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Research Article

Association Between Physical Activity and Self-management Behaviors and Its Effects on Glycemic Control Among Diabetes Mellitus Patients: A Longitudinal Design Study

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Abstract

Background: Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. This study aimed to explore the longitudinal relationship between physical activity and self-management behaviors, and their combined impact on glycemic control among patients with diabetes mellitus.

Methods: A longitudinal study was conducted at Al-Diwaniyah Teaching Hospital, involving 120 diabetic patients selected through simple random sampling. Data were collected at three time points using validated tools to assess physical activity levels (IPAQ), Self-Management Behaviors, and glycemic control (HbA1c). Demographic and clinical variables were also recorded. Statistical analysis was performed using SPSS version 26 to examine associations and changes over time.

Results: The longitudinal study followed 120 patients diagnosed with diabetes mellitus over three observation periods. Most participants were middle-aged and living with type 2 diabetes. Over time, physical activity levels showed a statistically significant improvement, with a marked shift from low to high activity categories (highly significant in the third observation of physical activity, $P < 0.001$; and in the third observation of self-management behaviors, $P < 0.000$). In contrast, self-management behaviors declined, as evidenced by decreasing DSMQ scores and a transition from “Perfect” to “Inadequate” self-care levels. Simultaneously, HbA1c values increased significantly across all time points (the three latest HbA1c observations; $P < 0.000$), indicating progressive deterioration in glycemic control despite improvements in physical activity.

Conclusion: This study demonstrates that while physical activity improved over time, declining self-management behaviors were linked to worsening glycemic control. These results emphasize the need for integrated lifestyle interventions to support long-term diabetes management.

Keywords: Diabetes Mellitus; Glycemic Control; Longitudinal Study; Physical Activity; Self-management

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1. Introduction

Diabetes mellitus (DM), especially type 2 diabetes, is expected to affect 1.3 billion people worldwide by 2050, making it a persistent public health concern [1]. To improve quality of life, lower mortality rates among diabetic patients, and lower the risk of microvascular and macrovascular consequences, effective glycemic management is crucial [2, 3]. A 1% drop in hemoglobin A1c (HbA1c) is linked to considerable reductions in cardiovascular events and diabetes-related mortality, making HbA1c a well-known biomarker for long-term glycemic control [4, 5]. Adults with diabetes should engage in resistance training in addition to at least 150 minutes of moderate-intensity aerobic activity per week, according to the American Diabetes Association and World Health Organization [8]. Randomized controlled trials and longitudinal investigations have repeatedly shown that persistent PA improves glycemic outcomes and slows the course of illness [9, 10]. Self-management behaviors (SMBs), which include diet control, medication adherence, glucose monitoring, and psychosocial coping techniques, are equally crucial. Health literacy, formal education programs, and self-efficacy all have a significant impact on these behaviors [11, 12]. Synergistic effects on glycemic control have been demonstrated when PA is incorporated into SMB frameworks, especially when treatments are tailored and maintained over time [13, 14].

The dynamic interaction between PA and SMBs is highlighted by recent longitudinal studies, which suggest that changes in one domain frequently enhance the other, resulting in long-lasting glycemic benefits [15]. However, there are still gaps in our knowledge of how these connections change over time and differ among clinical and demographic categories. There is still a significant lack of longitudinal studies examining the concurrent evolution of physical activity, diabetes SMBs (using the Diabetes Self-management Questionnaire [DSMQ]), and glycemic control (HbA1c) in Middle Eastern populations, especially in Iraq, despite the growing global evidence. The province of Al-Diwaniyah, which has a high prevalence of diabetes, little access to organized diabetes education, and cultural norms that may affect lifestyle choices, provides a special setting for examining these dynamics. Designing culturally sensitive interventions that address systemic and behavioral obstacles to successful diabetes management requires an understanding of how PA and SMBs interact over time in such settings.

2. Methods

2.1. Study design

This study employed a longitudinal observational design to assess the relationship between physical activity, SMBs, and glycemic control among patients diagnosed with DM.

2.2. Study setting and period

The study was conducted at the Diabetes Center, an outpatient clinic at Al-Diwaniyah Teaching Hospital in Iraq, which provides care for all patients with diabetes. Data collection extended from March 3, 2025, to September 16, 2025, through three planned observation points approximately 3 months apart (March, June, and September). A total of 120 patients with type 2 diabetes were enrolled and monitored across all three time periods. The same cohort was evaluated at each observation, and every effort was made to minimize loss to follow-up.

