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ORIGINAL PAPER

The effect of Ramadan fasting and physical exercise on fasting blood glucose in productive-age adults: A pilot study

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Abstract

Background: Productive-age adults are vulnerable to metabolic disorders due to unhealthy diets, low physical activity, which increase fasting blood glucose levels.
Objective: This study aims to analyze the effect of the combination of Ramadan fasting and physical exercise on fasting blood glucose levels in productive-age adults.
Methods: A quasi-experimental study with a non-equivalent control group design was conducted on 34 respondents aged 18-25 years with normal or prediabetes fasting blood glucose levels according to the American Diabetes Association classification. Participants underwent a two-week intervention during Ramadan. The intervention group fasted during Ramadan and underwent physical exercise, including walking and soleus push-ups, whereas the control group showed lower adherence to the intervention. Fasting blood glucose levels were measured at the beginning of Ramadan (T_o), the end of Ramadan (T_1), and one month after Ramadan (T_2). Analysis using Two-Way Repeated Measures ANOVA.
Results: Fasting glucose levels between the intervention and control groups at T_o, T_1, and T_2 showed no significant differences ($p>0.05$). Mixed ANOVA results also showed no effect of time ($p=0.159$), group effect ($p=0.855$), or interaction between time and group ($p=0.269$).
Conclusion: The combination of Ramadan fasting and physical exercise for two weeks did not result in significant changes in fasting blood glucose levels. However, both groups maintained glycemic homeostasis within the normal range.

Keywords: fasting blood glucose, Ramadan fasting, physical exercise, adults

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Introduction

Glucose metabolism disorders are a global health challenge that show an increasing trend year after year. The World Health Organization reports that more than 10% of the world's adult population lives with diabetes mellitus, while the International Diabetes Federation estimates that the proportion of individuals with prediabetes continues to increase globally.[1,2] Prediabetes conditions include impaired fasting glucose (IFG) and impaired glucose tolerance (IGT), which are major risk factors for the development of type 2 diabetes mellitus if not accompanied by appropriate lifestyle interventions.[3]

Southeast Asia is one of the fastest-growing regions in the world for cases of impaired glucose tolerance. The International Diabetes Federation reports that the prevalence of diabetes in adults in Southeast Asia continues to rise, accompanied by a high proportion of the population with prediabetes and impaired glucose tolerance.[2] Globally, an estimated 541 million adults have impaired glucose tolerance, and this number is projected to increase to more than 700 million by 2045 if effective preventive interventions are not implemented.[2] Furthermore, the global prevalence of impaired fasting glucose continues to increase, contributing to the high risk of developing type 2 diabetes mellitus in the adult population.[4]

The increasing prevalence of blood glucose disorders is inseparable from changes in modern lifestyles characterized by low physical activity, increased consumption of high-energy foods, obesity, and irregular sleep patterns.[5] Developing countries with high urbanization rates, including Indonesia, show a significant increase in the productive age group in the early stages of metabolic disorders.[2] This condition is a serious concern because diabetes mellitus is associated with various chronic complications such as cardiovascular disease, nephropathy, neuropathy, and retinopathy, which contribute to high global morbidity and mortality rates.[6]

At the national level, the prevalence of diabetes mellitus in Indonesia among people aged 15 years and older continues to increase. The Indonesian Ministry of Health, through the 2018 Basic Health Research (Riskesdas), reported that the prevalence of diabetes diagnosed by doctors was 2.0%, while the prevalence based on blood glucose levels reached 8.5%. These findings indicate a significant gap between diagnosed and undiagnosed cases in the community. Furthermore, the prevalence of impaired glucose tolerance in Indonesia aged 15 years and older reached 10.9%, while the prevalence of impaired fasting glucose was 26.3%.[7] These high proportions indicate that the number of individuals with prediabetes is much greater than the number of individuals with diagnosed diabetes.

Preliminary screening data from students at the Salewangang Maros Health Sciences College before Ramadan showed that 53.8% had fasting blood glucose levels in the prediabetes category, while 5.1% had fasting blood glucose levels within the diabetic range according to the American Diabetes Association classification.[3] These findings represent the results of initial screening in a limited population and do not reflect the general population prevalence. However, they do indicate potential impaired blood glucose regulation in young, productive-age adults. This indicates that metabolic disorders can begin at a young age and have the potential to worsen if not accompanied by healthy lifestyle management and adequate physical activity.

