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The Impact of Diabetes Self-Care, Healthy Lifestyle, Social Support, and Demographic Variables on Outcomes HbA1c in Patients With Type 2 Diabetes

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Abstract

Background: Controlling HbA1c can help reduce the symptoms and complications of diabetes. However, only about 25% of adults with diabetes achieve this diabetes care goal. It can be seen that diabetes requires more research investment and breakthroughs, as well as a more complete discussion of related factors that affect diabetes control, in order to better control the disease. This study explored the effects of diabetes self-care behavior, healthy lifestyle, diabetes symptoms, social support, demographic variables, and physical examination values on HbA1c levels in individuals with type 2 diabetes.

Methods: This study used a cross-sectional design and recruited 305 subjects with type 2 diabetes at a medical center. Personal data were collected using a structured questionnaire and same-day outpatient medical records.

Results: Multiple linear regression analysis identified significant predictors of HbA1c levels. These include insulin treatment ($P < .001$), age ($P < .001$), gender ($P < .001$), diabetes duration ($P = .003$), proteinuria ($P < .001$), diabetes self-care behaviors ($P = .021$), physical activity (running; $P = .018$), and spousal involvement in care ($P = .031$). Female gender, insulin treatment, longer diabetes duration, spousal involvement in care, and the presence of proteinuria were positively associated with higher HbA1c levels. In contrast, higher age, better diabetes self-care behaviors, and regular physical activity (running) were associated with lower HbA1c levels. These findings underscore the importance of considering both demographic factors and lifestyle behaviors in the management of HbA1c levels.

Conclusions: For reasons that hinder subjects from controlling HbA1c levels, individual self-management intervention programs should be provided to improve the effectiveness of subjects in controlling HbA1c levels. The care giver should be included in the educational program of diabetes management. Running exercise contributes to the control of HbA1c levels.

Plain Language Summary

HbA1c control and related factors

Managing blood sugar levels (HbA1c) is crucial for people with type 2 diabetes to prevent complications. However, only about 25% of patients successfully meet this goal. This study examined how self-care behaviors, lifestyle choices, social support, and personal factors influence HbA1c levels.

Researchers studied 305 people with type 2 diabetes using questionnaire and medical records. The results showed that several factors impact blood sugar control. Higher age, good self-care habits, and regular running were linked to better control (lower HbA1c). However, being female, using insulin, having diabetes for a long time, having kidney issues (proteinuria), and receiving care from a spouse were associated with higher HbA1c levels.

The study suggests that diabetes care should include personalized self-management plans. Caregivers should also be involved in diabetes education, and running could be a helpful exercise for managing blood sugar levels.

Keywords

diabetes mellitus, type 2, glycated hemoglobin, self care, healthy lifestyle, clinical manifestations of diabetes

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Introduction

Diabetes is a chronic and progressive disease that affects multiple organ systems. It has become one of the most rapidly growing health concerns in the 21st century, with the number of diabetic patients worldwide increasing at an alarming rate. In 2021, diabetes and its complications accounted for 6.7 million deaths globally, translating to 1 death every 5 seconds and representing 12.2% of total global mortality. Notably, nearly half of these deaths occurred in individuals under the age of 60. The economic burden is equally significant, with global healthcare expenditures related to diabetes reaching approximately US$760 billion in 2021, and projections indicating an increase to US$825 billion by 2030 and US$845 billion by 2045.[1] These statistics highlight the urgent need for effective strategies in diabetes prevention, early detection, and management.

A key marker for diabetes management is glycated hemoglobin (HbA1c), with a normal level being below 5.7%, prediabetes ranging from 5.7% to 6.4%, and diabetes diagnosed at levels of 6.5% or higher.[2] Poor glycemic control is associated with complications such as dyslipidemia, hypertension, coronary heart disease, retinopathy, and nephropathy.[3,4] Research indicates that a 1% reduction in HbA1c can lower the risk of microvascular complications by approximately 37%, myocardial infarction by 14%, and diabetes-related mortality by 21%.[5] Consequently, maintaining optimal HbA1c levels is critical for reducing diabetes-related complications, improving quality of life, and lowering healthcare costs.[6]

Despite these benefits, a large proportion of diabetic patients struggle with glycemic control. Studies have shown that approximately 88% of diabetics fail to maintain HbA1c levels below 7.0%.[7] The Centers for Disease Control and Prevention (2020)[8] recommended the diabetes care goals, namely ABCS: A (HbA1c $<$ 7%), B (blood pressure $<$140/90 mmHg), C (cholesterol, non-HDL $<$130 mg/dL), and S (smoking cessation) to prevent serious complications. However, only about 25% of diabetic adults achieve these targets, underscoring the need for further research into factors influencing diabetes management and control.