This investigation was designed as a longitudinal observational cohort study without a separate control group. The rationale for this design was to allow within-subject comparisons over time, thereby reducing variability related to inter-individual differences. While the absence of a control group limits the ability to establish external baseline values, the chosen approach was appropriate for assessing temporal changes in nutritional risk and self-management behaviors under real-world clinical conditions. The limitation has been acknowledged, and future research is recommended to incorporate matched control groups or randomized designs to strengthen causal inference.

2.3. Study population and sample

The study population comprised patients attending the outpatient clinics at the Diabetes Center of Al-Diwaniyah Teaching Hospital in Iraq. A simple random sampling technique was applied to select participants from a defined sampling frame of eligible patients who visited the center during the study period. Randomization was conducted using a computerized random-number generator to ensure equal selection probabilities.

Sample size estimation was performed using G*Power software. Assuming a medium effect size (f = 0.25), a power of 80%, and a significance level of 0.05, the minimum required sample size was calculated to be 102 participants. To account for potential attrition, 140 patients were initially recruited, and 120 completed all three observation points.

With respect to comorbid conditions, patients with type 2 diabetes frequently presented with additional health problems such as hypertension and obesity. These conditions were documented during recruitment and considered part of the cohort's clinical profile. The study was conducted in a center dedicated to diabetes care; however, HbA1c testing was performed in collaboration with the hospital's central laboratory to ensure standardized procedures and validated results. This explains why laboratory reports originated from a different unit within the same institution.

The cohort was followed consistently at three timelines (March, June, and September 2025), and every effort was made to minimize loss to follow-up. Laboratory testing was centralized to maintain quality assurance, even though patients were clinically monitored at the Diabetes Center.

Regarding disease incidence, type 2 diabetes represents a growing public health challenge in Al-Diwaniyah and across Iraq. Regional epidemiological reports indicate a rising prevalence, consistent with global trends in low- and middle-income countries. While precise incidence rates vary across studies, the burden of diabetes in this area is substantial, reinforcing the importance of investigating nutritional risk and self-management behaviors in this population.

2.4. Participant flow and retention

Of the 140 participants enrolled at baseline, 20 (14.3%) discontinued participation before completing all follow-up assessments. Reasons for attrition included relocation, loss of contact, or withdrawal of consent. As a result, 120 participants completed all three observation points (O1, O2, and O3) and were included in the final analyses.

To ensure consistency and comparability across timepoints, analyses were conducted on the subset of 120 participants with complete data. Missing data were addressed using pairwise deletion for descriptive statistics and multiple imputation for inferential analyses, where appropriate.

2.4.1. Participant flow summary

Enrolled (*n* = 140)

↓

Completed all timepoints and included in analysis: *n* = 120

↓

Observed at O1 (Baseline): *n* = 120

↓

Observed at O2 (3 months): *n* = 120

↓

Observed at O3 (6 months): *n* = 120

2.5. Inclusion and exclusion criteria

Individuals diagnosed with either type 1 or type 2 DM, aged 18 years or older, and willing to participate by providing informed consent were eligible for inclusion in this study. The rationale for including both types of diabetes was to capture the broader spectrum of patients attending the Diabetes Center, thereby reflecting the real-world clinical population managed in this setting. Although type 1 and type 2 diabetes differ in etiopathogenesis and age of onset, both groups share common challenges in nutritional risk and self-management behaviors, which were the primary focus of this investigation.

Patients who were pregnant or nursing, as well as those with cognitive impairments or other conditions that could interfere with participation, were excluded. Furthermore, individuals who had recently undergone major surgery, experienced a serious medical event, or were enrolled in another study that might affect the outcomes of this investigation were not considered for participation.

2.6. Study instruments and data collection procedure

Data were collected using a structured questionnaire administered between March 3, 2025, and September 16, 2025, at three scheduled observation points spaced approximately 3 months apart (March, June, and September). The instrument comprised three sections.

The first section gathered sociodemographic and clinical information, including age, gender, income, education, employment, marital status, residence, family history of chronic diseases, diabetes type and duration, medication use, and recent HbA1c levels. HbA1c values were self-reported by participants based on their most recent laboratory results, as communicated to them by their healthcare providers. Participants were instructed to retrieve and report their latest HbA1c result at each observation point. These values were not independently cross-examined against medical records or laboratory databases, and therefore, information regarding assay methods, analyzers, or quality control procedures was not available.

The study acknowledges the concern regarding laboratory consistency and inter-lab variation. Since HbA1c results were self-reported, it was not possible to confirm whether all tests were performed in the same laboratory or to account for inter-laboratory variability. This limitation introduces potential measurement bias and variability across timepoints. To address this, HbA1c was treated as a secondary, exploratory outcome rather than a primary endpoint, and no strong causal inferences were drawn regarding its association with behavioral variables. The primary focus of the study remained on behavioral factors—specifically physical activity and self-management—without adjustment for changes in treatment regimens.

