Jurnal Epidemiologi Kesehatan Komunitas
11 (3), 2026, 317-329

JEKK

Association between Physical Inactivity and Hypertension among Adults with Diagnosed Diabetes Mellitus in Indonesia: A National Cross-Sectional Analysis

Sely Anggraini[1*], Feranita Utama[2]

[1]Master's Degree Program in Epidemiology, Faculty of Public Health, University of Indonesia, Indonesia
[2]Department of Public Health, Faculty of Public Health, Sriwijaya University, Indonesia

Article Information : Received 15 May 2026 ; Last Revised 30 August 2026 ; Accepted 31 August 2026 ; Available Online 31 August 2026 ; Published 31 August 2026

ABSTRACT

Background: Diabetes mellitus and hypertension frequently coexist and increase the risk of cardiovascular complications. Although physical inactivity is a modifiable risk factor, national evidence on its association with hypertension among adults with diabetes mellitus in Indonesia remains limited.
Aims: To examine the association between physical inactivity and hypertension among adults with diagnosed diabetes mellitus in Indonesia.
Methods: This cross-sectional study analyzed Riskesdas 2018 data from 9,807 adults with diagnosed diabetes mellitus. Hypertension was defined as blood pressure ≥140/90 mmHg, while physical inactivity was defined as <3,000 MET-minutes/week based on GPAQ. Survey-weighted logistic regression was used to estimate adjusted odds ratios (aORs) and 95% confidence intervals (CIs).
Results: Overall, 38.2% of adults with diabetes mellitus had hypertension, and 58.0% had insufficient physical activity. After adjustment for age, sex, smoking status, duration of diabetes, anti-diabetic medication use, obesity, and central obesity, participants with insufficient physical activity had higher odds of hypertension than those with sufficient physical activity (aOR = 1.20; 95% CI: 1.06–1.35; p = 0.004).
Conclusion: Physical inactivity was significantly associated with higher odds of hypertension among adults with diabetes mellitus in Indonesia. These findings support the importance of promoting physical activity as part of comprehensive diabetes management.

Keywords: Physical inactivity ; Hypertension ; Diabetes mellitus ; Cross sectional studies

DOI : https://doi.org/10.14710/jekk.v11i3.32189

**Corresponding author, selyanggraini0412@gmail.com*

Introduction

According to the International Diabetes Federation (IDF, 2017), approximately 425 million adults aged 20–79 years (8.8% of the global population) had diabetes in 2017, with 79% of cases occurring in low- and middle-income countries (LMICs).[1] Indonesia was among the countries with the highest diabetes burden in 2019, with an estimated 10.7 million affected individuals—a figure projected to rise to 13.7 million by 2045.[2] According to the 2018 Indonesian Basic Health Survey (Riskesdas), the prevalence of hypertension was 30.8% based on blood pressure measurements and 8.6% based on physician diagnosis.[3]

Diabetes mellitus and hypertension are major noncommunicable diseases that frequently coexist and substantially increase the risk of cardiovascular complications. Their coexistence is supported by shared pathophysiological mechanisms, including insulin resistance, sympathetic nervous system activation, and sodium retention. Approximately 70% of adults with diabetes mellitus also have hypertension, highlighting the need for integrated chronic disease management.[4–6]

Physical inactivity is recognized as a major modifiable risk factor in the development of hypertension, particularly among DM populations.[7] However, recent national surveillance data reveal a concerning decline in physical activity prevalence from 73.9% (2013) to 62.6% (2023). The primary self-reported barriers to physical activity include time constraints (48.7%) and lack of motivation (32.6%).This physical inactivity contributes to impaired glycemic control in DM patients.[8]

The decreasing physical activity trend persists across all age groups, reflecting a growing sedentary lifestyle pattern, particularly in urban areas where motorized transportation is favored over walking.[9] Persistent physical inactivity has been consistently associated with increased Non Communicable Diseases(NCDs) burden, including cardiovascular diseases, hypertension, and diabetes, resulting in substantial healthcare expenditures and productivity losses in Indonesia.[10,11] These findings underscore physical inactivity as a critical modifiable risk factor requiring prioritized integration into national chronic disease prevention strategies.[12]

A hospital-based case-control study in Ethiopia reported that physically inactive patients with diabetes had higher odds of hypertension than those who were physically active (aOR = 5.84; 95% CI: 2.47–13.81).[13] However, this evidence was derived from a single-country hospital-based study and may not be generalizable to other populations. Moreover, nationally representative evidence from Indonesia remains limited, particularly studies using multivariable analyses to account for potential sociodemographic and clinical confounders. Therefore, this study aimed to examine the association between physical activity and hypertension among adults with diagnosed diabetes mellitus in Indonesia using data from the 2018 Indonesian Basic Health Survey (Riskesdas).

