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RELATIONSHIP BETWEEN PHYSICAL ACTIVITY LEVELS AND METABOLIC RATE AMONG THE ADULT POPULATION IN DENPASAR CITY

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ABSTRACT

Background: Physical activity level plays an important role in determining metabolic rate and energy balance; a decline in physical activity among urban adults may increase the risk of metabolic disorders. **Objective:** To determine the relationship between physical activity level and metabolic rate in the adult population of Denpasar City. **Methods:** An analytical cross-sectional study with sampling conducted during Car Free Day at Lapangan Renon from September to December 2025. Physical activity level was assessed using the International Physical Activity Questionnaire (IPAQ), while metabolic rate was measured with a Body Fat Scale (BFS). Analyses included descriptive statistics, Spearman's correlation, and multiple linear regression. **Results:** A total of 138 respondents were analyzed. Sample composition by activity level was 19.6% low, 71.0% moderate, and 9.4% high. Median metabolic rate by group were: low 1,203 kcal, moderate 1,446.5 kcal, and high 1,581 kcal. Spearman's correlation showed a moderate positive association between physical activity level and metabolic rate ($r = 0.355$; $p < 0.001$). In multiple linear regression, sex and body mass index (BMI) were significant predictors of metabolic rate, whereas physical activity level was no longer significant after multivariable adjustment. **Conclusion:** There is a significant positive relationship between physical activity level and metabolic rate in bivariate analysis. However, after adjustment for other variables, sex and BMI emerged as the primary predictors of metabolic rate in this sample.

Keywords: physical activity, metabolic rate, IPAQ, Body Fat Scale, Denpasar.

INTRODUCTION

Metabolic rate is the total amount of energy the body uses for all activities within a given period. It plays an essential role in determining an individual's total daily energy requirements. Several factors influence metabolic rate, including age, sex, muscle mass, body composition, genetics, hormones, dietary patterns, and physical activity levels. Physical activity is particularly important because it increases calorie expenditure during movement and helps build metabolically active muscle mass.

In the adult population, physical activity levels tend to decline due to work demands that often require prolonged sitting. A study published in Heliyon reported that physical activity levels measured using the International Physical Activity Questionnaire (IPAQ) showed that 23.06% of participants had low physical activity, 35.18% had moderate physical activity, and 41.76% had high physical activity. Physical activity contributes to increasing muscle mass, enhancing energy expenditure, and maintaining overall health, all of which are directly related to an increase in metabolic rate.

Additionally, the increasing use of technology in urban areas facilitates daily life but reduces the need for physical movement. Such lifestyle patterns contribute to a decline in metabolic rate, leading to energy imbalance and a higher risk of metabolic diseases. Previous studies have shown that the rise in metabolic disorders, particularly obesity, is associated with decreased metabolic rate in adults.[1] Previous studies have also stated that in adulthood, sex and age are not significant determinants of the decline in basal metabolic rate, whereas physical activity plays a crucial role in regulating metabolic rate.[2] According to studies conducted on sedentary adults, basal metabolic rate accounts for approximately 50% to 70% of total energy expenditure, food-induced thermogenesis comprises about 10% to 15%, and physical activity contributes the remaining 20% to 30%. These data indicate that a reduction in metabolic rate can occur when individuals do not engage in sufficient physical activity, which may lead to metabolic diseases, particularly in urban populations.[3]

Denpasar City is one of the largest cities in Indonesia experiencing rapid economic growth and urbanization, which brings challenges related to increasingly sedentary lifestyles. Sedentary behavior has become more prevalent among the residents of Denpasar. According to data from the Basic Health Research (Riskesdas), the proportion of individuals engaging in adequate physical activity remains low at 33.5%. This condition increases the risk of reduced physical activity levels, which negatively affects metabolic rate. On the other hand, rising public awareness regarding the importance of physical activity presents an opportunity to improve the metabolic health of the population in Denpasar City.

Based on the explanation above, the author is interested in conducting an in-depth study on the relationship between physical activity levels and metabolic rate among the adult population in Denpasar City. Previous research has shown that in adults, metabolic rate is not significantly influenced by sex or age, but is more strongly affected by physical activity levels. This study aims to determine the relationship between physical activity levels and metabolic rate, thereby providing a better understanding of how different levels of physical activity correspond to metabolic rate. This study aims to determine the relationship between physical activity levels and metabolic rate among the adult population, and to identify the factors (age, sex, caffeine consumption, body mass index, body fat, skeletal muscle, and occupation) associated with metabolic rate in the adult population of Denpasar City.