The second section employed the International Physical Activity Questionnaire – Short Form (IPAQ-SF) to assess physical activity. This validated self-report instrument was administered every 3 months to the same cohort, capturing the frequency and duration of walking, moderate, and vigorous physical activities, as well as sedentary behavior over the preceding 7 days. Physical activity was categorized into low (<600 MET-minutes/week), moderate (600–1500 MET-minutes/week), and high (>1500 MET-minutes/week) according to standard IPAQ scoring guidelines. Nonparametric statistical methods were applied to compare PA levels across time points, and results are presented as counts and percentages per category. Permission to use the IPAQ-SF was obtained from Dr. Al-Hazzaa.

The third section employed the DSMQ, a validated tool designed to assess self-care behaviors in individuals with DM. The DSMQ includes 16 items distributed across four domains: glucose management, dietary control, physical activity, and healthcare use. Each item is rated on a four-point Likert-like scale ranging from 0 (“does not apply”) to 3 (“applies to me very much”), producing a total score ranging from 0 to 48. For analytical purposes, total scores were transformed to a 0–10 scale. Based on this transformation, adherence to diabetes self-management behaviors was categorized into three levels: inadequate (<5), partially adequate (5–8), and perfect (>8). Permission to use the Arabic version of the DSMQ was obtained from Dr. Adnan Innab.

2.7. Data analysis

Both descriptive and inferential statistical methods were employed to analyze the study data. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize participants’ sociodemographic characteristics, physical activity levels, and glycemic control indicators across three observation points. Inferential analysis focused on assessing temporal changes in SMB scores and HbA1c values using paired *t*-tests. Statistical significance was determined at a threshold of $P \leq 0.05$. All analyses were performed using SPSS Statistics version 26.

3. Results

Table **1** summarizes the sociodemographic and clinical features of the study sample (N = 120). The majority of patients have type 2 diabetes that is treated with oral medications (83.3%), and the majority are between the ages of 40 and 50 (35.0%). Moreover, 45.0% of patients report earning less than 300,000 Iraqi dinars per month. Primary school is the most commonly attained educational level (26.7%). In terms of employment, more than half of the patients work for themselves (53.3%). The great majority have a positive family history of diabetes (83.3%) and live in cities (86.7%). Furthermore, the majority of patients (58.3%) have had the illness for longer than 5 years.

Figure **1** and Table **2** evaluate the patients’ levels of physical activity during the three observation periods (O1, O2, and O3). Patients were divided into three categories based on their levels of physical activity: low, moderate, and high. The findings show that throughout time, patients' levels of physical activity shifted from 24.2% at O1 to 64.2% at O3.

The diabetes SMB levels of the patients were also evaluated across the three observation periods (O1, O2, and O3; see Table **3** and Figure **2**. Patients were categorized into three tiers: Inadequate, Partially Adequate, and Perfect. According to the data, the percentage of patients with Perfect DSMQ levels decreased over time (from 75.0% at O1 to 2.5% at O3), while the Inadequate and Partially Adequate levels increased in tandem.

Table **4** presents the results of pairwise *t*-test comparisons of physical activity scores across the three observation periods (O1, O2, and O3). A considerable increase in physical activity over time was indicated by statistically significant differences between O1 and O2 ($P < 0.000$) and between O1 and O3 ($P < 0.000$). The comparison of O2 and O3, however, did not reach statistical significance ($P = 0.495$), indicating that the most significant improvement happened between the first and second observations, followed by relative stabilization.

The DSMQ scores from three observation periods (O1, O2, and O3) are compared using pairwise *t*-tests (Table **5**). The results indicate a shift in SMBs over time, showing statistically significant variations ($P < 0.001$) in DSMQ scores across all paired comparisons (O1 vs O2, O1 vs O3, and O2 vs O3). Table **6** and Figure **3** present pairwise *t*-test comparisons of the latest HbA1c scores across the three observation periods (O1, O2, and O3). The findings show that all paired comparisons (O1 vs O2, O1 vs O3, and O2 vs O3) had statistically significant differences ($P < 0.000$) in the latest HbA1c scores, indicating a change in HbA1c over time.

Table 1: Distribution of the study sample according to the sociodemographic data (*N* = 120).