Methods

This study employed a cross-sectional design and used secondary data from the 2018 Basic Health Survey (Riskesdas), which covered 34 provinces, 416 regencies, and 98 cities in Indonesia. Riskesdas 2018 was a nationwide survey conducted every five years by the Health Research and Development Agency, Ministry of Health of the Republic of Indonesia. The study population consisted of all individuals in Indonesia with physician-diagnosed diabetes mellitus who were successfully interviewed during the Riskesdas 2018 survey. The study sample comprised respondents aged ≥ 15 years with physician-diagnosed diabetes mellitus who were identified within selected census blocks and voluntarily completed the questionnaire for the study variables. Eligible respondents were those who met the inclusion and exclusion criteria. The inclusion criteria included individuals aged ≥15 years, medically diagnosed with diabetes mellitus, who responded to the physical activity section and had their blood pressure measured during the survey. Exclusion criteria included individuals with controlled hypertension, defined as systolic blood pressure <140 mmHg and diastolic blood pressure <90 mmHg due to regular antihypertensive medication use, and those with incomplete data. Because the primary outcome of this study was elevated blood pressure measured during the survey rather than clinically defined hypertension, respondents with controlled blood pressure receiving antihypertensive medication were excluded. This approach was intended to ensure that the outcome consistently reflected blood pressure status at the time of assessment and to specifically evaluate the association between physical inactivity and concurrent elevated blood pressure measured during the survey.

Blood pressure was measured three times following the standardized Riskesdas 2018 protocol, and the average of the three measurements was used for analysis. Respondents with fewer than three blood pressure measurements were excluded from the analysis. Respondents were classified as hypertensive if their systolic blood pressure was ≥140 mmHg or diastolic blood pressure was ≥90 mmHg. Physical activity was assessed using the Riskesdas 2018 physical activity questionnaire, which was adapted from the World Health Organization (WHO) Global Physical Activity Questionnaire (GPAQ). The questionnaire collected information on the frequency (days/week) and duration (minutes/day) of vigorous, moderate, and walking activities performed during a typical week. For each activity, MET-minutes/week were calculated by multiplying the frequency, duration, and the corresponding MET value (vigorous activity = 8 METs; moderate activity and walking = 4 METs). Total physical activity was obtained by summing the MET-minutes/week across all activity intensities. Following the WHO GPAQ Analysis Guide, adopted in Riskesdas 2018, respondents accumulating a total physical activity of ≥3,000 MET-minutes/week were classified as having sufficient physical activity, whereas those with <3,000 MET-minutes/week were classified as having insufficient physical activity. The 3,000 MET-minute/week threshold corresponds to the WHO criterion for a high level of physical activity based on the combined volume of vigorous-, moderate-, and walking-related activities.

Several confounding variables were considered in this study. Age was categorized into four groups: 15–25 years, 26–45 years, 46–65 years, and >65 years. The duration of diabetes mellitus was classified as <10 years or ≥10 years based on the time since diagnosis. Anti-diabetic medication adherence was assessed using the Riskesdas 2018 questionnaire by asking whether respondents took or injected anti-diabetic medication according to the physician's instructions. Responses were classified as adherent ("yes, according to the physician's instructions") or non-adherent ("no, not according to the physician's instructions"). Obesity was defined as a body mass index (BMI) >25, while central obesity was defined as a waist circumference >90 cm in men and >80 cm in women. The frequency of consuming salty, sweet, and fatty foods was classified as often, rarely, or never, following the Riskesdas 2018 questionnaire. Food consumption was categorized as “often” if respondents reported consuming the food ≥1 time per day or 3–6 times per week, “rarely” if they consumed it 1–2 times per week or less than 3 times per month, and “never” if they reported no consumption at all.

Emotional mental disorder was assessed using the Self Reporting Questionnaire-20 (SRQ-20), as implemented in Riskesdas 2018. The instrument consists of 20 yes/no questions assessing symptoms of emotional mental disorder. Each "yes" response was assigned a score of one, resulting in a total score ranging from 0 to 20. Respondents with a total score of ≥6 were classified as having an emotional mental disorder, whereas those with a score <6 were classified as not having an emotional mental disorder.

The sample selection framework for Riskesdas 2018 was developed by the Central Bureau of Statistics (BPS) based on the National Socio-Economic Survey (Susenas). A probability proportional to size (PPS) method with linear systematic sampling was applied using a two-stage sampling technique. From an initial 14,906 respondents aged ≥15 years with physician-diagnosed diabetes mellitus, 1,104 respondents with incomplete blood pressure measurements (fewer than three measurements) were excluded. Among the remaining respondents, 1,494 with controlled hypertension, defined as receiving antihypertensive medication with blood pressure <140/90 mmHg, were subsequently excluded. This resulted in 12,308 respondents meeting the study eligibility criteria. A complete-case analysis was then performed. Missing data were handled sequentially, with respondents excluded for missing age (n = 1,040), missing history of hypertension (n = 1,404), and missing emotional mental disorder data (n = 57), resulting in a total of 2,501 excluded respondents. These categories were mutually exclusive, with no overlap between exclusions. Missing data were identified only for these variables, whereas no missing values were observed for the other variables included in the multivariable analysis. The final analytical sample consisted of 9,807 respondents.

