



Original article. Obesity, physical activity, and diabetes mellitus in Indonesia: findings from IFLS-5  
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## Obesity, physical activity, and diabetes mellitus in Indonesia: findings from IFLS-5

## Obesidad, actividad física y diabetes mellitus en Indonesia: resultados del estudio IFLS-5

Sandhya Kresnajati<sup>1</sup>; Riki Edo Saputro<sup>2</sup>; Khoiril Anam<sup>1</sup>; Amadou Wurry Jallow<sup>3</sup>; Fajar Awang Irawan<sup>1</sup>; Sugiarto Sugiarto<sup>1</sup>; Fajar Syamsudin<sup>1</sup>; Johnlenon Aliser<sup>4</sup>

<sup>1</sup> Universitas Negeri Semarang, Indonesia

<sup>2</sup> Universitas Wahid Hasyim, Indonesia

<sup>3</sup> Taipei Medical University, Taiwan

<sup>4</sup> Mindanao State University – Iligan Institute of Technology, Philippines

\* Correspondence Author: Khoiril Anam, [khoiril.ikor@mail.unnes.ac.id](mailto:khoiril.ikor@mail.unnes.ac.id)

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**Ethical aspects:** This study used secondary data from the Indonesia Family Life Survey (IFLS-5), a publicly available dataset. The IFLS survey protocol was approved by Institutional Review Boards (IRBs) in the United States (RAND Corporation) and Indonesia (Universitas Gadjah Mada), and all participants provided informed consent. The dataset is fully anonymized and does not contain identifiable personal information. This study complied with the principles of the Declaration of Helsinki.



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## Abstract

Diabetes mellitus is a major global health problem. This study aims to examine the relationship between obesity and diabetes mellitus, while considering physical activity. This study used a cross-sectional design based on secondary data from the IFLS-5. A total of 34,241 respondents aged 15 years and older participated. Obesity was defined using BMI, and physical activity was categorized as low, moderate, and vigorous. Diabetes mellitus was determined using HbA1c measurements and medical diagnoses. Data were analyzed using the chi-square test and multivariable logistic regression, adjusted for confounding variables. Non-obese individuals had significantly lower odds of diabetes mellitus compared to obese individuals (OR = 0.45; 95% CI: 0.35–0.57;  $p < 0.001$ ). Vigorous physical activity was significantly associated with lower odds of diabetes mellitus (OR = 0.64; 95% CI: 0.45–0.91;  $p = 0.012$ ), while moderate physical activity showed a non-significant trend (OR = 0.83; 95% CI: 0.67–1.03;  $p = 0.097$ ). Low physical activity was not significantly associated with diabetes mellitus. Obesity is strongly associated with higher odds of diabetes mellitus, while higher levels of physical activity, particularly vigorous activity, are associated with lower odds of diabetes mellitus. Encouraging physical activity and maintaining a healthy body weight are important strategies for diabetes prevention.

**Keywords:** obesity; type 2 diabetes mellitus; physical activity; risk factors

## Resumen

La diabetes mellitus es un importante problema de salud a nivel mundial. Este estudio tiene como objetivo examinar la relación entre la obesidad y la diabetes mellitus, considerando la actividad física. Este estudio utilizó un diseño transversal basado en datos secundarios del IFLS-5. Participaron un total de 34 241 personas de 15 años o más. La obesidad se definió mediante el IMC, y la actividad física se categorizó como baja, moderada y vigorosa. La diabetes mellitus se determinó mediante mediciones de HbA1c y diagnósticos médicos. Los datos se analizaron mediante la prueba de chi-cuadrado y regresión logística multivariable, ajustada por variables de confusión. Las personas no obesas tuvieron una probabilidad significativamente menor de padecer diabetes mellitus en comparación con las personas obesas (OR = 0,45; IC del 95%: 0,35–0,57;  $p < 0,001$ ). La actividad física vigorosa se asoció significativamente con una menor probabilidad de diabetes mellitus (OR = 0,64; IC del 95%: 0,45–0,91;  $p = 0,012$ ), mientras que la actividad física moderada mostró una tendencia no significativa (OR = 0,83; IC del 95%: 0,67–1,03;  $p = 0,097$ ). La baja actividad física no se asoció significativamente con la diabetes mellitus. La obesidad se asocia fuertemente con una mayor probabilidad de diabetes mellitus, mientras que los niveles más altos de actividad física, particularmente la actividad vigorosa, se asocian con una menor probabilidad de diabetes mellitus. Fomentar la actividad física y mantener un peso corporal saludable son estrategias importantes para la prevención de la diabetes.