Demographic data	**Rating and intervals**	**Frequency**	**Percentage**
Age (years)	20 to <30	6	5
	30 to <40	26	21.7
	40 to <50	42	35
	50 to <60	26	21.7
	60 to <70	16	13.3
	70 to <80	4	3.3
Gender	Male	72	60
	Female	48	40
Monthly income (Iraqi Dinar)	<300,000	54	45
	300,000 to 600,000	44	36.7
	601,000 to 1500,000	20	16.7
	>1500,000	2	1.7

Table 1: Continued.

Demographic data	Rating and intervals	Frequency	Percentage
Educational level	Cannot read or write	4	3.3
	Can read and write	8	6.7
	Primary school	32	26.7
	Intermediate school	30	25
	High school	10	8.3
	Institute	14	11.7
	College	16	13.3
	Postgraduate	6	5
Employment status	Self-employed	64	53.3
	Works in the government sector	32	26.7
	Works in the private sector	6	5
	Retired	18	15
Area of residence	Urban	104	86.7
	Rural	16	13.3
Family history	No	20	16.7
	Yes	100	83.3
Type of diabetes	Type 1 diabetes (insulin)	20	16.7
	Type 2 diabetes (tablets)	100	83.3
Duration since diagnosis (years)	1 to 5	50	41.7
	>5	70	58.3

Table 2: Overall physical activity of the study sample across three observations (N = 120).

Variables	Levels	Frequency	Percentage (%)	SD	Mean	Overall assessment
Physical Activity Assessment _O1	Low physical activity	54	45	0.809	1.79	Low
	Moderate physical activity	37	30.8			
	High physical activity	29	24.2			
Physical Activity Assessment _O2	Low physical activity	49	40.8	0.813	1.86	Low
	Moderate physical activity	39	32.5			
	High physical activity	32	26.7			
Physical Activity Assessment _O3	Low physical activity	27	22.5	0.839	2.45	High
	Moderate physical activity	12	10			
	High physical activity	81	67.5			

Table 2: Continued.

Variables	Levels	Frequency	Percentage (%)	SD	Mean	Overall assessment
Overall Assessment of Physical Activity	Low physical activity	43.3	36	0.82	2.03	High
	Moderate physical activity	29.3	24.5			
	High physical activity	47.4	39.5			

Std, standard deviation; Low physical activity, <600 MET-minutes/week; Moderate physical activity, 600–1500 MET-minutes/week; High physical activity, >1500 MET-minutes/week.

Table 3: Overall diabetes self-management of the study sample across three observations (N = 120).

Variables	Levels	Frequency	Percentage (%)	SD	Mean	Overall assessment
DSMQ Assessment _O1	Inadequate	0	0	5.461	0.882	Perfect
	Partially Adequate	30	25			
	Perfect	90	75			
DSMQ Assessment _O2	Inadequate	27	22.5	5.579	1	Partially Adequate
	Partially Adequate	91	75.8			
	Perfect	2	1.7			
DSMQ Assessment _O3	Inadequate	14	11.7	5.822	0.941	Partially Adequate
	Partially Adequate	103	85.8			
	Perfect	3	2.5			
Overall Assessment of DSMQ	Inadequate	13	11	5.62	0.941	Partially Adequate
	Partially Adequate	75	62.6			
	Perfect	32	26.4			

SD, standard deviation.

Table 4: Comparison (pairwise t-test) of three physical activity observations.

Comparison	Mean difference	Standard error	Significance (*P*-value)
O1 vs O2	932.1	241.68	0.000
O1 vs O3	564.48	241.68	0.000
O2 vs O3	367.62	241.68	0.495

Table 5: Comparison (pairwise t-test) of three diabetes self-management observations.

Comparison	Mean difference	Standard error	Significance (*P*-value)
O1 vs O2	0.118	0.032	$P < 0.001$
O1 vs O3	0.361	0.033	$P < 0.001$
O2 vs O3	0.242	0.023	$P < 0.001$

Table 6: Comparison (pairwise t-test) of the three latest HbA1c observations.

Comparison	Mean difference	Standard error	Significance (*P*-value)
O1 vs O2	0.887	0.062	0.000
O1 vs O3	1.058	0.057	0.000
O2 vs O3	0.172	0.026	0.000

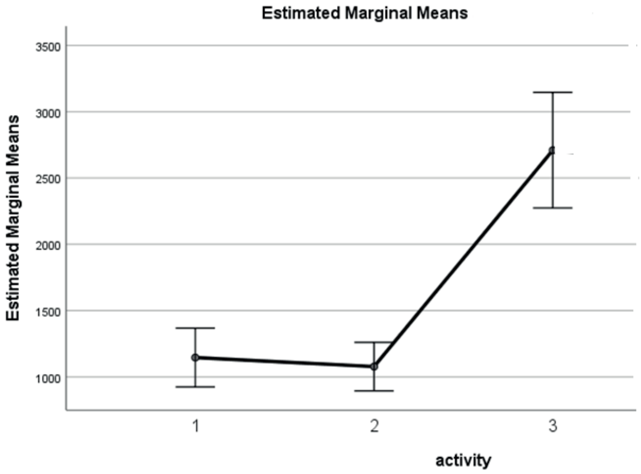

Figure 1: Three physical activity observations.

