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ASSOCIATION BETWEEN PHYSICAL ACTIVITY AND SOCIODEMOGRAPHIC FACTORS WITH OBESITY AMONG ADULTS IN JAKARTA: ANALYSIS OF THE 2023 INDONESIAN HEALTH SURVEY

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ABSTRACT

Background: Obesity is a global public health problem that carries an elevated risk of noncommunicable diseases. Behavioral factors that may be modifiable should be assessed to design effective preventive programs. This study aimed to determine the association of physical activity, sociodemographic factors, and obesity among adults in Jakarta.
Methods: This study employed a quantitative, analytical, cross-sectional design. Data collected by the second wave of the 2023 Indonesian Health Survey. We analyzed 7.163 adult participants. Statistical analyses used chi-square and survey-adjusted logistic regression, and risk was measured as Prevalence Ratios (PR) with 95% Confidence Intervals (CI).
Results: The prevalence of obesity in this study was 49.67%. Logistic regression analysis showed a significant relationship between obesity and physical activity (p=0.045; PR=1.126), age 30-44 years (p=0.000; PR=2.213), age 45-59 years (p=0.000; OR=2.352), gender (p=0.000; OR=1.713), employment status (p=0.000; OR=1.653), and marital status (p=0.000; OR=2.437). Conversely, educational level did not show a statistically significant relationship with obesity (p>0.05). Moreover, levels of physical activity, marital status, sex, and employment status accounted for the factors that increased the likelihood of adult obesity.
Conclusion: Adult obesity in Jakarta is significantly associated with sex, age, sex, physical activity level, employment status, and marital status. These findings indicate the need to address targeted behavior changes, especially increasing levels of physical activity and exercise to encourage cognitive dissonance of increasing the likelihood of obesity through healthy weight and obese adults, particularly in middle-aged and women.
Keywords: adults, obesity, physical activity, sociodemographic factors

INTRODUCTION

Adult obesity is an epidemic public health challenge of major importance worldwide. It has been recognized as one of the most important risk factors for increased non-communicable diseases (NCDs) such as type-2 diabetes mellitus, cardiovascular diseases, and hypertension. The proportion of overweight and obese adults has almost tripled between 1975 and 2016, with over 650 million individuals classified as obese according to the World Health Organization (WHO) (WHO, 2021b).

The rising adult obesity is attributed in part to modern lifestyles characterized by low physical activity and high sitting time, as a consequence of the transformation of

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telecommunications, advanced modes of transportation, and labor-saving technologies that are widespread and easily accessible (Kumareswaran, 2023).

Physical activity is important for maintaining energy homeostasis, improving insulin sensitivity, and controlling excess fat deposition. WHO recommends 150–300 min/week of moderate-to-vigorous intensity physical activity for preventing obesity and other NCDs in adults (PAGAC, 2018; WHO, 2020). However, there are few country-level observational studies on dietary compliance with these recommendations; globally, at least a quarter of adults do not meet them, particularly in urban settings. (Guthold et al., 2018). The epidemiological data have provided clear indications of the relevance of age, sex, education level, marital status (which could be interpreted as indicators of living conditions and subsequent lifestyle and behavioral patterns), occupational status, and district of residence as independent risk factors in the complex, intricate society lifestyle/behavioral pathway that leads to obesity (Pou et al., 2022; Septiyanti, 2020).

In Indonesia, overweight and obesity among adults have shown a continuous rising trend for the past decade. RISKESDAS in 2013 and 2018 showed obesity prevalence increased among those ≥18 years of age, rising from 14.8% to 21.8% (Kementrian Kesehatan Republik Indonesia, 2019). This rise is consistent with the high frequency of inactivity that exists among adults across (in our case, urban) populations. Some studies conducted in Indonesia before 2023 found that low physical activity was associated with obesity (Septiyanti & Seniwati, 2020a). However, those studies mainly investigated physical activity in general, accounting for demographic differences and gender only in one analysis model.

At the local level, DKI Jakarta, the Indonesian metropolitan with the highest urbanization, would have a higher risk of obesity than other regions. The heavy reliance on motorized transport, desk-job commuting patterns, and lack of room for exercise, as well as an obesogenic environment, render the adult population in Jakarta a susceptible group to obesity. In Jakarta, adult obesity is more common than according to the 2018 National Health Survey (Riskesdas). This state of affairs is further exacerbated by the COVID-19 pandemic, which has led to constraints in movement, an increase in home working, and the slashing of physical activity for populations in urban areas (Stockwell et al., 2021).

