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The relationship between physical activity and glycemic control among type 2 diabetes mellitus outpatients at Kawangkoan Baru Primary Health Center, Indonesia

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Abstract:

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disease, and physical activity is one of the main pillars of its management. At Kawangkoan Baru Primary Health Center, more than half of diabetic patients were uncontrolled every month and physical activity was poorly documented. This study analyzed the relationship between physical activity and glycemic control among T2DM outpatients. A quantitative, observational analytic study with a cross-sectional design was conducted from May to July 2026 among 80 patients selected by consecutive sampling. Physical activity was measured with a questionnaire adapted from the International Physical Activity Questionnaire (IPAQ) Short Form (low, moderate, high), and glycemic control was defined from fasting blood glucose in medical records (controlled: 80–130 mg/dL). Data were analyzed using the chi-square test and Cramér's V. Physical activity was low in 32.5%, moderate in 46.3%, and high in 21.3% of respondents, and 55.0% were uncontrolled. The proportion of controlled patients rose from 15.4% (low) to 51.4% (moderate) and 76.5% (high) physical activity ($\chi^2 = 16.619$, df = 2, $p = 0.000246$; Cramér's V = 0.456). Physical activity was significantly associated with glycemic control, with a moderate strength of association. Structured physical activity education and counseling in primary care should be strengthened.

Keywords: physical activity, type 2 diabetes mellitus, glycemic control, primary health center, cross-sectional study

1. Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disease and one of the largest global health challenges. The International Diabetes Federation estimated that 537 million adults were living with diabetes in 2021, a figure projected to reach 643 million by 2030 (IDF, 2021). Indonesia is among the five countries with the largest number of people with diabetes, with an estimated 19.5 million cases (IDF, 2021), and national prevalence rose from 6.9% in 2013 to 8.5% in 2018 (Kemenkes RI, 2018).

Poor glycemic control increases the risk of microvascular complications such as nephropathy, neuropathy, and retinopathy, as well as macrovascular complications such as coronary heart disease, stroke, and peripheral artery disease (WHO, 2023). Effective management of T2DM rests on four pillars: pharmacological therapy, dietary regulation, education, and physical activity. Physical activity has a distinctive role because it improves insulin sensitivity and facilitates the translocation of GLUT-4 to the muscle cell membrane, allowing glucose uptake that does not depend entirely on insulin (Colberg et al., 2016). Meta-analyses confirm that regular exercise significantly lowers HbA1c in patients with T2DM (Colberg et al., 2016; Qiu et al., 2022; Gallardo-Gómez et al., 2024).

Despite this strong evidence, the application of physical activity in daily life remains far from ideal. Alfetni et al. (2021) reported that 51.6% of 157 T2DM patients had low physical activity, with the main barriers being lack of energy, comorbid health problems, and limited exercise facilities. A similar situation is seen at Kawangkoan Baru Primary Health Center. Between September 2025 and January 2026 the center recorded 1,826 visits, including 235

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patients with diabetes, of whom only 103 (43.8%) were controlled and 132 (56.2%) were uncontrolled. Only 36 patients (15.32%) were classified as physically active, and physical activity data were missing for most patients (55.74%). No comparable study has been conducted at this center.

Based on this gap, the present study aimed to analyze the relationship between physical activity and glycemic control among T2DM outpatients at Kawangkoan Baru Primary Health Center, to provide a basis for planning promotive and preventive interventions in primary care.

2. Literature Review

T2DM develops progressively, beginning with insulin resistance in peripheral tissues, mainly skeletal muscle, liver, and adipose tissue, which impairs glucose uptake and increases hepatic glucose production. Pancreatic beta cells initially compensate by producing more insulin, but this compensation declines over time and chronic hyperglycemia follows (Kahn et al., 2024). Risk factors include non-modifiable factors such as older age (especially ≥45 years) and family history, and modifiable factors such as obesity, physical inactivity, and an unhealthy diet (Kahn et al., 2024; IDF, 2021; PERKENI, 2021).

Glycemic control is the systematic effort to keep blood glucose within a safe range in order to prevent short- and long-term complications (PERKENI, 2021). Fasting blood glucose is considered controlled within 80–130 mg/dL, and HbA1c below 7% is the usual target for adults (ADA, 2024). Because HbA1c is not always available in primary care, fasting blood glucose recorded in medical records is often used in routine practice.

Physical activity is defined as any bodily movement produced by skeletal muscle contraction that expends energy above the basal level, and includes occupational, transport, household, and recreational activity (WHO, 2020). Muscle contraction activates the AMPK pathway so that GLUT-4 moves to the cell surface and glucose can be taken up without insulin, while regular training improves insulin signaling and insulin sensitivity that persists for 24–72 hours after a single session (Colberg et al., 2016). ADA (2024) and WHO (2020) recommend at least 150 minutes per week of moderate- to vigorous-intensity aerobic activity for adults with T2DM, and Gallardo-Gómez et al. (2024) identified an optimal dose of about 1,100 MET-minutes per week for glycemic control.

