April – June, 2025
Original Article
DOI: http://dx.doi.org/10.30867/action.v10i2.2555

AcTion: Aceh Nutrition Journal
Pages: 485 – 493
p-issn 2527-3310; e-issn 2548-5741

Association between body composition and fasting blood glucose in patients with type 2 diabetes

Hubungan antara komposisi tubuh dan kadar glukosa darah puasa pada pasien diabetes tipe 2

Nazhif Gifari[1*], Rachmanida Nuzrina[2], Mury Kuswari[3], Laras Sitoayu[4]

[1] Nutrition and Dietetic Study Program of Universitas Esa Unggul, Jakarta. Indonesia.
E-mail: nazhif.gifari@esaunggul.ac.id
[2] Nutrition and Dietetic Study Program of Universitas Esa Unggul, Jakarta, Indonesia.
E-mail: rachmanida.nuzrina@esaunggul.ac.id
[3] Nutrition Study Program of Universitas Esa Unggul, Jakarta. Indonesia.
E-mail: mury@esaunggul.ac.id
[4] Nutrition and Dietetic Study Program of Universitas Esa Unggul, Jakarta. Indonesia. E-mail: laras@esaunggul.ac.id

***Correspondence Author:**
Nutrition and Dietetic Study Program of Universitas Esa Unggul, Jakarta. Indonesia.
E-mail: nazhif.gifari@esaunggul.ac.id

Article History:
Received: May 26, 2025; Revised: June 13, 2025; Accepted: June 15, 2025; Published: June 18, 2025.

Publisher:
Politeknik Kesehatan Aceh
Kementerian Kesehatan RI

Abstract

Type 2 Diabetes Mellitus (T2DM) has become a significant public health issue in Asia, with significantly increasing prevalence rates in recent decades, especially affecting blood glucose levels in patients with this type of diabetes. This study aimed to examine the correlation between body composition and fasting blood glucose levels in subjects with diabetes mellitus type 2. The observational research used a cross-sectional design that included a sample of 68 subjects, conducted between August and May 2024 at the RSUP Fatmawati Hospital in Jakarta. Data were analyzed using the chi-square test for bivariate analysis, and analysis of variance was used to compare the variables. Body composition was measured using body impedance analysis (BIA), physical activity levels were measured using the International Physical Activity Questionnaire Short Form (IPAQ-SF), and fasting blood glucose was measured using Accu-Chek Instant Strips. Dietary and beverage consumption habits, familial health history, smoking habits, sleep duration, and physical activity level were assessed using a structured questionnaire. The results showed a positive relationship between nutritional status, percent body fat, and waist circumference, with a negative correlation between muscle mass and fasting blood sugar levels. In conclusion, nutritional status, percent body fat, waist circumference, and muscle mass were associated with fasting blood glucose levels.

Keywords: Body composition, fasting blood glucose, type 2 diabetes

Abstrak

Diabetes Melitus Tipe 2 (T2DM) telah menjadi masalah kesehatan masyarakat yang signifikan di Asia, dengan tingkat prevalensi meningkat secara signifikan dalam beberapa dekade terakhir; status gizi terutama memengaruhi kadar glukosa darah pada pasien dengan diabetes tipe ini. Tujuan dari penelitian ini untuk menguji hubungan antara komposisi tubuh dan kadar glukosa darah puasa pada subjek dengan diabetes melitus tipe 2. Penelitian ini merupakan peneltian observasional dengan desain cross-sectional yang mencakup sampel sebanyak 68 subjek, yang dilakukan pada bulan Agustus hingga Mei 2024 di RSUP Fatmawati, Jakarta. Data dianalisis menggunakan chi-square untuk analisis bivariat, dan analisis varians digunakan untuk membandingkan variabel. Komposisi tubuh diukur menggunakan Body Impendence Analysis (BIA), tingkat aktivitas fisik diukur menggunakan *International Physical Activity Questionnaire Short-Form* (IPAQ-SF), dan glukosa darah puasa diukur menggunakan Accu-Chek Instant Strips. Kebiasaan makan dan minum, riwayat kesehatan keluarga, kebiasaan merokok, durasi tidur, dan tingkat aktivitas fisik dinilai menggunakan kuesioner terstruktur. Hasil penelitian menunjukkan adanya hubungan positif antara status gizi, persentase lemak tubuh, dan lingkar pinggang, dengan korelasi negatif dengan massa otot terkait kadar gula darah puasa. Kesimpulan, status gizi, persentase lemak tubuh, lingkar pinggang, dan massa otot memiliki hubungan dengan glukosa darah puasa.