In Indonesia, young adults, particularly college students, are beginning to show an increase in risk factors for metabolic disorders due to changes in modern lifestyles. Various studies report that college students tend to experience low levels of physical

activity, high-energy diets, inadequate sleep duration, and increased sedentary behavior, all of which contribute to an increased risk of overweight, obesity, insulin resistance, and metabolic syndrome.[8,9,10] These conditions make college students a vulnerable population to blood glucose regulation disorders, even though they are still of productive age. Furthermore, changes in activity patterns during Ramadan also have the potential to affect metabolic balance if not accompanied by healthy lifestyle habits and adequate physical activity.[5]

The productive-age adult group with normal blood glucose levels and prediabetes is an important target in metabolic disease prevention strategies. Individuals with prediabetes have experienced progressive impairment of insulin sensitivity that can be improved through lifestyle modifications, while individuals with normal blood glucose remain at risk of decreased insulin sensitivity if exposed to risk factors continuously.[11] Therefore, early detection and preventive intervention in this group are crucial to suppress the increase in type 2 diabetes mellitus cases in the future.

The productive-age adult group was chosen in this study because it is a group with high mobility and academic activity, making it vulnerable to changes in modern lifestyle patterns such as a sedentary lifestyle, irregular eating patterns, lack of sleep, and decreased physical activity. According to the Central Statistics Agency, the productive age range is 15-64 years.[12,13] However, this study focused on the 18-25 age group because this age range falls within the emerging adulthood phase, a transitional period characterized by increased independence, lifestyle changes, intense academic activity, and an increased risk of metabolic disorders due to poor health behaviors.[14] Previous research has shown that the 18-25 age group is a critical period for weight gain, insulin resistance, and cardiometabolic disorders due to changes in activity patterns and lifestyle habits.[8] In addition, students in this age range tend to experience poor sleep patterns, low physical activity, and suboptimal diet quality, potentially affecting blood glucose regulation.[9]

Physical activity is a non-pharmacological intervention that plays a crucial role in regulating blood glucose levels and controlling nutritional status. Aerobic exercise has been shown to increase glucose uptake by skeletal muscle, increase insulin sensitivity, and improve glycemic control.[15] Light aerobic activity, such as walking, is an easy, inexpensive, and safe form of exercise for adults. Previous research has shown that regular 30 minutes of walking exercise can lower fasting and postprandial blood sugar levels in individuals with prediabetes and type 2 diabetes mellitus.[16,17]

Physiologically, muscle contractions during aerobic activity increase the translocation of glucose transporter type 4 (GLUT-4) to the muscle cell membrane, thereby increasing glucose uptake more efficiently.[18] These metabolic adaptations contribute to increased insulin sensitivity and decreased peripheral insulin resistance. In addition to walking exercise, postural muscle activation, such as through soleus push-ups, has also been reported to increase muscle oxidative metabolism and improve blood glucose regulation in individuals with prediabetes.[15,19] A recent meta-analysis also showed that aerobic exercise interventions provide significant improvements in glycemic control in individuals with prediabetes.[18]

In the context of Indonesia, a predominantly Muslim country, Ramadan is a period characterized by changes in eating patterns, sleep patterns, and metabolic rhythms due to daily fasting. Ramadan fasting can affect blood glucose regulation through changes in energy intake, metabolic hormones, and physical activity.[20] Several studies have shown that Ramadan fasting can have a positive effect on glycemic control when accompanied

by adequate physical activity and a healthy lifestyle.[21,22] Conversely, changes in consumption patterns without sufficient physical activity have the potential to cause blood glucose fluctuations and worsen insulin resistance.[23]

Ramadan fasting combined with structured physical activity has been reported to have better metabolic effects than fasting without physical activity.[24] Light aerobic activity during Ramadan can help maintain insulin sensitivity, improve glucose oxidation, and reduce the risk of increased blood glucose levels during the fasting period.[25]

Although various studies have examined the effects of intermittent fasting and physical activity on glycemic control, previous research has yielded mixed results regarding changes in fasting blood glucose levels during Ramadan.[21,24] Furthermore, research specifically evaluating the combination of Ramadan fasting and light physical exercise such as walking and soleus push-ups in young adults is still limited, particularly in Indonesia. Most previous studies have been conducted in patients with diabetes mellitus, while research in productive age populations with normal blood glucose levels or prediabetes is still relatively limited.

Based on the description, this study was conducted to analyze the effect of Ramadan fasting and physical exercise on fasting blood glucose levels in productive-age adults in Maros Regency, especially in students of the Salewangang Maros Health Sciences College in 2026.