Evidence on the association is consistent. Colberg et al. (2016) reported that regular aerobic activity lowers HbA1c by an average of 0.6–0.7% and resistance training by 0.5–0.6%. Observational studies in Indonesia point in the same direction: Faswita (2021) found a significant association between physical activity and blood glucose among 42 patients ($p = 0.000$), with 81% of patients with light activity having fasting glucose above 200 mg/dL; Saragih et al. (2025) reported a significant association among 100 patients ($p = 0.000$); and Zamili et al. (2025) found that 66.7% of active patients had normal blood glucose ($p = 0.000$). In a case-control study of 472 participants, Setya et al. (2023) showed that low physical activity increased the risk of diabetes about 2.5-fold (OR = 2.532; 95% CI 1.221–5.253). Overall, higher physical activity is associated with better glycemic control, and the relationship appears dose-dependent.

3. Case and Methodology

This quantitative study used an observational analytic approach with a cross-sectional design, so that the independent variable (physical activity) and the dependent variable (glycemic control) were measured at a single point in time (Notoatmodjo, 2018). The study was conducted at Kawangkoan Baru Primary Health Center, Kawangkoan District, Minahasa Regency, North Sulawesi, Indonesia, from May to July 2026, with data collected in June 2026.

The population comprised all T2DM outpatients at the center (235 patients between September 2025 and January 2026). The sample size was calculated using the formula for analytic cross-sectional studies based on proportions (Lemeshow et al., 1990) at a 95% confidence level, 10% precision, and P = 0.23, giving 69 respondents; adding 10% for anticipated drop-out set the minimum sample at 76. Eighty eligible respondents were included through consecutive sampling. Inclusion criteria were a physician-diagnosed T2DM recorded in the medical record, ongoing outpatient treatment, age of at least 18 years, ability to communicate clearly, and willingness to participate. Exclusion criteria were emergency or severe illness preventing active movement, memory or cognitive impairment, no blood glucose result within the previous month, and refusal after explanation.

Physical activity was measured with a structured questionnaire adapted from the International Physical Activity Questionnaire (IPAQ) Short Form (IPAQ Research Committee, 2005) and categorized as low, moderate, or high based on MET-minutes per week. Glycemic control was determined from the most recent fasting blood glucose (FBG) in

the medical record within the previous month: controlled if FBG was 80–130 mg/dL and uncontrolled otherwise (ADA, 2024). The instrument was piloted on 30 respondents outside the sample. Item-total correlations (corrected item-total correlation, Pearson product moment) showed that all items were valid (r = 0.433–0.708, above the critical value of 0.361), and Cronbach's alpha was 0.875, indicating good reliability.

Primary data were collected through structured interviews after written informed consent, and secondary data were obtained from medical records. Data were edited, coded, entered, and cleaned. Univariate analysis presented frequencies and percentages (and mean and standard deviation for age). Bivariate analysis used the chi-square test at $\alpha = 0.05$, provided that no more than 20% of cells had expected counts below 5 (otherwise Fisher's exact test would be used). The strength of association was measured with Cramér's V.

4. Results & Analysis

Respondent characteristics

A total of 80 respondents were analyzed. Mean age was 55.0 years (SD 8.1; range 35–76), and most respondents were aged 45–59 years (58.7%). Slightly more respondents were female (52.5%), the largest education group was junior high school (40.0%), and the largest occupational group was unemployed/homemaker (35.0%). Most had lived with diabetes for 1–5 years (45.0%), were on oral medication (57.5%), and had a family history of diabetes (61.3%); 20.0% were current smokers (Table 1).

Table 1. Respondent characteristics (n = 80)

Characteristic	n	%
Age		
< 45 years	7	8.8
45–59 years	47	58.7
≥ 60 years	26	32.5
Sex		
Female	42	52.5
Male	38	47.5
Education		
No schooling/elementary	18	22.5
Junior high school	32	40.0
Senior high school	21	26.3
College	9	11.3
Occupation		
Unemployed/homemaker	28	35.0

Characteristic	n	%
Self-employed/farmer/trader	24	30.0
Private employee/laborer	19	23.8
Civil servant/military/police	9	11.3
Duration of diabetes		
< 1 year	16	20.0
1–5 years	36	45.0
> 5 years	28	35.0
Type of therapy		
Oral medication	46	57.5
Oral medication and insulin	28	35.0
Insulin injection	6	7.5
Smoking history		
Never	41	51.3
Former smoker	23	28.7
Current smoker	16	20.0
Family history of diabetes		
Yes	49	61.3
No	31	38.7

Source: primary data, 2026.

Physical activity and glycemic control

Physical activity was most often in the moderate category (46.3%), followed by low (32.5%) and high (21.3%). Based on FBG, 55.0% of respondents were uncontrolled and 45.0% were controlled (Table 2), consistent with the health center's visit data showing uncontrolled rates above 50% every month.

Table 2. Distribution of physical activity and glycemic control (n = 80)

Variable	n	%
Physical activity		
Low	26	32.5
Moderate	37	46.3
High	17	21.3
Glycemic control (FBG)		
Controlled (80–130 mg/dL)	36	45.0
Uncontrolled	44	55.0

Source: primary data, 2026.