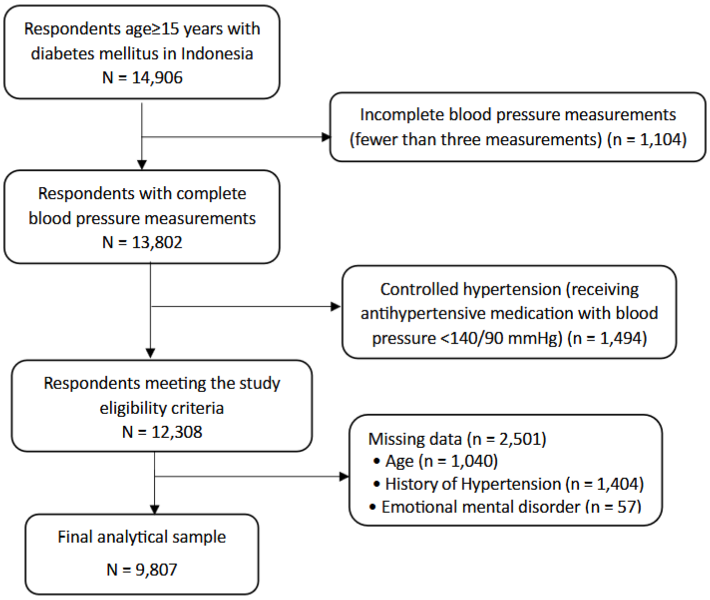

Figure 1. Flowchart of the Research Sample Selection Process

Data were analyzed using IBM SPSS Statistics version 26.0 (licensed under IBM Corp., Armonk, NY, USA). Complex sample analysis procedures were applied to account for the multistage sampling design. The analysis incorporated the stratification variable, primary sampling units (clusters), and normalized sampling weights. Normalized sample weights were calculated by dividing the original Riskesdas 2018 sampling weight by its mean value to ensure nationally representative estimates while preserving the original sample size. Descriptive (univariate) analysis were performed to present respondents' characteristics as unweighted frequencies (n) and weighted percentages (%) to account for the complex sampling design of Riskesdas 2018. Bivariate analysis using the chi-square test examined the association between independent variables and hypertension. Multivariable analysis was conducted using multiple logistic regression to identify adjusted associations between physical activity and hypertension after controlling for potential confounders. Potential confounders were assessed using a manual backward elimination approach. Variables were sequentially removed from the model starting with the highest p-value while monitoring changes in the odds ratio of the main exposure. Variables resulting in a change of ⩾10% in the estimated odds ratio were retained as confounders in the final model.

The 2018 Basic Health Survey (Riskesdas) received ethical approval from the Health

Research Ethics Committee of the National Institute of Health Research and Development, Ministry of Health of the Republic of Indonesia (approval number: LB.02.01/12/KE024/2018). All data were fully anonymized before release to researchers.

Results

A total of 9,807 respondents with diabetes mellitus were included in the analysis. The characteristics of respondents are presented by age and gender (Table 1 Most respondents were aged 46–65 years (68,5%), whereas only 0,65% were aged 15–25 years. The proportion of female patients was higher than males, accounting for 59,3% of all respondents. All percentages presented are weighted to account for the complex sampling design of Riskesdas 2018.

As shown in Table 2, 38,2% of diabetes mellitus patients were classified as having hypertension. More than half of the respondents (58,0%) engaged in insufficient physical activity. Regarding smoking behavior, 31,2% of the respondents were current smokers. The majority had been diagnosed with diabetes for less than ten years (78,9%), and approximately one-fifth (21,9%) reported not adhering to anti-diabetic medication. Almost half of the respondents (47,8%) were categorized as obese, while 58,6% experienced central obesity. In terms of dietary behavior, 39,4% of diabetes mellitus patients frequently consumed salty foods, 37,1% frequently consumed sweet foods, and 58,8% frequently consumed fatty foods. Meanwhile, only 4,3% of respondents were identified as experiencing emotional mental disorders.

Table 1. Distribution of Respondents Characteristics

Variables	n	%
Age		
>65 years	1348	13,7
46–65 years	6722	68,5
26–45 years	1679	17,1
15–25 years	58	0,65

Continued Table 1. Distribution of Respondents Characteristics

Variables	n	%
Gender		
Female	5820	59,3
Male	3987	40,7

Note: Counts (n) are presented as unweighted frequencies. Percentages (%) are weighted using the Riskesdas 2018 sampling weights.