Kata Kunci: Gula darah puasa, komposisi tubuh, tipe 2 diabates

Introduction

Body composition plays a role in type 2 diabetes mellitus (T2DM), as it influences metabolic health and the potential for problems such as sarcopenia. Bioelectrical impedance analysis (BIA) efficiently evaluates body composition, particularly muscle mass, which is crucial for the management of type 2 diabetes mellitus (T2DM). Research has shown that reduced muscle mass is associated with insulin resistance and several comorbidities (Sbrignadello et al. 2022). Basic Health Research 2018 (Riskesdas) demonstrated an increase in the prevalence of Diabetes Mellitus (DM) among people aged 15 years and older in Indonesia when compared to previous data. The incidence of Diabetes has increased from 10,9% to 11,7% (Kemenkes RI, 2018). According to the 2023 Indonesian Health Survey (SKI), the DKI Jakarta province has the highest prevalence of diabetes mellitus in Indonesia (3,1 %). In comparison to the findings of Basic Health Research in 2018, the prevalence of diabetes mellitus in Jakarta rose from 2,5% to 3,1% (Kemenkes RI, 2023). Type 2 diabetes mellitus is correlated with detrimental lifestyle characteristics, including insufficient physical exercise, sedentary behavior, and inadequate diet (Buss et al., 2021).

Type 2 diabetes mellitus may be caused by an unhealthy diet, including the consumption of fast food and items high in fat, salt, and sugar, which may precipitate the condition. Excessive fat intake is a contributing factor that may modify insulin function in the body, leading to elevated sugar levels, as cells are unable to utilize insulin effectively to regulate blood glucose (Wardani & Nugroho, 2023). Consumption of high-calorie foods can result in overweight or obesity, as sugar and fat are the primary contributors to caloric intake (Teo et al., 2021). The findings of this study demonstrated a significant correlation between BMI and blood glucose levels (Alam et al., 2019). Maintaining a normal IMT can prevent diabetes, as the Alternative Healthy Eating Index and Dietary Inflammatory Index indicate that BMI is associated with a 35-48% risk of developing type II diabetes mellitus (Hodge et al., 2021).

Body composition significantly influences the prevention and management of type 2 diabetes mellitus (T2DM). Many studies have emphasized the complex connection between fat distribution, muscle mass, and metabolic health. Increased body fat, especially in the trunk region, correlates with diminished insulin sensitivity and heightened insulin production, both of which are pivotal in the development of Type 2 Diabetes Mellitus (T2DM) (Kim et al., 2024). Lack of activity causes these problems by elevating body and trunk fat percentages while reducing skeletal muscle mass and bone mineral density, consequently complicating the management of diabetes (Meng et al., 2023). Nevertheless, research exploring the correlation between body fat percentage and blood glucose levels is limited.

The prevalence of obesity, evaluated by body fat percentage, is significantly higher than that assessed by BMI, which indicates that traditional indicators could underestimate obesity and the associated potential risks in T2DM patients (Wong et al., 2021). The relationship between food consumption, lifestyle choices, the risk of diabetes, and blood glucose levels is complex and encompasses numerous dietary and lifestyle variables. Research has repeatedly demonstrated that a low-risk lifestyle, defined by non-smoking, moderate alcohol intake, frequent physical exercise, and a balanced diet enriched in fruits and vegetables, strongly reduces the possibility of diabetes-associated complications and fatality (Sun et al., 2022).

These findings indicate that comprehensive assessments of body composition, more than basic BMI indicators, are essential for effective diabetes management and prevention, emphasizing the necessity for personalized approaches based on individual differences in fat distribution and muscle mass (Buyinza et al., 2023). Previous studies have mainly ignored body composition, focusing instead on body mass index. Therefore, in this study, the relationship between body composition and fasting blood sugar levels was more comprehensive. This study aims to analyze the association between body composition indicators such as fat percentage, muscle mass, and waist circumference and fasting blood glucose levels in type 2 diabetes patients in Jakarta.

Methods

This cross-sectional study aimed to investigate the correlation between body composition and fasting blood glucose levels in patients with type 2 diabetes. This study was conducted from August to

May 2024 at the RSUP Fatmawati Hospital, Jakarta. Ethical approval was obtained from the Health Research Ethics Committee of RSUP Fatmawati Hospital (No: PP.0802/D. XXI.18/72/2024).

The study population consisted of all outpatients at RSUP Fatmawati Hospital. The study sample consisted of 68 participants (95% confidence level and 5% margin of error). The subjects were selected using a purposive selection technique, involving the sample selected based on certain inclusion criteria, including age ≥40 years, residence in Jakarta, and ability to communicate actively. The exclusion criteria included illness problems, such as osteoarthritis, stroke, chronic kidney disease, and others.