Crosstabulation and chi-square test

Table 3 presents the crosstabulation of physical activity and glycemic control. The proportion of controlled patients increased with each higher category of physical activity: 15.4% (4 of 26) in the low category, 51.4% (19 of 37) in the moderate category, and 76.5% (13 of 17) in the high category. All cells had expected counts of at least 5 (minimum 7.65), so the Pearson chi-square test was used (Table 4). The test showed a statistically significant association (χ^2 = 16.619, df = 2, p = 0.000246) with a moderate strength of association (Cramér's V = 0.456), so the null hypothesis was rejected.

Table 3. Crosstabulation of physical activity and glycemic control (n = 80)

Physical activity		Controlled	Uncontrolled	Total
Low	Count	4	22	26
	Expected count	11.70	14.30	26.00
	% within physical activity	15.4%	84.6%	100.0%
Moderate	Count	19	18	37
	Expected count	16.65	20.35	37.00
	% within physical activity	51.4%	48.6%	100.0%
High	Count	13	4	17
	Expected count	7.65	9.35	17.00
	% within physical activity	76.5%	23.5%	100.0%
Total	**Count**	**36**	**44**	**80**

Physical activity	Controlled	Uncontrolled	Total
% of total	45.0%	55.0%	100.0%

Source: primary data, 2026. Controlled = fasting blood glucose 80–130 mg/dL. Expected counts are rounded to two decimals.

Table 4. Chi-square tests and symmetric measures

Test / measure	Value	df	Asymptotic significance (p)
Chi-square tests			
Pearson chi-square	16.619	2	0.000246
Likelihood ratio	17.961	2	0.000126
Linear-by-linear association	16.183	1	0.000058
N of valid cases	80		
Symmetric measures			
Phi	0.456		0.000246
Cramér's V	0.456		0.000246

Source: primary data, 2026. 0 cells (0.0%) had an expected count below 5; the minimum expected count was 7.65.

Discussion

Respondents were mostly of middle age (mean 55.0 years), which fits the epidemiology of T2DM, as declining beta-cell function and insulin sensitivity accompany ageing (Kahn et al., 2024; IDF, 2021). Most respondents had a middle-to-low level of education, which may affect how well health education is understood (PERKENI, 2021), and the family history reported by 61.3% of respondents supports a role for genetic factors. Vigorous physical activity was not yet a habit for most patients (21.3%), which is in line with the occupational profile of the sample, dominated by unemployed/homemaker and informal work with unstructured movement patterns. The finding that 55.0% of patients were uncontrolled matches the health center's own data and shows that glycemic control remains a problem.

This study found a significant association between physical activity and glycemic control, with a moderate strength of association ($p = 0.000246$; Cramér's $V = 0.456$). Patients with high physical activity were far more likely to be controlled (76.5%) than patients with low physical activity (15.4%), and the proportion rose stepwise through the moderate category (51.4%), which suggests a descriptive dose-response tendency; the linear-by-linear test ($p < 0.001$) is consistent with this trend. The finding agrees with the physiological mechanism in which muscle contraction promotes GLUT-4 translocation and improves insulin sensitivity for up to 24–72 hours (Colberg et al., 2016; ADA, 2024). It is also consistent with earlier studies reporting significant associations between physical activity and blood glucose (Faswita, 2021; Saragih et al., 2025; Zamili et al., 2025) and with the roughly 2.5-fold higher risk of diabetes associated with low physical activity reported by Setya et al. (2023).

Several limitations should be considered. First, the cross-sectional design shows association only and cannot establish causality; patients with poor control may also be less active because of fatigue or complications, so reverse causation is possible. Second, consecutive sampling may introduce selection bias. Third, physical activity was self-reported,

which is prone to recall and social desirability bias. Fourth, glycemic control was assessed from a single FBG measurement that reflects short-term status and is less comprehensive than HbA1c. Fifth, confounders such as diet, medication adherence, family support, and stress were not controlled. Finally, the study was conducted at a single site, which limits generalizability.

5. Conclusion

Physical activity was most often moderate (46.3%), and 55.0% of respondents had uncontrolled T2DM. There was a statistically significant association between physical activity and glycemic control among outpatients at Kawangkoan Baru Primary Health Center ($p = 0.000246$) with a moderate strength of association (Cramér's $V = 0.456$): the higher the physical activity category, the larger the proportion of patients with controlled blood glucose.

Patients with T2DM are encouraged to increase regular physical activity to at least 150 minutes per week at moderate intensity, as recommended by WHO (2020) and ADA (2024). The health center is encouraged to develop structured physical activity education and counseling, such as diabetic foot exercises or regular group walks, and health workers should ask about and record physical activity at every visit. Future studies should use longitudinal or cohort designs, probability sampling, objective measures such as pedometers or accelerometers, HbA1c as the outcome, multivariate analysis to control confounders, and multi-site samples.

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7. Disclosure Statement

The authors report no financial interest or benefit that has arisen from the direct application of this research.

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