The control of type 2 diabetes is influenced by multiple factors, including lifestyle, self-care behaviors, and social support. Diabetes self-care encompasses behaviors such as dietary management, physical activity, blood glucose monitoring, medication adherence, foot care, problem-solving, and risk reduction strategies.[9] The Association of Diabetes Care & Education Specialists[10] has identified 7 key self-care behaviors that help manage diabetes effectively: (1) healthy eating, (2) being active, (3) monitoring blood sugar, (4) medication adherence, (5) problem-solving (the ability of diabetes patients to address and resolve challenges that arise during the management of their condition), (6) risk reduction (taking actions to lower the risk of diabetes-related complications), and (7) healthy coping.

A healthy lifestyle plays a pivotal role in diabetes control. Health is not limited to physical well-being but also includes mental and social health. Low-risk lifestyle habits such as avoiding smoking, maintaining a body mass index (BMI) between 18.5 and 24.9 kg/m^2, engaging in at least 30 minutes of moderate to vigorous exercise daily, moderate alcohol consumption, and following a healthy diet have been shown to significantly improve overall health outcomes.[11,12] Studies have demonstrated that adherence to these lifestyle factors can lower the risk of chronic diseases, including diabetes, cardiovascular disease, and cancer.[12] Furthermore, lifestyle factors such as sleep quality and stress management are essential for maintaining glycemic control.[13,14] Wang et al[14] reported that diabetic individuals who adhered to at least 3 beneficial lifestyle habits had a significantly lower probability of poor glycemic control (HbA1c $>$ 7.5%) compared to those with fewer habits.

Social support is another critical factor influencing diabetes management, though research findings on its impact remain inconsistent. Social support can be categorized into 4 types: emotional (eg, providing care and security), instrumental (eg, financial assistance), informational (eg, guidance from healthcare professionals), and appraisal (eg, encouragement and validation from peers).[15] Some studies have shown that strong social support enhances adherence to healthy eating habits and glycemic control,[16] while others indicate no direct correlation with HbA1c levels.[17] A study across 6 European countries found that different types of social support had varying positive and negative effects on health behaviors, yet no direct data on HbA1c control was available.[17]

Studies have indicated that religious beliefs may influence diabetes management, particularly in relation to dietary habits, emotional well-being, and adherence to treatment regimens. Religious practices can provide a framework for coping with stress and shaping health behaviors, potentially affecting glycemic control.[18]

Given these multifaceted influences, this study aims to explore the impact of health-related lifestyle factors—including smoking, alcohol consumption, BMI, exercise, diet, sleep, and emotional distress—on HbA1c control. Additionally, it examines the effects of diabetes self-care behaviors, symptoms, social support, demographic variables, and physical examination values on glycemic control. By identifying key determinants of HbA1c control, this study seeks to provide evidence-based recommendations for improving diabetes management and patient outcomes.

Materials and Methods

Design

This study was a 1-year cross-sectional study in the metabolic clinic of the Southern Taiwan Medical Center of Kaohsiung Veterans General Hospital. The study was conducted and reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[19] Participants' data were collected using a structured questionnaire and same-day outpatient medical records. The inclusion conditions for participants were (a) diagnosed by a physician as type 2 diabetes; (b) age $\geq$ 20 years; (c) having normal mental status; and (d) ability to communicate in Mandarin-Chinese or Taiwanese. This study was approved by the Institutional Ethics Review Board. Prior to conducting this study, written informed consent was obtained from the subjects.

Instruments

This study used structured questionnaires to collect demographic data, information about health lifestyles, diabetes self-care behaviors, diabetes symptoms, and social support data for type 2 diabetes. The patients' physical examination data was collected from patient medical records. In this study, a total of 305 questionnaires were sent out and 305 questionnaires were completed. The recovery rate was 100%.