Relationships between exercise and obesity have been widely investigated in the literature; however, there still exist critical gaps. First, to address the data gap, most earlier studies in Indonesia still use 2018 Riskesdas or local surveys (of limited coverage) that cannot reflect changes in public health behavior after COVID-19. Second, in research results, the associations of physical activity with obesity were diverse across regions and demographic populations, which have potential for region-specific analysis, such as DKI Jakarta (Septiyanti & Seniwati, 2020a; Stockwell et al., 2021). Third, with respect to the theory-implementation gap: epidemiological and obesity science theories have long acknowledged that physical activity and demographic transitions play key roles in shaping obesity.

This study will provide a comprehensive description of the associations among physical activity, demographic correlates, and obesity in the adult population of DKI Jakarta Province during the post-COVID outbreak, using 2023 data from the Indonesian Health Surveys (SKI) as a proxy. Our study will not only provide updated empirical evidence using the most recent national data but also demonstrate the dynamics of physical activity behavior and changes in obesity risk among urban adults following the pandemic outbreak. Therefore, the study's findings could bridge a prior research gap and provide a foundation for more effective promotional and preventive policies and interventions for post-COVID-19 public health problems in urban areas.

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RESEARCH METHOD

This study employed a quantitative, analytical, cross-sectional design using secondary data from the 2023 Indonesia Health Survey (Riskesdas) to analyze the effects of physical activity and demographic characteristics on the prevalence of obesity among adult respondents in the province of DKI Jakarta.

The population of this study was all adults aged 18–59 years who lived in DKI Jakarta Province as respondents to SKI 2023 and provided complete information on physical activity, anthropometry, blood pressure, and sociodemography used in the analysis. Pregnant women and those with incomplete data were excluded from the analysis. According to the 2023 SKI, in the adult population (18–59 years) in Jakarta, there were 7,303 respondents. We excluded participants who were pregnant (n=164) or had incomplete anthropometry data (weight and height, n=297), leaving us with 7163 responses.

The SKI 2023 was carried out, including a household survey as part of multistage cluster sample censuses nationwide conducted by the Ministry of Health, Republic of Indonesia. Methods SKI 2023 was an interview, measurement and examination study. SKI 2023 instruments for the household and individual were administered by trained enumerators. Anthropometric measurements were made using digital scales (0.1 kg) and height/length boards (1 mm).

Variables in this study were categorized into several groups: physical activity variables (main independent variables), obesity (dependent variable), and other supplementary factors (age, sex, education level, employment status, and marital status).

Physical activity was assessed by questions adapted from the WHO Global Physical Activity Questionnaire (GPAQ) (WHO, 2021a). Physical activity behavior was assessed for heavy and moderate physical activity in daily activities (combined at work, at home, during leisure time, and during travel), measured by the number of days a week and minutes per day, as reported by the ARTs of 10 years old or older. The Metabolic Equivalent Task (MET) is an index of energy cost that expresses the cost of physical activities in minutes. MET minutes are used as an index of the amount of physical activity a person performs. The MET score used to calculate vigorous physical activity is 8. The MET score used to calculate moderate physical activity is 4. Physical activity categories are divided into two: sufficient (MET minutes ≥ 600) and insufficient (MET minutes < 600).

Obesity is defined as having too much body fat. Obesity is assessed through anthropometrical measurements on weight (BB) and height (TB), presented as Body Mass Index (BMI) indices, and waist circumference (WC) as a marker of central obesity. BMI is obtained by dividing the weight in kilograms by the square of height in Meters. Using BMI, obesity was$\geq$25 and non-obesity was <25 based on the WHO classification. Central obesity (abdominal obesity), colloquially known as belly fat, is a factor that contributes to an increased risk of metabolic and cardiovascular diseases. The value that constitutes central obesity is a waist circumference of greater than 90 cm for men and more than 80 cm for women (WHO, 2021b).

The sociodemographic factors considered in the current study included age (18–29, 30–44, 45–59), sex (male, female), education (no schooling, primary education, secondary education; high: higher education), job status (employed and unemployed), and marital status (married and not married).

All statistical data in this study were analyzed using STATA software. For the complex sample, the data were examined univariately by descriptive examination of the corrected design and bivariate analyses using survey-adjusted logistic regression. The size of the association was presented in terms of Prevalence Rate (PR), 95% confidence interval, and p-value, < 0.05, as statistically significant.

