Comparison of Fasting Blood Glucose and HbA1c Levels in Patients with Type 2 Diabetes Mellitus Based on Physical Activity

Yohana Berlina Saraswati Tuames[1], Elisabeth Levina Setianingrum[1], Halena Meldy Asa[1], Gottfrieda Patiencia Taeng-Ob Adang[1]
[1]Faculty of Medicine and Veterinary Medicine, Universitas Nusa Cendana, Kupang, Indonesia
Correspondence: **Yohana Berlina Saraswati Tuames**: Jl. Adisucipto, Penfui, Kupang, Indonesia; berlinsaraswati1911@gmail.com

ABSTRACT
Type 2 diabetes mellitus is a prevalent non-communicable disease associated with serious complications. Physical activity is a modifiable risk factor that plays an important role in glycemic control. This study aimed to analyze differences in fasting blood glucose and glycated hemoglobin (HbA1c) levels based on physical activity levels among patients with type 2 diabetes mellitus at primary health care centers in Kupang City. An analytic observational study with a cross-sectional design was conducted involving 71 respondents selected through consecutive sampling. Physical activity levels were assessed using the Global Physical Activity Questionnaire (GPAQ). fasting blood glucose was measured from capillary blood samples, while HbA1c was obtained from venous blood samples. Data were analyzed using univariate and bivariate methods, and mean differences across PA categories were tested using one-way ANOVA. The results showed no statistically significant differences in fasting blood glucose ($p = 0.610$) or HbA1c ($p = 0.283$) based on physical activity levels. In conclusion, physical activity level was not significantly associated with fasting blood glucose or HbA1c among patients with type 2 diabetes mellitus at primary health care centers in Kupang City. These findings suggest that optimal glycemic control requires a holistic approach, including physical activity, treatment adherence, and dietary management.
Keywords: physical activity; fasting blood glucose; glycated hemoglobin; type 2 diabetes mellitus; primary health care centers

INTRODUCTION
Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, impaired insulin action, or a combination of both mechanisms [1,2]. This condition represents one of the leading causes of morbidity and mortality related to non-communicable diseases worldwide. According to the International Diabetes Federation (IDF), approximately 537 million adults globally were living with diabetes, and this number is projected to increase to 643 million by 2030.

In Indonesia, data from the 2018 National Basic Health Research (*Riskesdas*) reported 44,782 cases of DM. In the Province of East Nusa Tenggara, the number of DM cases in 2018 was also recorded at 44,782, with Kupang City ranking second among districts/municipalities with the highest number of cases, totaling 3,524 reported cases [3]. This trend is consistent with data from the Kupang City Health Profile in 2022 and 2023, which documented an increase in the number of patients from 5,140 to 5,269 cases [4,5]. The rising prevalence highlights the urgent need for comprehensive monitoring and management strategies. Chronic hyperglycemia may lead to long-term complications affecting the cardiovascular system, kidneys, peripheral nerves, and visual function, thereby substantially reducing quality of life and increasing healthcare burden [6]. Therefore, regular monitoring of blood glucose levels is essential in diabetes management to prevent or delay the onset of complications.

One of the key parameters used to assess long-term glycemic control is glycated hemoglobin (HbA1c), which reflects the average blood glucose concentration over the previous two to three months [7]. In contrast, fasting blood glucose (FBG) is commonly used to evaluate short-term glycemic status [8]. Although HbA1c provides valuable information for long-term monitoring, its measurement is still limited in many primary healthcare facilities due to financial constraints and inadequate laboratory infrastructure. FBG remains the more frequently utilized indicator in primary care settings.

Physical activity is an integral component of diabetes management. Regular physical activity has been shown to improve insulin sensitivity, enhance glucose uptake by skeletal muscles, optimize metabolic control, and assist in maintaining a healthy body weight [9]. Several studies conducted in Indonesia have demonstrated a significant association between physical activity and blood glucose levels among patients with type 2 diabetes mellitus (T2DM). However, findings are not entirely consistent. Studies by Azitha et al. (2018) and Anggraeni et al. (2018) reported no significant association between physical activity and fasting blood glucose levels [9,10].

These inconsistent findings indicate the presence of a research gap that warrants further investigation, particularly among populations receiving care at the primary healthcare level. Patients in primary care settings may have distinct sociodemographic characteristics, lifestyle patterns, and healthcare access compared with those treated in referral hospitals. The increasing prevalence of T2DM, combined with the limited number of studies examining this relationship in primary healthcare centers, underscores the importance of further research on this topic.

Based on these considerations, this study was conducted to analyze differences in FBG and HbA1c levels according to physical activity levels among patients with T2DM attending primary healthcare centers in Kupang City. The findings are expected to contribute to the scientific evidence supporting diabetes control strategies at the primary healthcare level and to enhance understanding of the role of physical activity in optimizing glycemic control among patients with T2DM.