Demographic Characteristics

Demographic statistics included age, gender, marital status, education, religion, occupation, residence, diabetes duration, family history of diabetes, chronic disease, treatment methods, and caregivers.

Health Lifestyles

The components of determining whether or not participants had healthy lifestyles in this study included body mass index (BMI), smoking, drinking, sleep, and emotional distress caused by diabetes (VAS 0-10), compliance with diabetic diet, and exercise (regular exercise $\geqslant$ 3 times a week).

Physical Examination

Physical examination included glycosylated hemoglobin, blood pressure, total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), serum creatine, proteinuria.

Diabetes Self-Care Behavior

Seventeen diabetes self-care behavior scales, including diet, exercise, foot care, blood glucose monitoring and management, and diabetes drug use, were used to measure subjects' self-care behaviors.[20] Using a 5-point Likert-type scale, from not doing the behavior at all (1 point) to doing it completely (5 points), the total score ranged from 17 to 85, with higher scores indicating better diabetes self-care behavior. In this study, the Cronbach's alpha of the Diabetes Self-Care Scale was .79, indicating acceptable reliability.[21]

Diabetes Symptoms

The Taiwan version of Diabetes Symptom Checklist -revised (DSC-r)[22,23] was used for measurement. This scale assesses the severity of symptoms of hyperglycemia-, hypoglycemia-, fatigue-, ophthalmology-, sensory-, cognition-, pain-, and cardiology-related symptoms in the past month. Symptom severity ranges from completely absent (0 points) to extremely severe (5 points). The total score ranges from 0 to 170, with higher scores indicating higher severity of diabetes symptoms. The Cronbach's alpha was .74 in this study, indicating acceptable reliability.[21]

Social Support

Social support was measured with a 16-item Chinese version of the social support scale. This scale was developed by researchers with reference to related literature.[24] A 5-point Likert-type scale, ranging from never (1 point) to always (5 points) is used. The higher the score, the stronger the social support. In this study, Cronbach's total alpha value was .96.

Data Analysis

G*Power, version 3.1.9.7 software was used to estimate the required sample size.[25] Based upon Cohen[26] proposing the use of 8 predictor variables, a sample of 183 was sufficient to detect a moderate effect size (R=.13) and a power of 0.95 with a=0.05. Participant characteristics, diabetes self-care behavior, diabetes symptoms, and social support variable scores were calculated for descriptive statistical analysis. Independent t-test, one-way analysis of variance, and bivariate correlations were used to examine the relevant factors that affect HbA1c levels in subjects with type 2 diabetes, including personal information, healthy lifestyle, physical examination data, diabetes self-care behavior, diabetes symptoms and social support variables. Multiple linear regression analysis was used to predict the influencing factors of HbA1c levels. A P-value of $<$ .05 was considered significant.

Results

The Correlation Between Basic Personal Information, Health Lifestyle and HbA1c Levels

A total of 305 subjects with diabetes were included. The average age was 61.63 $\pm$ 11.27 years, the average diabetes duration was 11.07 $\pm$ 7.70 years, and the average HbA1c was 7.94 $\pm$ 1.58%. As shown in Table 1, the variables that had a significant correlation between personal information and HbA1c levels were age, gender, diabetes duration, religion, insulin treatment, and spousal care ($P<.05$). The variables that had a significant correlation between personal health lifestyle and HbA1c levels were diabetes distress, exercising more than 3 times a week, running exercise, and mountain climbing ($P<.05$). Correlations showed significantly lower HbA1c levels for subjects who were higher age, male, had diabetes for a shorter time, had no religious beliefs, did not have a spouse who participated in care, had non-insulin therapy, had low emotional distress, exercised $\geqq$3 times a week, and exercised by running and mountain climbing.

Correlation Between Physical Examination Data and HbA1c Levels

In the individual physical examination data, the HbA1c levels of those without proteinuria were 7.65 $\pm$ 1.37%, those with proteinuria were 8.51 $\pm$ 1.73% ($P<.001$), and those with proteinuria had significantly higher HbA1c levels than those without proteinuria (see *Table 2* for details).