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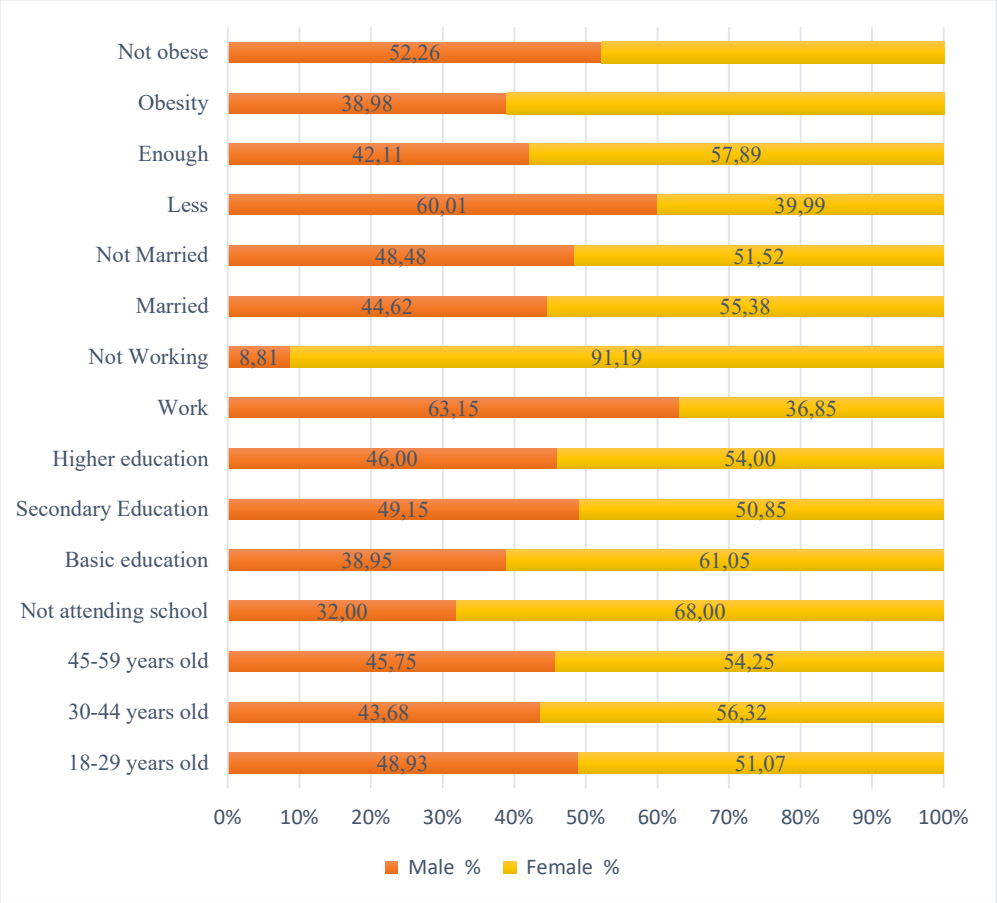
The Indonesian Health Survey (SKI) 2023: ethical clearance was obtained from the Health Research Ethics Committee, Health Research and Development Agency of the Ministry of Health of the Republic of Indonesia. Since this analysis used secondary, anonymous data collected and analyzed with ethical approval from the individual studies, no further IRB approval was required. The request for SKI-2023 data was approved by the Ministry of Health Data Service (agreement number FRM/SMKI-PUSDATIN/70/1519/2025, December 12, 2025).

RESULTS

Based on graphic 1 and table 1, it was found that most respondents residing in DKI Jakarta Province were in the 30-44 age group (39.96%) with a majority of women (56.32%), a majority of secondary education (55.27%), most are employed (67.82%), married (72.93%), have adequate physical activity (80.13%), and are not obese (50.33%).



Graphic 1. Comparison of Characteristics of Male and Female Respondents

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Table 1. Characteristics of Respondents

Features	Male		Women		Total		p-value
	n	%	n	%	n	%	
Age							
18-29th	821	48,93	857	51,07	1.678	23,43	0,003
30-44th	1.250	43,68	1.612	56,32	2.862	39,96	
45-59th	1.200	45,75	1.423	54,25	2.623	36,62	
Education*							
No school	64	32,00	136	68,00	200	2,79	0.001
Basic education	668	38,95	1.047	61,05	1.715	23,94	
Secondary Education	1946	49,15	2.013	50,85	3.959	55,27	
Higher education	593	46,00	696	54,00	1.289	18,00	
Employment Status							
Work	3.068	63,15	1.790	36,85	4.858	67,82	0,000
Not working	203	8,81	2.102	91,19	2.305	32,18	
Marital Status **							
Married	2.331	44,62	2.893	55,38	5.224	72,93	0,004
Not Married	940	48,48	999	51,52	1.939	27,07	
Physical Activity***							
Less	854	60,01	569	39,99	1.423	19,87	0.001
Enough	2.417	42,11	3.323	57,89	5.740	80,13	
Obesity ****							
Obesity	1.387	38,98	2.171	61,02	3.558	49,67	0,000
Not obese	1.884	52,26	1.721	47,74	3.605	50,33	