Methods

This study was a quantitative study with a quasi-experimental design using a non-equivalent control group design approach, conducted from February to April 2026 at the Salewangang Maros Health Sciences College. This study aimed to analyze the effect of Ramadan fasting and physical exercise on fasting blood glucose (FBS) levels in productive-age adults. The independent variables in this study were Ramadan fasting and physical exercise in the form of walking exercise and soleus push-ups, while the dependent variable was fasting blood glucose levels. Control variables included age, gender, body mass index (BMI), energy intake, carbohydrate intake, and family history of diabetes mellitus.

The study population consisted of all active students in grades I-III aged 18-25 years. Participants aged 18-25 years were selected because this age group represents the emerging adulthood phase and was considered the most appropriate target population for the objectives of this study. The sample size was determined using the Lemeshow formula and obtained a total of 34 respondents who were divided into an intervention group (n=17) and a control group (n=17). The sampling technique used purposive sampling in accordance with the research inclusion and exclusion criteria. The inclusion criteria included: (1) active students aged 18-25 years, (2) having fasting blood glucose levels in the normal or prediabetes category (<126 mg/dL) based on the American Diabetes Association classification,[3] and (3) willing to participate in the entire series of studies by signing an informed consent. The exclusion criteria included: (1) having fasting blood glucose levels >126 mg/dL (2) not taking all measurements until the end of the study.

Group determination used a per-protocol analysis approach based on the level of respondent compliance with the Ramadan fasting and physical exercise intervention during the study.[26,27] The intervention group consisted of respondents who fully observed the Ramadan fast and complied with the physical exercise program, while the control

group consisted of respondents who did not meet optimal compliance with the intervention.

The physical exercise intervention was conducted over a two-week period during Ramadan. It consisted of walking exercises for 30 minutes per session, three times per week, performed before breaking the fast. The duration and frequency of the exercise were adjusted to the World Health Organization's recommendation of at least 150 minutes of moderate-intensity aerobic physical activity per week to maintain metabolic health.[28] In addition, respondents also performed soleus push-ups for 10 minutes per session, six times per week, performed after breaking the fast or after meals to help improve oxidative metabolism and muscle glucose utilization during sedentary periods.[15] Compliance with Ramadan fasting and physical exercise was collected through daily Google Form filling and active monitoring via WhatsApp group throughout the study period.

Fasting blood glucose levels were measured three times during the study: before the intervention (beginning of Ramadan/T0), after the intervention (end of Ramadan/T1), and one month post-intervention (T2). The tests were performed before breaking the fast after fasting for at least 8–12 hours without caloric intake, as recommended for Ramadan fasting metabolism.[29] The measurements were performed using a calibrated EasyTouch GCHb 3-in-1 device. The classification of fasting blood glucose levels refers to the American Diabetes Association, namely normal (<100 mg/dL), prediabetes (100-125 mg/dL), and diabetes mellitus (≥126 mg/dL).[3]

Anthropometric data were obtained by measuring body weight using a OneMed digital scale and height using a SAGA stadiometer to calculate body mass index (BMI), which was classified according to the WHO Asia-Pacific classification.[30] Energy and carbohydrate intake were assessed using a 2×24-hour food recall method conducted on weekdays and weekends at baseline (T_0) before the intervention. Respondent characteristics, including age, gender, BMI, energy intake, carbohydrate intake, and family history of diabetes mellitus, were obtained using a structured respondent characteristics form. All collected data were checked for completeness and accuracy before data processing.

Data were analyzed using IBM SPSS Statistics 25. Univariate analysis was used to describe the distribution of respondent characteristics and research variables in the form of means and standard deviations (mean ± SD) as well as frequencies and percentages. Normality tests were performed using Shapiro–Wilk. Bivariate analysis used Two-Way Repeated Measures ANOVA to assess the effect of time (time effect), group effect (group effect), and time × group interaction on changes in fasting blood glucose levels at three measurement points (T0, T1, and T2).[31] A p-value <0.05 was considered statistically significant.

This study has been reviewed and approved by the Health Research Ethics Committee of the Muslim University of Indonesia (Approval Number 339/A.1/KEP-UMI/IV/2026). All respondents received an explanation of the study's objectives and procedures and provided written informed consent before participating. Respondent confidentiality and anonymity were maintained throughout the data collection, processing, and analysis.

