

Lifestyle Determination of Blood Glucose Levels in Type 2 Diabetes Mellitus Outpatients

Determinasi Gaya Hidup terhadap Kadar Gula Darah pada Pasien Rawat Jalan Diabetes Melitus Tipe 2

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Abstract: *Type 2 diabetes mellitus (T2DM) is a major public health problem characterized by poor glycemic control and influenced by various lifestyle-related factors. This study aimed to examine the correlation between the frequency of ultra-processed food (UPF) intake, blood pressure, and physical activity in outpatients with type 2 diabetes mellitus (T2DM) at RSAU dr. M. Salamun. A cross-sectional research design was employed. The study population comprised outpatients attending the Interne Polyclinic at RSAU dr. M. Salamun, and a total of 50 participants were selected using a total sampling technique. Data analysis was conducted using the Shapiro-Wilk test for normality and the Spearman Rho test for correlation. The results indicated a significant correlation between blood pressure and physical activity with fasting blood glucose (FBG) levels ($p < 0.05$). These findings suggest that elevated blood pressure and low levels of physical activity negatively impact glycemic control. Therefore, lifestyle interventions focusing on blood pressure management and increased physical activity may contribute to improved blood glucose regulation in individuals with T2DM.*

Keyword: Blood pressure, Fasting blood glucose, Physical activity, Type 2 diabetes mellitus, Ultra-processed foods

1. INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a major public health problem with an increasing prevalence worldwide and nationally. According to the International Diabetes Federation (IDF) in 2021, approximately 536,6 million people were living with diabetes globally, and this number is projected to rise to 783,2 million by 2045 (1). In Indonesia, the prevalence of T2DM is increased by 0,05% between 2013 and 2018, with West Java Province reporting a prevalence of 1,28% (2,3). At regional level, the number of T2DM patients in Bandung City reached 41.413 cases (4), whole data from RSAU dr. M. Salamun indicated a 1% increase in T2DM prevalence in recent years. This growing trend highlights the substantial burden of T2DM and emphasizes the importance of effective strategies to control blood glucose level. Blood glucose control is essential to prevent long-term complication of T2DM. Although pharmacological therapy remains the primary treatment, glycemic control is also strongly influenced by non-pharmacological factors, including dietary patterns, nutritional status, blood pressure, and physical activity (5). Over the past decade. Lifestyle transitions characterized by increased consumption of ultra-processed foods (UPF), which are high in added sugars and saturated fats but low in dietary fiber, along with reduced physical activity levels, have been associated with impaired glucose metabolism (6,7). In addition,

hypertension commonly coexist with T2DM and may exacerbate insulin resistance and endothelial dysfunction, thereby worsening glycemic control (8). Previous studies have examined the association between individual lifestyle factors and blood glucose levels. Zhang (9), reported that consumption of high-glycemic index carbohydrates leads to significant increases in blood glucose levels, while Stocks and Zierath (10) demonstrated that regular physical activity improves insulin sensitivity and enhances glucose uptake by skeletal muscle. Furthermore, Delpino et al (6), found that high consumption of ultra-processed foods increased the risk of developing T2DM by up to 31%. Consistent with these findings, national Indonesian surveys have shown that frequent consumption of sweet, fried, processed and ultra-processed foods is associated with impaired fasting blood glucose, hyperglycemia, and higher T2DM prevalence (11,12). Large Indonesian datasets also indicate that higher physical activity is linked to lower diabetes prevalence, and a community-based trial in Lombok demonstrated that 12-week brisk-walking program significantly reduced fasting blood glucose among T2DM patients (13,14). However, most existing studies have investigated these determinants separately and have rarely assessed their combined effects, particularly within the Indonesian population.

Therefore, a research gap remains regarding comprehensive evaluation of multiple lifestyle determinants influencing blood glucose levels simultaneously among T2DM patients, especially in specific healthcare settings such as military hospitals. Understanding these combined factors is important to provide a more holistic perspective on glycemic control in clinical practice. This study aims to analyze the relationship between blood pressure, physical activity level, and frequency of ultra-processed food consumption with blood glucose levels among T2DM patients at RSAU dr. M. Salamun, Bandung. This research is based on the theoretical framework that unhealthy dietary patterns and insufficient physical activity contribute to insulin resistance, while hypertension further impairs glycemic regulation through endothelial dysfunction and disrupted glucose metabolism (8,15). The findings of this study are expected to contribute to the scientific evidence on lifestyle determinants of blood glucose control in Indonesian T2D, patients and support the development of lifestyle-based interventions to improve disease management outcomes.