METHODS

This study was an analytic investigation with a cross-sectional design and a quantitative approach, aimed at assessing the relationship between physical activity level and metabolic rate among the adult population of Denpasar City. Data collection involved face-to-face interviews using the International Physical Activity Questionnaire (IPAQ), with responses entered into a Google Form, and measurements of metabolic rate and body composition using a Body Fat Scale (BFS). Height was measured with a standard stadiometer. All research procedures were conducted in accordance with research ethics; the study received ethical approval from the Research Ethics Committee of the Faculty of Medicine, Udayana University (Protocol No: 2025.01.1.0054). Written informed consent was obtained from each participant prior to study participation.

Study population and sampling

The target population comprised all adults (20–59 years) residing in Denpasar City. The accessible population was defined as adults attending the Car Free Day event at the Tenda Tensi TBM Janar Dūta, Lapangan Renon, Denpasar. The sample consisted of all individuals from the accessible population who met the inclusion criteria and did not meet any exclusion criteria. Inclusion criteria were: residents of Denpasar City attending the Car Free Day at Tenda Tensi TBM Janar Dūta, willing to participate in the study, aged 20–59 years, having body mass index (BMI), body fat percentage, and skeletal muscle percentage within normal ranges, not pregnant, and without mental or motor disorders that would impede participation. Exclusion criteria were participants who did not complete the examination or did not provide complete data. Sampling was performed by purposive sampling with consideration of the age criterion (20–59 years). Sample collection was planned to occur on three occasions during September at the Tenda Tensi TBM Janar Dūta posts.

Sample size calculation

The sample size was determined using Cochran's formula for large or unknown populations; assuming a 95% confidence level, an expected proportion of 0.5, and a margin of error of 0.1, the required sample was calculated and rounded up to 97 participants, so a minimum of 97 respondents was targeted for inclusion in the study.

Variables

The primary dependent variable was metabolic rate, measured using the Body Fat Scale (BFS) and reported on a ratio scale. The primary independent variable was physical activity level, assessed with the IPAQ and presented on an ordinal scale according to IPAQ categories (light, moderate, vigorous activity). Control variables collected included age, sex, body mass index (BMI), body fat percentage, skeletal muscle percentage, and occupation; these were obtained via questionnaire and BFS measurements and categorized as required for analysis (nominal, ordinal, or ratio).

Instruments

Data collection instruments included the IPAQ questionnaire for assessment of physical activity level, a written informed consent form as documentation of participant agreement, a Body Fat Scale (BFS) for measurement of metabolic rate and body composition, and a stadiometer for accurate height measurement. All IPAQ interviews and BFS measurements were conducted at Lapangan Renon, Denpasar, during the data collection period from September to December 2025, with primary sampling activities carried out on Car Free Day at the Tenda Tensi TBM Janar Dūta location.

Data collection procedures

Data collection proceeded through several stages. Preparatory activities included notification and coordination with TBM Janar Dūta management, briefing and training of research assistants (estimated n = 6) on interview and measurement procedures, and preparation and verification of research instruments. On data collection days (Car Free Day), the investigators and assistants explained the study objectives and procedures to potential participants, obtained written consent, screened candidates for inclusion and exclusion criteria, and conducted the IPAQ interviews. Each interview required approximately three minutes per participant. Participants who met the criteria were then directed to a designated station for measurement of metabolic rate and body composition using the BFS. Interview and measurement data were recorded and entered into the Google Form by the research assistants.

Data management and analysis

Prior to analysis, all data were checked for completeness to ensure there were no missing entries or input errors. Complete data sets were exported to Microsoft Excel 2021 for preliminary processing and analysis. Univariable analysis was performed to describe sample characteristics and the distribution of each variable using descriptive statistics (frequencies, percentages, means, and standard deviations). Bivariable analysis to test the association between physical activity level (independent variable) and metabolic rate (dependent variable) employed Spearman's rank correlation, given the ordinal nature of the IPAQ categories. Multivariable analysis was then conducted using multiple regression to evaluate the effect of physical activity level on metabolic rate while controlling for potential confounders (age, sex, BMI, body fat percentage, skeletal muscle percentage, and occupation). Results are presented in tabular form with accompanying narrative interpretation according to scientific reporting standards.