**Keywords:** obesidad; diabetes mellitus tipo 2; actividad física; factores de riesgo

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## Introduction

Type 2 diabetes mellitus (T2D) is a complex metabolic disorder whose prevalence continues to rise globally, driven by the interaction of genetic predisposition and lifestyle-related factors such as obesity and physical inactivity (Alkaf, Blakemore, Järvelin, & Lessan, 2021; Katzmarzyk, Friedenreich, Shiroma, & Lee, 2022). In Indonesia, Basic Health Research data show that the proportion of deaths due to diabetes mellitus in the 45–54 age group is 14.7% in urban areas and 5.8% in rural areas, making it the sixth leading cause of death (Mihardja, Soetrisno, & Soegondo, 2014).

Globally, the number of adults living with diabetes has increased substantially and is projected to continue rising in the coming decades. The International Diabetes Federation's report states that in 2021, 537 million adults aged 20–79 worldwide had diabetes. This number is expected to rise to 643 million by 2030 and 783 million by 2045. In Indonesia, national health data also indicate a significant upward trend in diabetes prevalence, accompanied by increasing rates of obesity and sedentary lifestyles. In Indonesia alone, cases increased from about 5,654 in 2000 to 7,291 in 2011, then sharply to 19,465 in 2021. Projections suggest this will further rise to 23,328 in 2030 and 28,569 in 2045.

Over the past three decades, the prevalence of obesity has increased significantly in low-and middle-income countries (LMICs). However, it was previously more associated with developed countries (Rachmi, Agho, Li, & Baur, 2016). Globally, the increasing trend of obesity has also been observed in both children and adults in at least 73 countries over the past 25 years (Cohen, 2017). Currently, obesity has become a global epidemic, contributing to a major risk factor for diabetes mellitus, including in young adults. Meanwhile, in Indonesia, the prevalence of obesity among individuals aged  $\geq 18$  years also shows a fairly sharp upward trend, rising from 10.5% in 2007 to 14.8% in 2013 and to 21.8% in 2018 (Mahwati & Nurrika, 2020).

Furthermore, physical activity has been shown to play a significant role in reducing the risk of cardiovascular disease associated with diabetes mellitus, including by preventing or delaying the development of prehypertension (Skalski, Kreft, & Kyryk, 2024). Conversely, unhealthy lifestyles such as lack of physical activity, alcohol

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consumption, smoking, and obesity are major contributing factors to the development of coronary artery disease (Alloubani, Saleh, & Abdelhafiz, 2018). In Indonesia, the burden of cardiovascular disease has increased significantly in recent decades, with hypertension being a leading cause of death (Hussain, Al Mamun, Reid, & Huxley, 2016). Globally, chronic conditions such as hypertension, diabetes, and overweight or obesity are also known to have a greater impact on ethnic minority groups, as reported in the United States (Commodore-Mensah et al., 2018).

Several previous studies have shown that demographic and lifestyle factors are significantly associated with the prevalence of diabetes mellitus (DM). Studies utilizing IFLS data with HbA1c measurements report that age, gender, and low levels of physical activity are associated with the incidence of DM, with the association tending to be stronger in individuals with obesity and hypertension (Zakaria, Alfian, & Zakiyah, 2022). These findings are supported by research by Griselda et al. (Griselda, Alfian, Wicaksono, Wawruch, & Abdullah, 2023), which shows that age and an unhealthy lifestyle are closely linked to various chronic diseases. Furthermore, lifestyle is also related to mental health, where high levels of physical activity are known to contribute positively to reducing depressive symptoms. In some cases, it may be associated with sleep quality (Djajadisastra & Batterham, 2024). Overall, these studies indicate that age and physical activity are important factors associated with chronic diseases, including diabetes mellitus and hypertension. This is in line with research by Tjhin et al. (Tjhin, Ridjab, Turana, & Rensa, 2025), which confirmed the relationship between hypertension, diabetes mellitus, and low physical activity.

Although studies have examined factors associated with diabetes mellitus, most have focused solely on the independent effects of obesity and physical activity. Available evidence on how these factors collectively influence diabetes risk remains limited, particularly in large, nationally representative populations in low- and middle-income countries like Indonesia. Therefore, this study aimed to examine the association between obesity and diabetes mellitus in the Indonesian population using IFLS-5 data, while considering physical activity. By using a large, nationally representative dataset and incorporating objective HbA1c measurements, this study provides a more robust assessment of diabetes risk than studies that rely solely on self-reported data.



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## Methods

### *Participants*

The fifth wave of the Indonesian Family Life Survey (IFLS-5) included approximately 50,580 households (Strauss, Witoelar, & Sikoki, 2016). The initial sampling frame was based on households in 13 of Indonesia's 27 provinces, representing approximately 83% of the national population in 1993, and was designed to ensure optimal population representation (Hussain et al., 2016).

The sample in this study included individuals aged 15 years or older who had undergone HbA1c testing and provided complete questionnaire data. Individuals with incomplete information on HbA1c, BMI, physical activity, or covariates were excluded from the analysis. The final analytical sample consisted of 34,241 participants. Prior to data collection, all participants received an explanation of the study's benefits and potential risks and provided written informed consent.