The primary data included nutritional status, dietary and beverage habits, familial health history, smoking habits, sleep duration, and physical activity levels. The International Physical Activity Questionnaire Short Form (IPAQ-SF). Secondary data consisted of blood pressure and fasting blood glucose measurements. Assessments of nutritional status included height, weight, and body mass index (BMI), BMI categorized according to the WHO guidelines, ranging from underweight (<18,5), normal weight (18,5-22,9), overweight (23,0-24,9), and obesity (≥25,0). Body composition was assessed by categorizing the data into body fat percentage, muscle mass, and waist circumference using the Body Composition Analysis (BIA) Omron KARADA Scan HBF-375. Data collection was conducted by experienced nutritionists. Fasting blood glucose assessments were performed using Accu-Chek Instant Strips. Subjects were instructed to fast from food for approximately 9 hours. Blood pressure measurements were performed using an Omron 8712 device. Healthcare professionals at the RSUP Fatmawati Hospital collected data.

Univariate analysis was used to summarize the descriptive frequencies of each variable. A person was used for bivariate analysis, and a study of variance was applied to compare the variables. Statistical analyses were performed using SPSS version 25,0 and statistical significance was identified by a p-value of less than 0,05.

Result and Discussion

The majority of the individuals were over 60 years old, comprising 57,4%, while those aged 50-59 years accounted for 27,9%, with 19 subjects. It may be stated that the majority of the subjects in this study were elderly. In terms of employment, the majority were housewives (50%), while the highest level of education was predominantly college graduates (33,8%), followed by high school graduates (30,9%), and junior high school graduates (17,6%). The subject characteristics, including age, height, weight, BMI, body fat percentage, and socioeconomic status, are shown in Table 1.

Table 1. Characteristics of the research subjects (n=68)

Characteristics	n (%)
Gender	
Male	27 (39,7)
Female	41 (60,3)
Age (year)	
<50	10 (14,7)
50-59	19 (27,9)
>60	39 (57,4)
Employment	
Employee	3 (4,4)
Self-employed	5 (7,4)
Housewife	34 (50,0)
Other	26 (38,2)
Level of education	
No	1 (1,5)
Elementary School	11 (16,2)
Junior High School	12 (17,6)
High School	21 (30,9)
University	23 (33,8)
Nutritional status	
Underweight	3 (4,4)
Normal	22 (32,4)
Overweight	9 (13,2)
Obese	34 (50,0)
Percent body fat	
Normal	47 (69,1)
High	21 (30,9)
Waist circumference	
Normal	16 (23,5)
High	52 (76,5)
Muscle mass	
Low	48 (70,6)
Normal	20 (29,4)
Blood pressure	
Normal	30 (44,1)
High	38 (55,9)

Many studies have demonstrated that a higher socioeconomic position, comprising an enhanced level of education, is positively associated with improved glycemic control over the years in African American individuals with

type 2 diabetes, as emphasized by the Jackson Heart Study (Sun et al., 2022).

The nutritional status in this study was predominantly obesity (50%), followed by normal (32,4%), and overweight (13,2%). Body fat percentage was predominantly classified as normal (69%) and elevated (30%). Waist circumference data indicated that 76,5% of the participants fell into the high group, while 23,5% were classified as normal. The risks of metabolic syndrome (MetS) and type 2 diabetes mellitus (T2DM) are consistently associated with waist circumference (WC) in elderly individuals. A study indicated that waist circumference and fasting blood glucose were strongly linked with diabetic retinopathy in individuals over 45 years of age with type 2 diabetes, suggesting that both parameters are essential in evaluating diabetes-related problems (Ranganathan et al., 2022). The combination of waist circumference (WC) and fasting plasma glucose, referred to as Waist Circumference Glucose (WyG), has been accepted as a significant predictor of type 2 diabetes mellitus (T2DM), with increased WyG levels being associated with an increased risk of diabetes (Zhao et al., 2024).

The history of hypertension, heart disease, and cholesterol in fasting blood glucose among the elderly is strongly linked to several risk factors and health consequences. Hypertension is a common illness among the elderly and is frequently caused by factors such as obesity, sedentary lifestyle, and inadequate dietary practices, which lead to cardiovascular consequences such as myocardial infarction and stroke. The results of this study indicate that a family history of hypertension (26%) and diabetes (70%) is a significant risk factor for hypertension in the elderly population (Hari et al., 2021).