* Education Category: not school, basic education (SD, SMP), secondary education (SMA) and higher education (D3, S1, S2, S3); ** Marriage status category: married and unmarried (unmarried, widow and widower); Physical activity category: less (MET<600) and adequate (MET ≥ 600); Obesity category: obesity (BMI> 25);

Based on a survey-adjusted bivariate logistic regression analysis, the prevalence of obesity among adults in DKI Jakarta Province was 17.6%. Associations of physical activity and other demographic correlates with obesity are shown in Table 2. Bivariate analysis demonstrated a significant relationship between physical activity and obesity (p=0.045). The obesity rate among those with low physical activity was 17.9%, higher than that in the high PA group (16.9%). Those respondents with low physical activity had a 1.13 times higher risk of obesity than those with adequate physical activity [PR=1.126 (95% CI: 1.002–1.264)].

There was a significant association between age and obesity ($p < 0.05$). Obesity was higher across all education levels in men and women. There was a significantly negative relationship between working status and obesity ($p<0.001$). Unemployed respondents were 1.65 times more likely to be obese than employed (PR = 1.653; CI95%: 1.495–1.827). Obesity was also associated with marriage status ($p<0.001$). The risk of obesity was 2.44 times higher among married than in unmarried people (PR=2.437; IC95%: 2.186–2.717).

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Table 2. The Relationship of Physical Activity and Sociodemographic Characteristics with Obesity

Variabel	Obesity				Total		PR	95% CI	p-value	r	X2
	Yes		No								
	n	%	n	%	n	%					
Physical Activity											
Enough	673	16,90	750	83,10	1.423	19,87	1,000	1,002 - 1,264	0,045	0,024	4,015
Less	2.885	17,90	2.855	82,10	5.740	80,13	1,126				
Age											
18-29th	539	14,80	1.139	85,20	1.678	23,43	1,000				
30-44th	1.554	19,70	1.308	80,30	2.862	39,96	2,511	2,213 - 2,848	0,000	0,167	271,321
45-59th	1.465	16,90	1.158	83,10	2.623	36,62	2,673	2,352 - 3,039	0,000		
Gender											
Male	1.387	16,70	1.884	83,30	3.271	45,67	1,000			0,133	127,242
Women	2.171	18,40	1.721	81,60	3.892	54,33	1,713	1,560 - 1,882	0,000		
Education											
Higher education	663	18,60	626	81,40	1.289	18,00	1,000				
Secondary Education	1.914	17,70	2.045	82,30	3.959	55,27	0,884	0,779 - 1,002	0,054	0,005	6,387
Basic education	876	17,30	839	82,70	1.715	23,94	9,986	0,853 - 1,139	0,847		
No school	105	17,00	95	83,00	200	2,79	1,044	0,774 - 1,406	0,779		
Employment Status											
Work	2.218	17,20	2.640	82,80	4.858	67,82	1,000	1,495 - 1,827	0,000	0,117	97,362
Not Working	1.340	18,70	965	81,30	2.305	32,18	1,653				
Marital Status											
Not Married	657	14,90	1.282	85,10	1.939	27,07	1,000	2,186 - 2,717	0,000	0,192	265,112
Married	2.901	18,30	2.323	81,70	5.224	72,93	2,437				

DISCUSSION

In total, 7163 participated in this study; the respondents' sociodemographic characteristics were mostly female (54.33%), those aged in the productive age group of 30-44 years (39.96%), and married category (72.93%). Overall, obesity was common (49.67%). The correlation results indicated that obesity was determined to a meaningful extent by physical activity (p = 0.045). The OR of obesity in low physical activity level was 1.126-fold that of high physical activity level among the respondents. It is a sign that

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the respondents are sedentary or have no physical activity, which in turn leads to fat accumulation in the body.