Results

The characteristics of the study respondents are shown in **Table 1**. This study involved 34 respondents consisting of 17 respondents in the intervention group and 17 respondents in the control group. The average age of respondents in the intervention group was 20.06

± 1.088 years, while in the control group it was 20.24 ± 1.251 years. The average body mass index (BMI) in the intervention group was 20.847 ± 3.0845 kg/m² and in the control group it was 21.329 ± 2.9404 kg/m². The average energy intake of respondents in the intervention group was 1421.903 ± 314.5599 kcal, while in the control group it was 1569.432 ± 518.2053 kcal. The average carbohydrate intake in the intervention group was 180.303 ± 37.1373 grams, while in the control group it was 185.274 ± 56.1283 grams. Based on gender, the majority of respondents were female (33 people) (97.1%), while only one was male (2.9%). A family history of diabetes mellitus was found in 12 respondents (35.3%), while 22 respondents (64.7%) did not have a family history of diabetes mellitus.

Table 1. Respondent characteristics

Characteristics Respondents	Intervention (n=17)	Control (n=17)	Total (n=34)	*p*-value
Age (years), mean ± SD	20.0 ± 1.0	20.2 ± 1.2	20.1 ± 1.1	0,664
BMI (kg/m²), mean ± SD	20,8 ± 3,0	21,3 ± 2,9	21,0 ± 2,9	0,644
Energy intake (kcal), mean ± SD	1421,9 ± 314,5	1569,4 ± 518,2	1495,6 ± 429,9	0,323
Carbohydrate intake (g), mean ± SD	180,3 ± 37,1	185,2 ± 56,1	182,7 ± 47,1	0,763
Gender , n (%)				
Man	1 (5.9%)	0 (0.0%)	1 (2.9%)	1.000
Woman	16 (94.1%)	17 (100.0%)	33 (97.1%)	
Family history of DM, n (%)				
Presence	7 (41.2%)	5 (29.4%)	12 (35.3%)	0.720
None	10 (58.8%)	12 (70.6%)	22 (64.7%)	

Changes in fasting blood glucose levels during the study are presented in **Table 2**. Overall, fasting blood glucose levels remained relatively stable in both the intervention and control groups throughout the study period. Although the intervention group showed a slight decline in fasting blood glucose from baseline to one month after Ramadan, no statistically significant differences were observed between the two groups at any measurement time (all $p > 0.05$).

Table 2. Changes in fasting blood glucose levels based on measurement time

Measurement Time	Intervention (mean ± SD)	Control (mean ± SD)	*p*-value
T_0 (beginning of Ramadan)	98.8 ± 10.2	95.5 ± 16.5	0.497
T_1 (end of Ramadan)	98.0 ± 7.1	97.4 ± 11.8	0.862
T_2 (1 month post Ramadan)	89.7 ± 22.8	95.5 ± 13.0	0.366

The Mixed ANOVA results are presented in Table 3. No significant main effects of time or group were observed on fasting blood glucose levels. Likewise, no significant time × group interaction was found ($p > 0.05$), indicating that changes in fasting blood glucose over time were comparable between the intervention and control groups.

Table 3. Effect of Ramadan fasting and physical exercise on fasting blood glucose levels

Analysis Parameters	F value	*p*-value
Changes in fasting blood glucose levels based on measurement time (*time effect*)	1,892	0.159
Differences in fasting blood glucose levels between groups (*group effect*)	0.034	0.855
The effect of Ramadan fasting and physical exercise on changes in fasting blood glucose levels (*time × group interaction*)	1,339	0.269

Discussion

Fasting blood glucose (FBS) is an important indicator in assessing glucose homeostasis and insulin sensitivity in the body. Blood glucose regulation is influenced by various factors such as diet, physical activity, sleep quality, nutritional status, and fasting duration.[32] Impaired blood glucose regulation is a global concern because the prevalence of diabetes mellitus and prediabetes continues to increase in various countries, including in productive age groups.[1,2] This increase in cases is closely related to changes in modern lifestyles such as low physical activity, sedentary behavior, inadequate sleep patterns, and increased consumption of high-energy foods.[5,10]

The results of this study showed that the average fasting blood glucose levels in the intervention group experienced a gradual decrease from the beginning of Ramadan until one month after the intervention, although the changes were not statistically significant. These findings suggest that the combination of Ramadan fasting and light physical exercise can maintain stable blood glucose regulation in young adults. Physiologically, fasting causes the body to undergo metabolic adaptation through glycogenolysis and gluconeogenesis mechanisms to maintain blood glucose levels within the normal range.[29] In addition, intermittent fasting also triggers metabolic switching from glucose utilization to fatty acid oxidation and ketone bodies as alternative energy sources, thereby helping to increase the body's metabolic efficiency.[33,34]

