect of lockdown and physical activity on glycemic control in Italian children and young patients with type 1 diabetes. Front Endocrinol (Lausanne). 2021;12:690222.
32. Saghir SAM, Alhariri AEA, Alkubat SA, Almiamn AA, Aladaileh SH, Alyousefi NA. Factors associated with poor glycemic control among type-2 diabetes mellitus patients in Yemen. Trop J Pharm Res. 2019;18(7):1539–46.
33. Abebe SM, Berhane Y, Worku A, Alemu S, Mesfin N. Level of sustained glycemic control and associated factors among patients with diabetes mellitus in Ethiopia: a hospital-based cross-sectional study. Diabetes, Metab Syndr Obes targets Ther. 2015;65–71.
34. Imran Kamarul M, Ismail AAA, Naing L, Wan Mohamad WB. Type 2 diabetes mellitus patients with poor glycaemic control have lower quality of life scores as measured by the short form-36. Singapore Med J. 2010;51(2):157–62.
35. Chen R, Li J, Chen D, Wen W, Zhang S, Li J, et al. Efficacy and Safety of DPP-4 Inhibitors and Metformin Combinations in Type 2 Diabetes: A Systematic Literature Review and Network Meta-Analysis. Diabetes, Metab Syndr Obes. 2024;17:2471–93.
36. Goddijn PPM, Bilo HJG, Feskens EJM, Groenier KH, Van der Zee KI, De Jong BM. Longitudinal study on glycaemic control and quality of life in patients with Type 2 diabetes mellitus referred for intensified control. Diabet Med. 1999;16(1):23–30.
37. Testa MA, Simonson DC. Health economic benefits and quality of life during improved glycemic control in patients with type 2 diabetes mellitus: a randomized, controlled, double-blind trial. Jama. 1998;280(17):1490–6.