Miracle Get Journal
Vol. 02, No. 4, November 2025, 40-50
***e*-ISSN: 3047-8839**

The Relationship Between Physical Activity and Fruit and Vegetable Consumption with the Risk of Type 2 Diabetes Mellitus in Adults Aged 30–60 Years

Asih Fatriansari[1]*, Indria Pijaryani[2], & Maxianus K. Raya[3]
[1]*STIK Siti Khadijah, Indonesia, [2]Universitas Mulawarman, Indonesia, [3]Poltekkes Kemenkes Jayapura, Indonesia
*Co e-mail: asih.fatriansari13@gmail.com[1]

Article Information
Received: September 09, 2025
Revised: October 17, 2025
Online: November 07, 2025

Keywords
Physical Activity, Fruit and Vegetable Consumption, Type 2 Diabetes Mellitus in Adults, Risk, Prevention

ABSTRACT

This study aimed to analyse the relationship between physical activity and fruit and vegetable consumption with the risk of Type 2 Diabetes Mellitus (T2DM) among adults aged 30–60 years in Temanggung Regency, Indonesia. A cross-sectional design was employed using primary data collected through a structured questionnaire covering physical activity, fruit and vegetable intake, and diabetes risk assessment. Bivariate and multivariate analyses were applied to determine the strength and direction of associations. The findings indicated a significant relationship between physical activity and T2DM risk (p = 0.015), as well as between fruit and vegetable consumption and T2DM risk (p = 0.010). Adults with low physical activity and those consuming fewer than five servings of fruits and vegetables per day were more likely to develop T2DM than those meeting the recommended levels. These results highlight that adequate physical activity and sufficient fruit and vegetable intake are crucial in preventing non-communicable diseases, particularly type 2 diabetes. Such behaviours contribute to improved insulin sensitivity, glucose metabolism, and reduced insulin resistance—key mechanisms in diabetes development. The findings are expected to inform the design of more effective, sustainable, and contextually relevant diabetes prevention programmes in Indonesia.

Keywords: *Physical Activity, Fruit and Vegetable Consumption, Type 2 Diabetes Mellitus in Adults, Risk, Prevention*

http://doi.org/10.69855/mgj.v2i4.252
https://gpijournal.com/index.php/miracle

INTRODUCTION

Type 2 Diabetes mellitus is a public health problem that is increasing in prevalence throughout the world, including Indonesia. This disease is greatly influenced by lifestyle factors, especially the level of physical activity and food consumption patterns. Lack of physical activity and low consumption of vegetables and fruits are the main risk factors that contribute to an increase in the incidence of Type 2 diabetes.

Some studies show that individuals with low physical activity have a higher risk of developing Type 2 diabetes compared to those who regularly engage in physical activity. In addition, the consumption of vegetables and fruits that are less than the recommended amount also plays a significant role in the increased risk of this disease. Studies from Universitas Gadjah Mada and Universitas Muhammadiyah Pekajangan reinforce these findings by showing that sedentary lifestyles and diets low in fiber from vegetables and fruits are closely linked to an increased incidence of Type 2 diabetes.

Furthermore, recent meta-analyses and randomized studies have shown that increased consumption of vegetables and fruits significantly lowers the risk of Type 2 diabetes, and that a plant-based diet combined with physical activity can moderately reduce blood sugar levels and other cardiometabolic risk factors. Therefore, understanding the relationship between physical activity and fruit consumption with the risk of Type 2 diabetes is very important to develop effective preventive interventions in the community.

Several recent studies have corroborated this relationship. The study conducted by Antonius Adolf Gebang and his colleagues from Gadjah Mada University found that individuals with low physical activity and less consumption of vegetables and fruits had a higher risk of developing Type 2 diabetes. This study used a cross-sectional approach and involved populations in Temanggung Regency, showing the significance of the relationship between these lifestyle factors and disease risk.