Table 2. Distribution of Hypertension Incidence and Associated Risk Factors

Variables	n	%
Hypertension		
Yes	3748	38,2
No	6059	61,8
Physical Activity		
Insufficient	5689	58
Sufficient	4118	42
Smoking Habit		
Yes	3061	31,2
No	6746	68,8
Duration of Diabetes		
≥10 years	2065	21,1
<10 years	7742	78,9
Anti-diabetic medication adherence		
No	2148	21,9
Yes	7659	78,1
Obesity		
Yes	4686	47,8
No	5121	52,2
Central Obesity		
Yes	5750	58,6
No	4057	41,4
Consumption of Salty Foods		
Often	3863	39,4
Rarely	4254	43,4
Never	1690	17,2
Consumption of Sweet Foods		
Often	3633	37,1
Rarely	4356	44,4
Never	1818	18,5
Consumption of Fatty Foods		
Often	5771	58,8
Rarely	3375	34,4
Never	661	6,7
Emotional Mental Disorders		
Yes	427	4,3
No	9380	95,7

Note: Counts (n) are presented as unweighted frequencies. Percentages (%) are weighted using the Riskesdas 2018 sampling weights.

Table 3 presents the crude and adjusted odds ratios (ORs) for hypertension among adults with diabetes mellitus according to sociodemographic, behavioral, and clinical characteristics. In the crude analysis, respondents with insufficient physical activity had higher odds of hypertension than those with sufficient physical activity (cOR = 1,11; 95% CI: 1,03–1,20; *p-value*=0,006). After adjustment for potential confounders, insufficient physical activity remained significantly associated with hypertension, with respondents having 1.20 times higher odds of hypertension than those with sufficient physical activity (aOR = 1,20; 95% CI: 1,06–1,35; *p-value* =0,004).

Age was strongly associated with hypertension in both the crude and adjusted analyses. Compared with respondents aged 15–25 years (reference group), those aged 26–45 years, 46–65 years, and >65 years had higher odds of hypertension, with adjusted odds ratios (aORs) of 6,20 (95% CI: 1,54–24,97), 9,20 (95% CI: 2,30–36,83), and 7,66 (95% CI: 1,89–31,00), respectively (all *p-value*<0,05). Female respondents had a higher odds of hypertension than males, with a crude OR of 1,27 (95% CI: 1,17–1,37), which increased to 1,79 (95% CI: 1,52–2,10) in the adjusted model (*p-value*<0,001).

Smoking habit was also associated with hypertension. Smokers had 1,10 times higher odds in the crude model (*p-value*=0,015), and this association strengthened after adjustment (aOR = 1,76; 95% CI: 1,50–2,07; *p-value*< 0,001). Similarly, the duration of diabetes of ≥10 years was linked to a higher prevalence of hypertension (aOR = 1,18; 95% CI: 1,02–1,37; *p-value*=0,030). Patients who did not adhere to anti-diabetic medication also showed a significantly higher odds of hypertension compared to adherent patients (aOR = 1,16; 95% CI: 1,00–1,35; *p-value*=0,044). Both obesity and central obesity demonstrated strong and independent associations with hypertension. Obese respondents had 1,68 times higher odds of hypertension (95% CI: 1,46–1,93), and those with central obesity had 1,35 times higher odds (95% CI: 1,16–1,57) after adjustment (p < 0,001 for both). In contrast, the frequency of consuming salty, sweet, and fatty foods, as well as the presence of emotional mental disorders, were not significantly associated with hypertension in either crude or adjusted models.

Table 3. Association of Sociodemographic, Behavioral, and Clinical Factors with Hypertension among Adults with Diabetes Mellitus

Variables	*Bivariate Analysis*		*Multivariable Analysis*	
	Crude OR (95%CI)	***p-value***	**Adjusted OR (95%CI)**	***p-value***
Physical Activity				
Insufficient	1,11 (1,03-1,20)	0,006	1,20 (1,06-1,35)	0,004
Sufficient[a]	ref			
Age				
>65 years	8,58 (2,30- 32,0)	<0,001	7,66 (1,89-31,00)	0,004
46–65 years	10,05 (2,72-37,14)	<0,001	9,20 (2,30-36,83)	0,002
26–45 years	7,08 (1,90- 26,36)	<0,001	6,20 (1,54-24,97)	0,010
15 –25 years[a]	ref		ref	
Gender				
Female	1,27 (1,17-1,37)	<0,001	1,79 (1,52-2,10)	<0,001
Male[a]	ref		ref	
Smoking Habit				
Yes	1,10 (1,01-1,18)	0,015	1,76 (1,50-2,07)	<0,001
No[a]	ref		ref	