The absence of significant differences in fasting blood glucose levels based on measurement time indicates that the body's glucose homeostasis was maintained throughout the study period. This can be explained by the fact that most respondents were in the normal and prediabetes categories, so that insulin compensatory mechanisms were still able to maintain stable blood glucose levels.[35] This study aligns with research by Pavlou et al., who reported that time-restricted eating did not significantly change fasting glucose levels in healthy adults.[36] Similar results were also reported by Yuan et al., who stated that intermittent fasting tends to have a stable effect on glycemic control in individuals with mild glucose intolerance.[37]

In addition to fasting, light physical activity performed during the study is thought to contribute to maintaining the stability of respondents' blood glucose.[18] Walking exercise and soleus push-ups are light aerobic activities that can increase glucose utilization by

skeletal muscle through increasing GLUT-4 translocation independently of insulin. Muscle contraction activity during exercise increases glucose uptake and insulin sensitivity, thereby helping maintain stable blood glucose levels during Ramadan fasting.[15,18] Previous research has shown that light to moderate intensity aerobic exercise can improve glycemic control and reduce insulin resistance in individuals with prediabetes.[16,38] In addition, soleus muscle activation has been reported to increase local oxidative metabolism and help regulate blood glucose during sedentary periods.[15,19]

However, the results of this study indicate that there were no significant differences between the intervention and control groups. A longer intervention duration may lead to more pronounced improvements in fasting blood glucose, as previous evidence suggests that exercise performed consistently over a longer period promotes metabolic adaptations and improves glycemic control in individuals with prediabetes.[18] Furthermore, respondents in the control group continued their routine daily activities during Ramadan, thus likely still experiencing the metabolic effects of Ramadan fasting even without structured physical exercise. Research by RezkAllah and Takla (2019) showed that interval training in individuals with prediabetes can improve glycemic control, as indicated by a significant decrease in fasting blood glucose (FBG) and HbA1c levels compared to the control group.[39] These results indicate that interval-based physical activity plays a crucial role in improving blood glucose regulation by increasing insulin sensitivity.

Another factor suspected of contributing to blood glucose stability in this study is hormonal adaptation and a reduced inflammatory response during Ramadan fasting. Intermittent fasting is known to affect the hormones leptin and ghrelin, which play a role in regulating appetite and energy balance.[20] In addition, Ramadan fasting has also been reported to reduce inflammatory mediators and increase insulin sensitivity through a mild metabolic adaptation mechanism (hormesis).[40,41] These adaptations allow the body to maintain stable blood glucose regulation despite changes in eating patterns and activity times during Ramadan.

The results of this study indicate that the combination of Ramadan fasting and light physical exercise is relatively safe for young adults with normal blood glucose levels or mild prediabetes. Although no statistically significant changes were found, this intervention has the potential to help maintain blood glucose homeostasis and prevent the worsening of metabolic disorders in productive age. These findings support the concept that lifestyle modification through dietary management and physical activity remains an important strategy in preventing type 2 diabetes mellitus from a young age.[7,38]

This study has several limitations, including a relatively small sample size, a short intervention duration, which may have limited the ability to detect significant changes in fasting blood glucose. In addition, physical activity and dietary intake were assessed using self-reported methods, which may be subject to recall and reporting bias. Future studies should consider using more objective measures of physical activity and dietary assessment to improve the accuracy of the findings.

Conclusion

This study shows that the combination of Ramadan fasting and physical exercise, such as walking and soleus push-ups, does not significantly change fasting blood glucose levels in productive-age adults. However, fasting blood glucose levels in both groups remained within the normal range throughout Ramadan and for one month after Ramadan,

indicating an adaptation of the body's glucose homeostasis during the fasting period. Further research is recommended using a larger sample size, longer intervention duration, and more comprehensive measurements of metabolic parameters to obtain a more in-depth picture of the effects of Ramadan fasting and physical exercise on blood glucose regulation.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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Author Contributions

NI**:** Data acquisition, formal analysis, interpretation of results, drafting the manuscript, and final approval of the version to be published. SM: Conceptualization, supervision, critical revision of the manuscript, and final approval of the version to be published. FW**:** Conceptualization, supervision, critical revision of the manuscript, and final approval of the version to be published. S: Conceptualization, supervision, critical revision of the manuscript, and final approval of the version to be published.

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