Hypertension and type 2 diabetes mellitus frequently occur because of common risk factors, and a history of hypertension significantly elevates the risk of developing type 2 diabetes mellitus. This is particularly noticeable in hypertensive individuals, where the duration of hypertension and peak diastolic blood pressure are independently correlated with the incidence of T2DM (Kemenkes RI, 2018). Hypertension is considered an important risk factor for cardiovascular diseases, particularly coronary heart disease (CHD), which can be accelerated by type 2 diabetes mellitus (T2DM) (Maulina et al., 2023). The relationship between T2DM and cardiovascular disease risk factors, including smoking and elevated cholesterol levels, is the strongest, suggesting that these factors significantly boost the probability of cardiovascular events in the elderly (Zhang et al., 2022).

The study found that 91% of the subjects were non-smokers, 4,4% were occasional smokers, and 4,4% were regular smokers. Smoking leads to oxidative stress and affects insulin sensitivity, potentially impairing pancreatic function and negative symptoms of diabetes mellitus (DM) (Pitoy et al., 2024). In individuals with type 2 diabetes, smoking correlates with increased fasting blood glucose and postprandial glucose levels, with significant differences in postprandial glucose levels between smokers and nonsmokers. The consumption of sweet or salty foods and beverages shows a varied pattern in its relationship with blood glucose levels depending on the specific type of food or drink (Sari et al., 2018).

The results showed that the subjects already highlighted commendable behaviors for vegetable and fruit consumption, with frequencies of ≥ 5 times per week at 83,8% and 70,6%, respectively. A meta-analysis of prospective studies revealed a slight inverse correlation between elevated fruit and vegetable intake and the risk of type 2 Diabetes Mellitus (T2DM), with particular fruits such as apples and blueberries showing more pronounced protective effects, whereas others, including cantaloupe fruit and fruit juices, were positively correlated with diabetes risk (Halvorsen et al., 2021).

Familial genetic susceptibility to diabetes, hypertension, and cardiovascular diseases (CVD) significantly predicts T2DM, as individuals with such a history are more inclined to adopt self-health care practices, such as daily evaluation of glucose and cholesterol levels, which are essential for the early identification and management of T2DM (Jabbar et al., 2023). Table 2 presents the variables.

Table 2. Variables of the research subject (n=68)

Variables	n (%)
Family history of diabetes	
Yes	37 (54,4)
No	31 (45,6)
Family history of hypertension	
Yes	51 (75)
No	17 (25)
Family history of heart disease	
Yes	27 (39,7)
No	41 (60,3)
Family history of cholesterol	
Yes	41 (60,3)
No	27 (39,7)
Smoking habit	
Former smoker	3 (4,4)
Current smoker	3 (4,4)
Never smoker	62 (91,2)
Vegetable consumption habits	
Yes (≥ 5times / week)	57 (83,8)
No (< 5times / week)	11 (16,2)
Fruit consumption habits	
Yes (≥ 5times / week)	48 (70,6)
No (< 5times / week)	20 (29,4)
Confectionery consumption habits	
Yes (4-5x/week)	67 (97,1)
No (1-3x/week)	1 (1,5)
Consuming sugary habits	
Yes (4-5x/week)	27 (39,7)
No (1-3x/week)	41 (60,3)
Duration of sleep	
<7 hours	33 (48,5)
7-8 hours	34 (50,0)
>8 hours	1 (1,5)
Physical activity	
Low	52 (76,5)
Moderate	16 (23,5)

The correlation between obesity and type 2 diabetes mellitus (T2DM) diminishes with age, indicating that older individuals may experience reduced advantages from weight loss programs intended to regulate fasting glucose levels (Sun et al., 2022). Moreover, although body mass index (BMI) might not be a reliable indicator of fasting glucose-related outcomes, waist circumference is a more acceptable measurement, as it showed a stronger correlation with cardiovascular risks and fasting glucose levels in older patients with diabetes (Hong et al., 2022). The correlations between these factors and fasting blood glucose levels are illustrated in Table 3.

Table 3. Correlation of variables with fasting blood glucose levels

Variables	r	p-value
Nutritional status	0,248	0,042*
Percent body fat	0,290	0,016*
Waist circumference	0,673	0,001*
Muscle mass	-0,688	0,001*
Blood pressure	0,011	0,927
History of diabetes	-0,120	0,328
History of hypertension	0,104	0,399
History of heart disease	0,206	0,092
History of cholesterol	0,088	0,474
Smoking habit	-0,122	0,321
Vegetable consumption habits	-0,073	0,554
Fruit consumption habits	0,079	0,521
Confectionery consumption habits	-0,030	0,809
Consuming sugary habits	-0,138	0,261
Duration of sleep	0,117	0,342
Physical activity	-0,40	0,748

The correlation between obesity and type 2 diabetes mellitus (T2DM) diminishes with age, indicating that older people may experience reduced advantages from weight loss programs intended to regulate fasting glucose levels (Sun et al., 2022). Moreover, although body mass index (BMI) might not be a reliable indicator of fasting glucose-related outcomes, waist circumference is a more acceptable measurement, as it showed a stronger correlation with cardiovascular risks and fasting glucose levels in older diabetic patients (Hong et al., 2022). The muscle mass was predominantly classified as low (70%), with a normal classification of 29%.