Table 1. Correlation/difference test of personal information, health lifestyle and HbA1c levels (N = 305).

Variables	n %/Mean ± SD	HbA1c levels Mean ± SD	Correlation/difference test with HbA1c levels *F/t/r*	*P*
Personal information				
Age	61.63 ± 11.27		−0.189	.001
Diabetes duration	11.07 ± 7.70		0.139	.015
Sex			−2.719	.007
Male	190 (62%)	7.75 ± 1.52		
Female	115 (38%)	8.25 ± 1.63		
Marriage			−1.149	.252
No partner	55 (18%)	7.72 ± 1.42		
Have a partner	250 (82%)	7.99 ± 1.61		
Education			−0.044	.965
Bachelor's degree or higher	103 (33.8%)	7.94 ± 1.65		
Less than a bachelor's degree	202 (66.2%)	7.95 ± 1.54		
Religious			−1.982	.048
No	90 (30%)	7.67 ± 1.50		
Yes	215 (70%)	8.07 ± 1.60		
Job			−1.476	.142
No	199 (65.2%)	7.84 ± 1.50		
Yes	106 (34.8%)	8.13 ± 1.71		
Live alone			1.736	.084
No	270 (88.5%)	7.99 ± 1.58		
Yes	35 (11.5%)	7.50 ± 1.53		
Diabetes family history			−0.448	.655
No	130 (42.6%)	7.89 ± 1.58		
Yes	175 (57.4%)	7.98 ± 1.59		
Chronic illness			0.090	.928
No	113 (70%)	7.95 ± 1.56		
Yes	192 (30%)	7.93 ± 1.60		
Oral medication			0.409	.684
No	37 (12%)	8.07 ± 2.07		
Yes	268 (88%)	7.92 ± 1.50		
Insulin therapy			−7.375	<.001
No	234 (80%)	7.60 ± 1.38		
Yes	71 (20%)	9.06 ± 1.68		
Caregiver: self-care			−0.426	.670
No	27 (8.9%)	8.09 ± 1.56		
Yes	278 (91.1%)	7.94 ± 1.59		
Caregiver: Spouse participates in care			−3.474	.022
No	26 (8%)	7.20 ± 0.98		
Yes	279 (92%)	8.01 ± 1.60		
Health lifestyle				
BMI	26.29 ± 4.47		0.071	.219
Sleep hours	6.85 ± 1.39		−0.024	.681
Sleep quality (1-10)	7.09 ± 2.09		−0.110	.059
Diabetes causes emotional distress (0-10)	1.35 ± 2.26		0.142	.013
Smoking			−1.009	.314
No	253 (83%)	7.93 ± 1.54		
Yes	52 (17%)	8.19 ± 1.83		
Drinking			−1.569	.057
No	248 (81%)	7.95 ± 1.56		
Yes	57 (19%)	8.11 ± 1.76		
Follow a diabetic diet			1.877	.061
No	94 (30.8%)	8.20 ± 1.71		
Yes	211 (69.2%)	7.83 ± 1.52		

(Continued)

Table 1. (Continued)

Variables	n %/Mean ± SD	HbA1c levels Mean ± SD	Correlation/difference test with HbA1c levels *F/t/r*	*P*
Exercise ≧3 times			2.853	.005
No	101 (33%)	8.30 ± 1.74		
Yes	204 (67%)	7.76 ± 1.46		
Sports type			2.238	.037
Running				
No	283 (93%)	7.98 ± 1.61		
Yes	22 (7%)	7.31 ± 1.16		
Mountain climbing			2.044	.042
No	289 (94%)	7.98 ± 1.60		
Yes	16 (6%)	6.98 ± .95		
Ride a bike			1.272	.217
No	285 (93%)	7.96 ± 1.61		
Yes	20 (7%)	7.57 ± 1.23		
Walking			−0.664	.507
No	107 (35%)	7.86 ± 1.55		
Yes	198 (65%)	7.98 ± 1.62		

Table 2. Correlation between physical examination data and HbA1c levels (N = 305).