RESULT

Respondent Characteristics

This study was conducted to determine the relationship between physical activity levels and metabolic rate among the adult population in Denpasar City. Data collection was carried out by distributing questionnaires, and the responses were processed using Excel. In this study, a total of 138 respondents were included. The respondent characteristics and results are presented in the following tables.

Tabel 1. Respondent Characteristic

Characteristic	Category	Number (n)	Percentage (%)
Sex	Male	78	56,5
	Female	60	43,5
Occupation	Student	43	31,2
	Formal Worker	46	33,3
	Entrepreneur	22	15,9
	Service Worker	10	7,2
	Courier	4	2,9
	Unemployed	13	9,4
Caffeine Consumption	Yes	73	52,9
	No	65	47,1
Body Mass Index	Underweight	5	3,6
	Normal	44	31,9
	Overweigth	30	21,7
	Obesity	45	32,6
	Obesity II	14	10,1
Body Fat	Low	4	2,9
	Normal	47	34,1
	High	38	27,5
	Very High	49	35,5
Skeletal muscle	Low	70	50,7
	Normal	67	48,6
	High	1	0,7
Tingkat Aktivitas Fisik	Light	27	19,57
	Moderate	98	71,01
	Heavy	13	9,42

The dominant findings showed a high prevalence of overweight and obesity, with 21.7% classified as overweight, 32.6% as obese, and 10.1% as obese class II (a total of 64.4%). A total of 63% of respondents exhibited high body fat percentages, while more than half (50.7%) were categorized as having low skeletal muscle mass. The majority of respondents reported a moderate level of physical activity (71.0%). The combination of high body fat, low skeletal muscle percentage, and the predominance of moderate physical activity levels are the key characteristics identified in this sample.

3.1 Descriptive Statistical Analysis

The analyzed data were derived from frequency distribution and descriptive statistics for metabolic rate variables, which were grouped according to physical activity levels.

Tabel 2. Frequency Distribution of Physical Activity Levels and Metabolic Rate Statistics

Physical Activity Levels	Frequency	Metabolic Rate		
		Median	Mean	Min-Max
Light	27	1203	1303,22	1025 - 1874
Moderate	98	1446,5	1483,53	1079 - 2082
Heavy	13	1581	1584,62	1249 - 1819
Total	138	1442	1457,78	1023 - 2082

The frequency distribution in the table shows 27 respondents with low physical activity, 98 with moderate activity, and 13 with high activity.[4] The median metabolic rates for each group were 1203 kcal for low activity, 1446.5 kcal for moderate activity, and 1581 kcal for high activity. The mean values followed a similar pattern, with 1303.22 kcal for the low-activity group, 1483.53 kcal for the moderate group, and 1584.62 kcal for the high-activity group. The moderate-activity group had the widest range of metabolic rate values, from 1079 to 2082 kcal.

Relationship Between Physical Activity Level and Metabolic Rate

To evaluate the normality of the data distribution, the Kolmogorov-Smirnov test was performed. This test is used to compare the sample distribution with a standard normal distribution. The results of the test are summarized in the following table.

Tabel 3. Normality Test

Variable	Kolmogorov-smirnov Statistic	Df	p
Physical Activity Levels	0,38	138	0,001
Metabolic Rate	0,60	138	0,200

The physical activity level variable had a p-value of 0.001. Because 0.001 is much smaller than 0.05, the null hypothesis (that the data are normally distributed) is rejected. Therefore, it can be concluded that the data for the physical activity level variable are not normally distributed.

Meanwhile, the metabolic rate variable had a p-value of 0.200. Since 0.200 is greater than 0.05, the null hypothesis cannot be rejected. This indicates that the data for the metabolic rate variable are normally distributed.

Tabel 4. Correlation Test Between Physical Activity Level and Metabolic Rate

	Metabolic Rate	
	r (rho)	p-value
Physical Activity Level	0,355	<0,001

The correlation coefficient found in this study was r = 0.355. This value has two crucial components of interpretation. First, the positive sign (0.355) indicates a positive relationship between physical activity level and metabolic rate. As an individual's physical activity level increases, their metabolic rate also tends to increase, and vice versa.