2. METHODS

This study employed a quantitative analytic design with a cross-sectional approach. The research was conducted at RSAU dr. M. Salamun, Bandung. Data collection was carried out in Februari 2025, while the overall research process, including preliminary study, administrative approval, data collection, analysis, and report preparation, was conducted from July 2024 to July 2025. The study population consisted of outpatients diagnosed with type 2 diabetes mellitus (T2DM). Subjects were selected using a total sampling technique, resulting in 50 participants. The inclusion criteria were T2DM outpatients aged 19-59 years who were willing to participate and able to communicate effectively during interviews. The exclusion criteria included patients undergoing dialysis and those with severe complications. Data were collected through structured interviews using questionnaires and by reviewing patients' medical records. After obtaining informed consent, interviews were conducted using research instrument consisting of subject identity forms, a food frequency questionnaire (FFQ) to assess the frequency of ultra-processed food, and the International Physical Activity Questionnaire – Long Form (IPAQ-LF) to measure physical activity levels. The FFQ instrument was validated using a 1×24-hour food recall method. Blood glucose levels

and blood pressure data were obtained from patients' medical records.

3. RESULTS

Table 1 shows the subjects characteristics. The characteristics in this study consist of age, gender, education, and occupation.

Table 1. The characteristic of the outpatients (n=50)

The characteristic of the outpatients	Frequency (n)	Percentage (%)
Age		
Sex		
Female	38	76,0
Male	12	24,0
Education		
Elementary School	17	34,0
Junior High School	7	14,0
Senior High School	18	36,0
University	8	16,0
Occupation		
Laborer/Construction Worker	4	8,0
Lecturer	1	2,0
Teacher	2	4,0
Housewife	34	68,0
Private Employee	4	8,0
Civil Servant/Military/Air Force	5	10,0
Fasting Blood Glucose (mg/dL)		
Controlled (<130 mg/dL)	17	34,0
Uncontrolled (≥130 mg/dL)	33	66,0
Blood Pressure (mmHg)		
Normal (<120/80 mmHg)	7	14,0
Pre-Hypertension (120 - 129/80 mmHg)	4	8,0
Hypertension 1 (130-139/80-89 mmHg)	26	52,0
Hypertension 2 (>140/90 mmHg)	13	26,0
Physical Activity Level (METs/Min/Week)		
Low (<600 METs/Min/Week)	28	56,0
Moderate (≥600 METs/Min/Week)	20	40,0
High (≥ 3000 METs/Min/Weeks)	2	4,0
Frequency of Ultra Processed Foods Consumption (times/month)		
Rarely (<56,08 times/month)	32	64,0
Often (≥56,08 times/month)	18	32,0

The subject characteristics in this study showed diversity in terms of age, gender, education, and occupation. Out of 50 subjects, the average age was 53.1 years, with a range of 36–59 years. In addition, 38 subjects were women (76.0%), 18 subjects had graduated from senior high school (36.0%), and 34 subjects were housewives (68.0%). Furthermore, 33 subjects had uncontrolled fasting blood glucose (66.0%), 26 subjects had stage 1 hypertension (52.0%), 28 subjects had low physical activity levels (56.0%), and 32 subjects rarely consumed UPF (64.0%).

Table 2 showed the results of the bivariate analysis using the Spearman test. The Spearman test showed a correlation between blood pressure and physical activity levels with fasting blood glucose levels. Meanwhile, no correlation was found between the frequency of ultra-processed food consumption and blood glucose levels.

Table 2. Spearman test results

Variable	r	p-value
Systolic Blood Pressure	0,383	0,006
Diastolic Blood Pressure	0,348	0,013
Physical Activity Levels	-0,343	0,015
Frequency of UPF Consumption	0,097	0,501

Based on the bivariate analysis using the Spearman test, blood pressure showed a significant correlation with FBG levels, with $p=0.006$ for systolic pressure and $p=0.013$ for diastolic pressure. The correlation coefficient for systolic pressure was 0.383 and for diastolic pressure was 0.348, indicating a weak positive relationship between blood pressure and FBG levels. These findings indicated that higher blood pressure was associated with higher blood glucose levels. In addition, physical activity levels showed a significant correlation with FBG, with $p=0.015$ and a moderate to weak negative correlation ($r = -0.343$). This indicated that higher levels of physical activity were associated with lower blood glucose levels. Meanwhile, no significant correlation was found between the frequency of UPF consumption and FBG levels, with $p=0.501$ and $r = 0.097$.