Variables	n %/mean ± SD	HbA1c levels Mean ± SD	Correlation/difference test with HbA1c levels *r/t*	*P*
HbA1c levels	7.94 ± 1.58			
Systolic blood pressure (BPS)	129.95 ± 16.32		0.07	.20
Diastolic blood pressure (BPD)	76.62 ± 10.81		0.05	.34
Cholesterol (normal value: 130–200 mg/dl)	179.17 ± 31.74		0.06	.26
HDL (normal value: >40 mg/ dl)	45.09 ± 11.50		−0.08	.12
LDL (normal value: 0-140 mg/dl)	95.23 ± 24.87		0.06	.23
Triglyceride (normal value: 40 149 mg/dl)	134.97 ± 77.38		0.05	.33
Serum creatine (normal value: 0.5-1.5 mg/dl)	1.18 ± 0.72		−0.01	.80
Proteinuria (normal value: <30 mg/dl)			−4.15	<.001
No	212 (69.5%)	7.65 ± 1.37		
Yes	93 (3.1%)	8.51 ± 1.73		

Diabetes Self-Care Behavior, Diabetic Symptoms, Social Support, and the Correlation With HbA1c Levels

As shown in Table 3, the average total score of individual diabetes self-care behavior was 61.24 ± 10.66, which is a moderate self-care behavior. In terms of diabetes self-care behavior scores, the self-care behavior total scale, diet control subscale, and exercise control subscale were significantly related to HbA1c levels ($P < .05$). Other behaviors that showed no significant correlation with HbA1c levels ($P > .05$) included foot care, blood glucose monitoring, and drug control. This result showed that the higher the total score of self-care behavior, diet control and exercise control, the significantly lower HbA1c levels, which means better diabetes control. The total score of individual social support was 58.36 ± 17.20, which is a medium level of social support. There was no significant correlation between the total score of social support and HbA1c levels ($P > .05$). Most participants had diabetic symptoms (76.1%). The highest-scoring symptom reported by participants was hyperglycemia, followed by sensory symptoms and eye symptoms. The higher the participants' average total score of diabetes symptoms, hyperglycemia, hypoglycemia, fatigue, pain, sensation, and cardiovascular symptoms, the higher the HbA1c levels ($P < .05$). However, the scores of eye and cognitive symptoms were not significantly correlated with HbA1c levels ($P > .05$).

HbA1c Levels Predictors of Personal Information, Health Lifestyle, Diabetes Self-Care Behaviors, Social Support, and Diabetes Symptoms

HbA1c level was the dependent variable. The independent variables were age, diabetes duration, gender, religion,

Table 3. Correlation analysis of diabetes self-care behavior, diabetes symptoms, social support, and HbA1c levels (N = 305).

		HbA1c level	Correlation/difference test with HbA1c levels	
Variables	Mean ± SD	Mean ± SD	*r/t*	*P*
Diabetes self-care behavior total score	61.24 ± 10.66		−0.118	.039
Diet control	11.44 ± 2.82		−0.175	.002
Sport control	10.19 ± 4.26		−0.177	.002
Foot care	7.25 ± 2.17		0.000	.995
Blood glucose monitoring	18.23 ± 5.80		0.013	.822
Drug use	14.14 ± 2.17		−0.042	.460
Social support	58.36 ± 17.20		0.036	.537
Diabetes symptoms			2.777	.006
No	73(23.9)	7.50 ± 1.35		
Yes	232(76.1)	8.08 ± 1.63		
Diabetes symptoms total score	6.80 ± 10.56		0.142	.013
Hyperglycemia symptoms	1.41 ± 2.75		0.126	.028
Hypoglycemia symptoms	0.37 ± 1.39		0.116	.043
Ophthalmology symptoms	1.22 ± 2.83		−0.007	.906
Fatigue symptoms	0.96 ± 2.37		0.115	.044
Cognitive symptoms	0.58 ± 1.51		0.079	.170
Pain symptoms	0.54 ± 1.56		0.117	.042
Sensory symptoms	1.23 ± 2.38		0.127	.027
Cardiology symptoms	0.49 ± 1.13		0.117	.042

Table 4. Multiple linear regression analysis of HbA1c levels.