Continued Table 3. Association of Sociodemographic, Behavioral, and Clinical Factors with Hypertension among Adults with Diabetes Mellitus

Variables	*Bivariate Analysis*		*Multivariable Analysis*	
	Crude OR (95%CI)	*p-value*	Adjusted OR (95%CI)	*p-value*
Duration fo Diabetes				
≥10 years	1,12 (1,03-1,22)	0,010	1,18 (1,02-1,37)	0,030
<10 years[a]	ref		ref	
Anti Diabetic Medication Adherence				
No	1,10 (1,02-1,20)	0,022	1,16 (1,00-1,35)	0,044
Yes[a]				
Obesity				
Yes	1,52 (1,41-1,63)	<0,001	1,68 (1,46-1,93)	<0,001
No[a]	ref		ref	
Central Obesity				
Yes	1,54 (1,42-1,66)	<0,001	1,35 (1,16-1,57)	<0,001
No[a]	ref		ref	
Consumption of Salty Foods				
Often	0,92 (0,78-1,09)	0,282	-	-
Rarely	0,87 (0,74-1,02)	0,282	-	-
Never[a]	ref		-	-
Consumption of Sweet Foods				
Often	0,88 (0,75-1,05)	0,370	-	-
Rarely	0,92 (0,78-1,08)	0,370	-	-
Never[a]	ref		-	-
Consumption of Fatty Foods				
Often	1,02 (0,80-1,29)	0,939	-	-
Rarely	1,04 (0,81-1,32)	0,939	-	-
Never[a]	ref		-	-
Emotional Mental Disorders				
Yes	1,01 (0,84-1,22)	0,916	-	-
No[a]	ref			

*Adjusted for age, sex, smoking habit, duration of diabetes, anti-diabetic medication adherence, obesity, central obesity

OR = odds ratio; CI = confidence interval; Ref = reference category [a] = references category

Discussion

Physical activity constitutes one of the four fundamental components of diabetes management and plays a crucial role in preventing noncommunicable diseases, including hypertension.[14] In individuals with diagnosed diabetes mellitus, insulin resistance leads to impaired glucose utilization and sodium retention, which increases sympathetic activity and blood pressure.[2] Regular physical activity improves endothelial function, reduces insulin resistance, and enhances glucose uptake in active muscles, thereby contributing to better blood pressure regulation.[15]

This study found that individuals with diagnosed diabetes mellitus who reported insufficient physical activity had higher odds of prevalent hypertension than those with sufficient physical activity (aOR = 1.20; 95% CI: 1.06–1.35). Similarly, a national survey in Spain showed that although diabetes independently increased the risk of hypertension (OR 1.44), patients with DM who regularly exercised had a significantly lower risk, approaching that of the non-diabetic population.[16] Consistent with these findings, a large meta-analysis of cohort studies also demonstrated a linear inverse association between physical activity level and the incidence of hypertension, with a 6% reduction in risk for every 10 MET-hours per week increase and up to a 33% reduction at higher activity levels.[17] These findings support the observed association between sufficient physical activity and lower odds of prevalent hypertension among individuals with diabetes mellitus.

Physiologically, physical inactivity may increase blood pressure through mechanisms involving insulin resistance, hyperinsulinemia, and sodium retention that occur independently of glycemic control.[18,19] Among individuals with diabetes, coexisting hypertension exacerbates endothelial dysfunction, oxidative stress, and chronic inflammation, further elevating cardiovascular risk.[20] Despite extensive evidence on these mechanisms, their integration into preventive strategies remains limited in LMICs, including Indonesia, where community-based interventions often face implementation barriers.[21] The present study contributes to addressing this evidence gap by providing nationally representative evidence on the association between physical inactivity and prevalent hypertension among adults with diagnosed diabetes mellitus in Indonesia.

The use of nationally representative data and multivariate modeling in this study enhances its validity and generalizability. Prior research in LMICs has demonstrated that physical activity interventions can effectively reduce blood pressure, emphasizing the relevance of promoting active lifestyles in resource-limited settings.[22] Comparable population-based studies in Malaysia have also demonstrated strong associations between physical activity, blood pressure, and glucose regulation, supporting the robustness of these findings across similar socioeconomic contexts.[23] Several additional factors such as smoking, duration of diabetes, age, gender, obesity, and medication adherence were also significantly associated with prevalent hypertension. These findings align with the syndemic framework of chronic diseases in developing countries, where biological, behavioral, and structural determinants interact to create complex risk patterns.[24]

Age-related vascular changes, hormonal differences in women, and prolonged hyperglycemia may contribute to elevated blood pressure through mechanisms such as endothelial dysfunction and reduced arterial elasticity.[25,26] Smoking exacerbates these effects through sympathetic stimulation and endothelial injury.[27] Poor adherence to antidiabetic medication has been shown to increase the likelihood of hypertension among patients with diabetes mellitus, as inadequate glycemic control induces oxidative stress, endothelial dysfunction, and renal impairment, leading to elevated blood pressure.[28] Moreover, both general and central obesity were identified as major contributors to hypertension, as visceral adiposity promotes sympathetic activation and reduces protective adiponectin, leading to increased vascular resistance.[29,30] These interrelated mechanisms highlight the need for integrated interventions that simultaneously address multiple lifestyle and metabolic risk factors.