The results indicated that the major education levels were High School (33,8%) and university (30,9%). A lower level of education was positively correlated with an increased chance of developing type 2 diabetes, resulting in an odds ratio (OR) of 1,24 (95% CI 1,04-1,48), which was maintained after adjusting for age, sex, lifestyle factors, BMI, clinical biomarkers, and comorbidities (Duan et al., 2022).

Nutritional status, determined by body mass index (BMI), is associated with blood glucose levels in the elderly population. A study identified a significant association between increased BMI and elevated blood glucose levels, indicating that weight management is essential for regulating glucose levels in this group of

people (Noviyanti et al., 2023). Low muscle mass is commonly observed in elderly patients diagnosed with type 2 diabetes mellitus (T2DM). Elevated levels of glycated hemoglobin (HbA1c) correlate with a higher incidence of low muscle mass, especially in women, as well as osteoporosis in men (Bulgakova et al., 2023). This research provided consistent results showing that increased muscle mass correlates with a lower risk of developing type 2 diabetes mellitus. Higher muscle mass reduces the risk of type 2 diabetes by enhancing insulin sensitivity, consequently helping the body to utilize glucose more efficiently. Resistance training is essential to enhance muscle strength and mass. One study indicated that resistance training with elastic bands, without leucine supplementation, significantly enhanced knee extension strength in elderly individuals with diabetes (Yamamoto et al., 2021). Moreover, behavioral changes that influence a balanced diet and consistent exercise are vital for the management of both sarcopenia and type 2 diabetes owing to their beneficial connection. To concurrently manage these conditions, experts recommend a combined exercise structure of aerobic and resistance training, along with a protein intake greater than 1 g/kg/day (Argyropoulou et al., 2022).

The consumption of sweet or salty foods and beverages shows variability in their relationship with blood glucose levels, depending on the specific type of food or drink. Generally, sweet meals and beverages are positively correlated with elevated blood sugar levels; however, salty foods can influence blood pressure and indirectly affect diabetes management. The consumption of foods and drinks with added sugars or simple carbohydrates is quickly metabolized and assimilated, contributing to a rapid elevation in blood glucose levels. can significantly reduce fasting blood glucose levels and enhance the overall glycemic regulation. This study includes examples of foods and beverages, such as soda, confectionery, pastries, and fruit juices containing added sugar. Excessive consumption of sugary meals and beverages can increase the likelihood of insulin resistance and type 2 diabetes mellitus. Insulin resistance impedes the body's ability to regulate blood glucose levels, which could result in hyperglycemia. This study revealed no correlation between blood sugar levels and the consumption of sweet meals and beverages ($p>0,05$), which was linked to the low intake of such items.

Consumption of fruits and vegetables that are abundant in polyphenols, including resveratrol and anthocyanins, significantly reduces fasting blood glucose and glycated haemoglobin levels, thereby enhancing glycaemic management in individuals with type 2 diabetes (Zin et al., 2022). The results of this study demonstrate that the consumption of vegetables and fruits improves the regulation of blood sugar levels. The common consumption of vegetables and fruits among the subjects included spinach, kale, carrots, green beans, keruk, apples, and melon. Overall, the integration of fruits and vegetables into the diet of elderly patients with diabetes can significantly reduce fasting blood glucose levels and enhance total glycaemic regulation through a combination of gut microbiota modulation, enhanced insulin signalling, and anti-inflammatory actions.

The research provided data results; the average sleep duration of subjects was 7 to 8 hours per day; nevertheless, several individuals experienced sleep durations of less than 7 hours. The Maastricht Study revealed that persons sleeping 5 or 12 hours had elevated probabilities of acquiring type 2 diabetes in comparison to those sleeping 8 hours, even after controlling for lifestyle factors, such as food and exercise (Albers et al., 2023). According to these results, it could be an urge to consider the length of time spent asleep to maintain the health and condition of the body.