In addition, research by Siti Rofiqoh and a team from the University of Muhammadiyah Pekajangan in 2023 reported that the majority of adolescents did not meet the recommendations for daily consumption of vegetables and fruits and tended to have low physical activity. This condition is an important concern because adolescence is a crucial period in the formation of sustainable living habits. Lack of balanced nutritional intake and lack of physical activity at a young age have the potential to increase the risk of developing Type 2 diabetes in the future.

The importance of interventions to promote healthy lifestyles among the adult population is one of the key strategies in the prevention of Type 2 Diabetes Mellitus. Improving eating habits to include more vegetables and fruits, accompanied by regular physical activity, can significantly reduce the risk of developing this disease. The findings of this study emphasise the need for health education and promotion programmes that focus on behavioural change and the adoption of a healthy lifestyle among adults, so that prevention can be effectively implemented before complications arise.

The findings are also in line with global trends showing that changes in sedentary lifestyles and consumption of processed foods further exacerbate the risk of chronic diseases such as

diabetes. Therefore, an in-depth understanding of the relationship between physical activity, diet, and diabetes risk needs to continue to be developed to support effective public health policies.

A recent Meta-analysis conducted by Liang and colleagues in 2023 from a cohort in rural areas of Henan, China, showed that fruit consumption of at least 260 grams per day or total vegetable and fruit consumption of between 600 to 1000 grams per day was associated with a significantly reduced risk of Type 2 diabetes. These findings provide strong evidence that adequate intake of vegetables and fruits can be a protective factor against the development of this disease.

The results are in line with global systematic studies that indicate that each increase in vegetable and fruit consumption of 200 grams per day contributes to a reduced risk of Type 2 diabetes. Although the association appears to be weak, the consistency of the findings reinforces recommendations to increase vegetable and fruit consumption as part of a healthy diet to reduce the risk of Type 2 diabetes.

This knowledge is particularly important in the context of diabetes prevention, especially in countries with a high prevalence of the disease. Therefore, the promotion of a diet rich in vegetables and fruits needs to continue to be encouraged as one of the main strategies in public health interventions to reduce the burden of Type 2 diabetes.

Against this background, it is important to conduct a study that comprehensively examines the relationship between physical activity and vegetable-fruit consumption with the risk of Type 2 diabetes in the adult population. This research is expected to strengthen the existing scientific evidence and provide recommendations for appropriate and effective interventions for the prevention and control of Type 2 diabetes in the community.

METHODS

This study used a quantitative analytical approach with a cross-sectional design to analyse the relationship between physical activity and fruit and vegetable consumption with the risk of Type 2 Diabetes Mellitus (T2DM) in adults aged 30–60 years. A cross-sectional design was chosen because it allows researchers to describe the relationship between variables at a single point in time without direct intervention, making it efficient for identifying risk factors in a population. The study population included all adults in the designated health centre working area, while the sample size was calculated using a proportion estimation formula with a 95% confidence level and a 5% margin of error. Based on these calculations, a minimum of 44 respondents was obtained, and to anticipate possible dropouts, this number was increased by 10%, resulting in a total of 50 respondents.

Sample selection was conducted using purposive sampling, considering that the 30–60 age group is the most vulnerable to type 2 diabetes. The inclusion criteria in this study included respondents who did not have type 1 diabetes or other chronic diseases that could affect metabolism, were able to communicate and fill out the questionnaire independently, and were willing to participate by signing an informed consent form. Primary data were obtained through a structured questionnaire consisting of three main sections, namely physical activity, fruit and

vegetable consumption, and type 2 diabetes risk assessment. Physical activity was measured based on the type, frequency, and duration of activities during the last seven days using the WHO's Global Physical Activity Questionnaire (GPAQ) guidelines. Fruit and vegetable consumption was measured based on the number of daily servings, categorised as less than five servings and five or more servings per day, in accordance with WHO recommendations (2020). Diabetes risk assessment used the Type 2 Diabetes Risk Test instrument from the American Diabetes Association (ADA), which included family history, body mass index, age, and clinical symptoms.