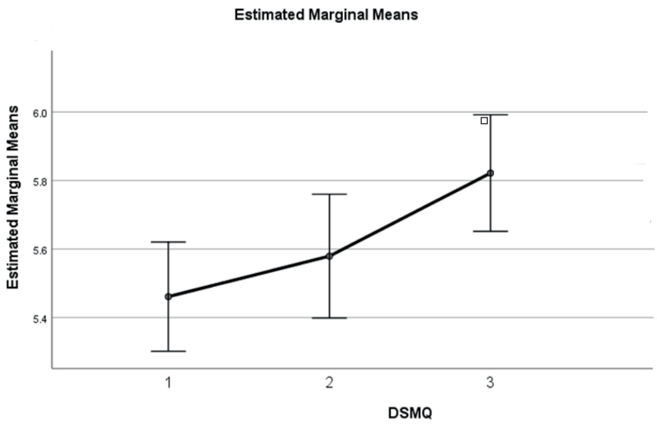

Figure 2: Three diabetes self-management observations.

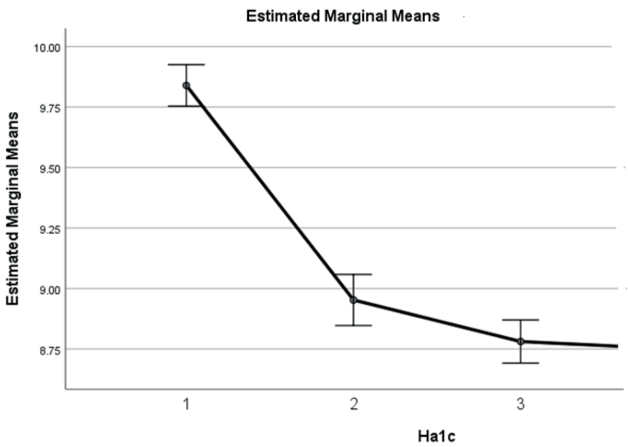

Figure 3: Three latest HbA1c observations.