Lifestyle modification interventions, particularly those promoting regular physical activity, remain central to hypertension prevention strategies for diabetic populations.[31] Evidence from LMICs indicates that multicomponent interventions combining community engagement, health education, and policy-level actions are more effective than isolated efforts.[32] For example, community-based programs in Bangladesh demonstrated meaningful improvements in blood pressure and glycemic control when incorporating structured physical activity and counseling delivered by trained non-health professionals.[33] Similar interventions in Nigeria also achieved reductions in body mass index and better metabolic outcomes.[34] These findings underscore the potential of community-based, multisectoral approaches to strengthen lifestyle modification programs in Indonesia.

Evidence from the Finnish Diabetes

Prevention Programme (FIN-D2D) further supports the integration of lifestyle interventions into primary healthcare.[35,36] In Indonesia, strengthening structured physical activity counseling through Puskesmas and existing community-based programs such as Posbindu and Prolanis may provide opportunities to promote healthy lifestyles among adults with diabetes mellitus.[37] Strengthening community-based physical activity programs and integrating structured lifestyle counseling into primary healthcare services, such as Puskesmas, represent crucial steps in addressing the dual burden of diabetes and hypertension in Indonesia. These initiatives can optimize existing programs like Posbindu and Prolanis by enhancing cross-sectoral collaboration and empowering community health workers to promote active lifestyles.

This study has several strengths. First, the use of nationally representative Riskesdas 2018 data enhances the generalizability of the findings among adults with diagnosed diabetes mellitus in Indonesia. Second, the large analytical sample and the application of complex survey-weighted analyses accounted for the multistage sampling design, thereby improving the validity of the estimates. Third, the analyses adjusted for several important sociodemographic, behavioral, and clinical confounders, providing more robust estimates of the association between physical inactivity and hypertension.

However, several limitations should be considered. First, the cross-sectional design precludes causal inference, and reverse causation cannot be excluded because individuals with hypertension may have reduced their physical activity owing to their health condition or medical advice. Second, physical activity was assessed using a self-reported questionnaire, which may have resulted in exposure misclassification. Third, participants with controlled blood pressure receiving antihypertensive medication were excluded because the outcome was defined according to blood pressure measurements obtained during the survey. This approach may have underestimated the prevalence of hypertension compared with studies that define hypertension based on measured blood pressure or antihypertensive treatment. Therefore, the findings should be interpreted as reflecting the association between physical inactivity and elevated blood pressure measured during the survey rather than the overall burden of clinically defined hypertension. Fourth, complete-case analysis resulted in the exclusion of respondents with missing data, which may have introduced selection bias if excluded participants differed systematically from those included in the final analysis. Finally, although the analyses accounted for several important confounding variables, the possibility of residual confounding due to unmeasured or imperfectly measured variables cannot be ruled out.

Conclusions

This study found that insufficient physical activity was significantly associated with higher odds of prevalent hypertension among adults with diagnosed diabetes mellitus in Indonesia (aOR = 1,20; 95% CI: 1,06–1,35). These findings support the importance of considering physical activity in the comprehensive management of adults with diabetes mellitus. Strengthening structured and culturally appropriate physical activity counseling within primary healthcare, supported by trained community health volunteers, may contribute to promoting healthy lifestyles among this population. Further longitudinal studies are needed to clarify the temporal relationship between physical activity and hypertension.

Acknowledgement

The authors thank the Ministry of Health of the Republic of Indonesia and the data managers of the Indonesian Basic Health Research (Riskesdas) for providing access to the dataset used in this study.