METHODS
This study employed an analytic observational design with a cross-sectional approach to examine differences in FBG and HbA1c levels based on physical activity levels among patients with T2DM attending primary healthcare centers in Kupang. The research was conducted from May to July 2024 at three primary healthcare centers: Oepoi Primary Health Center, Sikumana Primary Health Center, and Bakunase Primary Health Center. The required sample size was calculated using the Lemeshow formula for a known population, resulting in a minimum sample size of 69 participants. Consecutive sampling was applied to recruit participants who met the inclusion and exclusion criteria (71 participants; more than minimum sample size). The inclusion criteria were patients diagnosed with T2DM, aged 18–59 years, who were willing to participate by signing an informed consent form and agreed to fast for 8–10 hours prior to blood sampling. The exclusion criteria included patients who had communication barriers that could interfere with data collection and those with complications related to T2DM, such as renal impairment, anemia, or a history of blood transfusion within the previous three months.

This study assessed three variables. The independent variable was physical activity level, measured using the Global Physical Activity Questionnaire (GPAQ) developed by the World Health Organization (WHO). Physical activity was categorized as low (<600 MET-minutes/week), moderate (600–2999 MET-minutes/week), and high (≥3000 MET-minutes/week). The dependent variables were FBG and HbA1c levels. FBG was measured using capillary blood samples analyzed with a calibrated digital glucometer and categorized as controlled (<130 mg/dL) or

uncontrolled (≥130 mg/dL). HbA1c levels were measured from venous blood samples using the High-Performance Liquid Chromatography (HPLC) method and classified as controlled (<7%) or uncontrolled (≥7%).

All respondents agreed to participate and provided written informed consent. Data collection was conducted through structured interviews using the GPAQ instrument, followed by FBG measurement after a minimum fasting period of eight hours and HbA1c testing on the same day. Data analysis was performed using Jeffrey's Amazing Statistics Program (JASP). Univariate analysis was conducted to describe the distribution of respondents' characteristics. Bivariate analysis was performed using one-way ANOVA, followed by post hoc testing to assess differences in mean FBG and HbA1c levels across physical activity categories.

RESULTS

A total of 249 individuals from three primary healthcare centers initially met the preliminary eligibility criteria as potential respondents. Following confirmation, contact validation, and assessment of willingness to participate, 71 respondents completed the study through the final stage. The reduction in sample size was attributed to non-attendance, refusal to participate, and communication barriers encountered during the recruitment process.

Based on Table 1, most respondents were aged 50–59 years (63.4%). The majority were female (74.6%). The largest proportion of participants was recruited from Sikumana Primary Healthcare Center (45.1%).

As shown in Table 2, the highest proportion of respondents with uncontrolled FBG was observed in the low physical activity group (88.9%), whereas the highest proportion of controlled FBG was found in the moderate physical activity group (18.4%). For HbA1c, the highest proportion of controlled levels was observed among respondents with high physical activity (53.8%). Conversely, uncontrolled HbA1c levels were most frequently found in the moderate physical activity group.

Table 1. Distribution of respondent demographic characteristics

Characteristics	Frequency	Percentage
Age		
30–39 years	4	5.6
40–49 years	22	31
50–59 years	45	63.4
Sex		
Female	53	74.6
Male	18	25.4
Primary healthcare center		
Oepoi	16	22.5
Sikumana	42	45.1
Bakunase	23	32.4

Table 2. Distribution of FBG and HbA1c levels based on physical activity level

Physical activity	FBG controlled: f (%)	FBG uncontrolled: f (%)	HbA1c controlled: f (%)	HbA1c uncontrolled: f (%)
Low	1 (11.1%)	8 (88.9%)	3 (33.3%)	6 (66.7%)
Moderate	9 (18.4%)	40 (81.6%)	9 (18.4%)	40 (81.6%)
High	2 (15.4%)	11 (84.6%)	7 (53.8%)	6 (46.2%)

Table 3. The results of one-way ANOVA test

Dependent variable	Source of variation	p
FBG	Between physical activity groups	0.610
HbA1c	Between physical activity groups	0.283

The results of the one-way ANOVA test (Table 3) indicated no statistically significant differences in mean FBG or HbA1c levels across physical activity categories. The post hoc analysis using the Games–Howell test further confirmed that there were no significant pairwise differences in mean FBG or HbA1c levels among the three physical activity groups.

Table 4. The results of Post Hoc Games–Howell test for FBG

Comparison	p	Conclusion
Low–moderate	0.979	Non-Significant
Low–high	0.301	Non-Significant
Moderate–high	0.139	Non-Significant

Table 5. The results of Post Hoc Games–Howell test for HbA1c

Comparison	p	Conclusion
Low–moderate	0.794	Non-Significant
Low–high	0.304	Non-Significant
Moderate–high	0.378	Non-Significant

DISCUSSION

The findings of this study demonstrated that there were no statistically significant differences in FBG and HbA1c levels across physical activity categories among patients with T2DM attending primary healthcare centers in Kupang City, as evidenced by the results of the one-way ANOVA test. Furthermore, post hoc analysis using the Games–Howell test confirmed the absence of significant pairwise comparisons between physical activity levels and both FBG and HbA1c values. The mean FBG level of respondents was 210.9 mg/dL, while the mean HbA1c level reached 9.128%, indicating that the majority of participants had poor glycemic control. These findings suggest that the level of physical activity performed by respondents had not produced a measurable impact on reducing FBG or HbA1c levels, even though most participants reported engaging in moderate levels of physical activity.