4. Discussion

The majority of participants were middle-aged urban dwellers with only a primary education and a low income (see Table **1** for the descriptive data). Diabetes outcomes are known to be influenced by these sociodemographic characteristics through decreased health literacy and restricted access to care [16–20]. According to Hill-Briggs *et al.*, social variables, including income and education, have a significant impact on glycemic control and diabetes self-management. Furthermore, a population at increased risk for complications is suggested by the high frequency of family history (83.3%) and protracted disease duration (>5 years in 58.3%), which calls for ongoing behavioral treatments. According to the study, physical activity levels increased significantly over time, with high activity rising from 24.2% at the first observation (O1) to 64.2% at the third (O3). While the comparison between O2 and O3 was not significant ($P = 0.495$), pairwise t-tests (Table **4**) revealed statistically significant differences ($P < 0.001$) between O1 and both O2 and O3. These results are in line with earlier studies showing that regulated exercise increases insulin sensitivity and may affect glycemic management [23–26]. The rise in activity might also indicate greater patient comfort and greater involvement in diabetes management practices. For instance, Abdulyemmah and Majeed discovered that noninvasive methods, such as vibration and coughing during insulin injection, improve patient satisfaction and reduce pain, which may promote more engagement in physical activities [27–30]. DSMQ scores decreased significantly despite increases in physical activity, with "Perfect" self-management falling from 75.0% at O1 to only 2.5% at O3. Pairwise comparisons (Table **5**) showed significant deterioration ($P < 0.001$). This paradox may be attributed to behavioral fatigue or socioeconomic stressors that undermine sustained self-care. Previous studies have emphasized that while education can improve self-management, long-term adherence requires ongoing reinforcement, peer support, and real-world engagement [31–34]. Cognitive and psychological factors, such as time management and health quotient, also play a role in sustaining self-care behaviors. HbA1c levels showed a consistent and statistically significant increase across all observation periods ($P < 0.001$), indicating worsening glycemic control over time. This trend may reflect the cumulative impact of declining SMBs, despite increased physical activity. While prior studies have shown that exercise can reduce HbA1c even without major dietary changes [35, 36], the deterioration in overall self-care may have offset potential benefits. The parallel trends between declining DSMQ scores and increasing HbA1c levels point to a possible link that merits more research, even though this study did not use formal association studies like regression modeling. Glasgow *et al.* cautioned that the benefits of physical activity may eventually be compromised by noncompliance with medication and dietary regimens. To avoid a decline in metabolic outcomes, future treatments should combine the promotion of physical activity with organized assistance for self-management practices. Lastly, therapy compliance and glycemic results may be impacted by patient comfort during insulin delivery. Techniques like Shot-Blocker and vibration have been shown in randomized trials by Chyad and Majeed to dramatically reduce discomfort and improve satisfaction, potentially increasing overall participation in diabetes care [38–40]. These results imply that improving procedural experiences may influence clinical outcomes later on. The sociodemographic profile of low income, limited education, and self-employment indicates the need for customized, culturally aware treatments. Programs supervised by community health workers dramatically enhance diabetes outcomes in underprivileged people, as demonstrated by Heisler *et al.* [41]. Peer-led education improves behavioral and clinical parameters, as shown by Lorig *et al.* [42]. Additionally, research on patient-centered methods for administering insulin emphasizes how crucial comfort and satisfaction are for encouraging adherence [43]. However, it is important to recognize a few possible drawbacks. First, although a straightforward random sampling technique was used, selection bias cannot be completely ruled out, especially if some subgroups had lower participation or retention rates during the course of the study. Second, the use of self-reported measures for diabetes SMBs (DSMQ) and physical activity (IPAQ-SF) raises the risk of information bias, including recollection and social desirability bias. Third, although behavioral factors were the main focus of the investigation, HbA1c levels may have been impacted over time by unmeasured confounding variables, including changes in drug regimes, psychological stressors, or concomitant diseases. When interpreting the results and their consequences for clinical practice, these limitations should be considered.

5. Conclusion

This longitudinal study demonstrates that while physical activity levels improved over time with a marked increase in the proportion of patients achieving high activity levels, overall diabetes SMBs declined, particularly in areas beyond physical activity. The significant reduction in patients classified as having the Perfect DSMQ level, alongside a rise in Inadequate and Partially Adequate self-management, was accompanied by a progressive increase in HbA1c levels across the observation periods. These findings suggest that improvements in physical activity alone may not be sufficient to maintain optimal glycemic control. Therefore, integrating comprehensive behavioral education and structured self-care support remains essential to sustain long-term diabetes management and prevent metabolic deterioration.

Declarations

Acknowledgments

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Ethical Considerations

Ethical clearance and approval for this study were obtained from the Research Ethical Approval Committee at the College of Nursing, University of Baghdad (Approval No. 12, dated February 19, 2025), before the commencement of data collection. The researcher also submitted a detailed study protocol, including objectives and methodology, to the Ministry of Planning (Central Statistical Organization) and the Ministry of Health/Al-Diwaniyah Health Directorate to secure official authorization for conducting the study at Al-Diwaniyah Teaching Hospital. The study period extended from March 3, 2025, to September 16, 2025. Participation was entirely voluntary, and written informed consent was obtained from all participants, who were assured of the confidentiality and anonymity of their responses.

Competing Interests

None.

Availability of Data and Materials

Data and materials for the study are available upon request from the corresponding author.

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Abbreviations and Symbols

IPAQ: International Physical Activity Questionnaire

HbA1c: Hemoglobin A1C

SMP: Self-management behaviors

DM: Diabetes mellitus

PA: Physical activity

DSMQ: Diabetes Self-Management Questionnaire

Freq: Frequency

%: Percentage

Std: Standard Deviation

Low physical activity: <600 MET-minutes/week.

Moderate physical activity: 600–1500 MET-minutes/week

High physical activity: >1500 MET-minutes/week.

O: Observation

AI Use Disclosure

The authors declare that no AI tools were used in creating, analyzing, or contributing to the scientific content of this publication.

Author Contributions

Both authors contributed equally to the conception, design, and preparation of the study materials. They also approved the final version after drafting and critically revising it for significant intellectual content.

References

[1] Zhang C, Yang J. Personalizing physical activity for glucose control among individuals with type 2 diabetes: Are we there yet? Diabetes Care. 2024;47(2):196–198.

[2] Hamidi S, Gholamnezhad Z, Kasraie N, Sahebkar A. The effects of self-efficacy and physical activity improving methods on the quality of life in patients with diabetes: A systematic review. J Diabetes Res. 2022;2022:2884933.