The p-value represents the probability of observing the same or more extreme results if the alternative hypothesis namely, that there is a relationship between the variables is true. In this study, the alternative hypothesis states that there is an association between physical activity level and metabolic rate. The p-value obtained, which was less than 0.001, is extremely small. Given that the conventional threshold for statistical significance in scientific research is $p < 0.05$, this value falls far below the threshold, indicating a highly statistically significant result. This provides strong evidence supporting the alternative hypothesis and suggests that the positive relationship observed between physical activity level and metabolic rate in the sample is likely present in the broader population, rather than being the result of chance or random variation.

In analyzing the relationship between metabolic rate and the primary variable, this study treated sex, age, occupation, caffeine consumption, BMI, skeletal muscle, and body fat as control variables. These variables were included in the statistical model to adjust for their effects and reduce confounding bias, rather than to serve as the main focus of interpretation.

3.2 Relationship Between Metabolic Rate and Other Variables

In assessing the relationship between metabolic rate and the main independent variable, the study included sex, age, occupation, caffeine consumption, body mass index, skeletal muscle, and body fat as control variables. These variables were incorporated into the statistical model to adjust for their potential confounding effects and to minimize bias, rather than to be the primary focus of interpretation. The multiple linear regression analysis demonstrated the combined influence of these independent variables sex, age, occupation, caffeine consumption, BMI, skeletal muscle, body fat, and physical activity level on metabolic rate as the dependent variable. The regression analysis produced a constant value of 701.897, representing the estimated metabolic rate when all independent variables are set to zero.

Each independent variable was associated with a regression coefficient (B), indicating both the direction and magnitude of its effect on metabolic rate. The resulting regression equation was: $Y = 701.897 + 327.314X_1 - 0.695X_2 - 6.798X_3 + 29.444X_4 + 138.475X_5 + 49.434X_6 + 9.039X_7 + 29.825X_8$, where Y represents metabolic rate; X_1 denotes sex; X_2 age; X_3 occupation; X_4 caffeine consumption; X_5 body mass index; X_6 skeletal muscle; X_7 body fat; and X_8 physical activity level.

Tabel 5. Linear Regression Test

Model	Unstandardized Coefficients Std. Error		Standardized Coefficients Beta	t	P
	B	Std. Error			
Constant	701,897	102,018		6,880	<0,001
Sex	327,314	24,457	0,654	13,383	<0,001
Age	-0,695	0,977	-0,35	-0,712	0,478
Occupation	-6,798	7,783	-0,042	-0,873	0,384
Caffeine Consumption	29,444	21,735	0,059	1,355	0,178
Body Mass Index	138,475	10,874	0,612	12,735	<0,001
Skeletal muscle	49,434	26,706	0,102	1,851	0,066
Body Fat	9,039	11,974	0,033	0,755	0,452
Physical Activity Level	29,825	22,136	0,064	1,347	0,180

a. Dependent Variable: Laju Metabolisme

The linear regression results showed that two variables had a statistically significant influence on metabolic rate: sex ($B = 327.314$; $SE = 24.457$; $t = 13.383$; $p < 0.001$) and body mass index (BMI) ($B = 138.475$; $SE = 10.874$; $t = 12.735$; $p < 0.001$). Practically, the model estimated a baseline metabolic rate of 701.897 units when all independent variables were set to zero (constant: $B = 701.897$; $SE = 102.018$; $p < 0.001$). The standardized coefficients (Beta) for sex and BMI were also large (0.654 and 0.612, respectively), indicating that differences in sex and variations in BMI were the major contributors to metabolic rate variability in this sample.

The skeletal muscle variable showed a positive coefficient ($B = 49.434$) but did not reach statistical significance at $\alpha = 0.05$ ($SE = 26.706$; $t = 1.851$; $p = 0.066$), suggesting only a tendency for skeletal muscle percentage to be associated with metabolic rate. The other variables age, occupation, caffeine consumption, body fat, and physical activity level did not demonstrate significant effects after adjusting for the other predictors in the model.