This study used secondary data from the 5th wave of the Indonesian Family Life Survey (IFLS-5), which employed a cross-sectional design. The survey used a multistage stratified random sampling method to collect data at the individual, household, and community levels. Furthermore, the IFLS survey and its methodology underwent review and received ethical approval from Institutional Review Boards (IRBs) in the United States (RAND) and Indonesia (Gadjah Mada University) (Hussain et al., 2016).

### *Measurement of body size and physical activity*

Obesity was determined using body mass index (BMI) as a standalone measure. Participants with a BMI <25 kg/m<sup>2</sup> were classified as non-obese, whereas those with a BMI ≥25 kg/m<sup>2</sup> were classified as obese. The BMI cut-off was selected based on WHO recommendations for Asian populations, where a BMI ≥25 kg/m<sup>2</sup> indicates increased obesity-related health risk (Nishida et al., 2004). Height and weight, obtained during a physical exam, were used to calculate BMI. Height was measured with Shorr measuring boards, while weight was assessed using Seca floor-model scales, which were developed in partnership with UNICEF. These scales provided digital readouts and were precise to 0.1 kg. Waist circumference was measured with a tape to the nearest 0.1 cm. Physical activity was assessed using questionnaire items available in IFLS-5 that captured the

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duration and type of activities performed across occupational, household, transportation, and leisure-time domains. Based on the reported duration of daily activities, respondents were categorized into low (<2 hours/day), moderate (approximately 2 hours/day), and vigorous (>2 hours/day) physical activity groups. Because IFLS-5 does not provide standardized metabolic equivalent (MET)-based estimates or validated physical activity scores, these categories should be interpreted as proxy indicators of activity intensity rather than direct measures of energy expenditure.

### ***Dried blood spot analyses***

During the IFLS-5 survey, a dried blood spot (DBS) was collected. The study also retested measures of bodily inflammation associated with chronic conditions such as heart disease, as well as HbA1c levels, to identify Diabetes Mellitus. Haemoglobin was measured from the DBS using the HemoCue system, with the first blood drop mixed with haemoglobin before being applied to the Whatman card. The cards were dried on a special rack for at least 4 hours and stored in small Ziplock bags with desiccant until transportation. Later, they were brought to Yogyakarta and stored in a refrigerator with a plastic cooling bag. HbA1c levels were classified according to the American Diabetes Association criteria: >6.5% indicates diabetes, <6.5% indicates non-diabetes. In our study, DM cases were identified based on HbA1c measurements and questionnaire data on physician or paramedic diagnoses of diabetes.

### ***Socio-demographic characteristic***

We incorporated demographic and behavioral factors as confounding variables. For instance, we looked at respondents' age, sex, and education levels, which we categorized as low (below undergraduate level) and high (undergraduate level and above). We also considered marital status, classified as single, married, or divorced. Additionally, hypertension was included as a confounding factor, identified by whether participants reported a doctor or paramedic diagnosis or were on medication for it.

### ***Statistical analysis***

The research data were analyzed using SPSS Statistics version 26.0. Descriptive statistics were used to summarize the participants' characteristics. The chi-square test was used to examine the relationships between variables. Multivariate logistic regression analysis was performed to assess the relationship between obesity and diabetes mellitus



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while adjusting for potential confounding factors. Data analysis utilized two models. Model I was adjusted for age and sex, and Model II was further adjusted for education and marital status. Analysis results are presented as odds ratios (OR) with 95% confidence intervals (CI). A p-value < 0.05 was considered statistically significant (Wasserstein & Lazar, 2016). Multicollinearity among independent variables was assessed using the Variance Inflation Factor (VIF). Model fit was evaluated using the Hosmer–Lemeshow goodness-of-fit test.

## Result

The results of this study are presented in Tables 1–3. A total of 34,241 respondents were included in the analysis, of whom 779 (2.3%) were classified as having diabetes mellitus based on HbA1c measurements and medical diagnosis. Table 1 presents the baseline characteristics of the study population according to diabetes mellitus status.



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Table 1. Baseline Characteristics of Study Population According to Diabetes Mellitus Status