[3] Yuan S, Li X, Liu Q, Wang Z, Jiang X, Burgess S, et al. Physical activity, sedentary behavior, and type 2 diabetes: mendelian randomization analysis. J Endocr Soc. 2023;7(8):bvad090.

[4] Stratton IM, Adler AI, Neil HA, Matthews DR, Manley SE, Cull CA, et al. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): Prospective observational study. BMJ. 2000;321(7258):405–412.

[5] UK Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). Lancet. 1998;352(9131):837–853.

[6] Colberg SR, Sigal RJ, Fernhall B, Regensteiner JG, Blissmer BJ, Rubin RR, et al.; American College of Sports Medicine; American Diabetes Association. Exercise and type 2 diabetes: The American College of Sports Medicine and the American Diabetes Association: joint position statement. Diabetes Care. 2010;33(12):e147–167.

[7] Boulé NG, Haddad E, Kenny GP, Wells GA, Sigal RJ. Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: A meta-analysis of controlled clinical trials. JAMA. 2001;286(10):1218–1227.

[8] World Health Organization. WHO guidelines on physical activity and sedentary behaviour. Geneva: WHO; 2020.

[9] Umpierre D, Ribeiro PA, Kramer CK, Leit ao CB, Zucatti AT, et al. Physical activity advice only or

structured exercise training and association with HbA1c levels in type 2 diabetes: a systematic review and meta-analysis. JAMA. 2011;305(17):1790–1799.

[10] Thomas DE, Elliott EJ, Naughton GA. Exercise for type 2 diabetes mellitus. Cochrane Database Syst Rev. 2006;2006(3):CD002968.

[11] Shrivastava SR, Shrivastava PS, Ramasamy J. Role of self-care in management of diabetes mellitus. J Diabetes Metab Disord. 2013;12(1):14.

[12] Norris SL, Engelgau MM, Narayan KM. Effectiveness of self-management training in type 2 diabetes: A systematic review of randomized controlled trials. Diabetes Care. 2001;24(3):561–587.

[13] Tang TS, Funnell MM, Brown MB, Kurlander JE. Self-management support in “real-world” settings: An empowerment-based intervention. Diabetes Educ. 2010;36(2):258–268.

[14] Glasgow RE, Toobert DJ, Hampson SE. Effects of a brief office-based intervention to facilitate diabetes dietary self-management. Diabetes Care. 1996;19(8):835–842.

[15] Lorig K, Ritter PL, Villa FJ, Armas J. Community-based peer-led diabetes self-management: A randomized trial. Diabetes Educ. 2009;35(4):641–651.

[16] Walker RJ, Smalls BL, Hernandez-Tejada MA, Campbell JA, Davis KS, Egede LE. Effect of diabetes fatalism on medication adherence and self-care behaviors in adults with diabetes. Gen Hosp Psychiatry. 2012;34(6):598–603.

[17] Al-Reda JJ, Majeed HM, Hassan AF. Effectiveness of instructional program on nurses’ knowledge concerning palliative and supportive care for old adults with heart failure. Bahrain Med Bull. 2023;45(4):1823–1826.

[18] Ajil ZW, Majeed HM, Al-Reda JJ. Critical care nurses’ knowledge and perceived barriers regarding pressure injury prevention among critically ill patients at Baghdad teaching hospitals: A cross-sectional survey. Int J Crit Illn Inj Sci. 2024;14(4):215–220.

[19] Mohammed TR, Majeed HM, Abid R. I. Evaluation of quality of nursing documentation in surgical wards at Baghdad Teaching Hospitals. Med-Leg Update. 2020;20(3):605–609.

[20] Majeed HM, Hassan AF, Kadhim AJ. Students’ knowledge and attitude about hepatitis B and C viruses in Baghdad University. Med J Babylon. 2025;22(1):69–76.

[21] Hill-Briggs F, Adler NE, Berkowitz SA, Chin MH, Gary-Webb TL, Navas-Acien A, et al. Social determinants of health and diabetes: A scientific review. Diabetes Care. 2020;44(1):258–279.

[22] Shrivastava SR, Shrivastava PS, Ramasamy J. Role of self-care in management of diabetes mellitus. J Diabetes Metab Disord. 2013;12(1):14.

[23] Al-Saady ZM, Abadi NJ, Atiyah KG, Majeed HM. Impact of patients’ education upon reducing psychological distress during diabetic journey. J Nat Sci Med. 2026;9(1):44–48.