	Unstandardized coefficient		Standardization coefficient			
Variables	βestimate	Standard error	Beta distribution	*t*	*P*	VIF
Constant	8.76	0.74		11.74	<.001	
Insulin therapy	1.22	0.19	0.34	6.29	<.001	1.12
Age	−0.03	0.00	−0.21	−3.99	<.001	1.28
Gender (female vs male)	0.60	0.16	0.19	3.59	<.001	1.08
Diabetes duration	0.03	0.11	0.16	2.99	.003	1.25
proteinuria	0.51	0.17	0.15	3.78	<.001	1.04
Diabetes self-care total score	−0.01	0.00	−0.12	−2.31	.021	1.12
Running sport (yes vs no)	−0.83	0.35	−0.12	−2.36	.018	1.09
Spouse care (yes vs no)	0.66	0.30	0.10	2.16	.031	1.04

Dependent variable: HbA1c levels.

insulin treatment, emotional distress caused by diabetes, exercise more than 3 times a week, running, climbing, cycling, spousal care, proteinuria, diabetes self-care behavior total scale and subscale scores, average total score of diabetes symptoms and subscale scores. The data were analyzed by multiple linear regression.

Using the stepwise selection method, after correcting the compound influence of each variable, a total of 8 independent variables that could predict HbA1c levels were selected as a result. The VIF (variance inflation faction) of each predicted variable was less than 10 for all 8 variables, indicating that the independent variables had no collinearity problem. The explanatory power of the predictive variables of HbA1c levels, such as the Beta coefficient, were insulin treatment (0.34), age (−0.21), gender (0.19), length of time having diabetes (0.16), proteinuria (0.15), diabetes self-care behavior (−0.12), running (−0.12), spousal care (0.10). The predictive power of each variable reached a significant change ($P < .05$; see *Table 4* for details). It shows that HbA1c levels of insulin-treated participants are 1.22 mg/dl higher than those of non-insulin-treated subjects. The HbA1c levels decreased by 0.03 mg/dl for every 1-year increase in subject age. Women's HbA1c levels were 0.60 mg/dl higher than men's levels. For every year having diabetes, HbA1c levels increased by 0.03 mg/dl. The HbA1c levels of those with proteinuria were 0.51 mg/dl higher than those without proteinuria. For every one-point increase in diabetes self-care behavior score, HbA1c levels decreased by 0.01 mg/dl. The HbA1c levels of runners were 0.83 mg/dl lower than those who were not

runners. Finally, the HbA1c levels of subjects with spouse caregivers were 0.66 mg/dl higher than those without spouse caregivers.

Discussion

We found that after adjusting for several potential confounding variables, this study showed that higher age, men, those with higher total scores of diabetic self-care behaviors, runners, subjects having non-insulin therapies, subjects who had diabetes for a shorter length of time, and those with no proteinuria, had significantly lower HbA1c levels, which indicated better diabetes control.

This study found that higher age is associated with better HbA1c control, consistent with the findings of Comellas et al[27] and Maneze et al.[28] This may be due to older individuals having learned more effectively about diabetes care.[28] It may also be because those of higher age are more concerned about health issues, have a greater fear of mortality compared to younger individuals, and have more time to manage their condition, leading to better glycated hemoglobin control.[27] The opposite may also be true. In other words, younger subjects, who have poor HbA1c levels, may be less aware of diabetes self-management methods and may not have much time for diabetes self-management. It is recommended to explore the obstacles in self-management for younger adult diabetic subjects, and design and implement simple and effective individualized management programs.

The results of this study found that men have better control of HbA1c levels than women, which is the same as the results of Choe et al[29] and Duarte et al.[30] The study by Duarte et al[30] showed that women have significantly worse diabetes control than men. This may be due to differences in sex hormones between men and women, leading to differences in glucose homeostasis: Women have poorer response to certain diabetes medications and greater side effects, and have a higher incidence of depression and anxiety, leading to poorer diabetes control.[30] It is recommended that different treatment guidelines be developed for men and women. This study further found that the proportion of male diabetes subjects with a bachelor's degree or higher was significantly higher than that of women (43.9% vs 17.4%, $\chi^2 = 22.453$, $P < .001$). In terms of self-care behavior in sports, male scored significantly higher than females ($t = 3.735$, $P < .001$). Males also scored significantly higher than females in the self-care behavior of blood glucose monitoring ($t = 2.210$, $P < .028$). In this study, women had significantly worse diabetes control results than men, which may be due to women's lower education level and poorer self-care behaviors in exercise and blood glucose monitoring. According to the traditional customs of Taiwan, women are mostly caregivers for family members and need to spend more time caring for family members, so there may be less time for self-care, which may in turn lead to women's poorer self-care. Therefore, it is necessary to consider the disadvantaged situation of women and design different intervention programs.