4. DISCUSSION

The Correlation between Blood Pressure and Blood Glucose Levels

The analysis demonstrated a significant relationship between blood pressure and fasting blood glucose (FBG) levels among patients with T2DM. Statistical testing showed significant associations for both systolic blood pressure ($p= 0,006$; $r= 0,383$) and diastolic blood pressure ($p= 0,013$; $r=0,348$). The positive correlation coefficients indicated a weak but meaningful relationship, suggesting that higher blood pressure tended to be accompanied by higher blood glucose levels. Most respondents were classified as having stage 1 hypertension (52%), followed by stage hypertension (26%), normal blood pressure (14%), and pre-hypertension (8%). The relatively high prevalence of hypertension observed in this study may be explained by the demographic characteristics of the participants. The majority of subjects were categorized as pre-elderly adults, a group physiologically prone to increased vascular stiffness and declining pancreatic β -cell function associated with aging (16). Furthermore, most participants were female (76%), and hormonal changes following menopause have been reported to increase cardiometabolic risk, including hypertension and impaired glycemic regulation (17). These characteristics may partially explain the coexistence of elevated blood pressure and poor glucose control in the study population.

From a physiological perspective, insulin resistance plays a central role linking hypertension and hyperglycemia. Increased adiposity and metabolic dysfunction reduce insulin sensitivity, limiting glucose uptake by peripheral tissues (18). Elevated blood pressure further impairs endothelial function and cellular insulin signaling, contributing to disrupted glucose metabolism (19). Conversely, chronic hyperglycemia induces hyperinsulinemia, activates the sympathetic nervous system, and increases renal sodium reabsorption, which subsequently elevates blood pressure. Long-term hyperglycemia also promotes macrovascular damage, further aggravating hypertension (20–22). The findings of this study are consistent with Prameswari et al (21), who reported a significant association between hypertension and uncontrolled

blood glucose levels among 329 T2DM patients in RSUD Kabupaten Lombok Utara. However, the results differ from Hafid et al (23), who found no significant association in a study involving 306 patients at RSUD Kota Yogyakarta. Differences in sample characteristics, clinical management, measurement procedures, and potential confounding factors such as antihypertensive drug use and insulin therapy may explain these inconsistencies. These findings imply that although the correlation strength was relatively weak, blood pressure remains an important component of glycemic management in T2DM patients. Effective disease management should therefore adopt a comprehensive approach that integrates blood pressure control, dietary modification, increased physical activity, and management of blood pressure and blood glucose is essential, as their interconnected mechanisms may create a reinforcing pathological cycle that worsens disease progression.

The Correlation between Physical Activity and Blood Glucose Levels

The analysis revealed a significant relationship between physical activity levels and FBG levels ($p= 0,015$), with a negative correlation coefficient ($r= -0,343$), indicating a weak inverse association. Higher levels of physical activity were associated with lower FBG levels among patients with T2DM. Most respondents (56%) were categorized as having low physical activity levels, with an average metabolic equivalent (METs) value of $804,84 \pm 1133,45$, suggesting that the majority of participants had not achieved the recommended physical activity levels for diabetes management. The predominance of housewives among respondents (68%) may partly explain the low physical activity levels observed. Daily household activities such as cooking, sweeping, and washing are generally classified as light-intensity activities and may not provide sufficient metabolic stimulus to significantly improve insulin sensitivity (24). In addition, the dominance of pre-elderly participants may further contribute to reduced physical activity engagement and increased vulnerability to poor glycemic control due to age-related physiological decline (25). Physiologically, physical activity enhances glucose regulation through insulin-independent mechanisms. Muscle contraction stimulates the translocation of glucose transporter type 4 (GLUT4) to the cell membrane, facilitating glucose uptake into muscle cells even under conditions of insulin resistance commonly observed in T2DM patients (26). Furthermore, physical activity activates AMP-activated protein kinase (AMPK), which promotes the activation of TBC1D1 and TBC1D4 proteins involved in GLUT4 transport regulation (27). These mechanisms enable improved glucose utilization regardless of circulating insulin levels, highlighting the important role of physical activity in glycemic control.

The findings of this study are consistent with C. Zhang and Yang (28), who recommended 150-300 minutes of moderate-intensity physical activity or 75-150 minutes of vigorous-intensity activity per week for optimal diabetes management. Similarly, a systemic review by Asfaw and Dagne (29) reported that individuals engaging in regular physical activity were 2,4 times more likely to achieve adequate glycemic control compared with inactive individuals. Although high-intensity exercise such as high-intensity interval training (HIIT) was not observed among participants in this study, previous evidence suggest that light-to-moderate intensity activity still provides beneficial effects on blood glucose regulation (30). Several limitations should be considered when interpreting these findings. Physical activity was assessed using the IPAQ-LF questionnaire, which is subject to recall bias and potential overreporting. The instrument also excludes light activities lasting less than 10 minutes and only captures physical activity within the previous seven days. Moreover, the absence of objective measurements such as pedometers or accelerometers may limit measurement accuracy, and the length of the questionnaire could contribute to