DISSCUSION

Relationship Between Physical Activity Level and Metabolic Rate

The distribution of metabolic rate across different levels of physical activity shows a pattern that aligns with previous research findings. The heavy activity group has the highest median metabolic rate (1,581 kcal), followed by the moderate activity group (1,446.5 kcal) and the light activity group (1,203 kcal). The Spearman correlation analysis confirms a significant positive relationship between physical activity level and metabolic rate. This indicates that an increase in the intensity or volume of physical activity is associated with an increase in energy expenditure. According to other studies, more intensive exercise or higher activity volume enhances skeletal muscle and increases metabolic rate. Researchers have reported that moderate and high levels of physical activity volume are positively correlated with metabolic rate.[5] Thus, although the moderate physical activity group has a larger population, its metabolic rate values are consistently lower than those of the heavy activity group, indicating that the level of activity has not been sufficient to produce a significant increase in metabolic rate.[6]

Physical activity directly increases the body's energy expenditure, both during exercise and afterward. In the short term, intensive exercise elevates oxygen consumption and calorie use for several hours following the activity. Meanwhile, the long-term effects of regular exercise are more closely related to changes in body composition, particularly the increase in muscle mass, which can raise the resting metabolic rate. Studies show that an increase of approximately 2 kilograms of muscle mass can elevate the resting metabolic rate by about 50 kcal per day.[7] Resistance training that effectively increases muscle mass tends to elevate resting energy requirements more than aerobic exercise. A recent systematic review found that resistance training programs increased resting metabolic rate by approximately 96 kcal per day compared to controls, whereas aerobic exercise alone did not produce a significant increase in resting metabolic rate. Anaerobic or weight-bearing exercise is therefore more effective in raising long-term basal metabolic rate due to its impact on muscle gain, while aerobic exercise primarily burns calories during the activity itself, with a smaller post-exercise effect on resting metabolic rate compared to resistance training.[8]

Differences in types of physical activity can also be seen in the body's energy-use patterns. Aerobic exercises (such as running, cycling, and moderate-intensity swimming) increase energy expenditure during the activity, primarily through the oxidation of body fat, but they do not significantly elevate basal metabolic rate. In contrast, high-intensity or resistance-based exercise stimulates muscle hypertrophy, which in turn increases the body's minimum caloric requirements. Aerobic exercise improves cardiovascular fitness and reduces body fat, whereas weight training increases muscle mass and raises resting metabolic rate.[7]

Several studies in Asia support the finding that physically active adults tend to have higher metabolic rates. For example, research conducted in Korea reported that high levels of physical activity are positively associated with the preservation of muscle mass and resting metabolic rate among middle-aged adults.[9] This means that physically active older adults tend to maintain their resting metabolism more effectively. Reviews focusing on Asian populations also show that their resting metabolic rate tends to be lower compared to Caucasians, largely due to differences in body composition, particularly the generally lower muscle mass found in Asian individuals.[10] Considering this, increasing physical activity particularly resistance training is essential for boosting metabolic rate in Asian populations. For instance, studies on Indonesian populations during the pandemic reported that most migrant workers had low levels of physical activity and exhibited an average resting metabolic rate within the moderate range.[11] These findings underscore the need to increase physical activity in order to improve the body's metabolic function.

Relationship Between Physical Activity Level and Other Variables

The World Health Organization notes that adult women tend to be less physically active than men, and that physical activity declines in both sexes after the age of 60. Differences in body composition explain part of the metabolic variation between sexes; for example, men generally have greater skeletal muscle mass, resulting in a higher metabolic rate. This is consistent with the regression analysis in which male sex contributed significantly to the increase in metabolic rate. Conversely, in the multivariate model, age was not statistically significant. Nevertheless, physiologically, increasing age typically lowers metabolic rate due to reduced active skeletal muscle mass and hormonal changes, which causes older adults to have lower levels of physical activity and lower energy requirements.[12]

Among the other variables, most respondents in this study had excess nutritional status, consisting of overweight, obesity class I, and obesity class II, along with high body-fat percentages. Physical activity plays an essential role in regulating body weight and body composition. For example, other researchers have reported a significant negative correlation between physical activity levels and BMI among older adults, indicating that the more physically active individuals are, the lower their BMI tends to be.[13] The multiple regression results of this study also reinforce that BMI is a strong predictor of metabolic rate, as individuals with larger body composition require higher energy expenditure. In addition, large population studies have shown that groups with the highest levels of physical activity have 1.5 - 2.0% lower body-fat percentages compared with those with the lowest activity levels. This indicates that moderate- to high-intensity physical activity tends to reduce fat accumulation. Physiologically, increasing body fat typically decreases metabolic rate per kilogram of body weight. Therefore, regular physical activity helps prevent increases in BMI and body fat, consistent with the literature showing that high physical activity levels are associated with the prevention of obesity and weight gain.[14]