This study found that physical activity was significantly associated with obesity (p=0.045), indicating that physical activity level is a risk factor for obesity in the adult population in DKI Jakarta Province. Respondents who undertake lower physical activity (17,9%) have a significantly greater prevalence ratio of being obese compared with those who engage in adequate physical activity (16,9%). Although the prevalence difference is relatively small, this value indicates a trend toward increased obesity in groups with low physical activity. Low physical activity can reduce energy expenditure, resulting in a positive energy imbalance and body fat accumulation (WHO, 2024). Inadequate physical activity also decreases basal metabolic rate and insulin sensitivity, contributing to weight gain (CDC, 2025a). These findings align with previous research indicating that individuals with low physical activity have a higher risk of obesity than those who are physically active (WHO, 2025b). These results support the energy balance theory, which supposes that the low levels of physical activity play a role (Niezgoda et al., 2025). At the national level, these findings align with the RISKESDAS analysis, which found low physical activity as a risk factor for obesity among adult Indonesians, particularly those living in urban areas (Kementrian Kesehatan Republik Indonesia, 2019). Other Indonesian studies also found that, compared with physically active adults, those with low levels of physical activity tend to be more obese (Septiyanti & Seniwati, 2020). Across the globe, cohort studies and population surveys have all found comparable dose-response associations between low levels of PA and obesity, although the strength of association proportionally differs from population to population (Guthold et al., 2018; Hruby & Hu, 2015). A United Kingdom study (UK Biobank) found that those with genetic susceptibility to obesity could reduce their risk of obesity by 30% through regular exercise (Tyrrell et al., 2017). In addition, a study in China shows that JPA > 709 counts·min −1 is superior to diet alone for visceral fat reduction, suggesting that moderate-intensity physical activity was more effective than diet alone (Zheng et al., 2021). A Brazilian newspaper emphasizes that environmental barriers (inadequate parks/walking areas) are the predominant cause of low physical activity in developing countries (Christofoletti et al., 2022). Frequency, volume, and intensity of physical activity also determine obesity (Borde et al., 2015). The weak association found in this study suggests that obesity is a multifactorial condition, with other factors, particularly diet and environment, also involved (Ul Badriyah et al., 2022). Although the relative risk is small, the impact remains significant at the population level, given the high proportion of individuals with low physical activity. Therefore, increasing physical activity needs to be a key component of obesity prevention strategies through public health promotion and prevention programs.

Research findings indicate a significant relationship between age groups and the occurrence of obesity (p<0.001), suggesting that age is an important risk factor for obesity. The prevalence of obesity tends to increase with advancing adulthood, with those over 30 years old having higher rates than younger individuals. This pattern shows that the risk of obesity rises during adulthood compared to early adulthood. Age also shows an interesting trend, with the 45-59 year age group having the highest risk of obesity (PR = 2.673; p-value = 0.000). The increased risk of obesity in adulthood is associated with decreased basal metabolism and reduced physical activity as age increases (WHO, 2025a). Additionally, lifestyle changes, high-calorie eating patterns, and work-related stress during productive years contribute to weight gain (CDC, 2025b). These findings align with WHO reports stating that obesity prevalence tends to increase among middle-aged and older adults (WHO, 2025a). The aging process affects the structure and function of adipose tissue, ultimately increasing predisposition to obesity in adulthood. As age advances, there is a

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redistribution of body fat with an increase in visceral fat compared to subcutaneous fat, which is associated with higher metabolic risks, including insulin resistance and chronic low-grade inflammation (inflammaging). Inflammaging is characterized by infiltration of pro-inflammatory macrophages and secretion of pro-inflammatory cytokines in adipose tissue, leading to adipocyte dysfunction and disturbances in glucose and lipid metabolism (Lu et al., 2021). These findings are similar to those of longitudinal studies in Korea, which found that increasing age is intrinsically associated with changes in metabolism and body composition, characterized by decreased energy metabolism and fat redistribution. These factors significantly drive visceral fat accumulation in middle-aged and elderly adults. The decline in anabolic hormones, particularly Growth Hormone (GH) and Insulin-like Growth Factor-1 (IGF-1), along with adipose tissue redistribution, is identified as a key mechanism driving this metabolic aging (Siervo et al., 2016). Furthermore, aging causes the accumulation of senescent adipocytes, which pathologically release a senescence-associated secretory phenotype (SASP) that triggers local and systemic inflammatory responses and worsens insulin resistance (Ou et al., 2022). Fat redistribution to visceral tissue and mitochondrial dysfunction associated with aging increase oxidative stress and reduce fat metabolism, contributing to metabolic disorders and obesity (Park & Shimokawa, 2024). Additionally, physiological changes with age, including decreases in sex hormones like estrogen and testosterone, also influence fat distribution and adipocyte function, accelerating abdominal fat accumulation (Al-Regaiey, 2024; J. Kim & Ahn, 2016)This relationship is reinforced by findings from a study in Japan, which showed that both obesity and aging are associated with an inflammatory phenotype of adipose tissue, insulin resistance, and metabolic dysfunction, leading to health issues such as type 2 diabetes and cardiovascular disease (Lu et al., 2021). Therefore, the biological aging of adipose tissue is a key pathophysiological mechanism explaining the increased risk of obesity in middle-aged and older adults. Understanding this mechanism is crucial for developing preventive intervention strategies that consider adipose tissue aging and metabolic inflammation. Consequently, obesity prevention interventions should focus on adults by promoting healthy lifestyles from a young age.