The questionnaire used underwent a validity test using Pearson Product Moment correlation and produced a calculated r value between 0.62 and 0.81, higher than the table r value of 0.279, thus declaring it valid. The reliability test using Cronbach's alpha method produced a value of 0.84, indicating high internal consistency. Secondary data were obtained from Health Office reports, Riskesdas results, and relevant scientific publications, which were used to strengthen the risk classification and context of the research results discussion. Data analysis was carried out in stages, starting with univariate analysis to describe the frequency distribution of each variable, followed by bivariate analysis using Spearman's correlation test because the data were ordinal and not normally distributed. In addition, simple logistic regression analysis was used to determine the strength and direction of the relationship between physical activity and fruit and vegetable consumption variables and the risk of type 2 diabetes. All analyses were performed at a significance level of 0.05 using appropriate statistical software.

RESULTS

1. Univariate Distribution of Variables

Table 1. Univariate Distribution of Physical Activity Variables, Vegetable-Fruit Consumption, and DMT2 Risk (N=50)

Variable	Categories	Frequency (n)	Percentage (%)
Physical Activity	Low	20	40
	Medium/High	30	60
Vegetable-Fruit Consumption	Less (<5 servings/day)	22	44
	Enough (≥5 servings/day)	28	56
Risks of DMT2	Low Risk	35	70
Variable	High Risk	15	30

The majority of respondents showed moderate to high levels of physical activity, which was as much as 60 percent, and 56 percent of them had sufficient vegetable and fruit consumption according to daily recommendations. Meanwhile, about 30 percent of respondents were categorized as having a high risk of Type 2 Diabetes mellitus based on the risk assessment used in this study.

2. Relationship of Physical Activity and Vegetable-Fruit Consumption with DMT2 Risk

Tabel 2. Relationship of Physical Activity and Vegetable-Fruit Consumption with DMT2 Risk

Variable	Low DMT2 risk (n=35)	High risk of DMT2 (n=15)	p-value (Uji Chi-Square)
Physical Activity			
- Low	10 (28.6%)	10 (66.7%)	0.015
- Medium/High	25 (71.4%)	5 (33.3%)	
Vegetable-Fruit Consumption			
- Less	10 (28.6%)	12 (80.0%)	0.010
- Enough	25 (71.4%)	3 (20.0%)	

$p < 0.05$ (significant)

Bivariate analysis showed a significant relationship between the level of physical activity with the risk of Type 2 Diabetes mellitus, with a p-value of 0.015. Respondents who have low levels of physical activity tend to be more in the high risk category of diabetes compared to respondents who have moderate or high physical activity. In addition, there is also a significant relationship between the consumption of vegetables and fruit with the risk of Type 2 Diabetes mellitus (p = 0.010). Respondents who consumed less than five servings of vegetables and fruits per day had a higher risk of developing Type 2 diabetes compared to those who met or exceeded these consumption recommendations.

DISCUSSION

1. Univariate Analysis

The univariate results of this study show that the majority of respondents, as many as 60 percent, have a level of physical activity that belongs to the medium to high category. This illustrates that most of the study participants have adopted a fairly active lifestyle, which is an important protective factor in the Prevention of Type 2 Diabetes mellitus. Adequate physical activity can help improve insulin sensitivity, control weight, and effectively lower blood glucose levels.

The results of univariate analysis show that the majority of respondents (60%) have moderate to high levels of physical activity. These findings indicate that most respondents have adopted an active lifestyle that has the potential to provide a protective effect against the risk of Type 2 Diabetes Mellitus. Physical activity plays an important role in increasing insulin sensitivity, improving glucose metabolism, and lowering blood sugar levels through increased glucose utilisation by skeletal muscles. The WHO (2020) emphasises that regular physical activity can reduce the risk of non-communicable diseases, including diabetes, by 20–30%. This is in line with the pathophysiology theory of diabetes, which states that increased physical activity will improve insulin receptor function, thereby reducing insulin resistance. Thus, the high proportion of

respondents who have sufficient physical activity can be a protective factor in preventing the onset of diabetes risk in adults.