Skeletal muscle is the body's primary metabolically active tissue. The greater the skeletal muscle mass, the more calories are burned even at rest. The regression analysis in this study showed a positive trend between skeletal muscle percentage and metabolic rate, although the association did not reach statistical significance. This relationship is physiologically reasonable, as physical activity particularly resistance training stimulates muscle hypertrophy. Evidence from previous studies demonstrates that resistance exercise consistently increases skeletal muscle mass. Conversely, insufficient physical activity is a major risk factor for reduced skeletal muscle. Research has shown that sedentary behavior is significantly negatively correlated with skeletal muscle, meaning that the more time an individual spends sitting or inactive, the lower their skeletal muscle tends to be. In contrast, strength training and regular physical activity effectively increase skeletal muscle mass.[15] Thus, individuals who are more physically active tend to have greater skeletal muscle mass, which directly supports a higher metabolic rate.[16]

Occupational type contributes to physical activity levels and metabolic rate through differences in daily physical demands. Physically demanding jobs increase skeletal muscle, thereby supporting greater energy expenditure and a higher metabolic rate compared with sedentary occupations such as office work. This study found that individuals in physically heavy occupations demonstrated higher levels of physical activity than those in moderate or light activity categories. This finding is consistent with literature reporting that manual laborers can expend up to nine times their resting metabolic rate, whereas office workers typically expend only about twice their resting metabolic rate.[17] Meanwhile, caffeine consumption also has the potential to increase metabolic rate through stimulation of the sympathetic nervous system and enhanced thermogenesis.[18] Recent studies show that moderate to high caffeine intake can raise daily energy expenditure by approximately 3–10%, increase fat oxidation, and is associated with lower body fat percentage. Thus, a sufficient habit of caffeine consumption may contribute to an increase in metabolic rate, although its long-term effects may diminish due to physiological adaptation.[19]

Overall, the findings of this study demonstrate a high prevalence of overweight or obesity, elevated body fat, varying caffeine intake, low skeletal muscle, and diverse occupational patterns among adults in Denpasar, with the majority reporting moderate physical activity levels. These results align with existing research indicating that physical activity affects body weight and body composition, where higher levels of physical activity are associated with lower BMI and body fat, as well as increased skeletal muscle.[13,14,16] Although in the multivariate analysis variables such as age, occupation, caffeine intake, body fat, skeletal muscle, and physical activity level were not statistically significant, the positive effect of physical activity on metabolism is clearly evident in the simple correlation analysis and through mediating factors such as skeletal muscle and sex. These findings reinforce the importance of regular physical activity in maintaining healthy body composition and optimizing metabolic rate.[20]

CONCLUSION AND RECOMMENDATION

There is a significant positive relationship between the level of physical activity and metabolic rate. Higher levels of physical activity are associated with higher metabolic rates among the adult population in Denpasar City. Body mass index and sex contribute significantly to variations in metabolic rate, whereas age, occupation, caffeine consumption, body fat, and skeletal muscle do not show a significant effect in this population.

Further research is recommended to explore additional factors that may influence the relationship between physical activity level and metabolic rate, in order to exclude potential confounding factors that may arise among the variables studied.