[24] Zhang C, Yang J. Personalizing physical activity for glucose control among individuals with type 2 diabetes. Diabetes Care. 2024;47(2):196–198.

[25] Colberg SR, Sigal RJ, Fernhall B, Regensteiner JG, Blissmer BJ, Rubin RR, et al. Exercise and type 2 diabetes: ACSM/ADA joint position statement. Diabetes Care. 2010;33(12):e147–167.

[26] Garcia S P, Cureau FV, de Quadros Iorra F, Bottino L G, Monteiro L E, et al. Effects of exercise training and physical activity advice on HbA1c in people with type 2 diabetes: A network meta-analysis of randomized controlled trials. Diabetes Res Clin Pract .221:112027;2025

[27] Abdulyemmah AD, Majeed HM. Patient experience between vibration and coughing techniques during subcutaneous insulin injection on pain severity and individual satisfaction: randomized controlled trial. J Educ Health Promot. 2025;14(1):269.

[28] Abdulyemmah AD, Majeed HM. Shot Blocker versus vibration device: Which technique reduces pain and increases satisfaction in insulin injection among type 2 diabetes: A randomized controlled trial. J Integr Nurs. 2025;7(2):71–77.

[29] Abdulyemmah AD, Majeed HM. Pain and satisfaction among type 2 diabetic patients: Effects of coughing, shotblocker and vibration during insulin injection: A randomised controlled trial. Niger Postgrad Med J. 2025;32(2):97–103.

[30] Abdulyemmah AD, Majeed HM. The relationship between shot-blocker and vibration device and its effect on reducing pain and discomfort during insulin injection therapy: A randomized controlled trial. Int J Pediatr Adolesc Med. 2025;10(3):1–7.

[31] Norris SL, Engelgau MM, Narayan KM. Effectiveness of self-management training in type 2 diabetes: A systematic review of randomized controlled trials. Diabetes Care. 2001;24(3):561–587.

[32] Tang TS, Funnell MM, Brown MB, Kurlander JE. Self-management support in "real-world" settings. Diabetes Educ. 2010;36(2):258–268.

[33] Chen M, Liu M, Pu Y, Wu J, Zhang M, et al. The effect of health quotient and time management skills on self-management behavior and glycemic control among individuals with type 2 diabetes mellitus. Front Public Health 2024;12:1295531.

[34] Greenwood DA, Gee PM, Fatkin KJ, Peeples M. A systematic review of digital tools for diabetes self-management. J Diabetes Sci Technol. 2017;11(3):526–539.

[35] Boulé NG, Kenny GP, Haddad E, Wells GA, Sigal RJ. Meta-analysis of the effect of structured exercise on HbA1c in type 2 diabetes. Diabetologia. 2003;46(8):1071–1081.

[36] Mikus CR, Oberlin DJ, Libla JL, Boyle L J, Thyfault J, et al. Glycemic control improves with aerobic training in T2DM. Med Sci Sports Exerc. 2012;44(5):879–885.

[37] Glasgow RE, Toobert DJ, Hampson SE. Facilitating diabetes dietary self-management. Diabetes Care. 1996;19(8):835–842.

[38] Majeed HM, Al-Ganmi A, Flieh AH, Habeeb AJ. Patients' lived experiences, attitudes, and skills on insulin self-administration among diabetic patients: A cross-sectional study. Discov Public Health. 2026;23(240):2–10.

[39] Majeed HM, Hassan AF, Al-Ganmi AH. Nurses' performance and perceived barriers regarding pressure ulcers' prevention for critically ill patients at Baghdad teaching hospitals. *J Nat Sci Med*. 2024;7(4):293–298.

[40] Chyad HA, Majeed HM. The effectiveness of deep breathing exercise training program in reducing discomfort symptoms amongst undergoing haemodialysis: A randomized controlled trial. Niger Postgrad Med J. 2025;32(3):204–210.

[41] Heisler M, Choi H, Palmisano G, Mase R, Richardson C, Fagerlin A, et al. Comparison of community health worker-led diabetes intervention with usual care: A randomized controlled trial. JAMA Intern Med. 2014;174(10):1665–1673.

[42] Majeed HM, Kadhum SJ, Majeed HM, Hala Mohammed Majeed, Sahar Jabbar Kadhum, Haider Mohammed Majeed. Association of cytomegalovirus and high-risk human papillomavirus with breast cancer progression. Cell Mol Biol (Noisy-le-Grand). 2025;71(5):61–65.

[43] Asad MJ, Majeed HM. Relationship between cigarette smoking and anxiety level among nurses. Malays J Nurs. 2024;16(1):149–158.