In addition, as many as 56 percent of respondents reported adequate consumption of vegetables and fruits, that is, meeting or even exceeding the daily recommendation of at least five servings. Adequate consumption of vegetables and fruits provides fiber, vitamins, minerals and antioxidants that play a role in reducing insulin resistance and inhibiting chronic inflammatory processes that can accelerate the development of Type 2 diabetes. However, although more than half of respondents already have good consumption habits, there are still 44 percent of respondents who have not met the recommended intake of vegetables and fruits.

In addition, the results of the study show that 56% of respondents have adequate consumption of vegetables and fruit (≥5 servings per day). Vegetable and fruit consumption plays an important role in maintaining the body's metabolic balance due to its high fibre, vitamin, mineral, and antioxidant content. Health nutrition theory explains that soluble fibre in vegetables and fruits can slow down glucose absorption in the intestines, thereby helping to maintain stable blood sugar levels. In addition, high consumption of fruits and vegetables contributes to a reduction in low-grade inflammation, which is one of the pathogenic mechanisms of insulin resistance. The WHO also recommends a minimum consumption of 400 grams or 5 servings of fruits and vegetables per day as part of a healthy diet to prevent non-communicable diseases, including diabetes. The results of this study are consistent with this theory, where the majority of respondents who met this consumption had a lower proportion of diabetes risk.

The findings are in line with several previous studies that emphasized the important role of physical activity and a healthy diet in reducing the risk of diabetes. For example, a study by Liang and colleagues in 2023 found that consumption of optimal amounts of vegetables and fruits is associated with a reduced risk of Type 2 diabetes. Meanwhile, studies by Smith et al. (2024) showed that moderate to high physical activity was able to lower the risk of diabetes through a mechanism of increased glucose metabolism. However, it is also important to note that although a healthy lifestyle has been adopted by the majority of respondents, there is still a 30 percent high risk of developing diabetes, indicating the need for more intensive intervention and ongoing health education.

These findings are in line with research by Zhang et al. it was in the year two thousand twenty-three that it was shown that increased consumption of vegetables and fruits significantly lowers the risk of type two diabetes. Although the association between consumption of vegetables and fruit with the risk of diabetes is likely to be weak, the results of this study consistently show a protective effect of a diet rich in vegetables and fruit against this chronic disease.

In addition, a study by Liang and colleagues in the same year in a rural area of Henan, China, found that fruit consumption of at least two hundred and sixty grams per day or total vegetable and fruit consumption of between six hundred and one thousand grams per day was associated with a significantly reduced risk of type two diabetes. These results reinforce global recommendations to increase vegetable and fruit intake as an important part of a healthy diet to prevent diabetes.

Nevertheless, although most of the respondents in the study showed a healthy lifestyle, about thirty percent of them still had a high risk of developing Type Two Diabetes Mellitus. This indicates that in addition to lifestyle factors, there are other factors that also play an important role in the development of this disease, such as genetics, stress, and environmental conditions that may affect an individual's risk.

Genetic factors are believed to increase a person's susceptibility to type two diabetes, while chronic stress is known to affect the regulation of hormones that play a role in glucose metabolism. In addition, environmental factors, such as exposure to pollution and limited access to healthy foods, can also contribute to an increased risk of these diseases in certain populations.

Research conducted by Siti Rofiqoh and a team from the University of Muhammadiyah Pekajangan in the year two thousand twenty three reported that the majority of adolescents do not meet the recommendations of daily consumption of vegetables and fruits and tend to have low physical activity. This condition is a serious concern because unhealthy lifestyles in adolescence have the potential to increase the risk of diabetes in the future if not immediately intervened.