| Variable            | Total | Diabetes Mellitus Status |      |           |      | P Value |
|---------------------|-------|--------------------------|------|-----------|------|---------|
|                     |       | Yes                      |      | No        |      |         |
|                     |       | n = 779                  | %    | n = 33462 | %    |         |
| Sex                 |       |                          |      |           |      |         |
| Male                | 15242 | 328                      | 45.2 | 14914     | 46.8 | 0.42    |
| Female              | 17383 | 397                      | 54.8 | 16986     | 53.2 |         |
| Age                 |       |                          |      |           |      |         |
| 15-35               | 16318 | 73                       | 10.1 | 16245     | 50.9 | < 0.001 |
| 36-60               | 12862 | 453                      | 62.5 | 12409     | 38.9 |         |
| >61                 | 3440  | 199                      | 27.4 | 3241      | 10.2 |         |
| Education           |       |                          |      |           |      |         |
| Low                 | 27823 | 596                      | 81.1 | 27227     | 85.9 | < 0.001 |
| High                | 4620  | 139                      | 18.9 | 4481      | 14.1 |         |
| Marital Status      |       |                          |      |           |      |         |
| Single              | 6742  | 16                       | 3.9  | 6726      | 27   | < 0.001 |
| Married             | 16540 | 320                      | 77.3 | 16220     | 65.1 |         |
| Divorced            | 2039  | 78                       | 18.8 | 1961      | 7.9  |         |
| Hypertension        |       |                          |      |           |      |         |
| Yes                 | 4200  | 346                      | 44.5 | 3854      | 11.5 | < 0.001 |
| No                  | 30030 | 432                      | 55.5 | 29598     | 88.5 |         |
| Cholesterol         |       |                          |      |           |      |         |
| High                | 1393  | 210                      | 27   | 1183      | 3.5  | < 0.001 |
| Low                 | 32862 | 568                      | 73   | 32258     | 96.5 |         |
| Physical Activity   |       |                          |      |           |      |         |
| Vigorous activities |       |                          |      |           |      |         |
| Yes                 | 6923  | 94                       | 13.6 | 6829      | 22.2 | < 0.001 |
| No                  | 24528 | 597                      | 86.4 | 23931     | 77.8 |         |
| Moderate activities |       |                          |      |           |      |         |
| Yes                 | 17574 | 339                      | 49.1 | 17235     | 56   | < 0.001 |
| No                  | 13877 | 352                      | 50.9 | 13525     | 44   |         |
| Low activities      |       |                          |      |           |      |         |
| Yes                 | 21941 | 498                      | 72.1 | 21443     | 69.7 | 0.182   |
| No                  | 9510  | 195                      | 27.9 | 9317      | 30.3 |         |
| Obesity             |       |                          |      |           |      |         |
| Yes                 | 15024 | 481                      | 67.7 | 14543     | 45.9 | < 0.001 |
| No                  | 17374 | 230                      | 32.3 | 17144     | 54.1 |         |

Note: Due to missing data for some variables, the total number of observations may differ across categories. Percentages represent column percentages within diabetes mellitus status groups.



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Table 1 presents the baseline characteristics of the study population according to diabetes mellitus status. Among the 34,241 respondents, 779 (2.3%) were classified as having diabetes mellitus. The distribution of diabetes mellitus differed significantly across several variables, including age group, education level, marital status, hypertension status, cholesterol level, and physical activity ( $p < 0.05$ ). In contrast, no significant difference was observed between males and females ( $p = 0.42$ ). A higher proportion of diabetes mellitus was observed among older individuals ( $\geq 36$  years), those with hypertension, and those with high cholesterol levels. In terms of physical activity, individuals reporting vigorous activity had a lower proportion of diabetes compared to those with lower activity levels.

Table 2. Odds Ratios for Diabetes Mellitus According to Obesity Status

| Non-obese | OR   | 95% CI    | P-Value |
|-----------|------|-----------|---------|
| Crude     | 0.41 | 0.35-0.48 | < 0.001 |
| Model I   | 0.40 | 0.34-0.47 | < 0.001 |
| Model II  | 0.45 | 0.35-0.57 | < 0.001 |

\*Crude: unadjusted

Model I: adjusted for age and sex

Model II: adjusted for age, sex, education and marital status

Reference category: Obese participants

As shown in Table 2, non-obese individuals had significantly lower odds of diabetes mellitus compared to obese individuals. In the unadjusted model, the odds ratio (OR) was 0.41 (95% CI: 0.35–0.48;  $p < 0.001$ ). After adjusting for age and sex (Model I), the association remained significant (OR = 0.40; 95% CI: 0.34–0.47;  $p < 0.001$ ). Further adjustment for education and marital status (Model II) also showed consistent results, with non-obese individuals having lower odds of diabetes mellitus (OR = 0.45; 95% CI: 0.35–0.57;  $p < 0.001$ ).



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Table 3. Association Between Physical Activity and Diabetes Mellitus

| Physical activity | Low physical activity |           |         | Moderate physical activity |           |         | Vigorous physical activity |           |         |
|-------------------|-----------------------|-----------|---------|----------------------------|-----------|---------|----------------------------|-----------|---------|
|                   | OR                    | 95%CI     | P-Value | OR                         | 95%CI     | P-Value | OR                         | 95%CI     | P-Value |
| Crude             | 1.12                  | 0.95-1.33 | 0.182   | 0.75                       | 0.65-0.88 | < 0.001 | 0.55                       | 0.44-0.69 | < 0.001 |
| Model I           | 1.06                  | 0.89-1.26 | 0.504   | 0.89                       | 0.76-1.04 | 0.154   | 0.60                       | 0.48-0.76 | < 0.001 |
| Model II          | 1.11                  | 0.88-1.41 | 0.368   | 0.83                       | 0.67-1.03 | 0.097   | 0.64                       | 0.45-0.91 | 0.012   |

\*Crude: unadjusted

Model I: adjusted for age and sex

Model II: adjusted for age, sex, education and marital status

Note: Reference categories were participants without low physical activity, without moderate physical activity, and without vigorous physical activity, respectively.