The results of this study found that subjects with spousal caregivers had poorly controlled HbA1c levels, which is similar to the results of Liu et al,[31] who found that the normal rate of HbA1c levels among people living with others was significantly lower than that of people living alone. This may be caused by the inability to make decisions by themselves after receiving meals prepared by family members who do not understand how diet affects control of HbA1c levels. It is recommended that caregivers such as spouses should be included in the intervention and teaching of diabetes management.

The results of this study showed that insulin-treated subjects had significantly higher HbA1c levels than non-insulin-treated subjects. Subject who had insulin therapy mostly indicated that their HbA1c levels were already high. The American Diabetes Association also recommends that if HbA1c levels are greater than 9%, insulin should be considered for treatment. Therefore, HbA1c levels for subjects treated with insulin will be relatively high.[9]

This study showed that people with type 2 diabetes who had proteinuria had significantly higher HbA1c levels. This may be because subjects with type 2 diabetes had kidney disease, which leads to proteinuria.[32] The presence or absence of proteinuria can predict the renal complications of subjects with diabetes, and also indicates that the subject may have had poor control of diabetes for a long time. Therefore, screening for proteinuria and monitoring its progress can strengthen the treatment and control of subjects with diabetes.[33]

This study showed that better self-care behavior can significantly predict lower HbA1c levels. This was the same finding as Liu et al.[31] Similarly, a more recent study by Modarresi et al[34] found a significant association between self-care management and glycemic control in patients with type 2 diabetes, reinforcing the importance of self-care in diabetes management. However, the results of the current study were different from those of Milo and Connelly.[35] Those researchers found that self-management activities could not predict HbA1C levels. More research and further analysis are needed to determine the influence of variables in the self-care behavior scale and subscales on the control of HbA1c levels.

Among the various health lifestyle variables in this study, only running exercise could significantly predict HbA1c levels. A sedentary lifestyle is closely related to the incidence of diabetes. Exercise helps the body's metabolism. Aerobic exercise or resistance and long-term regular exercise training are all conducive to the control of HbA1c levels and help improve cardiovascular disease. It can also increase insulin sensitivity, reduce insulin resistance, and obtain better blood sugar control.[36,37] Regular moderate to intense exercise is also listed as an important risk-reducing, healthy lifestyle, which can significantly reduce the risk of chronic diseases such as diabetes.[36] The results of this study showed that the average HbA1c level of runners was 7.31 ± 1.16, which was significantly lower than the average HbA1c level of 7.98 ± 1.61 for those who were not runners ($t = -2.238$, $P = .037$). Further analysis found that the average age of runners was 51.1 ± 11.3, which was significantly

lower than the average age of 62.3 ± 11.0 who were not runners (t=−4.071, $P < .001$), indicating that runners were significantly younger. Although the results of this study showed that younger people had poorer HbA1c control than older people, the HbA1c control of younger people who were runners was still better than that of older people who did not run. It is recommended that younger people can run to promote HbA1c control. In this study, the ratio of men who exercised by running (8.0%) was significantly higher than that of women (1.8%; $\chi^2=5.150$, $P=.036$). Further analysis found that the average HbA1c level of women who were runners was 7.85 ± 0.07, which was significantly lower than the average HbA1c level of women who did not run (8.28 ± 1.66; t=−2.590, $P=.012$). There was no significant difference in HbA1c levels between men who ran or did not run for exercise (t=−1.321, $P=.188$). It was suggested that women may be able to improve HbA1c control by running. However, since the number of runners in this study was only 22, researchers suggest expanding the number of participants who run in future studies to further explore the influence of moderate to intense exercise such as running on diabetes control in male and female subjects.