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REFERENCES

1. Nugroho KPA, Kurniasari RRMD, Noviani T. Gambaran Pola Makan Sebagai Penyebab Kejadian Penyakit Tidak Menular (Diabetes Mellitus, Obesitas, Dan Hipertensi) Di Wilayah Kerja Puskesmas Cebongan, Kota Salatiga. J Kesehat Kusuma Husada. 2019;15–23.
2. Lazzer S, Bedogni G, Lafortuna CL, Marazzi N, Busti C, Galli R, et al. Relationship between basal metabolic rate, gender, age, and body composition in 8,780 white obese subjects. Obesity. 2010;18(1):71–8.
3. Pontzer H, Yamada Y, Sagayama H, Ainslie PN, Andersen LF, Anderson LJ, et al. life course. 2021;(August):1–5.
4. Pramartha IMDA, Putri WCWS, Weta IW, Pinatih GNI. Hubungan Aktivitas Fisik Terhadap Kebugaran Jasmani Mahasiswa Laki-Laki Program Studi Sarjana Kedokteran dan Profesi Dokter Fakultas Kedokteran Universitas Udayana Tahun 2019/2020. E-Jurnal Med Udayana. 2023;12(4):98.
5. Jaremków A, Markiewicz-Górka I, Hajdusianek W, Czerwińska K, Gać P. The Relationship between Body Composition and Physical Activity Level in Students of Medical Faculties. J Clin Med. 2024;13(1).
6. Speakman JR, Selman C. Physical activity and resting metabolic rate. Proc Nutr Soc. 2003;62(3):621–34.
7. Tan J, Krasilshchikov O, Kuan G, Hashim HA, Aldhahi MI, Al-Mhanna SB, et al. The Effects of Combining Aerobic and Heavy Resistance Training on Body Composition, Muscle Hypertrophy, and Exercise Satisfaction in Physically Active Adults. Healthc. 2023;11(17).
8. MacKenzie-Shalders K, Kelly JT, So D, Coffey VG, Byrne NM. The effect of exercise interventions on resting metabolic rate: A systematic review and meta-analysis. J Sports Sci. 2020;38(14):1635–49.
9. Hwang H, Jung WS, Kim J, Park HY, Lim K. Comparison of association between physical activity and resting metabolic rate in young and middle-aged Korean adults. J Exerc Nutr Biochem. 2019;23(2):16–21.
10. Wulan SN, Raza Q, Prasmita HS, Martati E, Maligan JM, Mageshwari U, et al. Energy metabolism in relation to diet and physical activity: A south asian perspective. Nutrients. 2021;13(11):1–13.
11. Hita IPAD, Kushartanti BMW, Nanda FA. Physical Activity, Nutritional Status, Basal Metabolic Rate, and Total Energy Expenditure of Indonesia Migrant Workers during Covid-19 Pandemic. J Pendidik Jasm dan Olahraga. 2020;5(2):122–8.
12. World Health Organization. Physical activity [Internet]. World Health Newsroom. 2024 [cited 2025 Nov 11]. p. 1. Available from: https://www.who.int/news-room/fact-sheets/detail/physical-activity
13. Fadila N, Wijaya A, Roni F. Hubungan Aktivitas Fisik Dengan Indeks Massa Tubuh Pada Lanjut Usia Di Desa Kalikejambon, Kabupaten Jombang. J Persat Perawat Nas Indones. 2024;9(2):125.
14. Zou Q, Su C, Du W, Ouyang Y, Wang H, Wang Z, et al. The association between physical activity and body fat percentage with adjustment for body mass index among middle-aged adults: China health and nutrition survey in 2015. BMC Public Health. 2020;20(1):1–12.
15. Suhada PD, Widyastuti N, Candra A, Syauqy A. Korelasi Aktivitas Fisik dan Persen Lemak Tubuh dengan Indikator Sarkopenia. Amerta Nutr. 2021;5(1):15.
16. Cartee GD, Hepple RT, Bamman MM, Zierath JR. Exercise Promotes Healthy Aging of Skeletal Muscle Primary versus Secondary Aging: Setting the Stage. Cell Metab. 2017;23(6):1034–47.
17. Mänttäri SK, Oksa JAH, Virkkala J, Pietilä JAK. Activity Level and Body Mass Index as Predictors of Physical Workload During Working Career. Saf Health Work. 2019;10(4):527–30.
18. Van Schaik L, Kettle C, Green R, Irving HR, Rathner JA. Effects of Caffeine on Brown Adipose Tissue Thermogenesis and Metabolic Homeostasis: A Review. Front Neurosci. 2021;15(February):1–15.
19. Alshahrani SH, Atia YA, Badir RA, Almalki SG, Tayyib NA, Shahab S, et al. Dietary caffeine intake is associated with favorable metabolic profile among apparently healthy overweight and obese individuals. BMC Endocr Disord. 2023;23(1):1–10.
20. Sutarini IDAAD, Muliarta IM, Dinata I Made Krisna. Perbedaan physical fitness pada berbagai frekuensi olahraga dan indeks massa tubuh mahassiwa program studi sarjana kedokteran dan profesi dokter fakultas kedokteran universitas udayana. Med Udayana [Internet]. 2019;8(11):2597–8012. Available from: https://ojs.unud.ac.id/index.php/eum