Table 3 shows the association between physical activity and diabetes mellitus. In the adjusted model (Model II), vigorous physical activity was significantly associated with lower odds of diabetes mellitus (OR = 0.64; 95% CI: 0.45–0.91;  $p = 0.012$ ). Moderate physical activity showed a non-significant trend toward reduced risk (OR = 0.83; 95% CI: 0.67–1.03;  $p = 0.097$ ), while low physical activity was not significantly associated with diabetes mellitus.

## Discussion

This study examined the association between obesity, physical activity, and diabetes mellitus in a large Indonesian population. The findings indicate that obesity is strongly associated with higher odds of diabetes mellitus. In contrast, higher levels of physical activity, particularly vigorous activity, are associated with lower odds of diabetes mellitus.

The multivariate analysis in Tables 2 and 3 supports the idea that both obesity and physical activity are important factors associated with diabetes mellitus. This result aligns with research by Chandrasekaran & Weiskirchen, which found that the rising prevalence of type 2 diabetes across different age groups is closely linked to the obesity epidemic (Chandrasekaran & Weiskirchen, 2024). Both conditions share a common pathophysiological mechanism, insulin resistance, where increased body mass plays a key role in disease progression. Conversely, high-intensity physical activity has been

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shown to offer physiological benefits, including increased muscle mass, reduced inflammation, and greater strength in T2DM patients (Colberg et al., 2016; Ruze et al., 2023; Wondmkun, 2020). Physical activity also directly promotes glucose uptake by muscles from the bloodstream, aiding in glucose regulation. Additionally, interventions combining energy restriction, behavioral modification, and increased physical activity were effective in managing patients with type 2 diabetes and obesity (Brown et al., 2020).

Although the present study examined the independent associations of obesity and physical activity with diabetes mellitus, potential interaction effects between these factors were not assessed. Future studies should investigate whether physical activity modifies the relationship between obesity and diabetes mellitus using more advanced analytical approaches.

The strong association between obesity and diabetes mellitus observed in this study is consistent with previous research demonstrating that excess body weight is a major risk factor for the development of type 2 diabetes. Obesity contributes to insulin resistance through the accumulation of adipose tissue, particularly visceral fat, which disrupts metabolic homeostasis and impairs glucose regulation. This mechanism has been widely reported in the literature, where increased body mass is closely linked to reduced insulin sensitivity and a higher likelihood of developing diabetes.

In addition, obesity is associated with chronic low-grade inflammation, characterized by the release of pro-inflammatory cytokines such as TNF- $\alpha$  and IL-6, which further exacerbate insulin resistance. These biological processes help explain why individuals with obesity are more likely to develop diabetes mellitus, as also reflected in the findings of this study. The consistency of our results with previous studies strengthens the evidence that obesity remains a critical modifiable risk factor for diabetes, particularly in rapidly developing countries such as Indonesia.

In this study, vigorous physical activity was associated with lower odds of diabetes mellitus, although moderate activity showed a non-significant trend. This finding supports previous evidence that higher levels of physical activity improve insulin sensitivity and glucose metabolism. Physical activity enhances glucose uptake by skeletal muscle and reduces insulin resistance, which are key mechanisms in diabetes prevention.

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These findings highlight the importance of activity intensity, as higher levels of physical activity appear to provide greater metabolic benefits compared to lower-intensity activity. This may explain why vigorous activity showed a significant association, while moderate activity did not reach statistical significance in this study. From a physiological perspective, higher-intensity activity is more effective in improving insulin sensitivity and enhancing glucose uptake, which are critical mechanisms in diabetes prevention. Regular physical activity improves glucose control, reduces insulin resistance, and lowers cardiovascular risk in individuals with diabetes (Kirwan, Sacks, & Nieuwoudt, 2017; Natesamurthy, Krishnan, & Sanjaykumar, 2025). These effects contribute to better glycemic outcomes, particularly in patients participating in structured exercise programs (Sigal et al., 2018).

These findings are consistent with previous studies highlighting the important role of physical activity in reducing the risk of metabolic and cardiovascular conditions. Regular moderate-to-vigorous physical activity has been shown to significantly improve cardiovascular health and reduce blood pressure (Börjesson, Onerup, Lundqvist, & Dahlöf, 2016). Similarly, a meta-analysis demonstrated that even modest increases in physical activity provide substantial health benefits, including reduced risk of diabetes and cardiovascular disease (Wahid et al., 2016).