Furthermore, based on gender, this study shows that the prevalence of obesity among women (18.40%) is higher than among men (16.70%), with a Prevalence Ratio (PR) of 1.713, indicating that women have a greater risk of obesity. These findings are relatively consistent with the pre-COVID-19 pandemic conditions as reported in previous research in Indonesia, which shows that obesity among adult women has become a persistent health issue (Ferdina et al., 2024). Various international studies also support these results, including research in Europe that reports depression and emotional eating behaviors are more common among women and contribute to an increased risk of obesity (Dakanalis et al., 2023)In addition to psychosocial factors, cultural aspects also influence differences in obesity prevalence between genders, as shown by research in South Africa that found cultural perceptions viewing a fat body in women as a symbol of prosperity can worsen obesity cases (Draper et al., 2016).

From a biological and pathophysiological perspective, gender differences in obesity are influenced by hormonal mechanisms, adipose tissue distribution, and metabolic functions that differ between men and women. Physiologically, women have a higher percentage of absolute body fat compared to men, influenced by estrogen hormones that promote subcutaneous fat accumulation and regulate lipid metabolism and insulin sensitivity (Mauvais-Jarvis, 2015). Conversely, androgens in men are more closely associated with fat distribution in visceral areas, which are more metabolically active and are associated with a higher risk of metabolic comorbidities. Studies in the United States show that adipocytes

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in men and women differ in proliferation, differentiation, and metabolic functions, resulting in different fat accumulation patterns between genders (Fitzgerald et al., 2018).

Additionally, hormonal differences affect the activity of brown adipose tissue: estrogen enhances thermogenesis and fat burning, while androgens tend to inhibit this activity, thereby impacting energy expenditure differences between men and women (H. Kim et al., 2025). The different fat distribution also influences the profile of adipokines and pro-inflammatory cytokines released by adipose tissue, which affect insulin sensitivity and systemic inflammatory responses, with different response patterns between men and women (Zore et al., 2018). Besides hormonal factors, genetic differences and gene expression that regulate fat metabolism and energy homeostasis also contribute to sexual dimorphism in obesity, with some genes showing gender-specific effects on adipose tissue expansion and function (H. Kim et al., 2025).

Overall, these biological and pathophysiological mechanisms indicate that gender differences in obesity are not only reflected in prevalence variations but also involve different metabolic and physiological pathways in energy storage and expenditure (Mauvais-Jarvis, 2015). Therefore, understanding these mechanisms is a crucial basis for developing gender-sensitive obesity prevention and intervention strategies, including tailored approaches in dietary regulation, physical activity, and hormonal therapy considerations.

The results of this study indicate that educational attainment is not significantly associated with obesity among adult respondents. These findings are consistent with several national studies reporting that obesity can occur across all educational attainment groups, particularly in urban areas with widespread access to high-energy foods and obesogenic environments. However, the results of this study differ from those of several other studies in Indonesia, which report that individuals with lower levels of education have a higher risk of obesity than those with higher levels of education (Asif et al., 2020; Saraswati et al., 2021; Ul Badriyah et al., 2022) Variations are likely to influence these differences in findings, particularly in the socioeconomic context, regional characteristics, and the different stages of nutritional transition across regions.

Internationally, the relationship between educational attainment and obesity also shows inconsistent results. In high-income countries, higher education is generally associated with a lower risk of obesity, which is linked to better health literacy and nutritional awareness. This is evident in a study in Korea, which shows that highly educated individuals tend to have healthier lifestyles, resulting in a lower risk of obesity (Chung et al., 2017; Sart et al., 2023).

Although this study found no significant relationship between education level and obesity ($p>0.05$), education can still influence obesity biologically and pathophysiologically through indirect mechanisms. Education serves as an indicator of socioeconomic status that influences lifestyle behaviors, eating patterns, and an individual's ability to manage their health, ultimately affecting weight regulation. Individuals with higher levels of education generally have better nutritional knowledge and greater awareness of the importance of healthy eating behaviors, so they tend to avoid consuming high-energy and ultra-processed foods, which are risk factors for obesity.