The results are consistent with previous studies by Azitha et al. (2018) and Anggraeni et al. (2018), which similarly reported no significant association between physical activity and blood glucose levels among patients with T2DM [9,10]. This pattern implies that glycemic control is not determined solely by physical activity but is influenced by multiple interrelated factors, including age, dietary patterns, medication adherence, duration of diabetes, and obesity status [11–15]. Suandy et al. reported that the highest proportion of T2DM cases occurred among individuals aged ≥60 years, emphasizing the role of aging in disease progression. With advancing age, structural and functional changes occur at the cellular, tissue, and organ levels, including in the pancreas, which may impair insulin production and glucose regulation [11].

Dietary factors also contribute significantly to glycemic outcomes. Aqilla et al. (2025) found that the consumption of foods with moderate to high glycemic index values was significantly associated with elevated FBG levels [14]. In addition, medication adherence plays a crucial role in maintaining stable blood glucose levels. Kadang et al. (2025) demonstrated that adherence to antidiabetic medication was strongly associated with improved glycemic stability [15]. Poor adherence to medication regimens represents a serious public health concern, as it not only worsens disease outcomes and increases mortality risk but also elevates healthcare costs [16].

The duration of diabetes is another important determinant of glycemic control. Kriswiastiny et al. (2022) reported a significant relationship between longer duration of diabetes and higher blood glucose levels [12]. Prolonged exposure to hyperglycemia may result in progressive dysfunction and loss of pancreatic beta cells responsible for insulin production, thereby worsening glycemic control over time [17]. Furthermore, Tinangon et al. (2025) identified a significant association between FBG, HbA1c, and nutritional status [13]. Higher body mass index (BMI) categories—ranging from overweight to obesity—were associated with poorer glycemic control, likely due to increased insulin resistance and metabolic dysregulation [18].

The elevated mean HbA1c level observed in this study (9.128%) indicates that most patients had not achieved the glycemic target recommended by the American Diabetes Association, which suggests an HbA1c level below 7% for optimal control. Previous studies have shown that physical activity exerts optimal glucose-lowering effects only when accompanied by appropriate dietary management and consistent medication adherence [7,19-2!]. Therefore, physical activity alone may be insufficient to achieve adequate glycemic control without concurrent lifestyle and pharmacological interventions.

Overall, these findings reinforce the concept that glycemic control is multifactorial in nature. Physical activity represents only one component within a broader network of interacting behavioral, metabolic, and clinical determinants. A single-intervention approach focusing exclusively on increasing physical activity, without integrating dietary counseling and pharmacotherapy optimization, is unlikely to yield substantial improvements in blood

glucose regulation. From a practical perspective, the results provide valuable insight for primary healthcare centers in Kupang City to develop integrated diabetes management programs. Such programs should emphasize not only the promotion of regular physical activity but also structured nutritional counseling, continuous medication monitoring, and patient education aimed at improving adherence. A comprehensive approach is expected to enhance treatment compliance and reduce the risk of long-term complications associated with poor glycemic control.

Scientifically, this study contributes to the growing body of evidence regarding the relationship between physical activity and glycemic indicators (FBG and HbA1c) among patients with T2DM in Indonesia. It highlights the importance of multidimensional interventions in diabetes management and supports the need for further research exploring the combined effects of lifestyle modification and pharmacological therapy.

Nevertheless, the absence of a significant association in this study should be interpreted with caution due to several limitations. The cross-sectional design captures data at a single point in time and therefore cannot establish causal relationships between physical activity and glycemic outcomes. Additionally, physical activity was assessed using a self-reported questionnaire, which relies on participants' recall and honesty, potentially introducing recall bias and social desirability bias. Moreover, this study did not comprehensively control for important confounding variables such as medication adherence, dietary intake, and comorbid conditions or complications. These uncontrolled factors may have influenced glycemic control and potentially obscured the true relationship between physical activity and blood glucose levels.

CONCLUSION

This study found no significant differences in FBG and HbA1c levels based on physical activity levels among patients with T2DM at primary healthcare centers in Kupang City. The overall glycemic profile indicated that most respondents had not achieved recommended glycemic targets. These findings suggest that physical activity alone may be insufficient to control blood glucose without the support of other factors, such as medication adherence, dietary management, and structured diabetes education.

Practically, the results highlight the importance of a multidimensional approach to T2DM management in primary care settings, including the development of integrated diabetes education programs. Future studies are recommended to employ longitudinal designs with larger samples and to incorporate additional clinical and lifestyle variables.

Ethical consideration, competing interest and source of funding

-This study received ethical approval from the Health Research Ethics Committee, Faculty of Medicine and Veterinary Medicine, Universitas Nusa Cendana, with approval number: 45/UN15.21/KEPK-FKKH/2025.
-There is no conflict of interest related to this publication.
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