Furthermore, evidence suggests that individuals who are obese and physically inactive face a substantially higher risk of developing chronic conditions compared to those who are more active (Cleven, Krell-Roesch, Nigg, & Woll, 2020). Physical activity also plays a critical role in improving metabolic function, partly through enhanced insulin sensitivity and reduced systemic inflammation. These effects are particularly relevant given the complex interplay between obesity, hypertension, and metabolic disorders (Banerjee & Mani, 2025; Khan et al., 2020; Zhang, Konja, & Wang, 2020). In addition, higher levels of physical activity have been associated with better functional movement quality, whereas higher BMI is associated with poorer movement performance and increased injury susceptibility among university students (Anam, Indardi, Setiowati, Muafi, & S, 2026). Objective measurement methods such as accelerometry provide more accurate estimates of physical activity compared to self-reported data, which may influence the assessment of disease risk (Sternfeld et al., 2019).



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The present findings are particularly relevant to Indonesia, which is currently experiencing a rapid epidemiological transition characterized by increasing rates of obesity, physical inactivity, and other non-communicable disease risk factors. Urbanization, changes in dietary patterns, and increasingly sedentary lifestyles have contributed to the growing burden of obesity and diabetes mellitus in the Indonesian population (Hussain et al., 2016; Katzmarzyk et al., 2022; Mahwati & Nurrika, 2020). In this context, the observed associations between obesity, physical activity, and diabetes mellitus highlight the importance of promoting active lifestyles and healthy weight management as key public health strategies to reduce the burden of diabetes in Indonesia.

This study contributes to the limited evidence examining the relationship between obesity and diabetes mellitus while accounting for variations in physical activity levels. The main advantage of this study is the use of data from the Indonesian Family Life Survey (IFLS), which represents approximately 83% of the national population and includes a sample of 34,241 individuals who meet the inclusion criteria. The IFLS dataset offers significant advantages, including a large sample size and heterogeneous respondent characteristics, which increase the generalizability of the findings and are more efficient than primary data collection at a national scale. Furthermore, potential selection bias can be minimized by using objective measurements performed by healthcare professionals, such as HbA1c testing to determine diabetes status and body mass index (BMI) to classify obesity.

This study has several limitations. First, the cross-sectional design limits the ability to establish causal relationships. Second, measurement bias may have occurred in assessing body weight and height. Additionally, physical activity data were self-reported, which may introduce recall bias. Furthermore, physical activity was categorized using proxy indicators derived from IFLS questionnaire items rather than standardized MET-based measures. Therefore, some degree of misclassification of physical activity intensity may have occurred. In addition, residual confounding cannot be completely ruled out because information on dietary intake, smoking status, alcohol consumption, family history of diabetes, and environmental factors such as urban–rural residence was not included in the analysis. Additionally, the study did not evaluate potential interaction effects between obesity and physical activity, which may provide further insight into their



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combined influence on diabetes mellitus. However, these limitations were minimized through the use of standardized procedures and trained personnel.

## Conclusion

This study demonstrates that obesity is strongly associated with higher odds of diabetes mellitus. In contrast, higher levels of physical activity, particularly vigorous activity, are associated with lower odds of diabetes mellitus in the Indonesian population. These findings highlight the importance of physical activity intensity and weight management in relation to diabetes mellitus. From a public health perspective, promoting regular physical activity and maintaining a healthy weight should be a priority and a key strategy for diabetes prevention in Indonesia.

## References

- Alkaf, B., Blakemore, A. I., Järvelin, M. R., & Lessan, N. (2021). Secondary analyses of global datasets: do obesity and physical activity explain variation in diabetes risk across populations? *International Journal of Obesity*, 45(5), 944–956. <https://doi.org/10.1038/s41366-021-00764-y>
- Alloubani, A., Saleh, A., & Abdelhafiz, I. (2018). Hypertension and diabetes mellitus as a predictive risk factors for stroke. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, 12(4), 577–584. <https://doi.org/10.1016/j.dsx.2018.03.009>
- Anam, K., Indardi, N., Setiowati, A., Muafi, S., & S, A. (2026). Physical Activity, Body Mass Index, and Functional Movement- Based Injury Risk. *Physical Rehabilitation and Recreational Health Technologies*, 11(2), 131–138. [https://doi.org/10.15391/PRRHT.2026-11\(2\).08](https://doi.org/10.15391/PRRHT.2026-11(2).08)
- Banerjee, D., & Mani, A. (2025). Obesity's systemic impact: exploring molecular and physiological links to diabetes, cardiovascular disease, and heart failure. *Frontiers in Endocrinology*, 16(November), 1–11. <https://doi.org/10.3389/fendo.2025.1681766>
- Börjesson, M., Onerup, A., Lundqvist, S., & Dahlöf, B. (2016). Physical activity and exercise lower blood pressure in individuals with hypertension : narrative review of 27 RCTs. *British Journal of Sports Medicine*, 1–8.