References

1. International Diabetes Federation. IDF Diabetes Atlas. 8th ed. Brussels: International Diabetes Federation; 2017.
2. Perkumpulan Endokrinologi Indonesia. Pengelolaan dan Pencegahan Diabetes

Melitus Tipe 2 di Indonesia. Jakarta: PB PERKENI; 2021.
3. Kementerian Kesehatan Republik Indonesia. Laporan Survei Kesehatan Indonesia (SKI). Jakarta: Kementerian Kesehatan Republik Indonesia; 2023.
4. Gheorghe A, Griffiths U, Murphy A, Legido-Quigley H, Lamptey P, Perel P. The economic burden of cardiovascular disease and hypertension in low- and middle-income countries: a systematic review. BMC Public Health. August 2018;18(1). doi:10.1186/s12889-018-5806-x
5. Landsberg L, Aronne LJ, Beilin LJ, Burke V, Igel LI, Lloyd-Jones D, et al. Obesity-related hypertension: pathogenesis, cardiovascular risk, and treatment: a position paper of The Obesity Society and the American Society of Hypertension. Journal of Clinical Hypertension. January 2013;15(1):14–33. doi:10.1111/jch.12049
6. American Diabetes Association. Standards of medical care in diabetes—2017 abridged for primary care providers. Clinical Diabetes. 2017;35(1):5–26. doi:10.2337/cd16-0067
7. Puspa Sari G, Samekto M, Sakundarno Adi M. Risk factors affecting hypertension in type II diabetic patients (studies at primary healthcare centers in Pati District). Jurnal Litbang. 2017;13(1):47–59.
8. Basrowi RW, Rahayu EM, Khoe LC, Wasito E, Sundjaya T. The road to healthy ageing: what has Indonesia achieved so far? Nutrients. October 2021;13(10). doi:10.3390/nu13103441
9. Kementerian Kesehatan Republik Indonesia. Laporan Riset Kesehatan Dasar 2018 Nasional. Jakarta: Kementerian Kesehatan Republik Indonesia; 2018.
10. Ranasinghe PD, Pokhrel S, Anokye NK. Economics of physical activity in low-income and middle-income countries: a systematic review. BMJ Open. January 2021;11(1). doi:10.1136/bmjopen-2020-037784
11. Schröders J, Wall S, Hakimi M, Dewi FST, Weinehall L, Nichter M, et al. How is Indonesia coping with its epidemic of chronic noncommunicable diseases? A systematic review with meta-analysis. PLoS ONE. June 2017;12(6). doi:10.1371/journal.pone.0179186
12. Ihyauddin Z, Marthias T, Anindya K, Ng N, Dewi FST, Hulse ESG, et al. The relative impact of underweight, overweight, smoking, and physical inactivity on health and associated costs in Indonesia: propensity score matching of a national sample. BMC Health Services Research. December 2022;22(1). doi:10.1186/s12913-022-08546-6
13. Kenore Y, Abrha S, Yosef A, Gelgelu TB. Determinants of hypertension among patients with diabetes mellitus in public hospitals of Kembata Tambaro Zone, Southern Nations, Nationalities and Peoples' Region, Ethiopia, 2021: a case-control study. Journal of Multidisciplinary Healthcare. September 2022;15:2141–2152. doi:10.2147/JMDH.S379293
14. Kementerian Kesehatan Republik Indonesia. Comprehensive Type 2 Diabetes Management Training Module for Doctors in Primary Health Care Facilities. Jakarta: Kementerian Kesehatan Republik Indonesia; 2023.
15. Gambardella J, Morelli MB, Wang X, Santulli G. Pathophysiological mechanisms underlying the beneficial effects of physical activity in hypertension. Journal of Clinical Hypertension. February 2020;22(2):291–295. doi:10.1111/jch.1380