Physical exercise is essential for enhancing metabolic health in elderly individuals with type 2 diabetes, as it correlates with improved glucose control and diminished arterial stiffness, both of which are vital for diabetes management and prevention of cardiovascular problems (Metsämarttila et al., 2018). The results indicated that the majority of respondents had low activity levels (76,5%). The majority of activities consisted of sitting and sleeping, with only a few expressing passion for recreational activity.

The limitations of this research relate to elderly subjects, which limits the interpretation of the communication strategy used. Additionally, this study could be subject to information bias, random errors from measurement devices (BIA), and the limitation

of assuming causality from cross-sectional designs. When assessing nutritional status, people may encounter several problems arising from multiple medical conditions. Collaboration with healthcare professionals is essential to ensure data quality and to provide comfort to participants during data collection.

Conclusion

The results indicated a significant connection between nutritional status, percentage of body fat, waist circumference, muscle mass, and fasting blood glucose levels. These findings highlight the significance of body composition in the early identification and management of blood-glucose disorders. Based on the findings of this research, it is recommended to determine the HbA1c level as a more advanced analytical tool. These findings suggest the need for routine body composition assessments in clinical diabetes management, especially targeting muscle mass preservation and abdominal fat reduction.

Acknowledgments

The authors express their appreciation to all participants who contributed to this study. Furthermore, LPPM Universitas Esa Unggul provided support through funding.

References

Albers, J. D., Meertens, R. M., Savelberg, H. H. C. M., Köhler, S., Wesselius, A., Schram, M. T., Stehouwer, C. D. A., De Galan, B. E., Van Greevenbroek, M. M. J., Van Der Kallen, C. J. H., Eussen, S. J. P. M., Bosma, H., Schaper, N. C., & Koster, A. (2023). Both short and long sleep durations are associated with type 2 diabetes, independent from traditional lifestyle risk factors—The Maastricht Study. *Sleep Health*, *9*(5), 733–741. https://doi.org/10.1016/j.sleh.2023.06.009

Angeles-Agdeppa, I. (2020). Food and Nutrient Intake of Filipinos with Diabetes. *Journal of Food and Nutrition Research*, *8*(6), 258–267. https://doi.org/10.12691/jfnr-8-6-3

Argyropoulou, D., Geladas, N. D., Nomikos, T., & Paschalis, V. (2022). Exercise and Nutrition Strategies for Combating Sarcopenia and Type 2 Diabetes Mellitus in Older Adults. *Journal of Functional Morphology and Kinesiology*, *7*(2), 48. https://doi.org/10.3390/jfmk7020048

Bulgakova, S. V., Treneva, E. V., Kurmaev, D. P., Pervyshin, N. A., Kosareva, O. V., Sharonova, L. A., & Dolgikh, Y. A. (2023). Assessment of muscle mass and bone density in elderly patients with type 2 diabetes mellitus depending on the level of glycated hemoglobin. *Science and Innovations in Medicine*, *8*(2), 96–102. https://doi.org/10.35693/2500-1388-2023-8-2-96-102

Buss, V. H., Varnfield, M., Harris, M., & Barr, M. (2021). Validation of a lifestyle-based risk score for type 2 diabetes mellitus in Australian adults. *Preventive Medicine Reports*, *24*, 101647. https://doi.org/10.1016/j.pmedr.2021.101647

Buyinza, R., Nsamba, J., Muyingo, A., Matovu, N., Nabirye, G., Kantengwa, A., Akandunda, S., Sseguya, W., & Mathews, E. (2023). Body composition of type 2 diabetes patients in Uganda: A case-control study. *Journal of Public Health in Africa*, *14*(1), 6. https://doi.org/10.4081/jphia.2023.2249

Chen, Y., Ma, J., Lu, D., & Fang, Y. (2022). The risk factors of type 2 diabetes in hypertensive subjects. *Frontiers in Endocrinology*, *13*, 901614. https://doi.org/10.3389/fendo.2022.901614

Collins, G. S., Mallett, S., Omar, O., & Yu, L.-M. (2011). Developing risk prediction models for type 2 diabetes: A systematic review of methodology and reporting. *BMC Medicine*, *9*(1), 103. https://doi.org/10.1186/1741-7015-9-103

Duan, M.-J., Dekker, L. H., Carrero, J.-J., & Navis, G. (2022). Lifestyle patterns and incident type 2 diabetes in the Dutch lifelines cohort study. *Preventive Medicine Reports*, *30*, 102012. https://doi.org/10.1016/j.pmedr.2022.102012

Halvorsen, R. E., Elvestad, M., Molin, M., & Aune, D. (2021). Fruit and vegetable consumption and the risk of type 2

diabetes: A systematic review and dose–response meta-analysis of prospective studies. *BMJ Nutrition, Prevention & Health*, *4*(2), 519–531. https://doi.org/10.1136/bmjnph-2020-000218