Original article. Obesity, physical activity, and diabetes mellitus in Indonesia: findings from IFLS-5  
. Vol. 12, n. ° 4; p. 1-18, August 2026. <https://doi.org/10.55040/r8w2v440>

<https://doi.org/10.1136/bjsports-2015-095786>

Brown, A., Dornhorst, A., McGowan, B., Omar, O., Leeds, A. R., Taheri, S., & Frost, G. S. (2020). Low-energy total diet replacement intervention in patients with type 2 diabetes mellitus and obesity treated with insulin: a randomized trial. *BMJ Open Diabetes Research & Care*, 8(1), 2–11. <https://doi.org/10.1136/bmjdr-2019-001012>

Chandrasekaran, P., & Weiskirchen, R. (2024). The Role of Obesity in Type 2 Diabetes Mellitus—An Overview. *International Journal of Molecular Sciences*, 25(3). <https://doi.org/10.3390/ijms25031882>

Cleven, L., Krell-Roesch, J., Nigg, C. R., & Woll, A. (2020). The association between physical activity with incident obesity, coronary heart disease, diabetes and hypertension in adults: A systematic review of longitudinal studies published after 2012. *BMC Public Health*, 20(1), 1–15. <https://doi.org/10.1186/s12889-020-08715-4>

Cohen, J. B. (2017). Hypertension in Obesity and the Impact of Weight Loss. *Current Cardiology Reports*, 19(10), 98. <https://doi.org/10.1007/s11886-017-0912-4>

Colberg, S. R., Sigal, R. J., Yardley, J. E., Riddell, M. C., Dunstan, D. W., Dempsey, P. C., ... Tate, D. F. (2016). Physical Activity/Exercise and Diabetes: A Position Statement of the American Diabetes Association. *Diabetes Care*, 39(11), 2065–2079. <https://doi.org/10.2337/DC16-1728>

Commodore-Mensah, Y., Selvin, E., Aboagye, J., Turkson-Ocran, R. A., Li, X., Himmelfarb, C. D., ... Cooper, L. A. (2018). Hypertension, overweight/obesity, and diabetes among immigrants in the United States: An analysis of the 2010–2016 National Health Interview Survey. *BMC Public Health*, 18(1), 1–10. <https://doi.org/10.1186/s12889-018-5683-3>

Djajadisastra, F. W., & Batterham, P. J. (2024). Physical activity intensity moderates the relationship between sleep quality and depressive symptoms among Indonesian working-age adults: Findings from the Indonesia Family Life Survey. *Journal of Affective Disorders Reports*, 16(December 2023), 100717. <https://doi.org/10.1016/j.jadr.2024.100717>

Griselda, M., Alfian, S. D., Wicaksono, I. A., Wawruch, M., & Abdulah, R. (2023).



Original article. Obesity, physical activity, and diabetes mellitus in Indonesia: findings from IFLS-5  
. Vol. 12, n. ° 4; p. 1-18, August 2026. <https://doi.org/10.55040/r8w2v440>

Findings from the Indonesian family life survey on patterns and factors associated with multimorbidity. *Scientific Reports*, 13(1), 1–16. <https://doi.org/10.1038/s41598-023-42603-2>

Hussain, M. A., Al Mamun, A., Reid, C., & Huxley, R. R. (2016). Prevalence, awareness, treatment and control of hypertension in Indonesian adults aged  $\geq 40$  years: Findings from the Indonesia Family Life Survey (IFLS). *PLoS ONE*, 11(8), 1–16. <https://doi.org/10.1371/journal.pone.0160922>

Katzmarzyk, P. T., Friedenreich, C., Shiroma, E. J., & Lee, I. M. (2022). Physical inactivity and non-communicable disease burden in low-income, middle-income and high-income countries. *British Journal of Sports Medicine*, 56(2), 101–106. <https://doi.org/10.1136/BJSPORTS-2020-103640>

Khan, M. A., Mathur, K., Barraza, G., Sin, S., Yang, C. J., Arens, R., ... Mahgerefteh, J. (2020). The relationship of hypertension with obesity and obstructive sleep apnea in adolescents. *Pediatric Pulmonology*, 55(4), 1020–1027. <https://doi.org/10.1002/ppul.24693>

Kirwan, J. P., Sacks, J., & Nieuwoudt, S. (2017). The essential role of exercise in the management of type 2 diabetes. *Cleveland Clinic Journal of Medicine*, 84(7), S15–S21. <https://doi.org/10.3949/ccjm.84.s1.03>

Mahwati, Y., & Nurrika, D. (2020). Obesity indicators and c-reactive protein in indonesian adults (more than equal to 40 years old): The Indonesian family life survey 5. *Kesmas*, 15(4), 169–174. <https://doi.org/10.21109/KESMAS.V15I4.3296>

Mihardja, L., Soetrisno, U., & Soegondo, S. (2014). Prevalence and clinical profile of diabetes mellitus in productive aged urban Indonesians. *Journal of Diabetes Investigation*, 5(5), 507–512. <https://doi.org/10.1111/JDI.12177>