In addition, education also modifies the relationship between lifestyle behaviors, such as eating patterns, physical activity, and sleep quality, and the incidence of obesity. Studies in Korea show that the effect of education on obesity can vary according to gender and health behavior patterns, making the influence of education on obesity complex and contextual (Chung et al., 2017) Differences in educational levels are also related to access to health resources and to cognitive ability in applying health information to daily practices,

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which, in turn, indirectly affect energy regulation, body composition, and metabolic responses through dietary choices, physical activity, and stress management.

In a pathophysiological context, behavioral factors influenced by educational attainment, such as diet quality and physical activity, affect energy balance and metabolic mechanisms, including insulin regulation, low-grade chronic inflammation, and adipose tissue storage. The complexity of these pathways explains why a direct relationship between education and obesity is not always statistically apparent, even though education still influences obesity determinants through behavioral pathways and access to health information (Chung et al., 2017). In addition, the distribution of obesity across educational groups is also influenced by the dynamics of nutritional transitions in society, where at certain stages of socioeconomic development, obesity increases more rapidly in low-educated groups due to exposure to obesogenic environments, such as high availability of high-calorie foods and low environmental support for physical activity (Liwin, 2022).

Several large studies also show that in adult populations, the relationship between education and obesity is not linear due to mediating factors such as income, type of work, physical activity patterns, and access to health facilities, which can strengthen or weaken the influence of education on obesity (Chung et al., 2017). Overall, although educational attainment did not show a significant direct relationship with obesity in this study, scientific evidence suggests that education continues to play an important role in the biological and behavioral processes that influence obesity, particularly through pathways of nutritional knowledge, lifestyle behaviors, and access to health resources. These findings confirm that obesity prevention interventions still need to consider education and health literacy as part of obesity control strategies in adulthood.

The employment status in this study shows a significant relationship with the incidence of obesity in adulthood. In general, these findings are in line with various national studies that report that employment, particularly jobs with low levels of physical activity, contributes to an increased risk of obesity in adults (Septiyanti, 2020; UNICEF, 2022). Work patterns dominated by sedentary activities, long periods of sitting, and limited time for physical activity are important factors that can trigger energy imbalance and weight gain. International studies in the United States also show that less physically active types of work and work-related lifestyles are associated with an increased risk of obesity in the adult population (Guthold et al., 2018; Hruby & Hu, 2015).

On the other hand, scientific evidence shows that unemployment status is a social determinant that plays an important role in obesity incidence through interactions among biological, behavioral, and environmental factors. Several international studies report that unemployed individuals have a higher risk of obesity than those who are employed, mainly due to the economic and psychosocial pressures associated with unemployment (Amenyah et al., 2022). The economic uncertainty experienced by unemployed individuals can trigger chronic stress, which is biologically associated with the activation of the hypothalamic–pituitary–adrenal (HPA) axis and increased secretion of the hormone cortisol (Zhang et al., 2024).

Chronic elevation of cortisol levels is known to increase appetite, particularly for foods high in fat and sugar, and to promote the accumulation of visceral fat, which is associated with high metabolic risks such as insulin resistance and dyslipidemia. Cortisol plays a role in adipocyte differentiation, lipid metabolism regulation, and fat redistribution to visceral depots through activation of the HPA axis, which in turn affects insulin regulation and energy metabolism(Knezevic et al., 2023). The study shows that food insecurity, defined as a condition in which individuals or households lack stable access to sufficient, safe, and nutritious food, is associated with poor diet quality among low-income adults. Limited access to healthy food encourages consumption patterns dominated by foods that are high

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in energy but low in nutritional value, thereby contributing to an increased risk of obesity (Jimenez Rincon et al., 2022).

Lifestyle changes resulting from unemployment, such as decreased physical activity, disrupted sleep patterns, and increased sedentary behavior, also contribute to energy imbalance and decreased basal metabolic rate. In the long term, this condition triggers low-grade chronic inflammation characterized by increased release of proinflammatory cytokines, such as TNF-α and IL-6, from adipose tissue, which further exacerbates insulin resistance and metabolic dysfunction (Zatterale et al., 2020). Several longitudinal studies have found that the relationship between obesity and employment status is bidirectional, whereby obesity not only increases the risk of unemployment but also reduces an individual's chances of returning to work, creating a mutually reinforcing cycle of obesity and unemployment. These findings are consistent with prospective studies showing that unemployed individuals with a high body mass index are less likely to escape unemployment than individuals without obesity (Dietrich et al., 2022).