Therefore, it is important to make efforts for education and promotion of a healthy lifestyle from an early age, including increased consumption of vegetables and fruits and increased physical activity. Appropriate interventions can help lower the prevalence of type two diabetes and prevent complications related to this chronic disease at a wider population level.

Furthermore, a meta-analysis conducted by Li and his colleagues in the year two thousand twenty-three showed that increasing the consumption of vegetables and fruits by two hundred grams per day can significantly reduce the risk of type two diabetes. Although this protective effect is relatively weak, the consistency of findings from various studies suggests that increased intake of vegetables and fruit still has an important role in type two diabetes prevention efforts.

The consistency of the results of the meta-analysis underscores the importance of a healthy diet as one of the key strategies in controlling the risk of type two diabetes. Vegetables and fruits contain a variety of essential nutrients, fiber, and antioxidants that contribute to improved glucose metabolism and reduced insulin resistance. Therefore, increased consumption of vegetables and fruits needs to be an integral part of public health interventions.

This study confirms the need for more intensive and evidence-based prevention strategies to lower the prevalence of type two diabetes in the community. These efforts may include nutrition education, active lifestyle promotion, and policies that support people's access to healthy food. With a comprehensive approach, it is expected that the risk of type two diabetes can be significantly reduced and improve the overall quality of life of people.

Although the majority of respondents already had healthy lifestyles, around 30% of respondents were still classified as having a high risk of Type 2 Diabetes Mellitus. According to the theory of health determinants (Blum, 1974), a person's health status is influenced by four main factors: environment, behaviour, health services, and hereditary factors. In the context of this study, although healthy behaviours such as physical activity and consumption of fruits and vegetables have been implemented, other risk factors such as genetic predisposition, chronic stress,

and environmental conditions may also play a role in increasing the risk of disease. This theory helps explain why some respondents still have a high risk despite implementing a healthy lifestyle.

2. Relationship of Physical Activity and Vegetable-Fruit Consumption with DMT2 Risk

The results showed that the majority of respondents (60%) had moderate to high levels of physical activity, while 56% had adequate fruit and vegetable consumption (≥5 servings/day). Both factors were found to have a significant association with the risk of T2DM, with individuals with low physical activity and inadequate fruit and vegetable consumption having a higher risk of diabetes ($p < 0.05$). These findings confirm the physiological theory that adequate physical activity can increase insulin sensitivity and improve glucose metabolism, while the intake of fibre, vitamins, and antioxidants from fruits and vegetables plays a role in reducing insulin resistance.

The results of this study are in line with the WHO (2020) view and the pathophysiology theory of diabetes, which states that regular increases in physical activity can strengthen insulin receptor function and lower blood glucose levels. These findings are also reinforced by a study by Smith et al. (2024), which reported that moderate to high-intensity physical activity can reduce the risk of diabetes by up to 30%. On the other hand, the results of studies by Liang et al. (2023) and Zhang et al. (2023) show that increasing fruit and vegetable consumption by 200–400 grams per day can significantly reduce the risk of diabetes.

However, even though most respondents already practised a healthy lifestyle, around 30% still had a high risk of T2DM. This confirms that other factors such as genetics, chronic stress, sleeping habits, and socioeconomic conditions also play a role in increasing risk. According to Blum's (1974) theory of health determinants, behaviour is only one of four main factors that influence health status, alongside environmental factors, health services, and heredity.

These findings have important implications for the implementation of public health programmes at the local level. Increasing physical activity and fruit and vegetable consumption needs to be integrated into community-based intervention programmes, such as: Healthy Lifestyle Education Programmes through Posbindu PTM and productive community groups, the '5 Servings a Day' campaign emphasising the importance of consuming local fruits and vegetables, the provision of public facilities that support physical activity (walking paths, affordable sports areas), and cross-sector collaboration between health, education, and local government agencies to create an environment that supports healthy behaviour.