16. Petrie JR, Guzik TJ, Touyz RM. Diabetes, hypertension, and cardiovascular disease: clinical insights and vascular mechanisms. Canadian Journal of Cardiology. May 2018;34(5):575–584. doi:10.1016/j.cjca.2017.12.005
17. Liu X, Zhang D, Liu Y, Sun X, Han C, Wang B, et al. Dose-response association between physical activity and incident hypertension: a systematic review and meta-analysis of cohort studies. Hypertension. May 2017;69(5):813–820. doi:10.1161/HYPERTENSIONAHA.116.08994
18. Booth FW, Roberts CK, Laye MJ. Lack of exercise is a major cause of chronic diseases. Comprehensive Physiology. April 2012;2(2):1143–1211. doi:10.1002/cphy.c110025
19. Sakr HF, Sirasanagandla SR, Das S, Bima AI, Elsamanoudy AZ. Insulin resistance and hypertension: mechanisms involved and modifying factors for effective glucose control. Biomedicines. August 2023;11(8). doi:10.3390/biomedicines11082271
20. Muniyappa R, Sowers JR. Role of insulin resistance in endothelial dysfunction. Reviews in Endocrine and Metabolic Disorders. March 2013;14(1):5–12. doi:10.1007/s11154-012-9229-1
21. Correia JC, Lachat S, Lagger G, Chappuis F, Golay A, Beran D, et al. Interventions targeting hypertension and diabetes mellitus at community and primary healthcare level in low- and middle-income countries: a scoping review. BMC Public Health. November 2019;19(1). doi:10.1186/s12889-019-7842-6
22. Monfared V, Hashemi M, Kiani F, Javid R, Yousefi M, Hasani M, et al. The effect of physical activity intervention on blood pressure in 18 low- and middle-income countries: a systematic review and meta-analysis of randomized controlled trials. Clinical Hypertension. December 2024;30(1). doi:10.1186/s40885-024-00281-w
23. Teh CH, Chan YY, Lim KH, Kee CC, Lim KK, Yeo PS, et al. Association of physical activity with blood pressure and blood glucose among Malaysian adults: a population-based study. BMC Public Health. December 2015;15(1). doi:10.1186/s12889-015-2528-1
24. Salameh AB, Hyassat D, Suhail A, Makahleh Z, Khader Y, El-Khateeb M, et al. The prevalence of hypertension and its progression among patients with type 2 diabetes in Jordan. Annals of Medicine and Surgery. January 2022;73. doi:10.1016/j.amsu.2021.103162
25. Chapman N, Ching SM, Konradi AO, Nuyt AM, Khan T, Twumasi-Ankrah B, et al. Arterial hypertension in women: state of the art and knowledge gaps. Hypertension. June 2023;80(6):1140–1149. doi:10.1161/HYPERTENSIONAHA.122.20448
26. Ramanathan S. Correlation of duration, hypertension, and glycemic control with microvascular complications of diabetes mellitus at a tertiary care hospital. Integrative Molecular Medicine. 2017;4(1). doi:10.15761/IMM.1000272
27. Kemche B, Saha Foudjo BU, Fokou E. Risk factors of hypertension among diabetic patients from Yaoundé Central Hospital and Etoug-Ebe Baptist Health Centre, Cameroon. Journal of Diabetes Research. 2020;2020. doi:10.1155/2020/1853516
28. Negussie YM, Abebe AT. Hypertension and associated factors among patients with diabetes mellitus attending a follow-up clinic in central Ethiopia. Scientific Reports. December 2025;15(1). doi:10.1038/s41598-025-97909-0

29. Jia G, Sowers JR. Hypertension in diabetes: an update of basic mechanisms and clinical disease. Hypertension. November 2021;78(5):1197–1205. doi:10.1161/HYPERTENSIONAHA.121.17981
30. Rahma G, Gusrianti G. Hubungan obesitas sentral dengan hipertensi pada penduduk usia 25–65 tahun. JIK-Jurnal Ilmu Kesehatan. October 2019;3(2):118. doi:10.33757/jik.v3i2.239
31. Hasandokht T, Farajzadegan Z, Dana Siadat Z, Paknahad Z, Rajati F. Lifestyle interventions for hypertension treatment among Iranian women in primary health-care settings: results of a randomized controlled trial. Journal of Research in Medical Sciences. 2015;20:54.
32. West-Pollak A, Then EP, Podesta C, Hedelt A, Perry ML, Izarnotegui WV, et al. Impact of a novel community-based lifestyle intervention program on type 2 diabetes and cardiovascular risk in a resource-poor setting in the Dominican Republic. International Health. 2014;6(2):118–124. doi:10.1093/inthealth/iht039
33. Kobashi Y, Haque SE, Sakisaka K, Amir I, Kaneko M, Mutahara M, et al. Community-based intervention for managing hypertension and diabetes in rural Bangladesh. Tropical Medicine and Health. December 2024;52(1). doi:10.1186/s41182-023-00574-0
34. Ozoemena EL, Iweama CN, Agbaje OS, Umoke PCI, Ene OC, Ofili PC, et al. Effects of a health education intervention on hypertension-related knowledge, prevention and self-care practices in Nigerian retirees: a quasi-experimental study. Archives of Public Health. May 2019;77(1). doi:10.1186/s13690-019-0349-x
35. Rautio N, Jokelainen J, Oksa H, Saaristo T, Peltonen M, Puolijoki H, et al. Family history of diabetes and effectiveness of lifestyle counselling on the cardio-metabolic risk profile in individuals at high risk of type 2 diabetes: 1-year follow-up of the FIN-D2D project. Diabetic Medicine. February 2012;29(2):207–211. doi:10.1111/j.1464-5491.2011.03388.x
36. Rintamäki R, Rautio N, Peltonen M, Jokelainen J, Keinänen-Kiukaanniemi S, Oksa H, et al. Long-term outcomes of lifestyle intervention to prevent type 2 diabetes in people at high risk in primary health care. Primary Care Diabetes. June 2021;15(3):444–450. doi:10.1016/j.pcd.2021.03.002
37. Rahajeng E. Penguatan Posbindu PTM dalam menurunkan prevalensi faktor risiko penyakit tidak menular utama. Jakarta: Badan Penelitian dan Pengembangan Kesehatan, Kementerian Kesehatan Republik Indonesia; 2020.