Overall, although employment status is not a direct biological factor, scientific evidence shows that both employment and unemployment can affect obesity risk through pathophysiological pathways mediated by psychosocial stress, changes in eating behavior, physical activity levels, and hormonal and metabolic dysregulation. Therefore, obesity prevention efforts in adulthood need to consider employment factors and socioeconomic conditions as part of a comprehensive, context-specific public health approach.

Marital status in this study showed a significant relationship with obesity, where married individuals had a higher risk of obesity than those who were unmarried. This finding is in line with several national studies in Indonesia that report an increase in weight and incidence of obesity after marriage, which is generally associated with post-marital lifestyle changes (Saraswati et al., 2021). Globally, similar results have also been found in various countries; a study in Pakistan showed that obesity was more common in married individuals and that post-marital weight gain was considered socially acceptable (Shaheen et al., 2017), while a study in China reported that marriage significantly increased the probability of becoming overweight and obese in adulthood (Tang et al., 2024).

Biologically and pathophysiologically, behavioral changes associated with marriage can lead to an imbalance between energy intake and expenditure. Increased consumption of high-energy foods, larger meal portions, and decreased routine physical activity after marriage encourage the storage of excess energy as adipose tissue, especially metabolically active visceral fat. This condition triggers lipogenesis and continuous body fat accumulation, contributing to an increase in body mass index and the development of obesity (Tang et al., 2024).

In addition to biological mechanisms, social and psychosocial factors within the household also contribute to the increased risk of obesity among married individuals. Family dining norms, changes in daily life rhythms, and reduced social pressure to maintain an ideal body weight after entering a long-term relationship, as described in the marriage market hypothesis, contribute to weight gain (Nikolic Turnic et al., 2024). Furthermore, evidence from systematic studies and meta-analyses shows that married individuals consistently have a higher risk of obesity than those who are unmarried, even after considering other demographic factors, confirming that marital status is an important social determinant in the epidemiology of obesity in adult populations (Nikolic Turnic et al., 2024).

This study has several limitations that need to be considered when interpreting the results. First, the use of a cross-sectional study design means this study can only identify relationships between variables without establishing causality, so it cannot determine whether low physical activity precedes obesity (Setia, 2016). Second, self-reported

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physical activity assessments are prone to recall and social desirability bias, which often lead to estimates of physical activity levels being higher than they actually are (Guthold et al., 2018). Third, this study did not measure dietary intake and daily eating patterns, which, according to the literature, are the main determinants that interact with physical activity in determining the body's energy status. Genetic factors and physical and social environmental characteristics also need to be considered, as there is the potential for residual confounding (Hruby & Hu, 2015). Finally, the use of Body Mass Index (BMI) as a single indicator of obesity has biological limitations because it cannot distinguish between fat mass and fat-free muscle mass, which can lead to inaccurate classification in individuals with high muscle mass (Nuttall, 2015).

CONCLUSION

Based on the study, physical activity has a clear association with obesity among adults in Jakarta DKI province, but at a low level. Low physical activity respondents would have a greater risk of obesity compared to their counterparts who engage in moderate to high levels of physical activity. Apart from physical activity, obesity is also associated with sociodemographic variables: age, gender, employment status, and marital status are significantly associated with obesity, but educational level is not related. Middle age, female gender, and being employed and married are associated with a higher likelihood of being obese. This evidence supports that obesity is a complex disorder modulated by the combined influence of behavioral and sociodemographic factors. Thus, efforts to prevent obesity must adopt integrated approaches, including not only promoting physical activity but also paying attention to vulnerable population groups and considering their sociodemographic characteristics. The findings from this study are hoped to be used as an evidence base for the development and implementation of more focused public health policies and interventions to prevent obesity in adults, particularly among urban populations.

RECOMMENDATIONS

Several key suggestions for future research are outlined in light of the findings and limitations of this study. Firstly, future studies should mainly be longitudinal or prospective in nature, and cross-sectional studies should be included for analysis, with the limitations of inferring a causal relationship between sociodemographic risk factors and obesity. Second, thorough evaluations for nutritional intake may need to be included (e.g., by FFQ), so that the interaction term between calorie consumption and energy expenditure, which we think should be examined in this study, is also considered. Third, combining the accelerometer for physical activity assessments and BIA for body composition will be optimal to prevent underreporting and provide better estimates of fat distribution rather than using BMI itself. Moreover, further investigations are needed for the psychological or social factors and behavior (e.g., stress and partner-provided social support) associated not only with weight gain but also health outcomes among high-risk populations, such as the married and unemployed populations, to explore the mechanism of weight gain among them.

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