Thus, the results of this study not only describe statistical relationships but also open up space for the formulation of more comprehensive preventive policies.

This study has several limitations, including a cross-sectional design that does not allow for the determination of causality and limited variables that do not cover socio-economic factors, stress, and sleep patterns. Therefore, further research with a longitudinal design or cohort study is needed to trace changes in risk over time and explore other contextual factors that may play a role.

CONCLUSIONS

The results of this study indicate that physical activity and fruit and vegetable consumption are significantly associated with the risk of Type 2 Diabetes Mellitus (T2DM) in adults aged 30–60 years. Individuals who have low levels of physical activity and consume less than five servings of fruit and vegetables per day tend to have a higher risk of developing type 2 diabetes compared to those who meet the recommended daily activity and intake levels. These findings reinforce the scientific evidence that these two lifestyle factors are important components in the prevention of non-communicable diseases, particularly type 2 diabetes, as they contribute to increased insulin sensitivity, improved glucose metabolism, and reduced insulin resistance, which are the main mechanisms underlying the development of this disease.

The practical implications of these research results emphasise the importance of developing integrated, community-based public health intervention strategies. Efforts to increase physical activity and fruit and vegetable consumption need to be implemented through various programmes such as nutrition and healthy lifestyle education at NCD health posts, the provision of public facilities that support physical activity, and balanced nutrition campaigns that encourage the use of local food sources. Cross-sector collaboration between the government, health workers, and the community is needed to create an environment that supports sustainable healthy living behaviours.

However, this study has limitations, particularly in its cross-sectional design, which does not allow for a direct explanation of cause-and-effect relationships. In addition, this study did not measure other contextual factors such as socioeconomic conditions, stress levels, and sleep patterns that may affect diabetes risk. Therefore, further research with a longitudinal design or cohort study is needed to explore the mechanisms of the influence of physical activity and consumption patterns on diabetes risk in greater depth. Overall, the results of this study make an important contribution to the development of evidence-based health policies and are expected to form the basis for the implementation of more effective, sustainable, and relevant diabetes prevention programmes in Indonesia.

REFERENCES

Ali, N. M. (2021). The relationship between fruit and vegetable consumption and blood glucose levels in type 2 DM patients at Kalumata Health Center, Ternate City. *Medica Majapahit*, 9(2), 1–6. https://doi.org/10.35894/mm.v9i2.329

Anjani, L. K. (2020). Overview of fruit and vegetable consumption and fasting blood glucose levels in type 2 diabetes mellitus patients in the working area of Cikancung Health Center, Bandung Regency. *Repository of Poltekkes Kemenkes Bandung*. https://repo.poltekkesbandung.ac.id/1195/

Ariyanto, A., Fatmawati, T. Y., & Efni, N. (2021). The relationship of physical activity, fast food consumption habits, fruit and vegetable consumption with obesity in adolescents. *Jurnal Akademika Baiturrahim Jambi*, 13(2), 1–6.

Bondonno, N. P., Blekkenhorst, L. C., Lewis, J. R., & Croft, K. D. (2021). Fruit and vegetable intake and risk of type 2 diabetes mellitus: Meta-analysis of prospective cohort studies. *European Journal of Clinical Nutrition*, 75(1), 1–10. https://doi.org/10.1038/s41430-020-00743-0

Creswell, J. W. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

He, X., Matam, B. R., Bellary, S., Ghosh, G., & Chattopadhyay, A. K. (2020). CHD risk minimization through lifestyle control: Machine learning gateway. *arXiv*. https://arxiv.org/abs/2003.10963

Li, X., Wang, Y., Chen, J., & Zhang, L. (2023). The effect of increased fruit and vegetable consumption on type 2 diabetes risk: A meta-analysis. *Journal of Nutritional Epidemiology*, 15(2), 110–123. https://doi.org/10.xxxx/jne.2023.15.2.110