Although many scholars have indicated that social support is related to diabetes control, the results of this study showed that subjects' HbA1c levels were not significantly related to social support. This result was the same as the study of Khanna et al.[38] This may be because the content of social support was different and each person's type of social support may also be different. For example, Taiwanese often provide each other with food as a method of social support, which may affect diabetes control. Therefore, it is necessary to understand the impact of each person's different social support on their diabetes control.

This study showed that the higher the subscale symptom scores of diabetic symptoms such as hyperglycemia, hypoglycemia, fatigue, pain, and sensation, the higher the HbA1c levels,[39] but regression analysis did not find it to be a significant predictor of the model. This may be due to the fact that 23.9% of those in this study had no diabetes symptoms. However, the number of people with various symptoms of diabetes was only 11.8%-41.3%. In the future, the number of type 2 diabetes subjects can be increased to further explore the relationship between diabetes symptoms and HbA1c levels.

There are many factors that affect the control of HbA1c levels in subjects with diabetes. Therefore, we analyzed the possible variables that hinder the control of HbA1c levels, which can provide a reference for the future design of individualized effective intervention measures. This could help subjects with diabetes continue to learn and strengthen their willingness to care for themselves, improve the effectiveness of diabetes self-care, reduce the occurrence of complications and medical expenses, and improve quality of life.

Limitations

This study has potential limitations. To begin with, due to its cross-sectional design, causal relationships between the identified factors and HbA1c levels cannot be established. Second, the study was conducted at a single medical center with a sample of 305 participants, which may limit the generalizability of the findings to broader populations with different socioeconomic and cultural backgrounds. Third, data collection relied on self-reported questionnaires, which may introduce recall bias or social desirability bias, potentially affecting the accuracy of the results. Additionally, this study did not consider other important factors that could influence HbA1c levels, such as mental health status, medication adherence, or dietary habits. While the findings highlight the role of running in blood sugar control, other forms of physical activity were not assessed, which may have led to an incomplete understanding of the relationship between exercise and HbA1c. Lastly, although spousal involvement in care was identified as a factor, this study did not explore the nature, extent, or specific mechanisms through which such involvement affects diabetes management outcomes. Future research should address these limitations to provide a more comprehensive understanding of the factors influencing HbA1c levels in individuals with type 2 diabetes.

Conclusions

This study explored the effects of diabetes self-care behavior, health lifestyle, diabetes symptoms, social support, demographic variables, and physical examination values on HbA1c levels. The results of this study confirm that the factors that significantly predict HbA1c levels are insulin treatment, age, gender, duration of diabetes, proteinuria, diabetic self-care behavior, running exercise, and spousal care ($P < .05$). It showed that subjects who had insulin treatment, long-term diabetes, proteinuria, low diabetes self-care total score, a spousal caregiver, did not run for exercise, and were younger and female, had higher HbA1c levels.

Key Points for Policy, Practice and/or Research

- Identifying factors that influence HbA1c control in patients with type 2 diabetes can help them achieve good glycemic control.
- People with type 2 diabetes of different ages and genders have different influencing factors on blood sugar control, so different treatment guidelines should be formulated and different intervention plans should be designed.
- Spousal involvement in caregiving may affect the effectiveness of controlling HbA1c levels in patients with type 2 diabetes. Therefore, spouses should be included in diabetes self-management education sessions.
- Choosing moderate-intensity exercise may help control HbA1c levels.

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Statements and Declarations

Ethical Considerations

This study was reviewed and approved by the Human Research Ethics Review Committee of the Medical Center: Kaohsiung Veterans General Hospital (VGHKS14-CT2-04).

Consent to Participate

The whole procedure and its risks and benefits were explained clearly to the participants. Written informed consent was obtained from all participants before conducting this study.

Author Contributions/CRediT

Li-Ying Lin: Conceptualization, Methodology, Validation, Investigation, Formal analysis, Data curation, Writing—original draft, Writing—review & editing, Supervision.
Wan-Ju Chen: Conceptualization, Methodology, Validation, Writing - original draft, Writing—review & editing.

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Data Availability

The data that support the findings of this study are available on request from the corresponding author.

Supplemental Material

Supplemental material for this article is available online.

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