Hodge, A. M., Karim, M. N., Hébert, J. R., Shivappa, N., & De Courten, B. (2021). Association between Diet Quality Indices and Incidence of Type 2 Diabetes in the Melbourne Collaborative Cohort Study. *Nutrients*, *13*(11), 4162. https://doi.org/10.3390/nu13114162

Hong, S., Park, J. H., Han, K., Lee, C. B., Kim, D. S., & Yu, S. H. (2022). Association Between Obesity and Cardiovascular Disease in Elderly Patients With Diabetes: A Retrospective Cohort Study. *The Journal of Clinical Endocrinology & Metabolism*, *107*(2), e515–e527. https://doi.org/10.1210/clinem/dgab714

Isfaizah, I., Murti, B., & Indarto, D. (2021). *Path analysis on the effects of diets and lifestyle modifications in blood glucose control in patients with type5 2 diabetes mellitus*. *10*(01).

Jabbar, J. A., Al Masri, A. H., Oweidat, F. A., Al Ahmad, M. M., Ali, O. B., Oweidat, Z. A., & Sreedharan, J. (2023). Family history of diabetes, hypertension, obesity and cardiovascular diseases in relation to self health-care. *International Journal Of Community Medicine And Public Health*, *10*(3), 919–923. https://doi.org/10.18203/2394-6040.ijcmph20230601

Kemenkes RI. (2018). *Laporan Riset Kesehatan (RISKESDAS)*. Kemenkes RI. https://repository.badankebijakan.kemkes.go.id/id/eprint/3514/1/Laporan%20Riskesdas%202018%20Nasional.pdf

Kemenkes RI. (2023). *Indonesian Health Survey*. https://repository.badankebijakan.kemkes.go.id/id/eprint/5539/1/LAPORAN%20SKI%202023%20DALAM%20ANGKA_FINAL.pdf

Kheriji, N., Boukhalfa, W., Mahjoub, F., Hechmi, M., Dakhlaoui, T., Mrad, M., Hadj Salah Bahlous, A., Ben Amor, N., Jamoussi, H., & Kefi, R. (2022). The Role of Dietary Intake in Type 2 Diabetes Mellitus: Importance of Macro and Micronutrients in Glucose Homeostasis. *Nutrients*, *14*(10), 2132. https://doi.org/10.3390/nu14102132

Kim, H. J., Lee, H.-W., Kang, M.-K., Leem, G. H., Kim, M.-H., & Song, T.-J. (2024). Association of Body Composition Changes with the Development of Diabetes Mellitus: A Nation-Wide Population Study. *Diabetes & Metabolism Journal*, *48*(6), 1093–1104. https://doi.org/10.4093/dmj.2023.0243

Mahboob Alam, T., Iqbal, M. A., Ali, Y., Wahab, A., Ijaz, S., Imtiaz Baig, T., Hussain, A., Malik, M. A., Raza, M. M., Ibrar, S., & Abbas, Z. (2019). A model for early prediction of diabetes. *Informatics in Medicine Unlocked*, *16*, 100204. https://doi.org/10.1016/j.imu.2019.100204

Maulina, N., Sawitri, H., Zakiyya, N., & Syifa, S. (2023). Diabetes Melitus Tipe 2 dan Hipertensi sebagai Faktor Risiko PJK pada Lansia. *Jurnal Ilmiah Manusia Dan Kesehatan*, *6*(1), 29–36. https://doi.org/10.31850/makes.v6i1.1894

Meng, C., Zhao, D., & Ye, X.-H. (2023). Association of body composition with bone mineral density and fractures in Chinese male type 2 diabetes mellitus. *Medicine*, *102*(14), e33400. https://doi.org/10.1097/MD.0000000000033400

Metsämarttila, E., Rodilla, E., Jokelainen, J., Herrala, S., Leppäluoto, J., Keinänen-Kiukaanniemi, S., & Herzig, K.-H. (2018). Effect of physical activity on pulse wave velocity in elderly subjects with normal glucose, prediabetes or Type 2 Diabetes. *Scientific Reports*, *8*(1), 8045. https://doi.org/10.1038/s41598-018-25755-4

Noviyanti, R. D., Dyah Kusudaryati, D. P., Visi Asmara, A.-N., & Hatifah, D. K. (2023). Correlation between Nutritional Status and Fasting Blood Glucose Levels in the Elderly: An Investigative Study. *Genius Journal*, *4*(2), 334–339. https://doi.org/10.56359/gj.v4i2.307