Natesamurthy, V., Krishnan, R. M., & Sanjaykumar, S. (2025). Power Yoga As an Effective Recovery Tool for Women Volleyball Players: a Comprehensive 12-Week Evaluation. *Rehabilitation and Recreation*, 19(2), 350–356. <https://doi.org/10.32782/2522-1795.2025.19.2.31>

Nishida, C., Barba, C., Cavalli-Sforza, T., Cutter, J., Deurenberg, P., Darnton-Hill, I., ... Zimmet, P. (2004). Appropriate body-mass index for Asian populations and



Original article. Obesity, physical activity, and diabetes mellitus in Indonesia: findings from IFLS-5 . Vol. 12, n. ° 4; p. 1-18, August 2026. <https://doi.org/10.55040/r8w2v440>

its implications for policy and intervention strategies. *The Lancet*, 363(9403), 157–163. [https://doi.org/10.1016/S0140-6736\(03\)15268-3](https://doi.org/10.1016/S0140-6736(03)15268-3)

Rachmi, C. N., Agho, K. E., Li, M., & Baur, L. A. (2016). Stunting, underweight and overweight in children aged 2.0–4.9 years in Indonesia: Prevalence trends and associated risk factors. *PLoS ONE*, 11(5), 1–17. <https://doi.org/10.1371/journal.pone.0154756>

Ruze, R., Liu, T., Zou, X., Song, J., Chen, Y., Xu, R., ... Xu, Q. (2023). Obesity and type 2 diabetes mellitus: connections in epidemiology, pathogenesis, and treatments. *Frontiers in Endocrinology*, 14. <https://doi.org/10.3389/FENDO.2023.1161521>

Sigal, R. J., Armstrong, M. J., Bacon, S. L., Boulé, N. G., Dasgupta, K., Kenny, G. P., & Riddell, M. C. (2018). Physical Activity and Diabetes. *Canadian Journal of Diabetes*, 42, S54–S63. <https://doi.org/10.1016/j.jcjd.2017.10.008>

Skalski, D. W., Kreft, P., & Kyryk, O. (2024). Introduction of Physical Therapy and Change of Diet in an Obese Patient with Hypertention - A Case Study. *Rehabilitation and Recreation*, 18(1), 29–34. <https://doi.org/10.32782/2522-1795.2024.18.3>

Sternfeld, B., Gabriel, K. P., Jiang, S. F., Whitaker, K. M., Jacobs, D. R., Quesenberry, C. P., ... Sidney, S. (2019). Risk estimates for diabetes and hypertension with different physical activity methods. *Medicine and Science in Sports and Exercise*, 51(12), 2498–2505. <https://doi.org/10.1249/MSS.0000000000002083>

Strauss, J., Witoelar, F., & Sikoki, B. (2016). *The Fifth Wave of the Indonesia Family Life Survey: Overview and Field Report* (Vol. 1). RAND Corporation. <https://doi.org/10.7249/WR1143.1>

Tjhin, C., Ridjab, D. A., Turana, Y., & Rensa, A. (2025). The Need of Support, Older Age, and Cognitive Impairment as Major Risk Factors of Poor Physical Performance in Elderly Based on Indonesian Family Life Survey-5 (IFLS-5). *Aging Medicine and Healthcare*, 16(1), 39–47. <https://doi.org/10.33879/AMH.161.2023.07070>

Wahid, A., Manek, N., Nichols, M., Kelly, P., Foster, C., Webster, P., ... Scarborough, P. (2016). Quantifying the Association Between Physical Activity and



Original article. Obesity, physical activity, and diabetes mellitus in Indonesia: findings from IFLS-5  
. Vol. 12, n. ° 4; p. 1-18, August 2026. <https://doi.org/10.55040/r8w2v440>

Cardiovascular Disease and Diabetes: A Systematic Review and Meta-Analysis.

*Journal of the American Heart Association*, 5(9).

<https://doi.org/10.1161/JAHA.115.002495>

Wasserstein, R. L., & Lazar, N. A. (2016). The ASA Statement on p-Values: Context, Process, and Purpose. *The American Statistician*, 70(2), 129–133.

<https://doi.org/10.1080/00031305.2016.1154108>

Wondmkun, Y. T. (2020). Obesity, Insulin Resistance, and Type 2 Diabetes: Associations and Therapeutic Implications. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, 13, 3611–3616.

<https://doi.org/10.2147/DMSO.S275898>

Zakaria, S. I., Alfian, S. D., & Zakiyah, N. (2022). Determinants of Cardiovascular Diseases in the Elderly Population in Indonesia: Evidence from Population-Based Indonesian Family Life Survey (IFLS). *Vascular Health and Risk Management*, 18(December), 905–914.

<https://doi.org/10.2147/VHRM.S390734>

Zhang, P., Konja, D., & Wang, Y. (2020). Adipose tissue secretory profile and cardiometabolic risk in obesity. *Endocrine and Metabolic Science*, 1(3–4), 100061. <https://doi.org/10.1016/j.endmts.2020.100061>