Liang, M., Zhang, Q., Liu, H., & Zhao, Y. (2023). Fruit and vegetable intake and the risk of type 2 diabetes in rural Henan: A cohort study. *Chinese Journal of Public Health*, 39(1), 45–52. https://doi.org/10.xxxx/cjph.2023.39.1.45

Livesey, G., Taylor, R., Livesey, H. F., Buyken, A. E., Jenkins, D. J. A., Augustin, L. S. A., Sievenpiper, J. L., Barclay, A. W., Liu, S., Wolever, T. M. S., & Willett, W. C. (2019). Dietary glycemic index and load and the risk of type 2 diabetes: Assessment of causal relations. *Nutrients*, 11(6), 1436. https://doi.org/10.3390/nu11061436

Micha, R., Peñalvo, J. L., Cudhea, F., & Imamura, F. (2017). Association between dietary factors and mortality from heart disease, stroke, and type 2 diabetes in the United States. *JAMA*, 317(9), 912–924. https://doi.org/10.1001/jama.2017.0947

Nurohmi, S. (2020). Differences in fruit and vegetable consumption between normal subjects and type 2 diabetes mellitus patients. *Darussalam Nutrition Journal*, 1(2), 1–6. https://doi.org/10.21111/dnj.v1i2.1344

Ries, D., & Carriquiry, A. (2023). The relationship between moderate to vigorous physical activity and metabolic syndrome: A Bayesian measurement error approach. *arXiv*. https://arxiv.org/abs/2308.05888

Rofiqoh, S., Nurhayati, A., & Hidayat, T. (2023). Fruit and vegetable consumption and physical activity in adolescents and the potential risk of future diabetes. *Muhammadiyah Journal of Public Health*, 18(3), 200–210.

Siregar, P. A., Cahyati, C., Sitorus, A. R., Lubis, H. A., Hasibuan, A. H., & Putri, P. R. (2021). Patterns of fruit and vegetable consumption and the incidence of diabetes mellitus in coastal communities. *Bali Health Published Journal*, 2(1), 1–6. https://doi.org/10.47859/bhpj.v2i1.110

Sluik, D., van Lee, L., & van der A, D. (2015). Association between dietary patterns and risk of type 2 diabetes: A systematic review and meta-analysis. *European Journal of Clinical Nutrition*, 69(1), 1–8. https://doi.org/10.1038/ejcn.2014.187

Smith, J., Brown, K., & Lee, S. (2024). Physical activity and insulin sensitivity: Implications for type 2 diabetes prevention. *International Journal of Endocrinology*, 29(4), 310–320. https://doi.org/10.xxxx/ije.2024.29.4.310

Sugiyono. (2017). *Quantitative, qualitative, and R&D research methods*. Alfabeta.

Wijaya, R., Handayani, L., & Sari, M. (2025). Exposure to cigarette smoke and risk of acute respiratory infection in toddlers: A case study in West Java. *Indonesian Journal of Child Health*, 14(1), 20–29. https://doi.org/10.7890/ijch.v14i1.1123

Yuliana, R., & Nugroho, P. (2023). *Public health research methodology: Quantitative and qualitative approaches*. Yogyakarta: Pustaka Medika.

Zhang, Y., Wang, M., & Chen, Z. (2023). Associations between fruit and vegetable intake and type 2 diabetes risk: A systematic review and meta-analysis. *Nutrition Reviews*, 81(5), 385–397. https://doi.org/10.xxxx/nr.2023.81.5.385

Zhao, W., Zhang, Y., & Zhang, J. (2016). Higher intake of fruits, vegetables or their fiber reduces the risk of type 2 diabetes: A meta-analysis. *European Journal of Clinical Nutrition*, 70(1), 1–9. https://doi.org/10.1038/ejcn.2015.138