respondent fatigue. Overall, this study confirms that physical activity level is significantly associated with FBG levels, although the correlation strength was relatively weak. These findings suggest that increasing physical activity, particularly among adult pre-elderly populations. Practical recommendations include engaging in at least 30 minutes of daily walking or achieving 150-300 minutes of moderate-intensity physical activity per week or 75-150 minutes of vigorous-intensity activity per week. These results contribute to strengthening evidence within the Indonesia context that regular physical activity remains an effective non-pharmacological strategy for blood glucose control in T2DM patients. The findings may serve as a basis for developing community-based intervention programs tailored to patient characteristics and lifestyle patterns in Indonesia.

The Correlation between Frequency of UPF Consumption and Blood Glucose Levels

Spearman correlation analysis showed no significant association between the frequency of ultra-processed foods (UPF) consumption, based on the NOVA classification, and FBG levels among patients with T2DM ($p= 0,501$; $r= 0,097$). The correlation coefficient indicated a very weak positive relationship. Based on Food Frequency Questionnaire (FFQ) results, 64% of participants were categorized as rarely consuming UPF, with an average frequency of 56 times per month. This level was considerably lower than the ≥ 90 times per month threshold reported by da Silveira et al. (2017) as being associated with increased metabolic risk. The relatively low frequency of UPF consumption in this population may therefore explain the absence of statistically significant association. These findings support the concept that the adverse metabolic effects of UPF tend to emerge when consumption exceeds certain quantitative thresholds and is sustained over time. A systematic review by Moradi et al (32). Demonstrated that each 10% increase in UPF consumption was associated with 12 – 15% higher risk of T2DM, while consumption exceeding three servings per day was linked to overweight and glucose metabolism disorders. UPF are typically high in energy density, saturated fat, added sugars, and food additives, all of which contribute to obesity and insulin resistance, key pathways in the development and progression of T2DM (33).

The discrepancy between the present findings and international studies may be attributed to differences in population characteristics and dietary patterns. Most previous studies were conducted in countries with substantially higher UPF consumption, such as France and Brazil, often among younger or highly urbanized populations with greater exposure to packaged and fast foods. In contrast, the majority of participants in this study were aged 36-59 and reported predominantly consuming unprocessed or minimally processed foods (NOVA category 1), including rice, vegetables, and home-cooked dishes. This pattern reflects a relatively traditional dietary model that remains common in certain Indonesia urban-semi-rural communities. In such contexts, the metabolic impact of UPF may not yet be sufficiently pronounced to significantly influence FBG levels. Nevertheless, the absence of a significant association in this study should not be interpreted as evidence that high UPF consumption is harmless. Extensive and long-term intake of UPF remains biologically plausible as a contributor to metabolic disturbances due to its high glycemic load, low micronutrient density, and elevated trans-fat and added sugar content, all of which may aggravate insulin resistance and glycemic dysregulation. Emerging evidence has also indicated a rapid increase in instant and processed foods consumption in Indonesian urban areas due to modernization and lifestyle transitions (34), suggesting that dietary

patterns may shift over time. Overall, this study indicates that in populations where traditional dietary patterns predominate and UPF intake remains relatively moderate, the frequency of UPF consumption may not show a significant association with FBG levels. However, these findings highlight the importance of preventive strategies in primary healthcare setting to maintain traditional whole-food dietary patterns and limit the increasing penetration of UPF, particularly among productive-age urban populations. The results reinforce the notion that cultural and contextual dietary factors influence the relationship between UPF intake and metabolic risk, underscoring the need for culturally adaptive nutrition interventions.

5. CONCLUSION

This study demonstrates that lifestyle-related factors contribute differently to glycemic control among patients with T2DM. Blood pressure and physical activity were identified as significant determinants of FBG levels, underscoring the importance of integrated cardiometabolic management beyond pharmacological therapy. In contrast, the absence of an association between UPF consumption and glycemic levels in this population suggests that the metabolic impact of dietary patterns may depend on the sociocultural context and overall consumption intensity. These findings highlight the need for comprehensive diabetes management strategies that integrate blood pressure monitoring, structured physical activity promotion, and sustained nutrition education emphasizing whole and minimally processed foods. Strengthening lifestyle-based interventions in primary healthcare settings may help prevent long-term complications and improve quality of life among T2DM patients. Future research employing longitudinal designs, objective lifestyle measurements, and larger samples is warranted to further clarify causal pathways and enhances the generalizability of findings.

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