Pitoy, F. F., Mandias, R. J., & Senduk, A. F. S. (2024). Perilaku Merokok dan Kadar Gula Darah Penderita Diabetes Melitus. *Nutrix Journal*, *8*(2), 171.

https://doi.org/10.37771/nj.v8i2.1129

Ranganathan, R. S., K, E. V., R, S., & Manimozhian, N. (2022). High Fasting Blood Sugar and Increased Waist Circumference as Risk Factors for Diabetic Retinopathy in Type 2 Diabetes Patients Older than 45 Years. *Cureus*. https://doi.org/10.7759/cureus.28291

Sari, M. I., Sari, N., Darlan, D. M., & Prasetya, R. J. (2018). Cigarette Smoking and Hyperglycaemia in Diabetic Patients. *Open Access Macedonian Journal of Medical Sciences*, *6*(4), 634–637. https://doi.org/10.3889/oamjms.2018.140

Sbrignadello, S., Göbl, C., & Tura, A. (2022). Bioelectrical Impedance Analysis for the Assessment of Body Composition in Sarcopenia and Type 2 Diabetes. *Nutrients*, *14*(9), 1864. https://doi.org/10.3390/nu14091864

Sri Hari, Ty., Sree Sudha, T., Varghese, A. M., Krishna Sasanka, K. S. B. S., & Thangaraju, P. (2021). A study of risk factors and complications in elderly hypertensive subjects. *Journal of Family Medicine and Primary Care*, *10*(6), 2230–2234. https://doi.org/10.4103/jfmpc.jfmpc_1959_20

Sun, Z., Hu, Y., Yu, C., Guo, Y., Pang, Y., Sun, D., Pei, P., Yang, L., Chen, Y., Du, H., Jin, J., Burgess, S., Hacker, A., Chen, J., Chen, Z., Lv, J., & Li, L. (2022). Low-risk Lifestyle and Health Factors and Risk of Mortality and Vascular Complications in Chinese Patients With Diabetes. *The Journal of Clinical Endocrinology & Metabolism*, *107*(9), e3919–e3928. https://doi.org/10.1210/clinem/dgac264

Teo, P. S., Van Dam, R. M., Whitton, C., Tan, L. W. L., & Forde, C. G. (2021). Consumption of Foods With Higher Energy Intake Rates is Associated With Greater Energy Intake, Adiposity, and Cardiovascular Risk Factors in Adults. *The Journal of Nutrition*, *151*(2), 370–378. https://doi.org/10.1093/jn/nxaa344

Wardani, E. M., & Nugroho, R. F. (2023). The Correlation Lifestyle with the Incidence of Diabetes Mellitus Type 2. *Jurnal Kedokteran Diponegoro (Diponegoro Medical Journal)*, *12*(3), 119–123. https://doi.org/10.14710/dmj.v12i3.37822

Wong, J. C., O'Neill, S., Beck, B. R., Forwood, M. R., & Khoo, S. K. (2021). Comparison of obesity and metabolic syndrome prevalence using fat mass index, body mass index and percentage body fat. *PLOS ONE*, *16*(1), e0245436. https://doi.org/10.1371/journal.pone.0245436

Yamamoto, Y., Nagai, Y., Kawanabe, S., Hishida, Y., Hiraki, K., Sone, M., & Tanaka, Y. (2021). Effects of resistance training using elastic bands on muscle strength with or without a leucine supplement for 48 weeks in elderly patients with type 2 diabetes. *Endocrine Journal*, *68*(3), 291–298. https://doi.org/10.1507/endocrj.EJ20-0550

Zhang, L., Yang, H., & Yang, P. (2022). The Correlation between Type 2 Diabetes Mellitus and Cardiovascular Disease Risk Factors in the Elderly. *Applied Bionics and Biomechanics*, *2022*, 1–7. https://doi.org/10.1155/2022/4154426

Zhao, X., Song, B., Yao, T., Fan, H., Liu, T., Gao, G., Wang, K., Lu, W., & Liu, C. (2024). Waist circumference glucose, a novel and effective predictor of type 2 diabetes: A prospective cohort study. *Frontiers in Endocrinology*, *15*, 1427785. https://doi.org/10.3389/fendo.2024.1427785

Zin, C. A. J. C. M., Mohamed, W. M. I. W., Khan, N. A. K., & Ishak, W. R. W. (2022). Effects of Fruit and Vegetable Polyphenols on the Glycemic Control and Metabolic Parameters in Type 2 Diabetes Mellitus: A Review. *Preventive Nutrition and Food Science*, *27*(3), 257–264. https://doi.org/10.3746/pnf.2022.27.3.257